Māris Kļaviņš
Professor, University of Latvia

For the development and growth of the country and society to happen, action is necessary; in order to act, we need knowledge. This book gives broad knowledge from an interdisciplinary perspective and in the context of societal processes. Understanding the processes in nature and society, we can attempt to solve the problems of today to create a better future.

Walter Leal Filho
Professor, Hamburg University of Applied Sciences

This book shows to students the complexity of matters related to sustainable development, at the same time showing the steps we all can take towards a more sustainable future.

Jānis Zaļoksnis
Associate Professor, University of Latvia

You who are students today will soon take over the responsibility for the fate of humankind and our planet. My wish is that you have more success than the previous generations had.

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ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

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PREFACE

Christine Jakobsson
Director of the Baltic University Programme

Latvia has seriously taken on the task of educating the Latvian population on environmental education and sustainable development. Latvia has been in the forefront of this area as already in 2006 a law was passed by the Saeima (Parliament) of the Republic of Latvia which makes such education obligatory for all university students. This book is an important tool to implement this law in Latvia and to broaden the interest and knowledge base of students at Latvian universities on environmental education and sustainable development. It can also be of interest for many others.

Sustainable development of the Baltic Sea Region has been the main focus of the Baltic University Programme (BUP) for many years. The paradigm shift to sustainable development is a precondition for a good future for the Baltic Sea Region and the people we know and care about. *Education for Sustainable Development* (ESD) is an important tool and the way to implement this paradigm shift. The current rigid horizontal academic structure of universities is a difficulty regarding the implementation of sustainable development and must be adapted to permit interdisciplinary cooperation and collaboration among the different faculties at universities.

The *Baltic Sea Region* (BSR) is well situated to take on this challenge as we have a long history of cooperation and we also have numerous organizations that are active in areas of importance for sustainable development. Baltic 21 – An Agenda 21 for the Baltic Sea Region was adopted in 1998 and is still functioning within the Council of the Baltic Sea States. This is also a region with a high level of education and stable political conditions compared to many other places in the world. Moreover, this region is rich in resources, and relatively sparsely populated. It should be possible to be self-sufficient in terms of energy supply in the long run. In 2009 the *EU* adopted their Strategy for the Baltic Sea Region. This is the first macro-regional strategy and will be followed by others, such as the Danube and Mediterranean regions.

Ecosystem services are crucial for the earth. To a large extent, we take them for granted but our lives depend on them. Some of them are *provisioning services,* such as energy, food, the air we breathe and the water we drink, some are *regulating services*, such as climate, nutrient flows and the self-cleaning and regulation of water, pollination of plants, and some are *cultural services*, such as enjoying nature and the environment. *Biodiversity* is one of the most threatened resources and ever more species end up on the Red List for extinction every year. The unintentional introduction of invasive species with, e.g., ballast water or animals and plants is a threat, just as uncareful use of land for agriculture, forestry or urban infrastructure. Everyone reading this book needs to contribute to the good management of ecosystem services to stop their degradation.

The use of *resources* is another area of great importance, where we can also improve the situation and use all resources as effectively as possible and, wherever possible, replace non-renewable resources with renewable resources. The goal should be to minimise all waste and redefine what was formerly considered to be waste to be a resource for another product. Here it is also suitable to promote the rule of the 3 Rs: Reduce; Reuse; Recycle. We all need to contribute to create a resource-efficient society!

One resource of pressing importance is *energy*. A large portion of the energy used in the BSR is based on fossils, which emit CO_2 during burning, which contributes to *climate change*. A switch to renewable energy is already taking place but must be speeded up. It is just as important to create more effective engines for transport as well as buildings that do not need energy for heating and cooling. Saving energy can mean a lot. *Decoupling*, economic development independent of the use of fossil carbon, is possible; it has been shown in some BSR countries such as Sweden.

Our environment has been affected by *pollution* for many decades. There are some success stories, such as the reduction in the depletion of the ozone layer and deposition of acid rain, pesticides such as DDT and some heavy metal compounds such as mercury compunds. On the whole, we must stop pollution at the source to reach sustainable development and not only tidy up afterwards. This is one of the distinctions between environmental protection and sustainable development. In sustainable development, we plan and take action to prevent problems that will affect future generations. In environmental protection, we solve problems afterwards! We need more proaction!

Recently a study of limits for several crucial processes on the Earth, *Planetary Boundaries*, was published. The limits were defined for nine processes and have already been exceeded for three: greenhouse gases in the atmosphere, the speed with which biodiversity decreases, and the amount of nitrogen and phosphorus flowing in the biosphere. This work helps us understand the limits of the Earth and where to concentrate our efforts.

For the business and industrial world, the concepts of *environmental management systems* and *corporate social responsibility*, as well as *cleaner production* are important as tools to improve the situation. We must also remember that the choice of the product to buy lies with us consumers, but we must have relevant information available to help us make the right choice. This brings us to *lifestyles* and the effects our choices in life have on the earth. Technological development, legislation, taxes and subsidies, procurement, improved infrastructure, e.g. for communication and travel, will all be of importance to speed up the shift to sustainable development.

The Baltic Sea Region is only one part of the globe and it has been affected by the global poverty crisis. Some countries have been hit harder than others. The population of the world is prognosed to increase considerably in the future; at the same time, climate change will seriously affect large areas, especially in the south. This will lead to even greater requirements of efficiency when producing food and fodder and for the use of all resources. In the near future, we will see a situation when clean water and food will be scarcely available and pose an increasing problem. The value of arable land will also increase, as it is necessary for the production of food and energy.

In my work in the Baltic University Programme, I have noted how important student activities and initiatives are. We have been organising annual student conferences for over than 10 years. As of 2008, we organise two per year. Each summer, we also take groups of students to sail on a tall ship, teaching them more about sustainable development at the same time. Team-building and personality devekopment while getting to know people with similar values creates life-long friendships and also serves as a powerful tool to implement change.

Finally, we are all important and all have a place and task in the exciting and necessary shift to sustainable development. During my years of working with sustainable development in the BSR, I have noticed that committed people working together across the national and academic boundaries have a tremendous potential. Our initiative and belief can change the world – just remember that it all depends on us!

TIME FOR A NEW VISION

Connie Hedegaard
European Commissioner for
Climate Action

Everything is a question of timing. This is true for climate change too. This presents both a problem and an opportunity. Briefly, the problem is that it is difficult to instil a sense of urgency when effects are slow to be felt. The time horizons are too long for us as individuals and politicians. We are all made to deal with near–term, more immediate problems first, even at the expense of longer-term well-being.

It is all very well saying that acting now to prevent serious climate change is like paying an insurance premium, but we do not generally pay premiums for the next generation, or for people who live on the other side of the Earth.

So how can the issue be framed in 'here and now' for the present generation in developed countries to be motivated to act?

In the European Union, we have put in place an emission trading system which requires that companies monitor their emissions of greenhouse gases, and they have to pay to emit more than the quota they have been assigned. The penalties are very heavy, and given that companies do not want to pay punitive penalties, in practice they are monitoring their emissions carefully and making sure that they buy extra allowances if needed. In other words, if you pollute more, it is expensive; if you emit less, you earn money. Logically and accordingly, the existence of a regulatory framework has made companies think in terms of 'here and now'. That is a real progress.

However, how do we make individuals think like this? We must accept that it is human nature to try to avoid and postpone difficulties. Is it not true that the more successful individuals face up to difficulties when they can see them – and even anticipate potential difficulties ahead, so as to be better prepared? My experience is that this is often true. Just as we might save for a rainy day, so we might invest now so as to save money later. Even if we have to borrow to invest, we do generally understand the interest of doing this, or few would own their own house or car.

ENERGY SECURITY

When the gas supplies to Europe were disrupted in January 2009, schools and factories had to close in some parts of Europe. That was a shocking reminder of how dependent we really are on others concerning our energy needs. It is perhaps worth remembering that many people with central heating would be unable to heat their homes if the electricity was cut that runs the pumps and thermostats that make central heating systems work. I do not want to imply that electricity cuts are likely, but I want to make the point that sometimes we are more vulnerable than we realise.

The EU imports a great deal to satisfy its energy needs. Today, Europe imports 54% of its energy. At the prices of 2008, these imports represent an estimated EUR 350 bn, or around EUR 700 per year per every EU citizen.

As the world's population increases, combined with the growing wealth of emerging economies and the fact that new sources of fossil fuels are proving more expensive to obtain, there is a substantial risk that fossil fuel prices will rise rather dramatically in the coming years. In its most recent World Energy Outlook, the International Energy Agency estimated that, under the business-as-usual scenario, global oil consumption is expected to rise by 1% per year until 2030. We saw commodity prices rise very quickly in 2007, with oil prices peaking at USD 147 a barrel in 2008. But even now, without the global economy having emphatically recovered from the recent financial and economic crisis, we see oil prices of around USD 80 a barrel, and, in recent months, a weakening euro. The result is that fuel prices at the pump are distinctly higher than they were just a few months ago: in fact, prices at the pump were not much higher when oil prices were at their peak. If oil prices were to rise substantially again, or the value of the Euro or a national currency to fall in relation to the USA dollar, we would be very vulnerable to having to channel more of our monthly income towards paying energy bills.

It would be wise to try and reduce our energy bills by improving our individual energy efficiency. I believe that this would be a wise step to take sooner rather than later. I am sure that acting now is the sensible thing to do.

LOW-CARBON ECONOMY FOR JOBS AND GROWTH

The beauty of renewable energy technologies, and their contrast with fossil-fuel-based technologies, is that there is no fuel cost. Yes, there are up-front costs to be borne. But after that, running costs are substantially lower due to no fuel costs for many renewable technologies (hydro, solar, wind, geothermal, tidal and marine). Over time, the lower running costs will compensate for the higher up-front costs, and the higher fossil fuel costs are, the shorter the pay-back time will be.

It is also a fact that, as many fossil fuels are imported from the third countries, the money generally leaves the EU. By contrast, as we are world-class producers of many renewable energy technologies, the money we pay for them remains within the European economy. European jobs are created. A recent study[1] for the European Commission estimated that reaching Europe's renewable energy targets in 2020 will create a significant boost to the economy and the number of jobs in the EU. Improving current policies so that the target of the 20% share of renewable energy in the total energy consumption in 2020 can be achieved will provide a net effect of up to 410,000 additional jobs and 0.24% additional gross domestic product. European jobs give families money to spend, and much of this spending further stimulates our economy. Thus, from an economic as well as energy security perspective, these useful steps have tangible benefits distinct from the climate benefits.

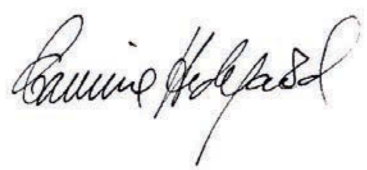
There is also the industrial perspective to bear in mind. To prosper, we must produce what people want. In a world of increasing energy demands, and increasing scarcity of that energy, not to mention a world more conscious of climate change, many will want to deploy renewable and energy-efficient technologies. The higher energy prices go, the greatest the competitive advantage for those whose energy costs are lower. Europe has a leading edge in the renewable energy field: EU companies are known worldwide for their innovation and technical excellence. Many small companies are also developing innovative technologies that can save consumers energy and money. There has to be a brighter future in manufacturing products adapted to the needs of tomorrow rather than the needs of yesterday. This is not just about a 'green' economy, but about investing in a thriving rather than a declining economy.

What value can we put on shielding ourselves from fluctuating energy prices? What price can we give to having an industrial base that is well-adapted to thrive in a world increasingly, if gradually, focussed on energy security and climate change? These benefits are not adequately covered by the economic modelling, but they do constitute real benefits with real value.

The British economist Lord Stern, who undertook the most comprehensive study of the economics of climate change that I am aware of, concluded very clearly that the costs of inaction were substantially greater than the costs of action. It is as true today as it was when he published his findings back in 2006. The costs of inaction could rise as high as between 5% and 20% of lost GDP each year. By comparison, the European Commission estimates that the cost of the climate-energy package in 2020 would be 0.32% of the GDP. Even stepping up the level of ambition to a 30% greenhouse gas reduction in 2020 would cost an estimated 0.5% of the GDP.

This is a small price to pay for the energy security benefits, insulation from the volatility of oil prices as the global demand increases, and the industrial transformation that the low-carbon economy offers.

The end result is that now is a good time to be addressing climate change. Not 'just' because of the climate challenge – although this is reason enough – but also because it is sound economics, seen from the perspective of this generation – as well as of future generations.



[1] **EmployRES:** The Impact of Renewable Energy Policy on Economic Growth and Employment in the European Union (April 2009).

WHAT IS BEST FOR THE ENVIRONMENT?

Janez Potočnik
European Commissioner for the Environment

What is best for the environment? And how can the best choices for the environment contribute to sustainable development? These are dilemmas many of us face every day in our lifestyle choices, but also the one that Europe faces as a developed economy. Assuming that we actually care about the environmental impact of our behaviour, how can we reduce it and how can we measure it?

We have spent 40 years developing the environmental laws that have given Europeans cleaner water and air, while providing a more level playing field for businesses. And, of course, we have new technologies at our fingertips. However, we still need to change our behaviour, as consumers and as producers. The effects of global population growth, our aging societies and many other challenges are having a major impact on our planet.

Efficient use of resources is the best way to help make the changes we need: managing our resources to reduce the environmental impact of their use; and living, producing and consuming within the physical and biological limits of this planet. This is true sustainable thinking. We have to think about all our material and natural resources, not only energy.

Efficient use of resources will underpin our future economic strategy and is a flagship item of our ten year Europe 2020 Strategy. We want to use it to generate growth that will be sustainable in the future and will put less pressure on energy and resources.

I want to decouple economic growth from the use of resources, and support the shift towards a low-carbon economy, increase the use of renewable energy sources, modernise our transport sector and promote energy efficiency. There is no contradiction between competitiveness and efficient use of resources: we have already seen that the most competitive countries are mainly the ones that are the most resource efficient.

Commitment is certainly a prerequisite. Otherwise efficient use of resources is doomed to become just another pointless rallying call with no substance. And this commitment must be backed up with a proper understanding of what it is and what we all must do to make it happen.

Efficient use of resources will need to be implemented as a multi-level government strategy, because it is a truly cross-cutting affair which touches many policy areas, many countries and regions. We will surely need the private sector. They are, after all, the people using those resources and they understand more than most what 'less in – more out' really means. Then there is the European consumer.

This will be a real challenge. Although efficient use of resources is not a new idea, the key to making it work will be in finding the practical tools to implement it in the context we live in today. We will have our work cut out integrating resource efficiency more generally across all relevant policies; especially when resources are becoming more valuable, even resources like waste.

Our work is not based on the need for flashy policies. There are growing moral and economic arguments for using resources better. The recent report on the Economics of Ecosystems and Biodiversity has shown that the loss of ecosystem services is costing us around EUR 50 billion annually. We have to reflect the real value of resources in our pricing. This means giving the right incentives, not only through the use of innovation. Fiscal policies will have to be adjusted to look beyond raising revenue to a new type of development; unnecessary subsidies, which lock in inefficient technologies and business structures, will have to be phased out.

Such readjustments in relative prices would drive greater innovation. Regarding demand, the most direct influence we have is through green public procurement. Public procurement accounts for 17% of GDP, and real savings can be made through better and greener public choices. It will need new ideas, such as the new Handbook on Life Cycle Assessment, which will help businesses, public authorities and policy makers better evaluate the environmental impacts of their activities.

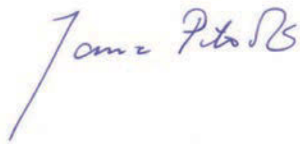
If nothing changes consumer habits like prices, then nothing induces innovation like changing market conditions. Eco-innovation is about new business models. It is also about looking at the whole business of business and thinking differently. For example, as waste has become more valuable, we have seen new technologies applied to treating it, as well as innovative markets developing to buy and sell it.

Some changes are simpler. Charging for plastic bags at supermarkets has encouraged people to reuse bags; putting smart energy meters in houses; these are simple and effective ways to help people make the right choices, sometimes without them even realising!

This is where we can make a difference: in changing behaviour through enterprise, markets and prices, rather than through environmental legislation and sanctions, even if we need both approaches.

One of the most pressing objectives will be to develop good indicators for efficient use of resources. Policy makers at all levels will need the right indicators and targets if the right changes are to be induced. This means looking beyond GDP and finding pragmatic indicators that will motivate policy changes.

Today's policy makers must use their legislative power to engage and guide the wider society, as it is only by changing our collective behaviour that we can leverage our environmental work to achieve sustainable growth.



Andris Piebalgs
European Commissioner for Development

We live in a world of unprecedented changes. Since the beginning of the industrial revolution, the activities of mankind have led to increasingly visible alterations in landscape and biosphere. Over the last 50 years, the world's population has almost tripled, reaching close to seven billion people. Humans have changed eco-systems extensively to meet the growing demand for food, fresh water, timber, fibre, medicine and fuel. Further population growth of two billion is predicted by 2030, combined with the goal to pull everyone out of extreme poverty, which will lead to an unprecedented pressure on ecosystems unless effective counteractive measures are taken.

Forests are cut; soil is converted for the purpose of agriculture, urbanisation and infrastructure, all to accommodate an increasing global population and accelerating economic development. Every day we get alarming messages about climate change and biodiversity loss. The oceans are overfished and several fish species are rapidly becoming extinct. A number of high-profile reports convincingly document these environmental challenges[1]. The economic and financial crisis makes the situation worse, in particular for the poorest countries and populations.

Environmental problems do not respect political frontiers, and globalisation is increasing the need to treat environmental issues internationally.

With these alarming trends, we should not be complacent. Mankind has constantly developed new technologies and skills to increase the effectiveness of using natural resources, which remains fundamental for economic development.

There have been substantial net gains in life expectancy and human well-being in general. The question is how to reverse the overexploitation of natural resources, and its devastating effects on our livelihoods, towards making good use of the resources for a living?

It is essential to ensure that natural resources are used responsibly so that production and consumption patterns do not exceed the Earth's capacity to supply resources or absorb the waste and emissions generated by such growth. This is a fundamental challenge for the world community, and especially for the emerging economies and developing countries.

Sustainable development may provide an answer to this fundamental question.

Sustainable development was defined by the Brundtland Report in 1987 as 'development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs'. It is development based on consumption and production patterns that do not degrade natural resources, protect the environment, promote equitable sharing of well-being to all and alleviate poverty.

In the international arena, a lot of work has already been done to further clarify these concepts and to get an international understanding and agreement on how they should be addressed. Over the last 50 years, a range of conventions and multilateral environmental agreements (MEAs) have been adopted covering almost all important environmental challenges such as climate change, biodiversity, chemicals management.

It is a platform to achieve global solutions to the environmental challenges. The most important conventions are the so-called Rio de Janeiro Conventions on Climate Change, Biodiversity and Desertification, originated in the United Nations Conference on Environment and Development in Rio de Janeiro in 1992.

Sustainable development has been a fundamental objective of the European Union since 1997. It was enshrined as Article 2 of the Lisbon Treaty as a long term goal, and is intended to underpin all EU policies and actions as an overarching principle.

The Sustainable Development Strategy of the European Union (EU SDS), as revised in 2006, is a framework for a long-term vision of sustainability in which economic growth, social cohesion and environmental protection go hand in hand and are mutually supportive of one another. The EU has also taken the lead in reaching international agreements on environmental commitments, and has been very conscious of the need to help developing countries fulfil their resulting obligations. Many of these commitments are embodied in the Johannesburg Plan of Implementation from the World Summit on Sustainable Development that took place in 2002.

Developing countries are generally more vulnerable and less able to cope with economic and environmental shocks. Moreover, they are least responsible for the change in climate that is

[1] See, for instance, the Millennium Ecosystems Assessment *(http://www.millenniumassessment.org/en/index.aspx)*, the Stern Review on Climate Change *(http://www.occ.gov.uk/activities/stern.htm)*, and Report on the Economics of Ecosystems and Biodiversity *(http://www.teebweb.org)*.

affecting the world. Indeed, environment most directly affects people living in poverty, who depend on ecosystem services for their livelihoods. Hence the importance of sustainable management of resources such as water, energy, soils, forests, wetlands, wildlife and fish stocks. Air and water pollution strongly affect the lives of the poor, in particular the urban populations.

The unique circumstances facing developing countries are recognised in the MEAs through the concept of common yet differentiated responsibility. This concept evolved from the notion of the 'common heritage of mankind' and is a manifestation of general principles of equity in international law[2]. The Rio de Janeiro Declaration[3] states: 'In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.'

Development cooperation can and should be used to foster sustainable development by enhancing livelihoods through ensuring continued access to natural resources, including sustainable energy, and by preventing environmental degradation. Health can be improved by improving the air and water quality, safely managing chemicals and wastes, and combating pollution.

The adverse effects of climate change will increase the vulnerability of the poor and will therefore need to be fully integrated into all aspects of development planning.

The EU supports environmental protection and sustainable management of natural resources as part of its efforts to strengthen the social dimension of globalisation, and it has made a number of ambitious commitments in this respect[4]. For example, in December 2008, the EU agreed on a Climate and Energy Package that sets ambitious targets for the EU, inter alia to reduce the overall greenhouse gas (GHG) emissions by 20% below 1990 levels by 2020. The EU is ready to increase this target to 30% provided other industrial countries make similar commitments, and advanced developing countries reduce the growth rate of their emissions. The EU also has set the targets of increasing the share of renewables in energy use and of energy efficiency by 20% by 2020.

As part of the Climate and Energy Package, the EU is committed to sourcing 10% of its transport fuel consumption from renewable energy sources, accompanied by binding sustainability criteria for biofuels included in the Renewable Energy Directive and the Fuel Quality Directive. The Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan will help improve the environmental performance of products, boost demand for more sustainable goods and production technologies and foster innovation.

In the development cooperation area, several EU initiatives have contributed to the objective of sustainable development. These include communications on progress towards the Millennium Development Goals, the Global Climate Change Alliance (GCCA), the EU Strategy for Disaster Risk Reduction in Developing Countries, the Strategic European Framework for International Science and Technology Cooperation, the work on improving environmental integration in development cooperation, and the Forest Law Enforcement, Governance and Trade (FLEGT) initiative. The latter comprises Voluntary Partnership Agreements (VPAs) with developing countries. VPAs have been concluded with Ghana, Congo and Cameroon, and negotiations are ongoing with several other countries. Finally, the European Commission and the EU Member States are developing a common strategy for integrating the environment in development cooperation.

As part of development cooperation, the European Commission funds a number of programs and projects to promote sustainable development cooperation agreed upon with developing countries and regional organisations.

2 *http://www.cisdl.org/pdf/brief_common.pdf*
3 *http://www.unep.org/*
4 See also the Communication from the Commission on Mainstreaming Sustainable Development into EU Policies: 2009 Review of the European Union Strategy for Sustainable Development.

1 INTRODUCTION

1.1 WHAT IS DEVELOPMENT?

The classical children's tale *Alice in Wonderland* begins with Alice noticing a white rabbit running while looking at its watch (!) complaining it is late. When she follows the rabbit, she falls deep into a rabbit hole. There she finds herself – unhurt – at the end of a long dark corridor. The story continues:

> There were doors all round the hall, but they were all locked; and when Alice had been all the way down one side and up the other, trying every door, she walked sadly down the middle, wondering how she would ever to get out again.
> Suddenly she came upon a little three-legged table, all made of solid glass: there was nothing on it but a tiny golden key, and Alice's first idea was that this might belong to one of the doors in the hall; but alas! Either the locks were too large or the key was too small, but at any rate it would not open any of them. However, on the second time round, she came upon a low curtain she had not noticed before, and behind it was a little door, about fifteen inches high: she tried the little golden key in the lock, and to her great delight it fitted.
> Alice opened the door and found that it led into a small passage, not much larger than rat-hole: she knelt down and looked along the passage into the loveliest garden you ever saw. How she longed to get out of that dark hall, and wander about among those beds of bright flowers and those cool fountains, but she could not even get her head through the doorway; 'and even if my head would go through,' thought poor Alice, 'it would be of very little use without my shoulders. Oh how I wish I could shut up like a telescope! I think I could if I only know how to begin.' For you see, so many out-of-the-way things had happened lately, that Alice had begun to think that very few things indeed were really impossible.[1]

Figure 1.1. **Alice in Wonderland**

The situation in which Alice finds herself, in this classical children and grown-ups' story, is chosen to comment on our lives and our societies today: in a dark corridor (difficulties); there is not much time; there are many doors (possibilities to continue); one can be opened with the golden key; and it leads to a beautiful garden. Alice does not quite know how to get there but believes she may: very few things are really impossible! Those who have read the book know that quite a number of unexpected things do happen later on.

Alice's situation is an illustration of our developmental dilemma. Where to go next? Developmental dilemmas and challenges are not new. We should remind ourselves that many times in history, also recent history, our societies have changed the direction, even changed the development paradigm; we have started to work for new goals and new objectives. During the last 100 years alone, four such changes of direction have occurred (Table). Industrialism, introduced even earlier, was revolutionary in terms of transformation of our society and its environmental consequences.

Table. **Developments**

Approx. year	A new paradigm	Character of the new development
1600	The scientific revolution	Modern natural sciences, resource use
1750	The Enlightenment	Development based on science and intellectual understanding
1850	The Industrial Revolution, urbanisation	Consumer goods produced by large-scale manufacturing in industries; use of fossil fuels on a large scale
1900	Socialism, Democracy	A stronger civil society: development for everyone
1920	Marxism/Capitalism (East/West)	A new economic order
1950	Modernism	State and market; economic growth
1980	Neoliberal capitalism	Margareth Thatcher, Ronald Reagan; globalisation
2000	*Wanted: a new development!*	*Sustainable development*

[1] Carol L. (1869) Alice in Wonderland. Macmillan.

The main message of this chapter is that we are on the verge of a new such shift of our societies, to introduce a new development paradigm. It is sustainable development.

During the last decades, new technologies, economic investments and political reforms have improved the lives of many. Material standards have advanced as we own more things, live better and travel more freely; health care is better, and communication is easier. It may be that these developments have been slower in some countries than others. However, in a global perspective, all countries in the Baltic Sea Region are considered 'rich'.

The changes of the last few decades are just the most recent part of a development which has steadily progressed in this way at least since the Enlightenment in the 18th century, or perhaps even since the beginning of the modern science. In general this development is perceived as an improvement. Only recently have we realised that this improvement has occurred with a cost, an environmental cost. Reformers of our societies, politicians and economists, have not included nature, or, if you wish, the environment, in their calculations. The environment has rather been understood as a background condition always available, always providing, limitless, robust, not really hurt.

In Marxist economics, it was expressed exactly in this way: nature and natural resources were perceived as free assets and were not given a price. In capitalism natural resources were exploited and sold for a price, but the cost of the environmental consequences of extraction were not included. They were the so-called 'externalities'. This was (and is) a classic market failure. The environmental costs of running society and providing everything from space, food and shelter to beauty and wilderness were not (and are not) taken care of properly in either system. Instead, we have created an even larger environmental debt.

At the same time, we use ever more of resources. Data is overwhelming: over the 100 years between 1900 and 2000, the world's population increased fourfold, from 1.5 to 6 billion people. On top of that, the resources each of these individuals uses have on average quadrupled. Resource use has thus increased close to 16-fold over this period; it varies for different kinds of resources.

At the end of the 1990s, the American historian John McNeill set out to write a global environmental history. When starting, his conviction was that the 'green people' complained about the impact on the environment without understanding that it was normal, that it had always been like that, that there is 'nothing new under the Sun', as the saying goes.

Yet during his research he changed his opinion. The situation at the beginning of the 21st century is unique and unparalleled in the history of our societies and the Earth. Some of his data on the developments between 1900 and 2000 are summarised below:

- global population increased 4 times from 1.5 to 6 billion people;
- global economy increased 14 times;
- industrial production increased 40 times;
- energy use increased 16 times, almost entirely due to fossil fuels;
- carbon dioxide emissions increased 17 times;
- sulphur dioxide emissions increased 13 times;
- ocean fishing catches increased 35 times;
- number of pigs increased 9 times (we eat twice as much meat per capita);
- deforestation was 20%;
- agricultural fields increased 2 times.

We certainly cannot go on like this forever. There are limits to growth. The limits are set by our planet.

Much of this development has occurred at an accelerating speed, that is, with a more or less constant doubling time. It can also be expressed as a constant percentage increase per year. We are used to ask for that as a goal of economic growth. However, if we talk about resource use in the same way, we will end up with collapse, as there is only so much of them. That is why we need a different development, not one which leads to collapse, but one which may continue – a sustainable development.

1.2 THE ENERGY DILEMMA AND NON-RENEWABLE RESOURCES

The present development is most clearly illustrated by the use of energy in our societies. As with many other resources, its use has increased many times, but there is an additional dilemma. In the world as a whole, 85% of the energy supply relies on fossil carbon: solid coal, liquid oil and gaseous natural gas. These stores of carbon are the result of processes which took the planet millions of years to complete. They are *non-renewable* for the simple reason that we use them about a million times quicker than they were formed. This means that the stock of these resources will end at some point, just as the money in the bank will be depleted if you take it out a million times faster than you put it in. There is only so much coal, oil and gas on the planet. According to recent estimations, about half of this amount was used up in 2008. Then we reached the global *peak oil*, i.e., the year of maximum extraction of oil and gas.

Figure 1.2. **The energy supply of the world**
Commercial energy supply has steadily increased in the world over time, most recently spurred by demand in China and Asia. Fossil fuels represent the largest part, about 85% of the total. The world faces the challenge to change to renewable energy in this generation.

Now the extraction of coal, oil and gas has started to decline. There will be ever less of it each year but a large demand will remain. The prices will increase. We need to find other energy sources.

How much energy do we use? Is it much or little? It can be illustrated with a comparison with the energy we need daily for our bodily functions. This is about 2.5 kWh (or about 2 100 kcal). This means that the effect of an active person is about 100 W or the same as a normal, rather bright lamp bulb. We feel the heat generated when many people assemble in a room with insufficient ventilation.

Very much can be achieved with one kWh. Not only is it enough for keeping a person running, with all their bodily functions, for about 10 hours. It is also enough for lifting a heavy car to the top of the Eiffel Tower (engineering students: make the calculation!). We use energy for many things: manufacturing, transportation, heating. In fact, in a modern western society, we use close to 100 times more energy per capita than the body itself. We have about a hundred 'energy slaves', each one of us.

The energy dilemma in our societies is three-fold:

- we use mostly non-renewable energy – coal, oil and gas;
- we use energy, for the most part, very inefficiently;
- we use too much energy.

In the pre-industrial society only renewable resources were used. For example, a mill to grind

Figure 1.3. **Belchatów**
The lignite power plant in Belchatów in Poland is typical of most electricity production; it is presently the largest emitter of carbon dioxide in the European Union. Lignite mining is seen in the foreground.

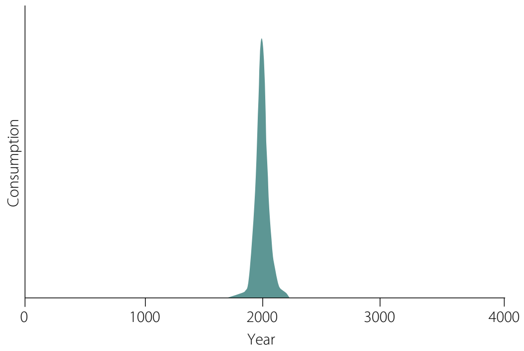


Figure 1.4. **Oil age**

It is obvious that non-renewable fossil fuel will soon end. The production of fossil oil and gas is predicted to continue up to 2050, at which time the known conventional resources could be depleted. At present for each barrel of oil found three are extracted. Peak oil, the year of maximum extraction, was registered in 2008. The oil age of mankind will be quite short in a historical perspective, only some 100 years of large-scale production.

the wheat was propelled by wind or water, and the house was heated by burning wood. Access to oil changed things dramatically. One litre of oil can provide very much energy. Life became simpler and the new energy source offered new opportunities. Industries were built, and the car with an engine run on oil was better than a wagon with a horse fed on oat. Oil was used for fuels, solvents, plastics, to produce crop fertilisers. The chemical industry, presently the largest industrial sector in the EU, with all its products characteristic of the modern society, has developed on fossils.

Historically, fossil fuels have been running our societies for a rather short period of time. Now we are amidst the ‘oil age’, and we are faced with the challenge to leave it. We will have to find out how to manage our lives with renewable energy, with less energy, and not the least by using the energy which we have much more efficiently. How do we do this in a way that does not lead to disaster but to a better society?

1.3 THE OTHER SIDE – CLIMATE CHANGE

Using fossil fuels as an energy source is not only connected to the dilemma of depleting non-renewables – to the detriment of future generations, which will not have them. It is also connected to the down-stream side of the process, that is, the waste produced.

For any process, we have to look at three stages: where does the *resource* come from, what is its *use*, and what kind of *waste* does it lead to. In the case of the combustion of fossil carbon, we will always have carbon dioxide, CO_2, as the waste product. Carbon dioxide goes to the atmosphere. Of course, all kinds of combustion processes, including our breathing and that of all living beings, lead to the emission of carbon dioxide. This carbon dioxide is taken up by plants and algae during photosynthesis and thus does not lead to any net accumulation of CO_2 in the atmosphere. The problem with the use of fossils is that it is not balanced by an equal amount of uptake. It is a *linear flow*, from source to waste, rather than a circular one.

The use of fossil fuels on a massive scale leads to the accumulation of massive amounts of carbon dioxide in the atmosphere. The use of fossil carbon has continued since the beginning of industrialisation, about mid-1700s. The data shows that from a pre-industrial level of about 280 parts per million (ppm) of carbon dioxide concentration in the atmosphere, we have reached 387 ppm in 2009. It should be compared to data on the atmosphere gathered through analysis of ice cores in the Arctic and Antarctic; it allows us to analyse the composition of air hundreds of thousands of years back. It is clear that the present level of carbon dioxide has not occurred for at least 800 000 years.

The changes are of such scope that the properties of the atmosphere change too. Along with water, carbon dioxide is the most important *greenhouse gas* in the atmosphere and thus a decisive factor for the temperature on the planet. The increased levels of carbon dioxide have, as expected, led to an increased average global temperature. The climate scientists use sophisticated models of the climate systems to predict what will happen in the coming years. The conclusions are alarming. If the concentration of carbon dioxide stops at the present level, we will have about 2 °C of temperature increase. If we continue to emit carbon dioxide into the atmosphere, we will experience even higher temperatures. Furthermore, we need to add emissions of other greenhouse gases, especially the increasing emissions of methane, to the increased carbon dioxide levels, as well as other effects such as feedback mechanisms studied by the climate scientists. All of them contribute to the predicted global warming.

Predictions are surely inexact, but who would like to chance that they are wrong? To date, the increase has been about 0.76 °C.

What will the consequences of an increase in the mean global temperature by a few degrees be? Does it really matter?

As a reference for how much a change of a few degrees means, we may compare the present with

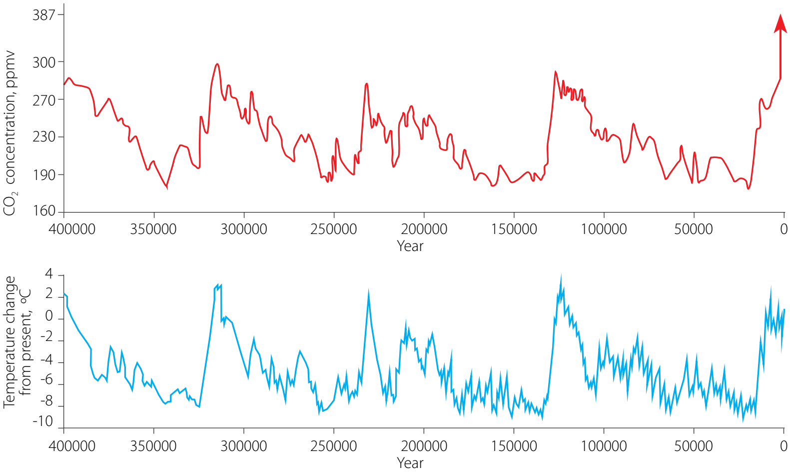


Figure 1.5. **Carbon dioxide and temperature in historic times**
A 3 600 m long ice core extracted at the Vostok Research Station in Antarctica by Russian, American and French scientists has allowed for the calculation of climate data for 800 000 years. It is clear that the present levels of carbon dioxide in the atmosphere did not occur during this period, and that carbon dioxide and the average temperature are closely connected.

the most recent ice age. Back then, the global mean temperature was about 5 °C lower than today. A few degrees do matter. In 2003, we had the highest mean summer temperature ever recorded in Europe (predicted to be normal about 2025). During that summer, about 35 000 additional deaths were caused by excessive heat, and the economic damages for farmers were about 25%, depending on the crop. A list of the most serious consequences of increased temperature includes health impacts, not only due to temperature itself but also due to increased incidents of insect-borne diseases, economic impacts because of reduced agricultural production, changed patterns of precipitation, landscape changes, e.g. rising sea levels, and more frequent extreme weather events which lead to physical destruction.

Even if the effects will be felt everywhere, they will be most serious in marginal areas which are already under stress. Thus, arid and semi-arid areas of the world will become even drier. Coastal areas already regularly inundated will suffer more. Areas already suffering water stress will have even more difficulties to find water. Most of these areas are in the south – Africa, Asia, Australia, southern United States and Mexico. When large areas become almost inhabitable, environmental refugees might become a reality.

We have to stop using fossil fuels, stop the emissions of carbon dioxide into the atmosphere, and find other, wiser ways to supply ourselves with energy.

Figure 1.6. **Destruction of polar ice sheets**
Climate change is causing the destruction of polar ice sheets.

1.4 SOLVING THE ENERGY DILEMMA

Thus, is it possible to run society without fossils, to be wiser than to dig out coal from the ground and burn it?

Yes, we may use renewable energy resources. One of the ways to classify them is the following:

- flowing energy resources – wind, water and sun;
- stored energy resources, bio-energy – solid resources such as, e.g., wood, liquid ethanol made from sugar, and biogas.

The technologies for an efficient use of flowing energy resources are both well-established and in a dramatic development. The most developed technology is hydropower energy production. Today wind energy production is second. Partly introduced, and very much on the engineers' drawing boards, are the wave power and several kinds of solar power. Both large- and small-scale versions of these technologies are used. Small-scale

Figure 1.7. **Porjus Hydropower Plant**
Hydropower offers large-scale production of renewable electricity for parts of northern Europe. The Swedish Porjus Hydropower Plant was built in 1915.

hydropower and wind power can supply a few households or a small industry with energy.

The cost is often brought up as an obstacle to change, but the comparisons are not always correct. The cost of constantly buying a fuel, fossil or non-fossil, should be compared to the investment needed to live on a flowing energy resource. Today in many countries flowing energy is already a cheaper alternative as the necessary investment is paid back after a few years. In some countries the government provides an economic incentive to support the development of alternatives to fossils. It should also be pointed out that independence of purchased fuel increases energy security. This is the main argument for change for many countries. In the long-term we have to create a society that runs on renewable energy either directly, as provided by flowing energy resources, or indirectly, by using bio-energy.

In Europe as a whole, the energy use is often both extensive and inefficient today. As we have been spoiled by cheap energy, a prudent use of it has not been a priority. From the short-term perspective, the energy efficiency increase is typically the most profitable strategy in the conversion to independency from fossil fuels. By improving, e.g., the insulation of buildings or the design of district heating, heat consumption may be reduced dramatically. Likewise, exchange of conventional lamps for low-energy models or improved design of machinery may increase electricity efficiency very much. The transport sector is the most difficult

Figure 1.8. **Uppsala biogas plant**
Fermentation offers small-scale renewable energy production, at Uppsala, Sweden, as biogas (methane) is formed in a microbiological process. Fermentation is also good waste management as food waste and sludge from wastewater treatment plants are converted into biogas to be used for heating or driving cars and buses.

to reform, but changes are in progress here as well, as the classic car is switching to renewable biofuels or the most efficient alternative – electricity.

A slow start of the necessary process can be observed. Comparing the countries in Europe, we find that the energy supply is mostly not increasing, and the economic turnover per kWh varies almost by a factor of ten. Making economic development independent of fossil carbon is called *decoupling*. It is the first step towards the conversion of an economy to fossil independency, which some countries have slowly begun. The figures are controversial, since all countries are highly fossil-dependent through import. In addition, increased efficiency is too often counteracted with increased consumption, called the *rebound effect*. The conversion of society to sustainability requires far more drastic measures, which remain to be seen.

1.5 PLANETARY BOUNDARIES

The use of fossil energy has made us painfully aware of the limits to growth of our societies and economies. *The Limits to Growth* was the title of a rather famous book published in 1972 and later translated into more than 50 languages. The study is about what will happen to our world if growth continues, the so-called 'business as usual'. The answer was that there would be overshoot, a peak and then collapse. In a 2004 update to the book, most parameters were shown to peak around 2025. Nevertheless, it will be different for different parameters. As we have seen, conventional oil and gas appear to have peaked already in 2008.

Overshoot and collapse have been seen in many smaller ecosystems, e.g. on islands, where the limits are obvious and often easy to measure. One may well compare our planet Earth to an island in the universe.

The year *The Limits to Growth* appeared was approximately the year when the consumption and use of natural resources passed what the environment could provide, and since then we have been living beyond our resources, into the overshoot. The over-consumption, still growing, was globally estimated to be about 50% in 2010 although it varies for different countries. In general in the European Union, the over-consumption is close to twice (200%) the available resources. Not surprisingly, it is much less in Africa and much more in the United States.

Recently a study has been carried out to define the limits for a number of processes on the Earth more precisely. These were called *planetary boundaries*. They have been defined for nine different processes or resources. Three of the defined boundaries are transgressed today. These are

- the concentration of greenhouse gases in the atmosphere,
- the speed with which biodiversity decreases,
- nitrogen and phosphorus inputs to the biosphere.

It is clear that these trends need to be reversed to protect future life. It is promising that the effects of transgression of one boundary some years ago have been reversed – the concentration of ozone-depleting gases in the stratosphere. This is now within safe limits, and the properties of protection against the UV radiation of the ozone layer are slowly being restored.

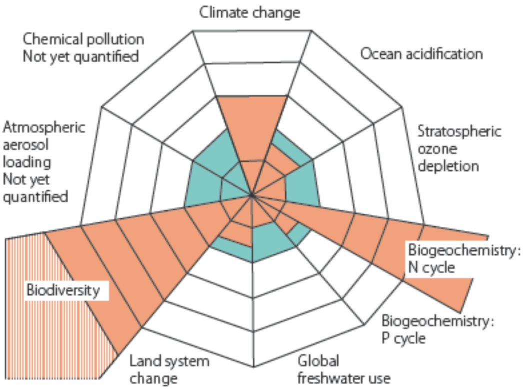


Figure 1.9. Planetary boundaries

In 2009 a detailed study by Stockholm Resilience Centre and Stockholm Environment Institute specified nine the so-called *planetary boundaries*. Outside these human society is not safe.

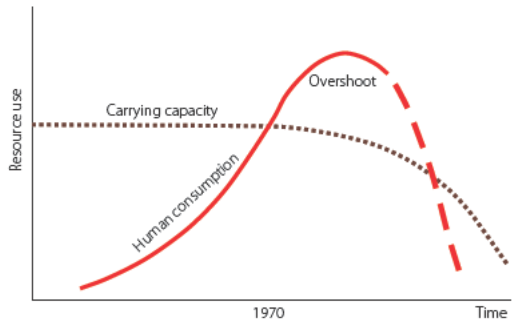


Figure 1.10. Overshoot and collapse

If the growth in a system continues unhampered, it will eventually use more resources than being produced (overshoot) and will collapse at some point; at the same time, the resource base is degraded. The alternative – a development which reaches a dynamic balance with the resource base – is sustainable development.

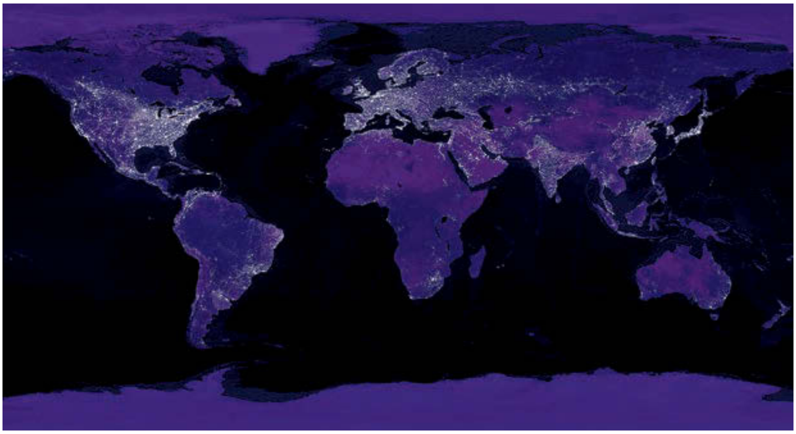


Figure 1.11. **Earth from space at night**
Human impact on planet Earth has become overwhelming, as seen in this image of our planet at night. We live in the Anthropocene.

1.6 ENVIRONMENTAL IMPACTS AND ECOSYSTEM SERVICES

Energy is just one of the services that the environment provides for us. There are many others. These include the food we eat, the water we drink and the fresh air we breathe. These are all necessary for our life. Yet they are threatened by the environmental impacts of our societies. Soil, water and air are polluted, and the pollutants eventually end up in plants and animals and, finally, in our food. Pollution has traditionally been the main concern of the green movements and environmental science. Even if much has been achieved to reduce the pollution of the environment, there is still much left to be done. It is especially important to understand that pollution is caused by the failure of our economic systems – we manufacture goods, provide food and supply services – and to improve the situation, we have to reform these systems.

However, pollution is not the only, or even the most serious, environmental impact. The consequences are even broader due to the reshaping of the landscape – deforestation, expansion of fields, cities and infrastructure. This has limited intact nature and the living conditions for a countless number of species. *Biodiversity* – the variety of life – has become one of the most seriously threatened resources. The estimation is that species extinction is today 100 to 1 000 times faster than ‘natural’, i.e., before civilisation. The most dramatic threat to biodiversity occurs in tropical forests where biodiversity is very large, but the Baltic Sea Region is also part of the decreased biodiversity. Life in the Baltic Sea has been especially drastically changed only over a few decades. Places where a rich and varying nature is still preserved need to be well protected. Nature protection and restoration are parts of sustainable development.

Nature is thus not only a pleasant fund. It provides what is called *ecosystem services* for us. The supply of food, water and clean air are called *provisioning* ecosystem services. Nature is also able to regulate such basic properties of our environment as climate, nutrient flows, the self-cleaning and regulation of water and secure the pollination of plants, which gives us fruits and berries. These are the *regulating* ecosystem services. Finally, the beauty of nature and joy of spending time in our living environment when walking, hiking, travelling on water or just resting are collectively called *cultural* ecosystem services.

It is obvious that all this is priceless in the basic sense – that we would not be able to live without these services. Yet it is possible to estimate their monetary value. The most cited assessment of the price is USD 33 trillion for the global society in 1997. This is more than the sum of all goods and

Figure 1.12. **Porpoise in the Baltic Sea**
The biological diversity in the world decreases 100 to 1 000 times faster than it would without humans. In the Baltic Sea, our only dolphin-like species – the Porpoise – is facing extinction.

services bought and sold over that year. However, we very seldom pay for this; and we need to take better care of ecosystem services. Natural resources have to be used with careful observation of limits to preserve their *carrying capacity*. Forests have to recover after timbering – foresters are well aware of this. Regrettably, some farmers are less careful about preserving the soil; therefore, desertification, salination and pollution are among concerns. But the most serious concern is the enormous expansion of fishing, which threatens fish populations in the oceans around the world. The world famous Newfoundland cod population collapsed; since 1992 fishing has ceased (and 40 000 people in the fishing sector lost their jobs) due to overfishing.

It is sad that we have to note that the majority of the ecosystem services are being degraded. In a large global estimation, the Millennium Ecosystem Assessment of 2005, 60% of 26 studied services were found to be declining. This, so far the broadest overview, again tells us that a major redirection of our societies is necessary.

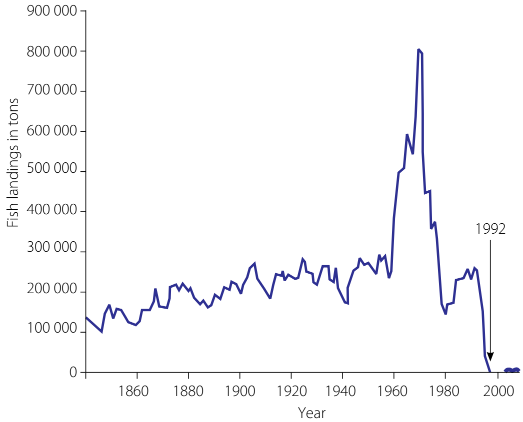


Figure 1.13. **Cod fishing in Newfoundland**
Overuse of biological renewable resources may lead to their destruction. Cod fishing in Newfoundland was one of the best in the world. When the Canadian state lifted restrictions in 1990, the cod population was over-fished and collapsed in 1992. It has not recovered. In addition, 40 000 people in the fishing sector lost their livelihood.

1.7 A WAY TO IMPROVE INDUSTRIAL PRODUCTION AND THE ECONOMY

A sustainable society needs to be economically viable. Obviously, the environment needs to be functional to allow for a functioning economy. Otherwise there would be no agriculture, forestry and fishery, production of energy. Besides, all economic units – companies, the public sector and the households – need to work in a way which allows for profit and prosperity without environmental disaster and resource expansion. Several means to work towards that goal have been introduced.

In the industrial sector, an important approach is cleaner production, a production that is resource efficient and does not lead to pollution. Cleaner production has its technical aspects – how to recycle resources, reduce leakage of energy and materials, and introduce ecodesign. This is developed systematically in the so-called environmental management systems (EMS). Companies working with EMS may become certified according to one of the international systems, among which the best known is the ISO 14001 certification (ISO – the International Organisation of Standardisation).

The large number of companies now certified according to ISO 14001 testifies to the success of the introduction of cleaner production. It is not surprising. It is better business to turn the resources into products to be sold, rather than into pollutants for which one may be taxed or fined. The investments needed to introduce cleaner production measures have often paid back in short time. In addition, many customers often require a certified EMS as it adds to a positive image of companies, as well as public authorities such as municipalities or hospitals. Almost any activity may have its own environmental management system.

The concern regarding a product does not stop at its production; the extraction of resources needed

Figure 1.14. **Sorting waste**
Efficient recycling at the household level is a prerequisite for good waste management in a sustainable society, here an example of Berlin.

for the product, the use of the product and its waste, i.e., its entire life cycle is the concern. The cycle needs to be environmentally and economically sound. Waste has been the most difficult to manage. Too often, waste ends up in landfills, a solution to be avoided for as long as possible. Instead, the rule of three Rs should be promoted: *reduce, reuse, recycle*. 'Reduce' means that we should make an effort to make without an additional product. For example, not everyone needs their own copy machine, it is a piece of equipment we can use together. 'Reuse' often means 'repair', i.e., do not throw out a product but take care of it. Finally, 'recycle' refers to the material the products are made of. At the household level, waste fractionation is essential.

The perspective needed is the entire material flows in society. In the end, we need a society where material cycles go from cradle to cradle: after a product is used, the material it consists of should come back as a resource for a new product. In general the economic growth is only possible if the rules of material flows are respected, especially in the expanding service economy. Travelling in particular is difficult in these conditions and much development is needed here. The first steps towards sustainability include proper material flows.

1.8 LIVING SUSTAINABLY

Some people believe that technological development and proper management systems will resolve all environmental concerns. This is not quite true. We need a combination of

- technology development;
- regulations, taxes and rules supporting sustainable solutions;
- new infrastructures, e.g. for communication and travel;
- life style changes.

Again, it is possible to exemplify with the energy sector. To use only renewable energy, we need technology to provide energy from solar cells, solar panels, wind and wave power stations. Nevertheless, there is also a need for policy instruments (regulations) that support it. A state policy of tariffs (guaranteed price) for renewable electricity has been pointed out as a key regulation in the energy sector. A scheme which improves the public transport and supplies renewable fuels, best electricity, for cars is important. Finally life style changes supporting living without using energy unnecessary, is also essential.

As part of an experiment, some families in Stockholm were asked to live as sustainably as they could. After a short while they were buying less, spent more time with their children, and in general found that they needed less money. As a consequence, they reduced their working hours. Their experience illustrates some of the main themes often brought up in discussions on how to live sustainably. First, a sustainable life needs to be more dematerialised – it is fine to do things which do not increase material flows that much, e.g. spending time with one's

Figure 1.15. **Low-energy house with solar panel and cells**
Beddington Zero Energy Development, the United Kingdom, the largest sustainable community in the UK, was completed in 2002. It uses 50% of the electricity and 20% of the heating of the UK average. The design, including solar panels and solar cells, helps the residents solve problems of heating and water use, facilitates walking rather than driving and improves the quality of life.

family, friends, playing music. Second, a sustainable life leads to less work – this is sometimes referred to as 'slow life'. This term comes from the 'slow cities' and 'slow food' movements which started in Italy.

There is a limit to how much we may consume, but it does not necessarily lead to a decreased life quality. It is interesting to note that a recent happiness research has discovered that in general in society, the perceived wellbeing or happiness increases with economy up to a point and then it starts decreasing. In the industrial West, the perceived wellbeing has been on the decline since the 1970s. The conclusion: we were happier with less material wealth.

1.9 WHERE ARE WE HEADING?

It is always difficult to see our present situation from a distance. However, some basic facts are obvious. From a distant historical perspective, we, the human society, are in a new and very critical period, well into the Anthropocene, a geological era dominated by man. With close to 6.8 billion inhabitants on the Earth, with the number sure to be going up to at least nine billion, the sheer number of people is threatening. We have moved well outside the envelope of our historical experience in terms of our relationship with our planet (Rockström *et al*, 2009). Our collective influence on the planet is of an order of magnitude of geological proportions. The situation requires a transformation of our society.

What we need to establish is a 'one-planet society', i.e., society which does not require more resources than the planet we live on can provide. One Planet Living is the title of a recent project of the World Wide Fund for Nature (WWF). It requires that we reduce our 'footprints' to the size available when we begin to share resources in a just way (an ecological footprint is a means to calculate and illustrate resource use). We will need to rethink our energy management, our nutritional and travelling habits. Some changes may be perceived as drawbacks in the short-term perspective, but many of them will be for the better, perhaps all of them.

A school teacher in Visby, Gotland, an island in the middle of the Baltic Sea, used to ask his pupils to design a space ship for a very long journey. They had to say what they would like to bring. The ship can only carry so much. The kids may disagree on what is the most important, but after much talking it turns out they agree on basic things needed to secure a reasonable life. Personal items vary. Only after a long discussion do they start to compare the spaceship with our planet Earth. Yet this is exactly what our planet is. It is a vehicle travelling through space, circling our life-giving Sun, with all of us on board. We will not be able to go somewhere else. We have to design our belongings and conduct our lives to fit for the situation – for us, for the future generations and all other forms of life on our beautiful blue pearl travelling in the immense space.

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Accessible: *http://www.ipcc.ch.*

Millennium Ecosystem Assessment.
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2 ECOSYSTEM SERVICES

2.1 WHAT DO 'ECOSYSTEM SERVICES' MEAN?

In the early 19th century, most people lived in a self-subsistence economy where nearly everything, from food to clothing to housing, was self-produced. However, even in natural economies there were craftsmen who were not involved in farming or cattle-breeding; they earned their living by providing special services to other members of their community. Among them were blacksmiths, shoemakers, tinkers, later doctors and teachers. The major division of labour was called forth by the development of towns.

In modern times, man strives to produce less and less by oneself; instead, the numerous needs are satisfied by receiving services provided by different members of society. We are all service users and service providers. Thus, services form the basis of our existence. We wish to receive services both cheap and of quality. Sometimes, although rarely, service providers would offer something for free, usually for advertising purposes.

Can we imagine a situation when indispensible services are provided free of charge? Not likely. However, man receives such *gratis* services from ecosystems (Greek *'oikos'* – home, native country), systems of a very complex structure.

There is such a wide range of ecosystem services that it was necessary to devise a special classification system. It singles out five groups of services:

- provisioning services,
- regulation services,
- supporting services,
- cultural services,
- preserving services.

The first four groups of ecosystem services are directly related to man's everyday life, while ensuring self-preservation of the system is only indirectly connected to the services provided for man. To ensure services vital for human existence, the ecosystem must be whole, unspoiled. Man has not been careful to choose the means and has obtained from ecosystems more than they can yield. It is amazing that even under such conditions, ecosystems strive to adapt, restructure and preserve themselves, and we continue to receive their services. However, the self-preservation capacity of ecosystems is not inexhaustible. As a rule, we do not appreciate the things we get for free. It is high time we started receiving ecosystem services with gratitude and respecting the capacity of ecosystems to provide these services for us.

2.2 PROVISIONING SERVICES

2.2.1 WATER

Preparing for a trip south, we are warned to use drinking water only from securely sealed bottles bought from trustworthy providers to avoid falling ill. Having been considered a *gratis* resource just like air, in over less than a century water has turned into a profitable business for many companies both in dry climate countries and all over the world (Figure 2.1).

Figure 2.1. **Today shops offer a wide choice of drinking water**

For humans, water is the most important chemical compound. All living organisms basically consist of water, some jellyfish contain as much as 98% of water. The human body contains 55–60% of water. Life has evolved in an aquatic environment; fertilisation and development of an embryo takes place in a liquid environment. All biochemical reactions in cells occur only in an aquatic environment and involve water. Plants can only assimilate mineral substances from soil and, to maintain a continuous flow, they keep discharging the absorbed water through leaves in the form of vapour. Animals lose water by breathing and metabolism waste products. This is why all living organisms need constant replenishment of water.

Humans need an average consumption of two litres of water per day but can survive seven days without water at most. Death of thirst may occur in a desert just like in the ocean, which means that both the amount and the quality of water are of importance. Admittedly, the quality of water in the world is on the decline because of human economic activities and environmental pollution.

Over the last 40 years, human consumption of water, including water for irrigation, households and industrial needs, has increased twofold. Today over a billion of the Earth's human population have no access to drinking water free from health hazards (Figure 2.2), while 40% cannot enjoy living conditions that meet sanitary criteria. Many countries of the world have introduced water-saving programmes.

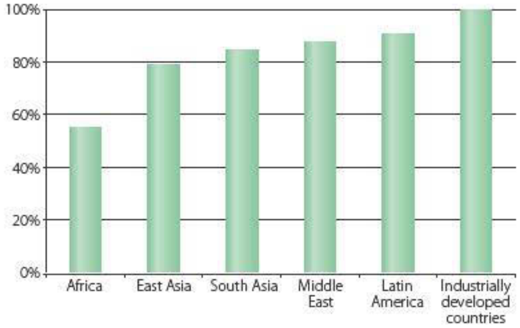

Figure 2.2. **World regions that have access to safe drinking water and live in conditions that meet sanitary criteria**

The US government spends 13 billion dollars on clean water resources each year. Humanity finds itself in such a dramatic situation only because it has inconsiderately refused ecosystem services that offer to purify water for free.

Many chemical substances dissolve well in water. Even those that do not dissolve in water are still found in it as tiny particles – sediment or microscopic drops. Water also is an enabling environment for the life of various microorganisms – viruses, bacteria, parasitic monads and worms.

Water, in fact, is never absolutely clean. Rain water, too, contains chemical impurities, sometimes even microorganisms that air currents have lifted from the ground to the atmosphere. Spring water, which is usually considered to be the standard of clean water, is actually not clean as it contains various salts that have dissolved in water as it flows through subterranean rocks. Spring water is mostly harmless or even recommended as a source of some indispensable mineral substances. Water from ponds, lakes or rivers is only recommended for use when boiled. If possible and to be on the safe side, it is also worth having its chemical composition analysed.

Before drinking water enters the city water main and flows into our cups from the tap, it is carefully purified, filtered, disinfected with ozone or chlorine, and for that reason the consumer receives a bill for each consumed litre of water.

Ecosystems serve as natural water purification filters. The major purifiers of water are forests and wetlands, which filter water through foliage, moss and soil before it penetrates subterranean waters and flows into rivers. The main precondition for successful water purification is slowing down the flow rate because biological purification processes take time. The slower the water flow, the greater the possibility that water will get purified by biological processes. This is why the structure of ecosystems in the drainage basin is so very important (drainage basin is the territory from which both surface and subterranean precipitation waters are discharged into a river or a lake) (Figure 2.3).

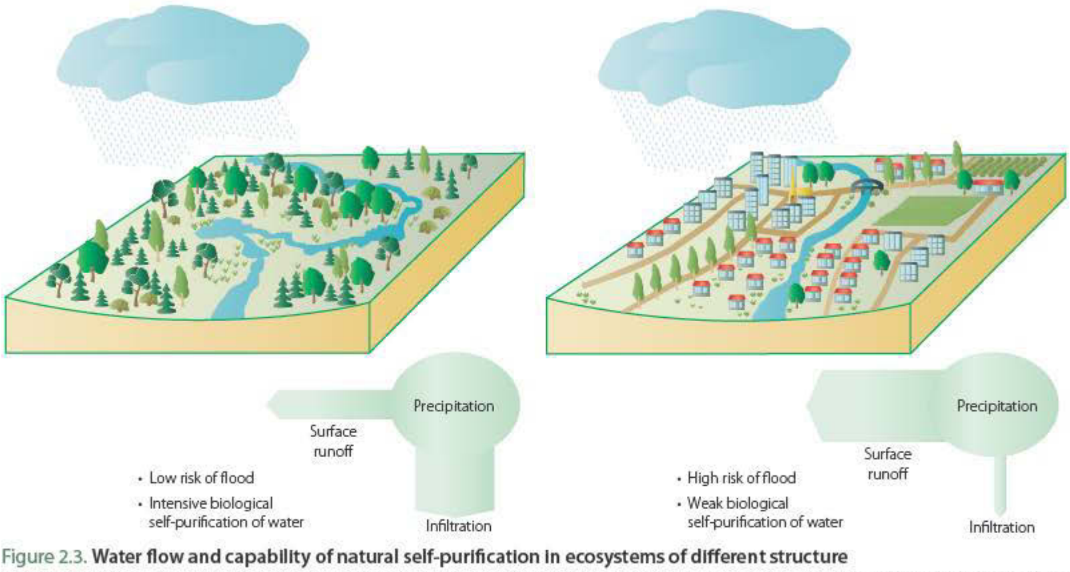

Figure 2.3. **Water flow and capability of natural self-purification in ecosystems of different structure**

In natural environment the water flow rate is low, and intensive processes of biological self-purification as well as water infiltration into subterranean strata take place. Such circumstances diminish the probability of flood. In a human-transformed environment, surface runoff predominates while biological self-purification is weak, and there is a high risk of flood.

The more forests and marshes there are in the drainage area, the slower the flow. If natural vegetation has been destroyed and soil is trampled because of human activity, there is practically no water filtration. Water flows and on its way washes pollutants, microorganisms and excrements left by pets away from asphalt, cobblestones and roofs. Surface runoff waters carry away and discharge all of this into a river or a lake. If there are no wastewater treatment plants in populated areas or industrial enterprises, the pollutants brought by surface runoff waters are complemented by wastewater.

If the natural terrestrial filters are ineffective, the river ecosystem gets involved in fighting pollution. A lower flow rate facilitates better purification of water. The velocity of the river current is effectively slowed down by such natural obstacles as trees fallen into the river, snags, water plants and, above all, beaver dams. Beaver activity results in an impoundment on the river collecting sediments along with river-carried pollutants (Figure 2.4).

Figure 2.4. **Beaver dam**
Beaver activity has been controversially evaluated. On the one hand, because of beavers, the rivers' self-purification capacity increases; on the other hand, beavers hamper economic activities by flooding woodland territories and fostering swamping of agricultural lands.

The pollutants – organic substances, heavy metal compounds, radionuclides and others – usually stick to tiny sediment particles. As the water flow slows down, pollution together with the sediment sinks to the bottom of the river and clings to water plants, sunken trees and stones.

2.2.2 FOOD

Modern humans have largely lost the connection with the natural processes that form the basis of food production. Generally, we get food in shops – ready-to-use, pre-wrapped. As the consumers pay for the service (bread, milk or meat) at the cash-point, they are unaware of the fact that they are actually not paying for the product but for other persons' labour invested in growing and processing the raw material to produce foodstuffs and take them to shops.

The grain for baking bread, the milk from a cow, the meat from slaughtered cattle, in fact, cost nothing. People have not actually participated in creating these foodstuffs; these services have been provided by ecosystems. We have to bear in mind that there are kinds of food accessible for free in most cases: forest fruits and berries, mushrooms, nuts, also fish and game if one does not have to buy a licence.

At the basis of grain farming lies the ability of cereals to use the energy of the Sun in the process of photosynthesis to create, from carbon dioxide, water and mineral substances of soil, carbohydrates that are part of the composition of a grain. The grass of the pastures and silage, which are the principal components of feed, are also formed by photosynthesis, while physiological processes in the cow's organism form milk.

Theoretically, analogues of these products can be created artificially via synthesis, but the end product will be considerably more expensive. As matters stand now, humans just add their work to the ready product of ecosystems.

However, in the formation of the product man interacts with ecosystem processes with the aim to intensify them so that the natural yield – biomass, grain or milk – is as high as possible. This is achieved by changing the environmental factors that determine the direction and intensity of ecological processes – by supplying nutrients with mineral fertilizers, by selecting highly productive species of plants and cattle, and with the help of other measures. However, insufficient understanding of ecological regularities may result in an adverse effect: the end product is either hazardous for human health or it degrades the environment in which it is produced. By adding their service, humans can either improve the ecosystem service or spoil it. The worst case scenario develops in the situation when, because of human activities, ecosystems cannot provide their services.

Ecosystem services for food supply are effectuated in the ecological food chain. The starting point is the green plants that produce organic substances in the process of photosynthesis. Plants get the necessary energy from the Sun and transform it into the molecules of organic substances which are mostly composed of carbon atoms of carbon dioxide (CO_2), adding many other chemical elements from soil. In this way plants accumulate both substance and energy. Herbivores, for example, cows, obtain the substances and energy for their life processes by consuming plants.

To produce a nutrition unit from the plant kingdom, an ecosystem consumes ten times less energy on average than for the production of a nutrition unit from the animal kingdom, in accordance with the law on energy flows in the ecological food chain. This why the impact of the production of a nutrition unit from the animal kingdom on the environment is ten times larger on average than the impact of the production of a nutrition unit from the plant kingdom.

To produce more food, man constantly strives to improve ecosystem services. One way to boost yield capacity is selection of new species of plants and livestock, which would be impossible if, at the dawn of civilisation, ecosystems had not 'donated' species of wild plants and animals that were turned into cultivated plants and domestic animals over thousands of years. For example, the progenitors of wheat and barley grow in Asia and Africa; potatoes and corn come from South America and Mexico, while soya, rice and tea come from China and Japan.

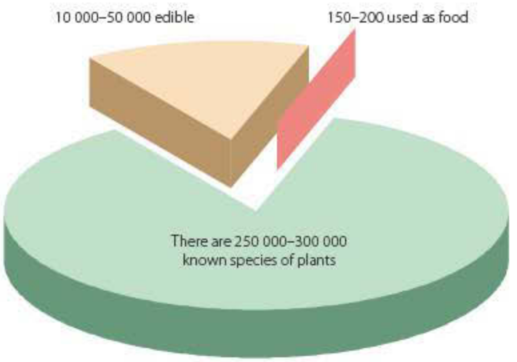

Figure 2.5. **Number of plant species consumable as food compared to the total number of plant species in the world**

Humans are far from having used all the wild species that ecosystems offer for food requirements. There are approximately 300 000 species of plants in the world, approximately 50 000 species are edible, but only some 200 species of plants are widely used for food (Figure 2.5). Only three species – rice, corn and wheat – provide nearly 60% of the food calories consumed by mankind. Among the flaws of modern intensive farming is the unification of the genetic material of plants when large areas are planted with only one species. This approach poses a catastrophic economic hazard in the case of a massive spread of diseases of cultivated plants. Diversity of species is necessary to ensure, in a critical situation, the creation of new, disease-resistant species by hybridisation and selection to replace the former non-resistant ones. For example, the potato crop failure in Ireland in 1840 that was caused by a parasitic fungus calling forth potato rot resulted in the death of a million people, while over a million left the country.

Humans receive certain foodstuffs directly from ecosystems, for example, fish. This is the main source of animal protein for around 20% of population in Africa and Asia.

The ecologically admissible amount of the world's annual catch has so far been about 85 million tons. Unfortunately, man has made an unsparing use of the ecosystems of seas and oceans and with modern fishing technologies has increased the catch to the extent that fish populations can no more reproduce themselves. Fish resources in nine world's major fishing areas have decreased. In the Baltic Sea, for example, the resources of cod have been critically depleted, considering that in mid-20th century cod was a principal type of seafood for the population of this area.

2.2.3 TIMBER

The sheet of paper with this printed text is only partly the product of a paper-mill. If we burned the paper, a tiny part of the Sun's energy would be released in the form of light and heat. This energy had been accumulated by the tree cells to produce the fibre that forms paper. Essentially, paper is the product of the forest ecosystem, just like the table at which we eat or work. Man's contribution consists of merely having learned how to endow nature's products with a different form (Figure 2.6).

Figure 2.6. **Timber is a product of an ecosystem that man has been using to make various objects and materials since ancient times**

Since the 17th century, when paper was still produced from flax fibre, the paper industry has developed extremely rapidly. The world's paper industry uses different kinds of wood: spruce, pine, aspen, birch, larch and even eucalyptus. To produce a ton of high-quality writing paper, about 24 medium-sized trees, 12 m tall and 15–20 cm thick need to be cut (Figure 2.7).

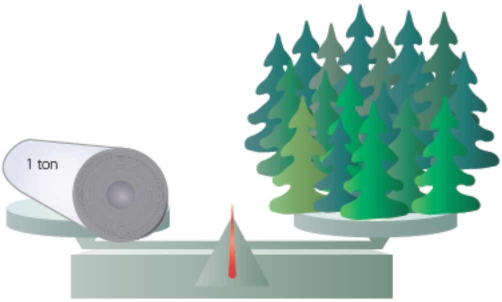

Figure 2.7. **To produce a ton of high-quality writing paper 24 medium-sized trees are necessary**

To print the books that are annually sold in the USA, about 30 million trees must be cut. However, the rate of paper consumption continues to grow. In an attempt to decrease the impact of paper consumption on natural forest ecosystems, the timber for the paper industry is procured from special tree plantations and from recycled raw materials – wastepaper and scraps of natural fibre fabric. Unfortunately, the resource-saving paper industry does not occupy the dominating position in the world. Only 8% of all paper is produced from other raw materials than timber. Of 335 million tons of the produced world paper, 70% still come from natural forests. For example, in forest-rich Canada, as much as 90% of timber for paper production comes from state-owned primeval forests.

Paper is just one of many ecosystem-produced timber products. Timber is widely used in construction, furniture making and as fuel. Compared to the mid-20th century, the world's total consumption of timber has grown by nearly two thirds. The use of plastics and synthetic materials as building materials, especially for private estates, is out of fashion now. Plastic windows have again been replaced by wooden frames. Life in wooden buildings is healthier; thus, many people choose to return to the architecture of their ancestors – horizontal log buildings in modern forms.

To satisfy mass demand for cheap building materials and furniture, they are now mostly made of waste timber or timber fragments, compressing and gluing them together with synthetic substances. This is how chipboards, plywood and boards are mass-produced as material for one-day furniture beyond repair, should any damage occur. An average citizen has long since put up with such furniture: it can be changed with the changing fashions, and it is cheaper to buy new furniture than repair the used one. The furniture industry, for its part, finds the production of such furniture profitable as design can be changed as often as necessary. We can easily imagine what could happen to the business of furniture making if people purchased furniture for life with an ultimate plan to leave it to their grandchildren.

Ecosystems cannot provide each inhabitant of our planet with a natural walnut or oak writing desk. Demand exceeds the supply by far, which makes objects of expensive woods extremely costly.

It would be a fallacy to think that the pressure the owners of expensive furniture put on ecosystems is smaller than the one exerted by the buyers of chipboard furniture. Tropical forests suffer most as they are the only ecosystems that provide mahogany, rosewood and other woods of rare species for the production of high-class furniture. In the previous century, to pay off the country's debt, Brazil sold huge tropical forest territories to transnational logging companies, which cleared them mercilessly. Since mid-20th century already 1/5 of tropical forests have been destroyed.

The services of natural forests to timber industry have turned out to be insufficient. The industry's demand for timber has called forth the necessity to set up plantations of trees to relieve forest ecosystems from further exploitation for timber harvesting.

Since the 1980s, the total area of the world's tree plantations has increased tenfold and constitutes nearly 200 million hectares. Although it makes only 5% of the world's total forest area, it yields about 35% of round timber production, with an outlook of 44% in 2020. So far, most of timber comes from cutting natural forests.

2.2.4 TEXTILE FIBRES

The first humans – Adam and Eve – are usually depicted naked, covered only by a fig-leaf. If ecosystems had allotted just a fig-leaf for the dressing-room of the crown of all life, they would not have survived either the Ice Age or droughts over the last millennia.

Ecosystems have taken care to ensure that clothing not only would protect humans from cold and heat but that it should also be pretty. The primeval hunter's clothing was made of pelt; the ancient cattle breeder did not necessarily need to slaughter animals as he could make clothing of sheep's wool; the ancient farmer enjoyed an even greater choice offered by the plant kingdom – natural plant fibres – flax and cotton. To produce fabric, people in China even used insects – silkworms (Figure 2.8).

Attempts to refuse these ecosystem services and use chemical fibres like nylon, viscose, glass fibre and others have not been successful enough to fully replace natural textile fibres. The latter have always appeared to be more user-friendly and pleasant to wear.

However, with the growing number of the Earth's population and their demand for cheap clothing, man's competition with Nature in the production of textile fibres is going on as natural materials become increasingly more expensive. The ancient

Figure 2.8. **Silkworms and their cocoons from which the silk thread comes**

man's pelt was an everyday wear while today furs are used to produce expensive coats and mantles. The number of ladies who can afford such cloaks considerably exceeds the number of fur animals in nature. Because of intensive hunting, many species are facing extinction.

As a result of overuse of the animal population, the ecosystem services which provide furs are depleted in many areas of the world, and man has had to breed fur-bearing animals in farms.

For centuries, woollen clothing has been one of the most popular types of garment in the world. Pastures for sheep have considerably shaped the landscape in Europe, the Middle East and Central Asia (Figure 2.9).

To expand wool production, Europeans took sheep to Australia where they, sadly, degraded the unique local ecosystems and deprived the local fauna – marsupials – of food and living space.

Flax, too, is an ancient fibre crop. Ancient Egyptians used linen to wrap mummies. These days, because of cotton expansion in the world, flax-growing has considerably decreased.

Cotton is a typical fibre crop in southern countries, cultivated for several millennia (Figure 2.10). Cotton fabric came to Europe in the Middle Ages.

Cultivating cotton by using labour force from colonies proved to be cheap, and this textile fibre quickly inundated the world market and drove back wool and flax. Today cotton accounts for 40% of all natural textile fibres in the world. Over the last 40 years, the volume of cotton production has doubled.

Cotton is grown on irrigated lands. The need to supply cotton plantations with huge amounts of water and the use of chemical means for pest control in these regions have caused ecological problems: degradation of soil and environmental pollution. Countries in Central Asia, which use the waters of the Amu Darya and the Syr Darya to irrigate cotton plantations, have brought the Aral Sea to extinction, with just several detached aquatoria remaining.

2.2.5 MEDICATIONS

Before Alexander Fleming discovered the antibiotic penicillin in 1928, a substance produced by *Penicillum* genus mould fungus to fight competing microorganisms, thousands of people died of bacterial infections and war wounds. Antibiotics (Greek *anti* – 'against', *bios* – 'life') are substances that kill bacteria or inhibit their propagation. In nature antibiotics produce various microorganisms to inhibit the development of their competitors – other species of microorganisms. Special technologies have been developed to cultivate valuable microorganisms for industrial production

Figure 2.9. **For centuries, sheep-farming has been the source of the invaluable wool textile fibre**

Figure 2.10. **Cotton is the most extensively cultivated textile fibre culture**

Figure 2.11. **Meadowsweet and milfoil, the medicinal plants that man has been using since ancient times, are commonly found in meadows**

of antibiotics in quantities that can satisfy medical needs. Since the 1930s, about 100 various antibiotics have been introduced in medicine (streptomycin, penicillin, oxacillin, tetracycline, ampicillin and others). Due to misuse of antibiotics (non-observance of the length of treatment and dosage), many pathogens, for example, staphylococci, have become antibiotic-resistant and, in case of illness, antibiotics are ineffective. To solve the problem, pharmacologists have to look for ever new antibiotics and develop special medicines that can fight the resistance of pathogens to antibiotics.

Today many people, without going into the heart of the matter, would distinguish folk medicinal substances from antibiotics by claiming that the latter are all chemistry and should be avoided as much as possible. Of course, many modern medications are chemically synthesised; however, they constitute analogues of natural substances. In this respect, antibiotics cannot be considered purely chemical products as they are substances that nature has donated to us in the form of microorganisms. Antibiotics were indirectly known in ancient China, Egypt and Greece where mould was used to treat and cure wounds.

Natural medications – products of flora and fauna – have been used by mankind since ancient times (Figure 2.11). The curative properties of medicinal plants can be explained by the organic substances that they contain, including alkaloids, glucosides, vitamins and essential oils. Many invaluable medicines, for example, morphine, codeine, quinine and others, are derived from medicinal plants. There is hardly a person who has never had camomile, linden, meadowsweet or milfoil medicinal tea.

Many plants, for example, garlic, onion, eucalyptus leaves, aloe and others, contain inhibitors of microorganisms – phytoncides. There are substances in many plants that enhance the immunity of the organism and slow down the ageing processes of cells, for example, the legendary root of ginseng. The perfume industry is unthinkable without plants, the most essential being rose and lavender. The price of attar is comparable to the price of gold.

In general, about 35 000 species of plants are used in medicine in the world. Most of the world's medicines, about 80%, are substances produced by living organisms – microorganisms, plants and animals. The Amazonian indigenous tribes use at least 1 300 species of plants for curative purposes. Of 150 prescription medicines used in the USA 118 are of natural origin, of them 74% are of plant origin, 18% of fungal origin, 5% of bacterial origin and 3% of animal origin.

Ecosystems hold huge, so far unidentified medication reserves. Up to now, the chemical composition of about 1% of the species of tropical forest plants has been identified. A species of periwinkle, indigenous to Madagascar, is the source of 80 alkaloids used to treat leukaemia. 70% of all plants registered in the USA National Cancer Institute as having anti-cancer properties grow only in tropical forests.

Compared to plants, animals are less used for medical purposes. Many valuable substances come from bees – bee poison, royal jelly, propolis and wax. Medicine makes wide use of snake venom and snakes are bred in special serpentariums. The application of leeches in medicine, widely practised in ancient times and the Middle Ages, has now been given a new lease of life.

2.2.6 SOIL

Since prehistoric times, agriculture has been the basis of food production. Ancient civilisations formed in the areas that nature itself had endowed with fertile soil – in river valleys and forest-rich lands. Unfortunately, history holds stories of ancient civilisations becoming suddenly extinct, the main reasons for which, according to archaeologists, were crop failure and famine caused by soil depletion. What conditions lead to soil depletion and how can an ecosystem itself sustain continuous fertility of soil?

The ancient people's understanding of the fertility of soil was for the most part limited to maintaining the necessary level of moisture for the plants to grow. Ancient civilisations had already practised methods of irrigation while they had not understood the importance of the most essential fertility factor – nutrients and organic substances.

Slash-and-burn farming was widespread in ancient Europe and, even today, in the countries of the tropical climate zone. It is based on clear-cutting or burning down of a plot of forested land, removing the stumps and roots from the soil by burning them. The ashes would be dispersed over the vacated area and, as ashes contain nutrients for plants, their content in the soil was sufficient for quite some time. Such fields yielded reasonably good crops.

Plant nutrients are chemical elements available for plants mainly as water-soluble salts which plants consume together with water from soil. There are macroelements – nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulphur (S) and magnesium (Mg), which are present in plants in relatively large amounts. There are also trace elements, less than a millesimal per cent; however, without them plants would wither away or deform.

Every year, the farmer removed, together with the crop, some of the plant nutrients which lead to the nutrient deficit. Soil was rapidly losing its fertility, and the farmer faced crop failure. The only solution was to leave the depleted field and start clearing another plot.

The abandoned fields gradually grew back to a forest, and over decades the fertility of soil was re-established. Slash-and-burn farming yielded satisfactory results in the temperate climate zone where the ecological substance turnover is rather slow and soil contains large resources of organic substances and nutrients.

In the countries of the tropical climate zone, substance turnover is extremely intensive – dead plants and animals are rapidly mineralised, plant roots immediately absorb the nutrients, and practically no excess organic substances accumulate in soil. For this reason, the beneficial effect of soil in the clearings of tropical forests usually is short-lived. In a couple of years the soil is impoverished and has lost its structure; it is easily washed out by rain, leaving deep erosion furrows. Such a field can no longer be used for crop-growing and a new clearance is necessary. Unfortunately, according to research, the ecosystems of tropical rainforests are more vulnerable than the forest ecosystems in the temperate zone and their regeneration is a slow process. Secondary forests in such places never reach the biodiversity that was there before woodland was cleared. Cutting down tropical rainforests leads, without doubt, to the reduction of the biodiversity of our planet.

Formation of soil is a process that takes hundreds, even thousands of years. It starts on bare lifeless rocks – bedrock, sometimes on marsh deposits. Bedrock can be sand, clay, gravel or even hard granite, as it is often the case in Northern Europe. The properties and fertility of soil are largely determined by the chemical composition of the bedrock and the size of the particles.

Sandy soils are usually less fertile than clayey soils. However, a lifeless bedrock is not soil. The formation of soil is impossible without the participation of microorganisms, plants and animals. Microorganisms and plant roots not only consume nutrients and water from soil; they also discharge substances into the surrounding environment that chemically interact with rocks to dissolve and transform them. Living organisms constantly grow, multiply and wither away. The remains are consumed and minced up by insects, ticks and worms that live in soil. They enrich soil with their excreta and activate microorganisms. In the early stages of decomposition, it is still possible to determine to which organisms the dead parts had belonged; however, as decomposition proceeds, the mass of remains becomes homogeneous, and humus has formed.

The microorganism-produced substances and decomposition products interact chemically to form specific complex chemical compounds – humic substances. They glue rock particles and parts of semi-decomposed plants, producing the loose structure that is typical of fertile soil.

Climate plays a significant role in the formation of soil. In wet climate rainwater washes the soluble substances from the surface of soil deeper down into groundwater.

In dry climate, as the surface of soil dries, groundwater climbs up the tiny capillary cracks in soil and evaporates, leaving the water-dissolved salts on the surface. Thus, in wet climate soil is washed out while in dry climate it gets salinated. As water and water-carried substances leach through soil, it obtains a layered structure. Usually, the surface layer of soil, or horizon, is darker as it contains more organic substances. With a high concentration of plant nutrients, it is in this layer that life processes are most intensive. Rocks, remains of plants and animals, humus, microorganisms, plant roots and soil animals are the components of the ecosystem of soil whose interaction provides the ecosystem service which is vitally important for human existence – sustaining wild plants and animals as well as cultivated plants and domestic animals in all biodiversity of species and breeds.

Figure 2.12. **Man-cultivated areas (at least 30% of the territories are tilled)**

The world area of cultivated land increased more between 1950 and 1980 than during the whole of the 18th century and the first half of the 19th century. Today it covers a considerable part of the Earth (Figure 2.12). Compared to the origins of agriculture, with the development of civilisation, human demands to soil as the provider of existence have grown out of proportion. We are no more content with what soil can naturally offer but would try different means to make soil yield more and more of the biomass that we need. To fight the competitors of cultured plants – wild plants that we call 'weeds' – various methods of ploughing and chemical substances, herbicides, are used (Latin *herba* – 'grass').

Ploughing and turning over the upper layer of soil spells disaster for the soil ecosystem. Although ploughing would partly destroy the wild vegetation, loosen the soil and bring the plant nutrients closer to the surface, in dry climate it can lead to soil degradation due to wind erosion. In the 1950s and 1960s, a political decision was adopted in the former USSR to cultivate the virgin lands – the fertile zone of steppes in Southern Russia and Kazakhstan, where soil is particularly rich in organic substances and nutrients. The plan was to establish the state granary – to reap rich harvest of wheat. However, this region is notorious for frequent dust storms. In the first years, they took away the loose fertile layer of fields, laying the roots of crops bare and dry. Hundreds of hectares of planting perished, and an acute deficit of white bread set in the country. To prevent wind erosion, a special ploughing method was worked out that left the sod unturned.

For soil to yield crops in a dry and hot climate, plantings need artificial irrigation provided by conveying water from rivers or wells by special drain systems to the fields. However, if the irrigation waters have a high concentration of salts, as water evaporates, salts gradually accumulate in the upper layer of soil and it becomes unfit for agriculture.

During the early stages of agriculture, soil salination caused the decline of ancient civilisations and turned fields into desert. Unfortunately, desertification continues to be an ongoing process even today, claiming about 200 000 square kilometres of agricultural land per year.

By depleting soil and removing plant nutrients from fields when harvesting, as well as by over-fertilizing soil with nitrates, man destroys the natural capacity of soil to provide ecological services. In the first case the soil simply does not provide crops while in the second case it yields both nitrate-polluted plants and drinking water.

To prevent problems of fertilisation of soils, humans have attempted to refuse its services. A method of growing plants without soil was worked out – hydroponics (Greek *hydros* – 'water', *ponos* – 'labour') (Figure 2.13). Hydroponics is growing plants in a nutrient-rich water solution. To keep plants vertical, the hard substrate, such as plastic or ceramic granules or plates, is used for plants to root. Hydroponics provides the possibility to apply very precise dosages of nutrient concentration in the water solution. The method of hydroponics

Figure 2.13. **Growing plants with the method of hydroponics**

is applied in greenhouses, including for growing cucumbers and tomatoes.

Hydroponics prevents problems connected with the heterogeneous composition of soil, weeds and pests by precisely monitoring the composition of nutrient solution and supplying it to plants automatically. However, the method has its flaws: even a slight deviation in the chemical composition of the nutrient solution may cause the death of plants or loss of crops. On the surface of its particles, soil absorbs substances that are toxic for plants, which is something surrogate soils cannot do.

Hydroponic cultures can be easily invaded by bacteria and fungi that may cause plant diseases, while in natural soil they are under constant control of other microorganisms. This makes harvests of hydroponic cultures much more expensive than the field-grown harvests.

2.3 REGULATION OF ENVIRONMENTAL PARAMETERS

2.3.1 AMOUNT OF OXYGEN IN AIR

In March 2007, the New York Times editorial came out with a suggestion to the USA government to impose a tax on breathing. The author drew a parallel between an industrial enterprise and a citizen, claiming that both consume oxygen and discharge carbon dioxide into air.

Such speculations could be considered superficial if not for the ecological crisis that gave rise to them. Air comprises 21% oxygen (O_2). It is necessary to ensure respiration of all aerobic organisms on the Earth, including humans. Deprived of oxygen, human brain cells usually die in five minutes. The critical oxygen concentration in air for many animals and humans constitutes 14–15%.

We are not concerned with oxygen on a daily basis. Its deficit poses a problem only in extreme situations – submarine accidents and mine cave-ins, also when planning long-term cosmic flights.

The seeming abundance of oxygen in the Earth's atmosphere is ensured by green plants in photosynthesis (Figure 2.14), including algae in the World Ocean.

Photosynthesis is a process in which, under the impact of solar energy, complex molecules of organic substances (sugars, starch) are synthesised in plants from molecules of simple substances – carbon dioxide (CO_2) and water (H_2O). The end product of the process, oxygen, is released into the atmosphere.

Man has not so far been able to construct technical systems that could effectively compete with the green plants. To synthesise a ton of biomass, the green plants consume about 2.0 tons of CO_2 from the atmosphere and release 1.5 tons of O_2. An average-sized leaf-bearing tree annually produces the oxygen that two people require for breathing.

American scientists have calculated that the country's suburban forests annually produce 67 million tons of oxygen, which satisfies the breathing needs of about 2/3 of the US residents. In the major cities of Japan and the United Kingdom, there are oxygen bars with oxygen vendors (Figure 2.15.). A portion of clean air containing 40% oxygen costs around three dollars.

The average annual consumption of oxygen by a human being comprises 260 kilograms. If we were to buy it in a shop like we buy drinking water, we would spend at least EUR 30–50 per year on breathing. Ecosystems provide this service without charge, but man's economic activities can facilitate or, quite the contrary, hamper this function of the ecosystem.

It has been estimated that green plants release into the biosphere 2.6×10^{13} tons of oxygen per

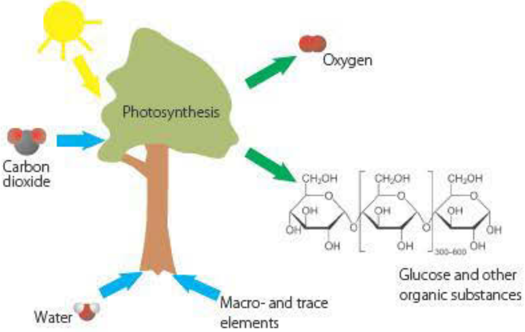

Figure 2.14. **In the process of photosynthesis, glucose is formed in plants from carbon dioxide and water under the impact of solar energy**

Figure 2.15. **Oxygen bar in San Diego, USA**

year. Most of it (73–87%) is produced by algae in the World Ocean, the rest by terrestrial ecosystems. Trees are the most effective at photosynthesis on land as their foliage comprises the largest total photosynthesising surface in relation to the land area that they occupy. The oxygen produced by photosynthesising plants is consumed by animals, aerobic organisms as well as the plants themselves in the process of respiration.

Some of the oxygen is used in chemical oxidation, including burning. The amount of oxygen used in natural fires is insignificant compared to the amount that man uses to burn fossil fuels – coal, oil and gas. For example, driving a car at a speed of 50 km per hour consumes over 22 kg of O_2 in an hour. The same amount would be used by 750 rickshaw riders if they took care of our trips instead of cars.

Usually, when treating global environmental problems, the potential changes of oxygen concentration in air are not discussed, which creates a wrong impression that the amount of oxygen is constant and invariable. Palaeontological research demonstrates the contrary. The oxygen content has considerably varied at different historical periods on our planet. For example, in the Early Permian Period 290–248 million years ago, it had reached as much as 35%, while in the Triassic 248–208 million years ago, it had decreased to the level of 13–14%. In the Tertiary Period 65 million years ago, the oxygen content in air was 26% and then gradually descended to the level of our time – 21%.

Oxygen concentration is also subject to considerable local variations, under the impact of the amount of consumption and the ability of vegetation to renew oxygen. Research in Alabama, the USA, showed fluctuations within the 19–22% range, but in the major Asian cities, the concentration of oxygen can drop to the critical mark of 14–15%. Such conditions present real hazard for human health and the number of deaths increases. Over the last decade, because of air pollution in Mexico, 5 000–15 000 people have died every year.

2.3.2 CARBON CYCLE

The main element in all organic substances is carbon. Carbon dioxide is created as molecules of organic matter split and C atoms combine with oxygen. This occurs when organic matter burns, or living organisms breathe, or in the processes of decomposition and fermentation, for example, when microorganisms transform sugar into spirits. Burning always releases energy – heat and light, which we see as a flame.

In the microbial decomposition process, a compost pile only heats up while the nature of respiration is slow burning. In respiration the substance to burn usually is sugar – glucose, but if there is not enough of it, fat is burned. The respiration-released energy is used for the growth and movements of the organism, but part is released as heat that ensures constant body temperature. The exhaled air contains 4% CO_2 on average, which is 100 times more than in the inhaled air.

Carbon dioxide is a waste product of the life processes of aerobic organisms. The average proportion of carbon dioxide in atmospheric air amounts to 0.03%. However, in places of high concentration of respiring organisms, for example, in the upper layer of soil and the lower layers of the atmosphere, the concentration of CO_2 can reach up to 0.5–4%. Aerobic organisms are sensitive to a heightened content of carbon dioxide in air. If the concentration of CO_2 is just 1%, human beings feel considerable discomfort but, with the CO_2 level over 10%, human beings die.

Carbon dioxide is one of the principal components in volcanic gases; it is released from the underground hot springs and lake sediments. For example, in 1986 in Cameroon, a sudden landslide in Lake Nyos situated in an area of volcanic activity resulted in a CO_2 emission, causing deaths of 1 700 people and 3 500 livestock.

Thus, natural sources of carbon dioxide are

- respiration of living organisms,
- decomposition of organic matter (rotting and fermentation),
- fires caused by lightning,
- volcanic processes.

Due to these processes, the amount of CO_2 in the atmosphere should be constantly on the increase but since this gas is water-soluble and thus forms carbonic acid, huge amounts of CO_2 are accumulated by the World Ocean. There CO_3^{-2} reacts with Ca^{+2} ions and forms a limestone deposit. Carbon dioxide as a nutrient is of vital necessity for plants. They take it from the atmospheric air and, by photosynthesis, form organic substances from it. Photosynthesis can be considered an opposite process to respiration – individual C atoms are linked in chains, molecules of organic matter, and each chemical bond is charged with a tiny part of solar energy. This energy and organic substances are available to herbivores who cannot use solar energy directly. In this way C atoms are constantly cycling:

$$\text{air} \rightarrow \text{organism} \rightarrow \text{air}$$

While the carbon atom is in plants, it is excluded from the cycling. Usually, plants can produce more organic matter than animals and microorganisms can consume. This is why organic substances and carbon gradually accumulate in soil and deposits. In the history of our planet, some of carbon was excluded from the cycle and deposited in the form of coal, oil or peat. In this way, for example, some of the carbon dioxide that was exhaled by dinosaurs or mammoths was captured in the plant remains of the time, which we find today in organic deposits. In them, like in a huge battery, the solar energy of the time has also been stored.

Ever since man learned how to make and maintain fire in the hearth, he has been using this richly stored energy for his own needs: heating, preparing meals, operating industrial equipment and vehicles. Firewood, turf, coal, oil and gas are being burned, but as this is organic matter accumulated over tens, hundreds and thousands of years, it burns and releases such a quantity of CO_2 that neither the World Ocean nor the planet's vegetation can remove. The situation is aggravated by the fact that man has considerably decreased the capability of plants to remove carbon dioxide by destroying natural vegetation (deforestation, urban development, agriculture). This is why, due to human activity, the amount of carbon dioxide in the atmosphere has rapidly increased over the last decades.

The growth of the CO_2 content in the atmosphere prevents the surface of the Earth from reflecting solar heat back to space, just like the greenhouse glass prevents heat from escaping out of the space under the glass. This has called forth global warming. As climate grows warmer, the rate of the increase in the CO_2 content in the atmosphere may be even faster because the millennia-old non-decomposed organic substances and bog peat in arctic soils thaw and begin to decompose intensively. The warm season draws out and the breakdown of organic matter deposited in forest soils of the temperate zone also becomes faster.

Green plants could hamper the increase of CO_2 in air. Many studies show that an increased concentration of CO_2 in air increases the biomass of plants. This regularity has been widely used in greenhouse farming by artificially increasing CO_2 concentration in greenhouses. During the last century, along with the growing CO_2 content, a faster growth of the plant biomass has been actually registered, for example, an increase in timber biomass and the productivity of individual agricultural crops. An optimistic prognosis has been voiced about the increase in CO_2 as a facilitating factor for a lusher and richer vegetation on our planet. However, more recent experiments show that such optimism is ungrounded. Apart from CO_2, plants need nitrogen and other nutrients. In the case of their deficit, the increase in CO_2 alone cannot yield the desirable effect. Much of CO_2 dissolves in the World Ocean to form carbonic acid. If there is a calcium deficit in water, the World Ocean acidity may rise, which leads to the deterioration of habitats of numerous oceanic organisms, including corals, and their eventual extinction.

2.3.3 NITROGEN CYCLE

Nitrogen (N_2) as a gaseous substance is the basic component of air (78%), while nitrogen as a chemical element is found in molecules of all vitally important organic substances, including proteins, enzymes and DNA. Although plants and animals literally swim in nitrogen, they cannot, in a paradoxical way, obtain it from the atmosphere. The only way for the atmospheric nitrogen to enter plants and animals is through soil. However, before that the gaseous nitrogen must be converted to a chemical form so that plant roots can take it in.

This vital ecological service can be provided only by special soil bacteria – nitrogen-fixing bacteria. Some species of such bacteria live freely, others have adapted to mutually beneficial life – symbiosis – with plant roots. Plants supply bacteria with the substances produced on the surface in the process of photosynthesis, and bacteria supply plants with nitrogen from soil air. As bacteria die, the nitrogen in cells, mostly as nitrate ions (NO_3^-) and ammonium ions (NH_4^+), enters soil. Nitrate ions and ammonium ions become accessible to plant roots through soil water. From plants nitrogen travels down the ecological food chain – to herbivores, predators and, through food, to humans.

Symbiotic bacteria cannot coexist with all plants, only with some species of privileged families. Of the temperate zone plants, papilionaceous plants must be noted, for example, peas and beans, while the exception among trees is the Grey Alder. The rest of plants can obtain nitrogen as ions from soil water. Nitrogen fixation and cycling of nitrogen in soil is fundamentally important for agriculture and food production. If plants suffer from nitrogen deficit, they wither and do not form biomass. Because of agricultural activity, the natural nitrogen cycle is deformed to some extent – a large amount of nitrogen along with other nutrients is removed from the fields during harvesting. In the temperate zone, when harvesting cereals, 90–100 kilograms of nitrogen are removed annually per hectare of land. Thus, one of the principal problems of agriculture has been nitrogen provision for plants to ensure high productivity.

When the field had lost its fertility, the ancient farmers used to leave the depleted land and clear another forest area. Later, with the growing density of population and shrinking resources of land, farmers learned how to renew the fertility of soil by manuring and green-fertilizing it, also by crop rotation with papilionaceous plants as a compulsory culture.

The introduction of artificial fertilizers – mineral fertilizers – revolutionised agriculture. Nitrogenous fertilizers, mostly nitrate salts, are produced industrially. Hundreds of millions of tons of nitrogenous fertilizers are produced every year as ammonium nitrate, ammonium sulphate and other chemical compounds, but the production process consumes a lot of energy. Microorganisms return nitrogen to soil for free while the costs of industrially produced nitrogenous fertilizers depend on the global price of natural gas, a non-renewable energy resource that is used in nitrogen production.

The unlimited possibility of enriching soil with artificial nitrogen soon proved to be the cause of new, unprecedented problems. Problems were caused both by the nitrogen deficit and the abundance of nitrogen. If only mineral fertilizers are used over a long period of time, soil gradually loses organic substances. The remains on the field after harvesting constitute an insufficient amount for normal renewal of humic substances. Humus deals with the structure of soil and accumulation of plant nutrients in the upper, root-permeated layer of soil.

As humus disintegrates, soil is degraded and turns into dust – a dense, lifeless substrate. The nutrients, including nitrates, necessary for plants are easily washed down into groundwater and water bodies, causing 'overfeeding' or eutrophication of rivers and lakes. Due to eutrophication, cyanobacteria or blue-green algae multiply in water, creating toxins hazardous to human and animal health. Mineral fertilizers also have an adverse effect on soil animals, including earth worms, the main soil-forming creatures in the temperate zone.

Oversaturation of soil with nitrates has a negative impact on the quality of agricultural products which show an increased content of nitrates. Nitrate-polluted food causes methemoglobinemia – inhibition of oxygen transfer in organisms; it also increases the risk of malignant tumours as the chemical transformation of nitrates calls forth cancerogenic substances – nitrozoamines – in the digestive tract. Nitrogen pollution has become a major problem in the areas of intensive cattle-farming where both food and well-water pollution with nitrates has been observed.

Nowadays a source of considerable nitrate pollution is exhaust fumes from ground vehicles which contain nitrogen compounds, mainly the oxides NO and NO_2. In the reaction with water vapour in air, they produce nitric acid and fall out as acid precipitation. Under their impact, plant nutrients, especially potassium ions (K^+), are washed out of soil. In forest soils they upset the nutrient balance of plants, thus causing an adverse effect on the growth and development of coniferous trees.

2.3.4 MICROCLIMATE REGULATION

On a hot summer day, nothing provides a better shelter from the hot sun than the foliage of a big tree. If there are no trees, man has to procure at least a parasol or invest money in building a lean-to or a shed. Trees provide shade for free (Figure 2.16). In hot weather the temperature in the forest is lower by 10 °C compared to an open space.

Foliage of trees hinders drying of soil. Forest considerably slows down wind. At the height of two metres above the tree-tops, wind velocity can reach 3–4 m/sec, but inside a fir-tree forest it is over two times slower. In early spring, before the field crops have sprouted, the vast farmland areas, widespread now not only in the steppe zone but also in the temperate climate zone, suffer from wind erosion. To prevent wind erosion, it has been advised to plant strips of forest between the fields in large open areas.

Trees have an essential role in regulating micro-climate in cities. Under the summer sun the city

Figure 2.16. **On a summer day, the foliage of a big tree provides excellent protection from the hot sun**

territory heats up much more than the surrounding rural areas. Asphalt, walls of buildings, roofs and pavement warm up in the sun and warm the air. As the warm air rises above the city, a traction effect is created: the air of a lower temperature from the periphery flows to the city centre. In this case the quality of the air that goes to the city centre is extremely important. If there are industrial enterprises or junctions of heavy traffic in the city periphery, the air flowing to the city centre can bring along more pollutants than there were initially in the centre.

However, if the city is surrounded by woods, they act like the respirator of a protective mask: they filter dust, take up carbon dioxide, and enrich the city air with oxygen. To improve the quality of life in the city, when planning the city development, it is essential that suburban woods are preserved wherever possible so that they can provide the vitally important ecological service – to clean the air humans need for breathing.

Parks and trees that line the streets in the city centre also purify air. The surface of innumerable leaves absorbs dust, takes up carbon dioxide and enriches air with oxygen.

2.3.5 ROLE OF ECOSYSTEMS IN RUNOFF REGULATION

Water in nature is constantly circulating. It reaches the atmosphere by evaporating from the surface of water basins, soil and plants. In the atmosphere water vapour condenses and produces clouds. Depending on the air temperature, water returns to the Earth as precipitation, either snow or rain, less often as hail. Part of precipitation waters go into soil, while another part flow down the topsoil, forming runoff. The steeper the slope and the smaller the water infiltration capability of soil, the larger is the runoff amount of precipitation. If infiltration is weak, during continuous and heavy rain, the surface runoff rapidly increases, rivers leave their banks and overrun lower land. World floods cause losses that run to hundreds of millions of euros annually.

In such cases, ecosystems serve as a gigantic sponge, increasing infiltration and decreasing the amount of surface runoff. Water infiltration is most effective in forest ecosystems where water is retained by the cover of moss and the thick layer of humus. During incessant rain, highly wooded regions usually suffer less frequently than populated places where forests have been cleared, soil surface is trampled, and large areas of it are covered with asphalt or cobbles. Clear-cutting the slopes of mountains creates an extremely dangerous situation because the wet topsoil can create landslides and mudslides that frequently bury whole villages with their residents. Mountain forests can be considered lifeguards of the people who live in the valleys.

Forests serve not only as regulators of the regional runoff level, they also are climate regulators. Trees transpire a huge amount of water into the atmosphere; this is why the air above massive woodlands contains much water vapour. Condensed into drops and clouds, the amount of vapour above the continent decreases. This causes a flow of humid air from the ocean towards the centre of the continent. This explains why the climate is wet in forest-rich continents, for example, the equatorial zone of South America, while the central parts of Australia are dry.

Forest ecosystems also largely regulate the amount of carbon dioxide in the atmosphere of the planet. Forests cover 30% of the world land surface and contain over 300 gigatons of carbon absorbed from air, which is by 50% more than the total existing amount of carbon in the atmosphere. To sustain forest ecosystems as climate regulators, we need not only to decrease the use of fossil fuels and timber in energy production; we must stop cutting forests and increase forested areas. Until the middle of the previous century, forest lands in the world, including Europe, were shrinking rapidly. Recently, a positive development can be observed: in several European and Asian countries forest areas are growing. According to the UN data, in 2007 over a billion trees have been planted in the world. At the same time, in many poor countries of the tropical zone, for example, Indonesia, Brazil and the Philippines, rapid deforestation is going on.

2.4 SUPPORT SERVICES

2.4.1 POLLINATION

In the process of evolution, many flowering plants and insects have established mutually beneficial relations – this is called mutualism. Insects – bees, butterflies, flies, beetles – feed on nectar and pollen.

To be able to produce seeds, many plant species require that their flowers are fertilised with pollen of another individual of the species. As insects feed on nectar, they visit hundreds of flowers. Research shows that in one flight a simple honey bee can visit 500 to 1000 flowers, and it makes 10–15 flights a day. Moreover, there are several thousands of such active nectar collectors in a family of bees. As a rule, the number of insects is sufficient to ensure pollination of plants in nature.

The wild entomophylous species of flowering plants fully depend on insects-pollinators to ensure the propagation and dissemination of these species. Many species of wild plants do not care which insects carry their pollens. However, individual flowering plants have adapted to mutualism with strictly selected species of insects because the form of these insects, the length of their proboscises and the time of flight have been precisely harmonised with the form of the flower, depth of its cup and its flowering time. If the number of a certain insect species decreases for some reason, the existence of the dependent species of flowering plant is also endangered.

Very serious problems arise in the case of non-pollination of agricultural crops. The yield of most of the plants (76%) that humans use for food depends on the pollinating insects. Out of European-cultivated plant species, 84% depend on pollinators. By pollinating different agricultural crops, honey bees in the USA annually ensure a harvest whose value amounts to approximately EUR 10 billion. In several countries of Asia, including Japan and China, a catastrophic decrease in pollinating bees was recorded, which has caused serious problems for fruit-growing in these countries. For example, in the Sichuan province of China, to ensure harvest when the ecosystem cannot provide this service due to the decrease in the number of bees, people are involved in pollination of fruit-trees: at flowering time, many girls make the rounds of orchards and carefully treat each flowering twig with special brushes.

In the mid-20th century, the decrease in the Red Clover yield caused problems in Europe. It was identified that the problem was caused by the decreased number of bumblebees. Bumblebees are the only insects whose proboscises are long enough to collect nectar from the tubular cup of the Red Clover (Figure 2.17).

Figure 2.17. **Bumblebees are the main pollinators of the Red Clover**

Honey bees cannot do that and for that reason they do not visit red clover fields. The decrease in the number of bumblebees was connected with the expansion of the field area characteristic of intensive agriculture. The huge expanses swallowed up boundary strips between fields and meadows – biotopes in which bumblebees make their nests. To attract bumblebees to agricultural lands, methods have been devised to grow them on a commercial basis. They are bred in several countries of the world, also in the EU, the USA, Canada and Israel. The world's annual sale of bumblebees exceeds a million commercially bred colonies. They are used to pollinate tomatoes, strawberries, beans, avocados, kiwi fruit and other cultivated plants. It takes at least three bumblebee nests to ensure the pollination of tomatoes in a large greenhouse.

2.4.2 DECOMPOSITION OF THE REMAINS OF ORGANIC MATTER

Any dead organism, be it a plant, an animal, or a human being, ends up in the concluding block of the ecosystem's trophic chain where it turns into food for microorganisms and soil animals. During their life bodies of plants and animals accumulate a sufficient amount of chemical substances and solar energy that after death they can become attractive food for decomposers.

130 billion tons of dead organic matter are produced on the Earth annually, including plant litter and roots, animal bodies and excreta. Around 30% of such remains are the results of human activity. In the forest ecosystems of the temperate zone 1–5 tons of dead leaves annually fall to the surface of soil. If all of this mass of organic matter were not decomposed, the Earth would be wrapped in a thick layer of remains in no time. The decomposers that live in soil take care that it should never happen. The majority of them are microscopic or very tiny organisms, and humans have no clue about their existence. For example, the research of Denmark's pasture soil has revealed that one square metre of soil is home for about 50 000 enchytraeids and earthworms, 50 000 soil mites and insects, and around 30 000 nematodes. There are many more bacteria and fungi. A teaspoonful of fertile soil contains over 30 000 cells of soil protists, 50 000 cells of soil algae, 400 000 cells of microscopic fungi and several billions of bacteria cells.

These millions of invisible organisms do an invaluable service to humans by cleaning the environment from various biological remains and returning plant nutrients to soil. Soil saprophytes have specialised in decomposing different organic substances; moreover, each stage of decomposition is characterised by a definite complex of soil organisms. Proteins and fats are decomposed first. They decompose in several hours or days – the higher the temperature and moisture, the faster the decomposition. Since animal bodies basically consist of protein and fats, the early stages of their decomposition happen very fast, with the participation of mainly bacteria, fungi, larvae of flies and nematodes. The chemical products of decomposition are hydrogen sulphide, mercaptans and other substances of offensive cadaveric odour. The decomposition of the skeleton, horny substance, skin and hair is much slower, and this matter is also decomposed by special species of microorganisms and soil animals.

Plants largely consist of cellulose and lignin; thus, they decompose slowly. A leaf that has fallen in a forest in the temperate zone will be fully decomposed in 2–3 years, needles of coniferous trees in 4–5 years, but the trunk of a fallen tree or stump soil organisms can decompose only in 10–20 years. In a tropical rainforest the decomposition of litter and timber is much faster – termites manage to do it effectively in several months. As the production of organic substances in the forests of the temperate zone is faster than their decomposition, the fully and partially decomposed remains and humus gradually accumulate and form a dark, 5–20 cm thick layer of soil. In the tropical rainforests such a layer usually is not formed as decomposition immediately produces mineral substances that are absorbed by plant roots.

An ecosystem has never had problems of dealing with its own remains. The situation is different with human waste products that complement the natural remains and create an extra pressure on the ecosystem. Unfortunately, not all waste products of human activity are ecologically degradable. The ecosystem can decompose a cotton rag in 1–5 months, paper in 2–5 months, worn-out woollen socks in 1–5 years, old leather footwear in 25–40 years. However, over millions of years of evolution, ecosystems have not adapted to degrading certain kinds of waste that humans throw away as garbage and in this way pollute the environment. Thus, for example, nylon rags would be preserved in soil for nearly 30–40 years, aluminium tins for 80–100 years, but glass and plastic bottles might disintegrate no sooner than in a million years, and rather as a result of physical and chemical processes, for example oxidation or corrosion, not in biological processes.

Even so, ecosystems can be trusted with the recycling of many kinds of food and household waste. Composting has long since been used as a way to utilise gardening and food waste. In many countries of the world people use small reactors for recycling food waste (Figure 2.18), in which microorganisms are involved in the process of decomposition.

For composting, waste is piled so that aeration and moderate moisture are ensured. Soil animals and microorganisms find the compost pile

Figure 2.18.
Special mini-reactors are used for composting household waste

themselves. Microorganisms and their spores are everywhere. The potential decomposers are on the leaves while they are still on the trees, but decomposition can be speeded up by adding manure or old compost to the pile. In a short time, the compost that includes cattle (cow or horse) dung is invaded by a huge number of bacteria and fungi that get down to the biochemical decomposition of organic waste. Their life processes release so much heat that the compost pile heats up. The high temperature kills pathogens as well as eggs of parasites, such as roundworms. When the work of microorganisms and soil animals is done, the pile of organic waste has been turned into a homogeneous dark mass – humus. The process takes about 1–2 years. To obtain quality humus, Californian earthworms, a special breeding sort of earthworms of high efficiency of labour, are involved in composting.

Recycling compost and food waste provides a valuable, humus- and plant-nutrient-rich substratum which can be efficiently used to fertilize indoor plants and to improve the quality of garden soils. To prevent environmental pollution with plastic bags, they are now produced of biodegradable material (Figure 2.19).

Figure 2.19.
Plastic bags are now produced of biodegradable material

2.5 NON-MATERIAL SERVICES

Researchers of pharaohs' burial grounds were surprised to find, along with the mummies of high-born Egyptians, thousands of embalmed mummies of cats inside the pyramids. The cat was considered a sacred animal in Ancient Egypt; killing it intentionally or even accidentally was punishable by death (Figure 2.20).

Figure 2.20. **Cat – a sacred animal in Ancient Egypt**

Civilised Europeans might be confused by the tolerance and respect that Indians display to sacred cows that wander along the streets of big cities; however, we must remember that Europeans themselves are not free from archaisms, for example, concerning the white stork. This long-legged bird is associated with scores of beliefs and, although the majority of modern educated people would treat them as a joke, they would gladly allow storks to build their nests on the roofs of their houses or electricity poles. Even though the destruction of a stork's nest is not severely punishable, it will eventually face strong public condemnation.

In our time, people in many countries of the world revere different animals and plants. Among plants, trees enjoy a special place, for example, oaks, olive trees, plane trees, apple-trees, fir-trees and others. The tradition of decorating a Christmas tree, whose origin goes back to the 13th century and has been ascribed by historians to the merchants of the Brotherhood of Blackheads, has spread all over the world.

Today a special conservation status has been granted to sacred groves and sacred forests although the rituals for which they were intended have long since faded from people's memory.

Civilisation has developed in close contact with natural environment. Depending on the natural region in which a particular nation has formed and developed, the peculiarities of the local ecosystems have left an everlasting imprint on the people's psychology, language, religion, beliefs, folklore and customs. Ecosystems, in the form of forests, fields and waters, have a direct impact on culture and art, find expression in books, magazines, films, photos, fine arts, music, dances, national symbols, fashion, architecture and even advertising.

Many works of fiction have been inspired by nature, and numerous literary and art works comprise a tribute to the beauty, power and harmony of nature. The American naturalist John Muir wrote that virgin nature reflects the divine, nurtures the humane, and liberates the spirit.

In these times, industrialisation, development of intensive agriculture and urbanisation have created a real threat to ecosystems and their non-material services to an enormous number of the world's population. Under the pretext of economic development, numerous natural landscape territories of high aesthetic value, incommensurable in terms of money, are being destroyed and degraded. At the same time, research has proved that a degraded, unsightly environment has a disruptive effect on the people's psyche. Such environment increases stress and causes stress-related diseases. Thus, man's aesthetic qualities correlate with ecological qualities.

The modern man's desire to leave the urban environment and seek nature can be observed in the growing popularity of rural tourism, ecotourism and bird-watching among the residents of developed countries. In recent years, Europeans have embraced ecotourism to distant regions of the world with rich biodiversity, defying potential health hazards in the absence their familiar urban comfort. To ensure the development of rural tourism and ecotourism, these countries need an appropriate infrastructure, tourist guides and service institutions. As the provision of these services is economically lucrative but impossible without the non-material ecosystem services, the situation facilitates a deeper understanding of the necessity to preserve and protect treasures of nature in these countries.

2.6 WHAT IS THE PRICE OF AN ECOSYSTEM?

It is in human nature to undervalue things that are there. When German tourists stopped their bus and, spellbound, watched and took pictures of storks that were standing on one leg in their nests at the top of telephone poles in Latvia, local farmers regarded them with a smile, as if they were slightly touched in the upper storey. Latvians take it for granted that every spring the stork returns to its home on the roofs of their houses, and they would start worrying only if suddenly it would not come back. Research shows that urban populations are much more appreciative of natural landscape than the country-folk. It is to be expected that, under growing urbanisation, people will be increasingly disposed towards natural environment. These processes will lead to the paradoxical situation when the majority of the world's population will be concentrated in big cities and will dream of unspoiled nature which will have long since ceased existing. It will be then that mankind will truly appreciate the value of ecosystems, which will have to be restored like ancient castles or works of art.

The existing experience in the restoration of ecosystems demonstrates that it is both complicated and costly. Denmark, for example, invested approximately EUR 35 million in the project to restore the 2 200 hectares of artificially drained wetlands of the Skjern River.

The Seychelles project envisages restoration of ecosystems of 14 islands of the archipelago to preserve the unique local fauna of mammals and birds. To implement it, the plan is to change the structure of the vegetation and eradicate the invasive species. However, these measures do not include a total restoration of the ecosystem; they only aim at certain improvement, with no manipulations involving most of the ecosystem elements, such as microorganisms, insects and plants. The change of species affects only a limited number of target objects, for example, introduction of amphibians and seeds of several plants in the restored wetlands or eradication of aggressive ants and rats on the islands.

The creation of such artificial ecosystems that would ensure human existence is far more expensive. This was the task of the unique experiment 'Biosphere-2', implemented in the USA. In the course of the experiment, eight volunteers spent two years in a totally isolated structure, a model of the Earth, where the contents of the air for breathing and drinking water as well as food resources were provided by miniature ecosystems: 1 900 m² of tropical forest, 1 300 m² of savannah, 1 400 m² of coastal desert, 450 m² of mangroves, 850 m² of ocean with a coral reef, as well as 2 500 m² of agricultural land for plant and animal food. The total area of the structure, including the residence of the participants of the experiment and the laboratories, was that of 2.5 football fields – 12 700 m². The total cost of the experiment was EUR 150 million. The problems that emerged during the experiment showed how limited our existing knowledge about ecosystems actually is. During the period of two years, 'Biosphere-2' could not manage to provide the inhabitants of the Earth's model with normal living conditions. The experiment elicited numerous problem situations when oxygen content in air dropped to a critical level (14%), there were huge fluctuations of carbon dioxide and nitrogen, at times reaching a level that was hazardous to human life. During the experiment, 19–25 species of vertebrates, including birds and mammals, perished. All the pollinators that had to ensure the ripening of fruit and seeds also perished. At the same time, over-reproduction of aggressive climbers, algae, ants, cockroaches and grasshoppers was observed.

Thus, so far the attempts to build spatially isolated ecosystem modules that could ensure sustained human existence have proved unsuccessful. It shows that human knowledge about the structure and functions of ecosystems is extremely limited. For that reason, people should act with extreme circumspection when altering ecosystems and the biosphere.

Considering the costs of ecosystem restoration, the economic gains against the background of degradation of ecosystems and the biosphere are in the red. Humans cannot manage the biosphere. The biosphere sets limits to human activity, and this must be reckoned with. Humans can interrupt an unsuccessful experiment of an expensive biosphere module at any time should a life-threatening situation arise; nevertheless, it will be impossible to abandon a degraded biosphere.

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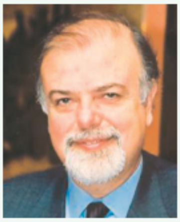
CASE STUDY: GREECE

THE CURRENT ENVIRONMENTAL CHALLENGES AND INITIATIVES IN THE MEDITERRANEAN



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Trying to promote the sustainable development of any society as a system, small or large – concerning its geographical and geopolitical dimensions – we need to examine its current environmental, socio-cultural and economic aspects and challenges. Such an in-depth study is necessary in order to draft the sustainable development pyramid for each case or region (Figure). At the basis of the pyramid lies governance which, in our case, at the level of the Mediterranean, includes both formal and informal structures and initiatives. We will review the major environmental challenges in the Mediterranean several of which are common to many European regions (including the Baltic Sea Region) and beyond. We will list the major regulatory frameworks, initiatives and partners of relevance for the sustainable development of the Mediterranean.

MAJOR ENVIRONMENTAL CHALLENGES IN THE MEDITERRANEAN

During the last five decades, the quality of the Mediterranean environment has been increasingly degraded and/or threatened by human activities, with a particular impact on the coastal and marine areas. Rapid and insufficiently controlled urbanisation, unsustainable development of industry, agriculture and tourism, poorly managed waste discharges through rivers and from coastal settlements (pollution by wastewater and solid waste), maritime traffic, ship-generated oil spills and overfishing exert severe pressures on the Mediterranean environment.

1 DRIVING FORCES OF ENVIRONMENTAL PRESSURES

Urbanisation: urbanisation is an important process in the Mediterranean. Peri-urban areas and new urban settlements have dramatically increased in number and size over the past decades, leading to significant social, economic and environmental changes. According to the Blue Plan's estimates, urbanisation in the Mediterranean will continue at a fast pace, while rural populations will decrease considerably, especially in the countries of the eastern and southern Mediterranean. The growth prospects of the Mediterranean cities are closely linked to exacerbated pressure on water resources, pollution of aquifers, inefficient solid waste management, excessive land use followed by irreversible loss of arable land and biotopes, and atmospheric pollution, including a significant increase in greenhouse gas emissions.

Tourism: tourism – both international and domestic – is one of the most important economic sectors in the Mediterranean, particularly in regions with limited industrial or agricultural development options. Nowadays the Mediterranean is the biggest tourist destination in the world, accounting for 30% of international tourist arrivals and for 25% of the income from international tourism. In most Mediterranean countries the development of tourism is neither well planned nor controlled and integrated into a wider sustainable development policy, resulting in a number of pressures related to land use, over-consumption of water resources in periods of water scarcity, pollution and waste, as well as to the degradation of coastal and marine ecosystems, including fragile natural habitats.

Agriculture: agriculture in the Mediterranean is traditionally considered to be the basis of economic and social structures. However, unsustainable agricultural practices are recorded throughout the region and are among the main driving forces for environmental degradation, leading to severe impacts on water resources and soil. Irrigation agriculture is the largest consumer of water (it accounts for up to 80% of total freshwater use in the region). The detrimental effects of unsustainable agriculture practices include water pollution – mostly due to nutrient and pesticide leaching – and intrusion of seawater into groundwater aquifers, as well as soil degradation due to erosion, desertification, salinisation, compaction and pollution.

Pollution by solid waste and marine litter: throughout the Mediterranean, the growth of the population, as well as the currently prevailing high consumerism patterns, result in a continuous increase in solid waste generation and secondary problems arising from this, e.g. water pollution by leachates and damages to biota. The problem of urban solid waste is many-faceted and has many aspects, as revealed by the cases recorded throughout the Mediterranean. There are cases of total absence of waste collection and disposal schemes; of poorly designed or dysfunctional systems; of non-existent recycling facilities; heaps of recyclable materials laying unprocessed or unused

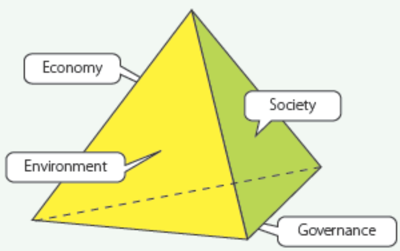

Figure. **Key principles of sustainable development** at waste processing plants; uncontrolled dumping sites; rejection of projects of modern sanitary landfills or waste treatment facilities by local communities due to lack of proper information or confidence in the relevant authorities. The problem of urban waste management is connected in numerous ways to many environmental, economic, social and technical issues, while most of solutions have broader implications. In addition, the Mediterranean Sea faces a very serious marine litter problem. Even the remotest parts of the Mediterranean Sea are affected by marine litter deriving primarily from lack of proper management of land-based littering activities, combined with waste left by beach users, ships and fisheries. All of it leaves a severe negative impact on marine ecosystems.

Pollution by wastewater: one of the major environmental problems of the Mediterranean is the still-ongoing discharge of considerable quantities of untreated municipal and/or industrial wastewater in coastal areas or rivers flowing into the Mediterranean Sea. Absence of management or poor management of wastewater not only leads to pollution and degradation of freshwater and the marine environment but also induces pressures on human health and ecosystems.

Industrial pollution: a large range of different industrial activities scattered all around the Mediterranean are responsible for emissions of contaminants posing severe environmental threats. Pressures from industry in the region include the food processing and packaging industry, the energy production sector, chemical/petrochemical and metallurgy sector, surface treatment of metals and the cement industries, tanneries and textile industries, fertilizers, pharmaceuticals and oil refining. The main pollutants released by industrial sources include heavy metals, dioxins and phenols, polycyclic aromatic hydrocarbons (PAHs) and benzenes, organohalogens and nutrients.

Maritime traffic and oil spills: although land-based pollution contributes to more than 80% of the overall pollution of the Mediterranean, maritime transport is also a significant pressure. Maritime transport has significantly grown in the last decade, mainly due to the increase in traffic and size of ships. It is estimated that about 220 000 vessels heavier than 100 tons cross the Mediterranean Sea each year, which is an estimated 30% of the total commercial shipping in the world and 20% of oil shipping. Maritime traffic is a source of environmental pressure. Ships and their cargo constitute a direct threat to the marine and coastal environment as the oil market is at the core of commercial links between countries of the north and south Mediterranean. Therefore, the possible environmental pressures of maritime traffic, considering risks of maritime accidents are high, taking into account the high annual number of maritime accidents in the Mediterranean, of which one fourth involve ships causing oil and chemical spills leading to direct ecological effects mainly on birds and marine mammals as well as fish and invertebrates. Besides accidents and oil spills, certain operational practices, such as tank cleaning and deballasting, release various pollutants into the marine environment.

Fisheries and Aquaculture: the Mediterranean Sea is characterised by an abundance and unique diversity of fish and other marine organisms (crustaceans, marine mammals, turtles, shellfish, mollusks) of high ecological, economic and commercial value. However, over-fishing and excessive bycatches due to unsustainable fishing methods and the impact of intensive aquaculture have led to a state of alarm regarding certain species, affecting biodiversity and coastal and offshore biotopes.

Transport: road and air transport have shown a steady increase during the past decades. Road transport accounts for most of the increase in the total energy consumption of the transport sector due to a massive increase in private cars in the Mediterranean countries. In addition, many of these cars use old technologies which, in combination with the poor quality of fuel, result in higher emissions of pollutants, especially in the large Mediterranean metropolitan areas. Transport-related emissions contribute to greenhouse gases as well as to a series of toxic substances such as nitrogen oxides, volatile organic compounds, metals.

2 STATE OF THE MEDITERRANEAN ENVIRONMENT AND EMERGING THREATS

The exposure of the Mediterranean environment to a combination of the above-mentioned pressures generates major environmental issues analysed below. Most if not all of these issues (water scarcity, desertification, soil erosion, soil sealing, droughts and floods, biodiversity loss) are expected to be further exacerbated by climate change.

Eutrophication: the Mediterranean Sea is characterised by low nutrient/phytoplankton levels and therefore is one of the most oligotrophic seas in the world. In general, eutrophication in the Mediterranean Sea seems to be limited to eutrophication events (algal blooms) occurring in coastal or lagoon areas. These events are caused mostly by discharges of untreated municipal and industrial wastewaters, runoff and leaching of agricultural fertilizers, and lead to severe ecological effects such as biodiversity loss, changes in species composition and dominance of toxic species (e.g. dinoflagellates). The most important cases of eutrophication are found along the northern and western coasts of the Adriatic Sea with some less frequent, periodic phenomena in other semi-enclosed coastal embayments.

Pollution from heavy metals and organochlorine compounds: heavy metals and organochlorine compounds are pollutants that pose severe risks to the health of ecosystems and humans. In the Mediterranean the anthropogenic activities accounting for the emissions of heavy metals into the air are the metal industry (Cd, Pb, Cr, Hg), the cement (Hg) and energy industry (Hg, Ni), while the release of heavy metals directly into water is caused by the metal industry (Cd, Ni, Zn), production of fertilizers (Pb, Hg, Cr), oil refining (Cr) and the tanning industry (Cr).

Organochlorine compounds (e.g. chlorinated pesticides, polychlorinated biphenyls) which originate entirely from anthropogenic processes are found in a wide range of concentrations in the Mediterranean. In general, the concentrations are very low in seawater. However, high concentrations have been reported in sediments in the north-western Mediterranean, while the concentrations of these compounds in benthic organisms (e.g. mussels) vary widely and no clear trends can be safely demonstrated.

Oil pollution: a high number of oil-related sites (pipeline terminals, refineries, offshore platforms) are scattered along the coastal zone of the Mediterranean. As a result, the Mediterranean Sea waters are particularly rich in petroleum hydrocarbons. However, relatively little information is available on the actual impacts of oil pollution in the Mediterranean.

Climate change: climate change is an increasingly urgent global problem with potentially far-reaching consequences for life on the Earth. The Mediterranean is predicted to be one of the most severely affected regions with possible threats to its biodiversity and the increase in the intensity and frequency of floods and droughts and repercussions on the quality and quantity of water resources. These changes are expected to exacerbate the already existing drought risks in most parts of the Mediterranean, resulting in severe, detrimental effects on the coastal biotopes of the region. Especially wetlands, which constitute important buffer zones for water quality and flood prevention, are under immediate threat due to reduced water availability, further water abstraction and aggravated evaporation due to higher temperatures foreseen. Furthermore, such phenomena will impact on the overall ecological balance and also on the provision of ecosystem services and goods on which people's livelihoods depend.

Desertification, soil erosion, soil sealing: on a different front, due to reduced humidity, Mediterranean forests and macchia plant-cover are more exposed to wild fires that reduce the cover of vegetation. This development accelerates land degradation and soil erosion in arid and semi-arid areas and leads to further release of greenhouse gases. Phenomena such as recurrent and persistent droughts, an overall decrease in precipitation followed by a river flow decrease, more intense rainfall over fewer days accelerate soil erosion and a serious long-term decrease in soil moisture. Thus, the vicious circle continues.

Water scarcity: in the Mediterranean, water is a scarce and threatened resource, characterised by an unequal distribution in space and time. Over 180 million people lack water in the region, while people faced with water shortage exceed 60 million. Increasing water demand, coupled with the looming climate change threat, make the problem of water scarcity very critical. Intensive abstraction of water for domestic, agricultural and industrial purposes has led to depletion of surface water and groundwater reservoirs and seawater intrusion in coastal aquifers. In addition, discharges of untreated wastewater from domestic, industrial and agricultural use have led to the deterioration of water quality.

Biodiversity loss: biodiversity is a crucial natural asset that directly or indirectly provides or contributes to the maintenance of important ecosystem services. The Mediterranean is considered to be among the critically endangered hotspots of the world, where biodiversity continues to decrease as human development and expansion result in the fragmentation and loss of habitats for flora and fauna.

MEDITERRANEAN ENVIRONMENTAL REGULATORY FRAMEWORKS, INITIATIVES AND PARTNERS

The environmental problems of the Mediterranean are closely linked to governance problems which include delayed/limited implementation of legislation, the political and social instability of the region (due to conflicts, lack of dialogue), the limited productivity and slow introduction and use of innovations, the limited investment in research, the heavy bureaucracy, the democratic deficit, issues of corruption and insufficient education. The major regulatory frameworks, initiatives and partners of relevance for the sustainable development of the Mediterranean are listed below.

- GEF Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem: *http://www.medpartnership.org*
- Global Water Partnership Mediterranean (GWP-Med): *www.gwpmed.org*
- *Institut de Prospective Èconomique du Monde Medéditerranéen* (IPEMED): *http://www.ipemed.coop*
- *Institut Europeu de la Mediterrània* (IEMED): *http://www.iemed.org*
- Mediterranean Component of the EU Water Initiative (MED EUWI): *http://www.euwi.net*
- Mediterranean Education Initiative for Environment and Sustainability (MEdIES): *www.medies.net*
- Mediterranean Environmental Technical Assistance Programme (METAP): *www.metap.org*
- Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE): *www.mio-ecsde.org*
- RAMOGE Agreement: *http://www.ramoge.org*
- Regional Cooperation Council: *http://www.rcc.int*
- Stability Pact and Regional Environmental Reconstruction Programme (REReP): *http://rerep.rec.org/default.html*
- Stability Pact for South Eastern Europe: *http://www.stabilitypact.org/default.asp*
- Euro-Mediterranean Parliamentary Assembly: *http://www.europarl.europa.eu/intcoop/empa/default.htm*
- Parliamentary Assembly of the Mediterranean (PAM): *http://www.apm.org.mt*
- Union for the Mediterranean: *http://www.ufm-water.net/UfM*
- United Nations Economic Commission for Europe (UNECE): *http://www.unece.org*
- United Nations Environment Programme/Mediterranean Action Plan (UNEP/MAP): *http://www.unepmap.org/*

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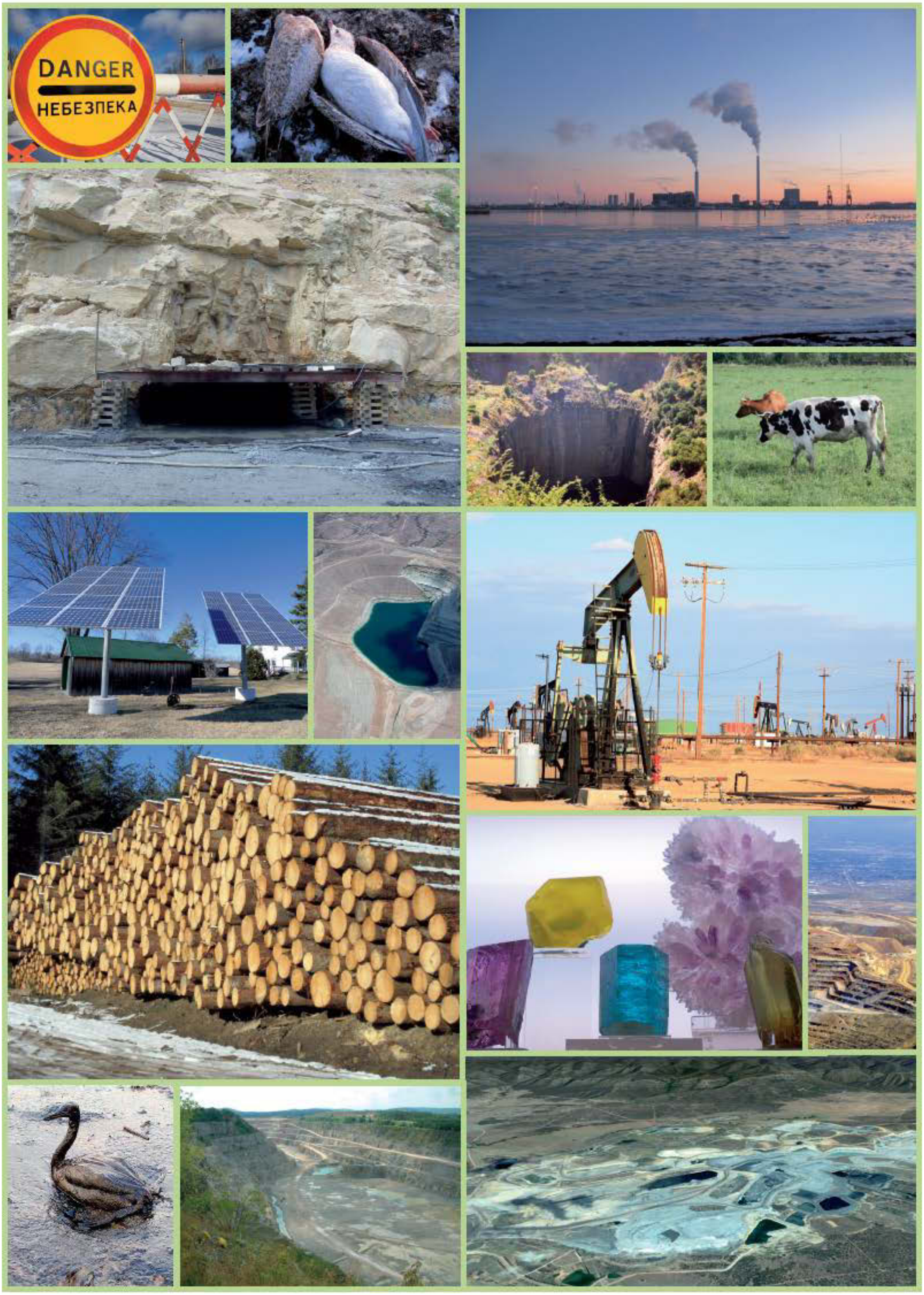
3 RESOURCES



3.1 NATURAL AND ENVIRONMENTAL RESOURCES, THEIR VALUE

However rich our planet's nature and however diverse its resources, the reserves are not inexhaustible. As consumption increases, some of the resources will be depleted faster than they can be reproduced, or faster than science and industry can offer solutions for replacing them with other resources or raw materials. Therefore, the development and environmental policy documents of many countries as well as the activities of international organisations devote great attention to the agenda of use and management of nature and environmental resources. Natural resources are gifts of nature that the mankind uses or can potentially use to create material wealth, to ensure its existence and an increase in welfare. Such are elements of nature or their properties of a certain economic use within a given territory; for example, air, water, vegetation, mineral resources, soil. As a rule, the economic value of natural resources is identifiable.

The notion of 'environmental resources' is increasingly being used in environmental policy and development planning. In modern terms, environmental resources are natural resources of an essential present or future value within a given territory. Thus, 'environmental resources' broadens the notion of natural resources and includes the diversity of plant and animal species, the aesthetic quality of landscape, and educational, research or emotional value of environmental resources. The value of environmental resources usually cannot be measured in economic categories.

The economic value of resources is directly related to the use of natural resources and making profit. For centuries, the economic value of resources was determined on the basis of the direct income from processing certain natural resources (mineral resources, timber) and selling the product. In the second half of the 20th century, more attention in the valuation of natural resources was paid to the indirect use of resources. Additional profit is made, for example, from forest resources using them for health improvement, tourism, educational and recreation purposes (Figure 3.1). For example, supplementary income from the use of suburban forests for recreation usually exceeds the income from logging forests and timber processing.

To describe environmental resources and, in individual cases, natural resources, five different values have been recently used. One is the aesthetic value, which can be considered the real value. It means that any natural object (a lake, a mountain, birds) have a right to exist, irrespective of its use. Real values are eco-centric (environment-centred).

The other four values of resources, including the economic value, are called external values (Figure 3.2). These values are related to the properties that the resources provide for human needs. They are anthropocentric (human-focused). They are more utilitarian (of practical use) than real values, which is why they have been discussed for a longer time in political and economic debates concerning use and management of resources. The aesthetic value of resources is connected with human senses: vision, hearing and smell. Many people set high value on, for example, walking along the beach at sunset. The aesthetic quality of environmental resources determines the development of several branches of economy, for example, tourism, as well as the choice of place of residence. Since there are many people who would wish to live in beautiful places, the demand for them is growing, thus determining the economic value of such places. The emotional value of resources is connected to the perception of place, senses and memory. Some people, for example, have highly developed emotional ties to a specific nature territory or plant or animal species. Sometimes it is referred to as sense of place. Psychologists consider that nature's biotopes are of essential importance for one's mental health, especially children's.

Figure 3.1. **Direct and indirect profits from exploiting forest resources**
Indirect profit comprises most of the value of nature protection areas and urban and suburban forests.

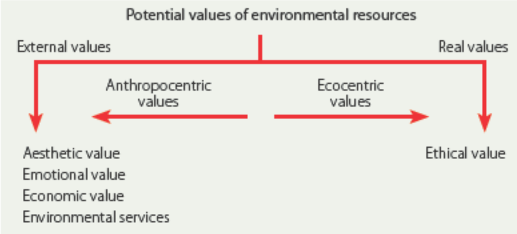


Figure 3.2. **Types of values of environmental resources**

With the knowledge of a range of environmental values, ever more attention is being paid to ecosystem services.

Many environmental problems arise if resources are valued on the basis of their short-term economic value; thus, the real value of resources is artificially decreased over a long-term period. This is partly determined by the fact that utilization of resources provides immediate benefit. At the same time, production at the expense of environmental resources may diminish or destroy other values of resources. A complex valuation of resources is affected by the fact that it is easier to measure the economic value of resources, and ethical and emotional values are usually subjective and difficult to evaluate. If society included all the indirect values of environmental resources in the price of the product, it would show the real cost of the environment and facilitate its more considerate use. To convert the aggregate natural resources that are used or can be used for producing various goods into monetary value, economists resort to the notion 'natural capital'. Over the last years the meaning of the term has been expanded to include ecosystem products and services in terms of money.

Economists have attempted to use various methods to determine the value of the sensations and emotions people experience when they receive the benefits of environmental resources. Differences of real estate market values are often analysed, seeking regularities correlating them with natural values within the territory or in the neighbourhood of the real estate, assuming that people are willing to pay a higher price in such cases. In other cases they examine how much people would pay to reach one or another object of nature they are interested in, assuming that it reflects how the given individuals evaluate this object. An opinion poll can also be conducted to elucidate the price people would be willing to pay in order to, for example, preserve an object of nature. Different methods have been devised to try and determine the value of ecosystem services in terms of money. In Switzerland, for example, many town-dwellers, choosing their homes in the vicinity of parks, are ready to pay 35% more compared to a life in a densely developed territory. In contrast, only a small part of Rīga's residents are ready to pay more for a dwelling near a park. This clearly demonstrates that living standards and other factors have an impact on the values of ecosystem services. At the same time, we have to understand that so far it has not been possible to devise a precise mathematical calculation of the importance of ecosystems in the preservation of biological diversity and hydrological regime as well as other natural processes. The precise calculation of the total value of ecosystem services is not always required; however, it is nearly always important to understand that the use of environmental resources does not entail merely acquiring certain products. The use of natural resources must be valued in a far wider context.

3.2 CLASSIFICATION OF NATURAL RESOURCES

Natural resources can be divided into several groups, and this classification lets us understand the formation of natural resources, their potential use, the importance and renewal of their reserves. There are real, or identified, and potential natural resources. Real natural resources include those that have been identified and evaluated, and whose use is economically grounded. Nearly all natural resources are mineral deposits, soils, timber, as well as protected areas, sand beaches and a microclimate that is suitable for life and recreation. From a historical perspective, this is a dynamic classification since the needs of society are constantly changing; however, this classification is essentially influenced by technological developments. Potential natural resources include those that have not yet been discovered, sufficiently explored or whose use is not economically justified. Among the typical examples are wave and earthquake energy, and iceberg freshwater.

It is difficult to establish a border between these groups. For example, the riches of larch timber in Siberian taiga should belong to real natural resources as they constitute a calculated or practically verified quantity. However, this timber becomes a real natural resource only through an economically grounded use of this resource and a traffic infrastructure for the transportation and subsequent processing of timber. A similar approach applies to the valuation of the volume of water in Greenland's glaciers, the heat released from the active zone of the Atlantic volcanic ridge, or natural building material from Vesuvius. If we subtract the costs of building roads and creating infrastructure

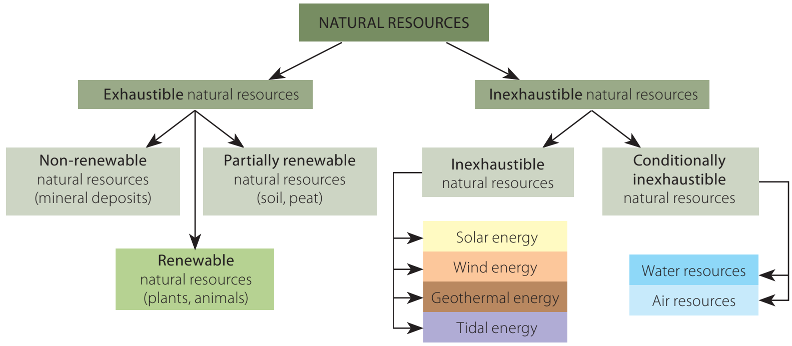


Figure 3.3. **Classification of natural resources**

from the potential value of the resources, it is evident that these resources can be classified only as potential resources.

Traditionally, natural resources are classified according to their accessible quantity and rate of the substance turnover cycle:

- inexhaustible resources,
- conditionally inexhaustible resources,
- exhaustible – partially renewable resources,
- exhaustible – non-renewable resources (Figure 3.3).

It must be noted that even this classification is conditional and the belonging of some natural resources to one or another group may be reconsidered; classifications in popular publications and scientific research can also demonstrate essential differences. Inexhaustible natural resources are the resources whose reserves are not depleted by use, for example, solar energy, wind energy and heat of the Earth's interior. Water resources have long been regarded to be inexhaustible natural resources; however, now many would class them as conditionally inexhaustible or partially renewable resources, considering the particular importance of freshwater for sustaining life and its increasing consumption in the world.

In dividing resources into renewable and non-renewable, it is important to consider the time necessary for the used natural products to be replaced by new ones. It is assumed that it takes several generations for the renewable natural resources to be replaced by other resources. Such are, for example, timber, game animals, fish. Non-renewable resources can never be renewed, for example, fossil fuels (oil and coal) and metallic ores. It is necessary to determine the period of renewal since some resources are renewed over a very long time. Oil or coal has formed over millions of years, which is thousands of times slower than their human consumption rate.

The inclusion of some natural resources among renewable resources lacks justification. For example, resources of the sea (fish, crustaceans) were long considered exhaustible renewable natural resources. At the turn of the 20th century, the per capita consumption of fish was ~16 kilograms. For many peoples fish and other seafood are their principal daily sustenance. It has been calculated that the total admissible annual harvest of fish and other sea animals in the world amounts to 85 million tons. However, the figure was ignored until fishing exceeded the species replenishment rate. 47–50% of fish and other populations of sea animals have decreased so rapidly that their natural replenishment is nearly impossible; 15–18% of populations are potentially endangered; 9–10% have decreased but their natural replenishment is possible; 21% are moderately exploited, while only 4% of populations have not been affected.

3.3 DEPLETION, EXHAUSTION AND MANAGEMENT OF NATURAL RESOURCES

There are numerous examples of ill-considered human activities or mismanagement of natural resources when stores of some resources have been essentially diminished or destroyed. The most dramatic example of the negative impact of human economic activity on natural resources is the decline or total extermination of populations of game animals. It has been estimated that during the last 3 000 years over 100 species of mammals and about 150 species and subspecies of birds have become extinct. In many cases animals disappear not only as a result of their extermination but also due to environmental changes, when the environment can no longer ensure the conditions necessary for the life and reproduction of animal populations. Thus, sustainable use of natural resources is connected not only with the very use of particular resources but also with numerous other environmental conditions.

Humans extract different substances and energy from the Earth's interior. The substances extracted from the Earth usually are concentrated in certain geological deposits. For several centuries, the world has exploited only very rich ores. The availability of deposits and resources of rich ores does not encourage use of lower-grade (lean) ores or an essential improvement of extraction and processing technologies. As a rule, the extraction of resources grows exponentially, similarly to the depletion of resources. As people discover the possibilities of utilization of certain resources, their extraction shoots up. The availability of all the Earth's resources is limited in a way, either due to insufficient reserves, complicated extraction or transportation, inadequate technology of extraction and processing. Thus, a moment comes when the demand for certain resources exceeds that of their extraction. Society responds to this by attempts to develop the research and extraction of mineral deposits and to improve extraction technologies. However, such activities gradually come in conflict with the law of diminishing marginal productivity. It stipulates that, with a fixed resource, a unit of another resource(-s) will yield a progressive decline in productivity when a certain output level is exceeded.

As the provision of natural resources decreases, prices go up, unemployment climbs, and it is the availability of natural resources that largely dictates the migration of population, formation of new settlements and the abandonment of inhabited places in the world. Historically, the world society has responded to a decrease in the availability of resources with a price rise or replacement of one resource with another. For example, in Great Britain, around 1800, in response to total deforestation people started using coal instead of firewood, while a century later oil became the main energy resource, cheap and widely available. This scheme of society turning from one unsustainable resource to another has determined and advanced the development of mankind for a long while.

Social development and provision of the planet's population with food and drinking water go hand in hand. The world's population annually increases by 83 million, and the forecast is that in 2012 it will reach seven billion. The human population growth rates vary across the Globe, with 99% of the increase in the developing countries of Africa, Asia, Latin America and Oceania, where food shortage is increasingly frequent. According to the existing prognosis of the population growth, in 2025 only three of the most developed countries (The USA, Russia and Japan) will continue to be the world's most populated countries. There are different views on the sufficiency of resources in relation to the human population growth in the world.

Strict observance of the availability limits of natural resources can ensure sustainable development of society, in tandem with the use of natural resources. The principles of sustainable development for the use of natural resources are the following.

Principle 1. Substances that have been extracted from the lithosphere should not be allowed to accumulate systematically in the environment. The principle is violated when, for example, the use of fossil fuels leads to the formation of acid rain, or when in the process of extraction and use of phosphorus compounds, they accumulate in waters.

Principle 2. Human-made substances should not be allowed to accumulate systematically in the environment. The principle is violated when, for example, persistent organic pollutants accumulate in ecosystems.

Principle 3. Physical conditions of production and natural diversity should not deteriorate systematically. The principle is violated, for example, in the cases of deforestation, followed by desertification and decline in the fertility of soil.

Principle 4. Use of resources must be effective by respecting people's needs. This principle is of an ethical nature.

Principle 5. The nature's capital must be conserved. Decrease in any resource, if unavoidable, should be compensated by an increase of resources in some other place (way), thus preserving the total amount unreduced.

In their publications, many scientists stress that over a long period of time humanity has not been able to manage natural resources effectively, and this is why sustainable use of resources is required. It is necessitated by the growth of the human population, diminished availability of many resources resulting in intensified use of the remaining resources. With the growing number of people and the development of technologies, the impact on the environment will inevitably increase. It is a matter of historical experience that restriction or suspension of the extraction or use of one or another resource will eventually lead to the conflict of the parties concerned. For example, the decrease in the cod population in the Baltic Sea in the early 21st century caused heated discussions about their fishing restrictions. Several European Union countries maintained that cod fishing should be banned, while others considered that it should be only restricted. Under the circumstances the European Commission adopted a compromise decision which stipulated that cod fishing quotas will be reduced every year by 15%.

The future economic development and growth of the human population in many countries will cause shortage of natural resources, energy, food and water significant for the development of humanity. Global society will face difficult and complex environmental challenges. Under such circumstances, it is simply common knowledge that an optimal use of one or another resource will ensure their sustainability. In view of the economic, political and environmental interests of the numerous parties involved, any decision on the restrictions of the use of resources in the modern world should be looked upon as a remarkable success.

3.4 MINERAL RESOURCES OF THE EARTH

In addition to renewable biological resources, soil and dynamic resources (air, water), the non-renewable resources of the Earth's interior also play an important role. Owing to their aggregative state, they are often referred to as minerals.

'Mineral resources' is a widely used term to include all the substances and their properties useful in economy. Mineral resources are inorganic or organic substances whose use is feasible and economically profitable. A mineral is a natural aggregate of such mineral resources whose amount, quality and conditions of their extraction have been evaluated and whose practical use is possible. Resources are potential minerals – the estimates of their amount are based on theoretical assumptions, conformity to general geological laws in the given territory, as well as on the research results of individual objects. Reserves of mineral deposits are identified through a detailed exploration when the properties and the amount of the minerals within definite boundaries are established. Only reserves have a definite commercial value which consists of the minerals themselves and information about them. Thus, reserves are primarily an economic category, them being a technological category is secondary, and only after that are they a geological category. For example, half a century ago it was established that sea water contains all the known chemical elements; over thirty years ago scientists succeeded in experimentally extracting most of them; however, only in several regions of the world it has proved to be economically profitable to produce drinking water or, more rarely, water for crops. Today, to extract a certain component from sea water, its world market price would have to rise at least ten or more times; therefore, the Earth's interior continues to be exploited because there the concentration of the components is higher.

The existing consumption of resources and its prognosis are based on the average consumption in the world over the last years, pertaining to the export market of a particular resource (Table 3.1).

The data of the table show that the volumes of the extracted mineral resources are comparatively stable and growing (in units of the end product) in the most important sectors of economy and the energy industry. It is worth noting that the majority of the basic consumption of metal and energy resources depends on the rapidly growing industrialisation in Southeast Asia. The USA and developed European countries are marked leaders in the consumption of precious metals and uranium. The vision of a future that would be a replica of the present is unacceptable – billions of people are scrambling for survival while the USA, with just 3% of the world's human population, consume 20–25% of all extracted minerals in the world. Together with Europe and other developed countries, which constitute 20% of the world's population, the consumption of non-renewable fossil fuel energy resources reaches 80%.

The above-mentioned facts testify to the concentration of consumption in definite regions. Today, extraction of minerals is not monopolised, and there are certain intensity consequences

Table 3.1. **The total established world consumption of resources**

Resource	Unit of measurement	2004	2005	Weighted average per capita, per annum
Oil	million barrels per day	83.04	89	8.03 t
Natural gas	billion m^3	2 397	2 571	38 m^3
Coal	billion t	5.26	5.45	0.84 t
Aluminium*	million t of metal	29.8	31.2	4.8 kg
Copper	million t of metal	14.6	14.9	2.3 kg
Iron	million t of metal	1 340	1 520	234 kg
Manganese	million t of concentrate	9.35	9.79	1.5 kg
Lead	million t of metal	3.15	3.09	0.48 kg
Nickel	million t of metal	1.40	1.5	0.23 kg
Tin	million t of metal	0.264	0.28	0.04 kg
Uranium	thousand t of metal	40.25	42.89	0.07 kg
Silver	thousand t of metal	19.73	20.3	0.001 kg
Gold	thousand t of metal	2.43	2.44	0.0004 kg

*For all metals, without reuse and recycling

Table 3.2. **Production of raw materials**

Resource	Unit of measurement	Declared supplies in exploited deposits	Calculated and economically evaluated resources	Number of countries extracting raw materials
Oil	trillion barrels	1.29	3.5	124
Natural gas	trillion m³	151.4	175	91
Coal	trillion t	1.01	1.167	76
Aluminium	million t of pure metal	900	13 000	57
Copper	million t of pure metal	470	940	34
Iron	million t of pure metal	51 000	230 000	15
Manganese	million t of 46–48% concentrate	430	5 200	17
Lead	million t of metal	67	140	41
Nickel	million t of pure metal	62	140	13
Tin	million t of pure metal	6.1	11	35
Uranium	million t of pure metal	0.72	1.885	29
Silver	million t of pure metal	0.27	0.57	94
Gold	million t of pure metal	0.042	0.090	71

(Table 3.2). On the contrary, minerals are extracted and processed in many countries. Mineral raw materials do not comprise an offer controlled by some countries or groups of countries; modern processing technologies are available in numerous countries with a high-concentration of mineral deposits as well as resources for future yield of raw materials.

The world economy uses about two billion tons of non-fuel minerals every year. Their fast flow rate lowers the quality of ore, increases energy consumption and the amount of waste, fills the refuse dumps and causes environmental pollution. Even if there is no future increase, the existing utilisation rates will fail to ensure balanced development over a longer period of time. The number of the human population is constantly growing and, if people wish to receive sufficient quantity of materials in the future, it will be necessary to apply all the technologies of restricted extraction, efficient use and recycling of materials. In the future we will have to use materials as a limited and precious gift of nature, which, in fact, they really are.

At present an undeniable dominant phenomenon is globalization of consumption and public interests, the constantly growing number of the population (consumers) and diversification of their needs. The existing management encourages the extraction of only the richest ores and other natural raw materials ('skimming the cream'), and there will never be a sufficient amount of such raw materials.

Although the modern mining industry has less impact on the land tenure and the territories necessary for urban development and the infrastructure of transport and communications, mineral extraction leaves negative effects on the environment. They are connected with loss of agricultural and forest lands and biotopes – in these territories, the natural table of subsurface waters is deformed, and all these territories should be treated as potentially polluted unless appropriate care has been taken of the environment there.

3.5 FOREST RESOURCES

World forests occupy about 30% of the land territory of all continents, with the exception of Antarctica. Since huge territories are covered by deserts, mountains and glaciers, it can be safely assumed that forest is the biggest ecosystem of the Earth's terrestrial part. The total forested area is 4.14 billion hectares, with forests of sufficient density occupying about 3 billion hectares. The above figures show that approximately a quarter of the forested areas are covered by low-density forests and only 1.9 billion hectares by productive forest stands. Brushwood and degraded forest lands, formerly covered by forest, take up vast areas. That notwithstanding, the world is still very rich in forests (Table 3.3).

Between 2000 and 2005, forested areas in South America and Africa have annually decreased by approximately 3.9–4.2 million hectares; areas also decrease in North America and Central America (by 0.3 million hectares a year), and Oceania (by 0.4 million hectares a year). The areas constantly increase only in Europe (by 0.6–0.8 million hectares a year) and over the said period in Asia (by nearly 1 million hectares a year).

Concerning natural forests, statistics shows that in 2005 there were only 36.4% of primeval forests in the world, 52.7% of transformed natural forests, 7.1% of partly natural forests, 3.0% of forest plantations, and 0.8% of areas afforested to restrict soil erosion. These figures testify to the fact that world forests

Table 3.3. **World forests (2000)**

Region	Europe	North America and Central America	South America	Asia	Oceania	Africa
Number of countries	40	34	14	49	20	56
Population, million	729	478	341	3 634	30	767
Area, million ha	2 260	2 136	1 754	3 085	849	2 978
Total forested land area	1 039	549	886	548	198	65
Other forest lands	29	335	69	142	424	430
Changes in forested areas 1990–2000, thousand ha	881	–570	–3 711	–364	–365	–5 262
Timber increase in forested lands						
Timber increase, million m^3 (solid volume)	116 448	67 329	110 826	34 506	10 771	46 472
Increase in wood volume, m^3/ha	112	123	125	63	54	72
Per capita increase of wood volume, m^3	160	141	325	9	359	61

constitute comparatively natural systems – a treasure to be protected and taken care of.

For a long time, it was mistakenly believed that timber constituted the greatest value of forest resources. Timber resources serve as the basis for many industries: furniture making, paper and pulp production, some chemical industries and the building material industry. Forest management and use, for example, make a significant contribution towards the employment of people in the rural areas. Nevertheless, regarding the aims of utilization of forests in 2005, only 34.1% of forests were assigned for timber and 33.8% for various other aims. This means that the world forested areas have significantly increased with the aim to preserve biodiversity (11.2%), to protect waters and soil (9.3%), to promote social needs (3.7%), and with an unknown aim – 7.8% of forests.

To supply the timber market, it is important to maintain forest productivity and vitality, as well as to preserve forested areas. Forest management in many countries devotes much attention to fast-growing plantations to satisfy the economies with timber. Compared to the traditional forest management, the management of plantations requires intensive care of the territory (fertilization, pruning and other measures) and a relatively large capital investment for return of the funds in the shortest time possible. Most of plantations are put on agricultural lands, thus securing a bigger growth of the wood volume.

However, the importance of forests is much wider; for example, they are a significant tourism and recreation resource. The regions rich in forests are favourable for the development of rural tourism, hunting tourism, ecotourism and other types of tourism. To promote hunting tourism, special deer parks are established. Forests are significant for the preservation of biological and landscape diversity, water decontamination and control of soil erosion. For this reason, sustainable use of forest resources in the world is connected with the preservation of the numerous functions and treasures of forests – timber supplies for national economies, protection of biodiversity, environmental protection, recreational functions, landscaping, and protection of cultural and historical values.

It is vital to bear in mind that forest is an ecosystem with trees being the principal producer of organic mass. Forest is a complex system which includes trees of different ages, brushwood and dead soil covering vegetation and animals, soil with its rich fauna, bacteria, algae and other microorganisms. All of these organisms are involved in a complex interaction and they are interconnected in very complex food chains.

In the European Union countries there is a great diversity of forest types, area coverage, forest ownership, as well as forest-related social and economic conditions. In 2007, the total area of forests and forest lands in the 27 Member States of the Europan Union constituted approximately 117 million hectares; besides, owing to the implementation of afforestation programmes and natural rotation of plants, in the past 10 years the territory of forest lands has been increasing by 0.4% a year on average.

The ecological environment of forests in the territory of the European Union is characterised by wide diversity because forests grow from the very north of Sweden and Finland to the Mediterranean, both in mountainous areas and plains. Of all European biotopes, it is forests that provide the habitat for the greatest number of plant and animal species, and forests perform the important environmental functions of preservation of biodiversity and water and soil protection. Therefore, about 12% of forest lands are protected areas. Approximately 60% of forest lands in the EU are private property of around 15 million individual proprietors. The average area of privately owned forest land is 13 hectares although, for the most part, it is less than 3 hectares.

All in all, the European Union is one of the world's biggest producers, traders and consumers of forest industry goods. Approximately 2.5 million workers in forest management and industries directly related to forestry annually produce an output to the value of about 460 billion euros (data of 2005). On average, the EU produce nearly 450 million cubic metres of timber a year, consuming just over 60% of the annual forest volume increase. However, even in the European Union, forests are endangered and require additional protection. A major threat arises from various biotic impacts and depletion of forests by grazing cattle there. Forests are largely affected by air pollution, storms and forest fires. For example, about 0.5 million hectares of forests and forest lands are annually destroyed by fire, mostly in the countries of the Mediterranean region.

The recent EU enlargement has also resulted in a considerable development of the forest industry, evidenced in the forest area as well as the production and economic potential. Many new Member States have reinstated ownership rights; forest areas and other forest-related values have been privatised; several forest management activities, formerly under government control, have been transferred to the private sector. Notwithstanding that, the new Member States still own much more forest land than the old European Union Member States.

In Latvia forests occupy 2 950 267.3 hectares of the whole territory and, in comparison to other European countries, Latvia belongs to the forest-rich states. 1 481 551.9 hectares (50.2%) of forests are under governmental management, the rest of the forests constitute 1 468 551.4 hectares (49.8%).

Various information sources often claim that forests are being cut out, that soon forests will disappear altogether, and so on. Indeed, deforestation is topical in many countries where tropical forests are being injudiciously cut, while in Latvia the situation has been different for many years. Under the impact of natural factors (soil properties, climate) and human activities (the area of agricultural lands shrinks), the proportion of forest territories nearly doubled between 1923 (forest coverage was 23%) and 2005 (forest coverage was 45.2%) (Figure 3.4).

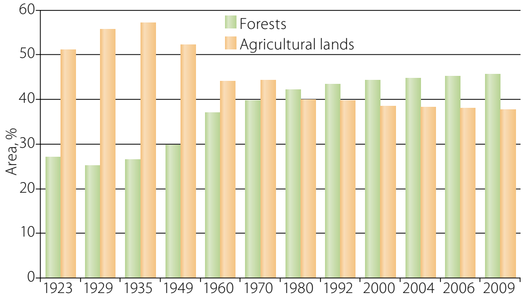


Figure 3.4. **Changes in the forest and agricultural land areas in Latvia over the last century**

A further increase in forest areas is expected as natural overgrowing and afforestation of non-agricultural lands are in progress.

As trees grow, the timber volume increases every year; according to the present estimates, in Latvia it is 16.5 cubic metres a year. Timber is harvested in the principal wood logging sites as well as in selective and sanitary cutting sites to improve the quality of stands. In Latvia in 2005, 11.26 million cubic metres of timber were harvested. Forests in Latvia are replanted with the aim to grow highly productive and biologically sustainable forest stands to provide timber resources for the national economy. At the same time, care is taken to preserve the ecological balance of the environment and to improve the recreational and aesthetic qualities of forests. In 2006, the total area of replanted forests in Latvia constituted 29.5 thousand hectares.

The large forest territories provide favourable habitats for various species, which makes it even more important to preserve the forests rich in wetlands with many protected species, as well as rainforests, marshes and coastal lagoons.

3.6 NON-RENEWABLE AND RENEWABLE ENERGY RESOURCES

Today the greatest attention in the world is devoted to energy resources because their use is usually irreversible, but the supplies of traditional fossil fuels (oil, natural gas) are running out fast. This is why over the last decades attention is focused on renewable energy resources and ways to increase energy efficiency.

3.6.1 COAL

Coal is traditionally looked upon as the most typical fossil fuel. Today coal is primarily used for energy and coke production for producing iron and steel. Coal of a lower quality is used in cement and food production as well as in several less important industries.

Scientists have repeatedly tried to determine the amount of coal in the Earth's interior. At present, the most thorough assessment was carried out in 2006, stating that coal resources suitable for energy production amount to 1.081 trillion tons. Thus, their energy value is equivalent to 4.789 billion barrels of oil.

Although coal is often considered a widely distributed deposit and found in all continents in commercial amounts, 67% of reserves whose extraction is economically grounded are concentrated

Table 3.4. **Energy sources and their brief characterisation**

Energy source	Brief description	Source type
Oil	Fossil fuel, extracted from the Earth	Non-renewable
Natural gas	Fossil fuel, extracted from the Earth	Non-renewable
Coal (incl. brown coal)	Fossil fuel, extracted from the Earth	Non-renewable
Nuclear energy	Energy released in the fission of the nucleus of a uranium atom; uranium ore is extracted from the Earth	Non-renewable
Hydroelectric power plants	Energy from the natural movement of water	Renewable
Solar energy	Energy from solar radiation	Renewable
Wind power	Energy from air movement	Renewable
Geothermal energy	Energy from the Earth's interior	Renewable
Biomass energy	Energy produced by converting plants into gas or oil	Renewable
Tidal power	Energy from the rise and fall of tides in the ocean or sea	Renewable
Electricity	Energy generated from primary power sources	Secondary source
Hydrogen	Hydrogen is obtained from water or other substances	Secondary source

only in four major countries: the USA (27%), Russia (17%), China (13%) and India (10%). These countries provide ~65% of coal extraction in the world.

Active extraction of coal for commercial purposes is being practised in 50 countries, and the total volume of coal is increasing year by year. Over the last 25 years, extraction of high-quality coal has increased by 50% and reached 3.639 billion tons a year, of these, 1.171 billion tons in China, 899 million tons in the USA, 310 million tons in India, 259 million tons in Australia, and 225 million tons in South Africa.

The explored coal reserves and their extraction are geographically unevenly dispersed, which places coal, together with iron and aluminium ores, among the top three commercial cargoes and makes it a powerful impetus for world markets. The total explored world coal reserves comprised 795 billion tons in 2005, but, considering their extremely diverse uses, two basic groups should be singled out: high-quality coal (including anthracite) and low-grade coal (only for energy production).

All in all, coal is a widespread and widely accessible resource in the world market, easy to transport and store. Its advantage lies in the possibility to burn it together with biomass and other types of solid fuels, thus diminishing the impact on the environment and expanding the use of renewable resources.

3.6.2 PEAT

Peat is black, brown or yellowish-brown sedimentary rock which, when dry, consists of over 50% organic substances. It is formed of plant material at different stages of decomposition, having accumulated in extremely wet conditions. Peat forms slowly, and it is assumed that a one-metre thick layer of peat takes a thousand years to form. The botanic composition of the plants, the conditions under which peat had formed and its decomposition degree determine its chemical composition, physical properties and structure.

Peat is classified according to a number of features. Considering the degree of peat decomposition, there is little-decomposed peat (the degree of decomposition < 20%), medium-decomposed peat (20–35%) and

Figure 3.5. **Extraction of brown coal (Garzweiler, Germany)**

well-decomposed peat (> 35%). Another classification of peat is based on the plants that formed peat, that is, according to the botanic composition, and that includes over 40 types of peat. However, the most widely used classification is based on the conditions under which peat had formed. Peat is a renewable resource, and it is forming even at the present time in wetlands and bogs.

Peat resources are unevenly dispersed in the world. A peat layer is deemed suitable for use if it is over 30 cm thick in the natural environment. Peat areas, covering 271.391 million hectares throughout the world, are unevenly distributed among various regions. Most of peat resources are found in North America; about half of that amount is in Europe, followed by peatlands in Asia, while Australia and Oceania have the smallest area of peatland (with no assessment for Antarctica).

According to historical data, peat extraction has fundamentally changed throughout the world in the last century. After World War I, peat extraction amounted to slightly less than 15 million tons a year. In the 1930s this figure grew to 31 million tons, while the development of agriculture caused a rapid rise at the end of the 1950s and after the first oil crisis in 1974. The last peak – 370 million tons of air-dry peat a year – was the absolute maximum, which persisted for almost a decade. After that peat extraction became economically unprofitable as oil products and, since the 1980s, also natural gas were cheaper and more easily available. This was also the time when public interest in nature protection grew considerably; therefore, peat extraction decreased and the number of protected bog areas increased, and many countries had established such high emission standards for thermal power plants that using peat was practically out of the question. Thus, since the mid-1990s, the world peat extraction has only slightly exceeded the amount extracted in the early years of the 20th century.

Today most peat goes to seed farms to propagate seedlings for forests, parks and gardens. Peat is extracted for commercial purposes, and just over 800 companies extract more than 95% of the total amount to produce approximately 55 million tons of air-dry peat a year.

In Latvia peat bogs and several wet forest types on peaty soils (thickness of the peat layer exceeds 30 cm) cover 10.4% of the country's territory. At present the territory of peat extraction comprises 0.4% of the country's territory, with about 25% of the available peateries. Nevertheless, in its energy development programme, the European Union is oriented towards locally exploitable biomass, including peat.

Marshes are important in sustaining both climate and water regime. As ecosystems, they cover 4.9% of the country's territory. Since biotopes are classified according to plant communities, any place with the characteristic marsh flora can be considered a marsh. Marshlands have developed a specific flora and fauna, preserving certain species as relics of the postglacial period. All in all, 12 marsh ecosystems are under protection as restricted areas and natural reserves, and the number of such territories constantly increases.

3.6.3 OIL

In energy production, the oil-bearing mineral deposits as raw materials are strictly divided into two separate parts – oil and oil shale.

Today oil is a principal source of fossil energy production. Usually it is an oily liquid with a characteristic smell; the colour of oil ranges from light brown to black. According to its composition, oil is a complex mixture of hydrocarbons with admixture – up to 20% of dissolved gasses, water and mineral salts. Historically the amount of oil is measured in barrels, the average calculation being that 1 barrel equals 0.1589873 cubic metres.

The origin of oil has not been fully established; however, most of scientists tend to claim that organic substances have participated in the formation of its composition. It has been experimentally proved compounds similar to crude oil can be produced from non-organic substances.

In nature oil is a liquid that fills in empty spaces, crevices and caverns in rocks, forming deposits in anticlines, folds at plate boundaries and foothills, more rarely – in dips of mountains. Oil can also be found in pores or on grains of rocks. Such oil can form oil-saturated sandstone and limestone rocks, or plastic and hard layers of crust, most often called natural asphalt or oil shale.

In the Earth liquid oil is usually buried to the depth of 0.3–5 km; when deeper, it can be found only as admixture in deposits of natural gas. In shallower sediments, oil has usually oxidised and lost its liquid properties.

More than a hundred thousand oil deposits in the world have been identified and explored by drilling. Of the known about 14.7–17 trillion barrels of oil, only 12.9% trillion barrels have been proven by investigation; the extraction of only 9 trillion barrels is economically profitable. However, the necessary exploration and infrastructure for oil production has been created for a limited number of oil fields (~800 fields) with only 1.05 trillion barrels of oil. Because of the recent environmental protection demands, extraction in a number of oil fields has been prohibited. The principal potential oil recovery regions are the Persian Gulf and the Arabian Peninsula, followed by western Africa, the northern part of the USA and Canada, the fourth place occupied by southern China and the fifth by the Caribbean Basin. The assessment of oil supplies by region presents a similar picture (Figure 3.6).

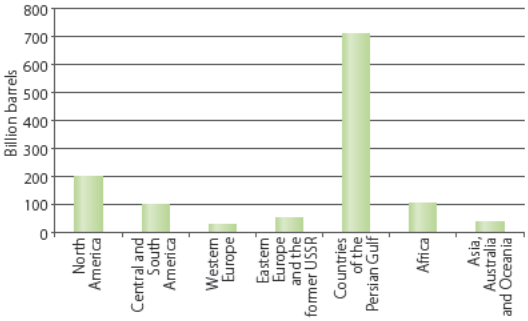


Figure 3.6. **Oil reserves in proven deposits, suitable for economically profitable extraction (billion barrels)**

Only a small part of oil is refined in the countries where it is extracted. This is why transit of oil and oil products is enormous (in 2005, slightly over 2.5 billion tons, or 7 million tons a day). The leading oil-exporting countries are arranged in the following order: Saudi Arabia (12.2%), the USA (10.5%), Russia (10.2%), Iran and Mexico (4.6% each), China and Norway (2004–2005). This sequence of countries is expected to remain unchanged for the next 5–7 years.

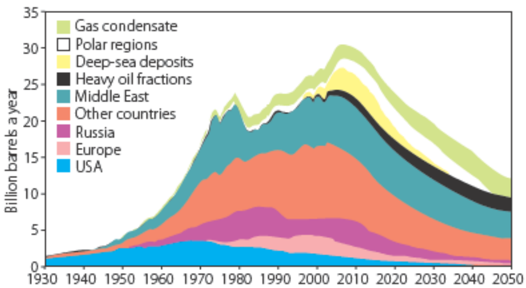


Figure 3.7. **Forecast of oil extraction and consumption**

The consumption of oil products is very dynamic and, since 2000, over a period of five years, the majority of oil products have been used in fuel and lubricant industry (62%), chemical industry (17%), energy generation (15%), heating (5%) and just 1% in other industries.

3.6.4 NATURAL GAS

For at least 2500 years, natural gas has been known in China where it has been used not only for cooking and various rituals but also for extracting metals and firing ceramic wares. However, the exploration of gas deposits is technically very complicated, and up to World War II, gas deposits as such were not searched for. People used the natural gas that was found as a by-product in oil deposits. At present deposits at the depth of 100 metres to 9.15 kilometres have been explored and are used or are being prepared for use. Their area varies from several tens of hectares to hundreds of square kilometres. Altogether several tens of thousands of natural gas concentration sites and deposits of commercial importance have been identified, and over 6 000 deposits are of economic significance.

Natural gas is measured in cubic feet (in calculations 1 cubic foot equals 0.02831685 cubic metres); energy value of gas is 38 megajoules (10.6 kWh) when the energy of burned gas is measured in British thermal units (1 cubic foot of natural gas, when burned, produces 1 031 British thermal units, or BTU).

The estimate of exploitable gas deposits is 6 112.144 trillion cubic feet (Figure 3.8).

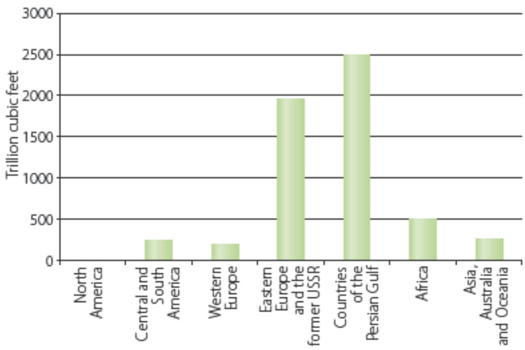


Figure 3.8. **Estimated and economically profitable gas reserves in gas fields (trillion cubic feet)**

Since the beginning of the new millennium, the role of the major gas-exporting countries in the global market has essentially changed compared to the previous decades. In recent years Russia has exported 25% of the world gas reserves, the USA 22%, Canada 7%, the United Kingdom 4%. Algeria and the Netherlands export smaller amounts, while the share of other countries amounts to less than 1%. It is noteworthy that the USA, Canada and the United Kingdom also are the biggest natural gas importers, which is yet another aspect of globalisation of the modern world.

3.6.5 URANIUM ORES

The most common uranium and also thorium mineral is uraninite. It nearly always contains admixtures of rare minerals, especially technetium and radium, also iron, lead and helium. It is the richest and almost the only industrially utilizable uranium ore and the only radium ore. The first nuclear reactors were created to produce plutonium for nuclear weapons, and it was only in the mid-

1950s that the first projects of nuclear reactors were developed for non-military purposes. The first commercial nuclear power plant came into operation in 1956, and further construction of nuclear power plants and reactors expanded fast until the Chernobyl accident. At present in the world over 400 nuclear reactors produce electricity (apart from the reactors for military purposes).

In 2006, 61 countries extracted uranium; however, uranium extraction has decreased in many countries because of the overproduction of the ore. Although the actual amount of the exploited nuclear energy sources is on the increase, only some of the raw material is mined; instead, reserves of nuclear weapons are being intensively reprocessed (65% of the total amount of sources). These energy sources have an essential impact on the competitiveness of the mining industry, but it is estimated that they will have been reprocessed by 2020. In 2005, the volume of mined uranium ore amounted to 40 251 tons (converted into pure uranium), most of it in Canada (28.8% of the total world uranium extraction).

On average, nuclear power produces 17% of the world's electricity, and since 1990 its role has changed little (Figure 3.9). In the European Union countries nuclear power used for electricity generation comprises about one-third of the total amount of energy, but in several member states it constitutes over 60%, and there is no reason to believe that the consumption of nuclear energy might decrease in the future.

Nuclear technologies provide a possibility to generate electricity and reduce the impact on climate change at the same time; however, they are a serious challenge to governments when choosing scenarios for power sector development plans. Once public support has been gained, the implementation of such a plan will take at least ten years. The costs of new nuclear reactors should include the expenses of storing nuclear waste and compensations in the case of potential damage. Thus, nuclear energy cannot be considered cheap when generated with due safety measures.

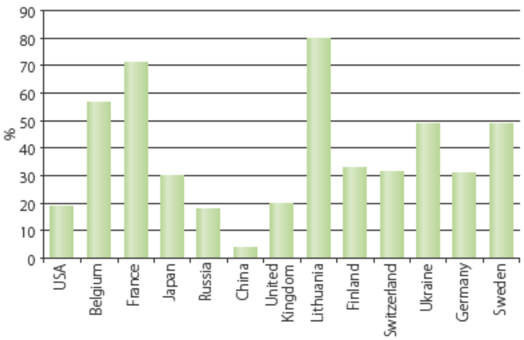


Figure 3.9. **The share of nuclear energy in electricity production in countries (2005, data of the USA Energy Department)**

3.6.6 RENEWABLE ENERGY RESOURCES

The development of civilisation is closely connected with the production and use of energy. Although new technologies are introduced in industries and households, world energy consumption increases year by year while in many regions the shortage of energy resources hampers economic development, causes public protest and heated discussions between heads of states. In the course of time the role of different energy sources in generating energy has changed. In the 19th century coal was the dominating source of energy production; the 20th century came with a rapid increase in oil use, but the 1950s were characterised by the boom of nuclear power.

Most of primary energy sources are fossil energy sources. Their use in the future may be restricted by the decrease in their reserves and the increase in the extraction costs. Therefore, countries are searching for solutions for replacing fossil fuels with renewable energy sources. The principal source of renewable energy is the Sun and gravitation. Their significance increases in many countries, mostly in the EU and other economically highly developed countries where the use of natural resources or a positive public opinion, public awareness of environmental issues and the long-term vision are oriented towards sustainable development. According to the prognosis, the importance of renewable energy sources and nuclear electric power in the world energy production will rapidly grow in the future, after the period of stagnation following the accident in the Chernobyl Nuclear Power Plant in 1986.

Conventionally, renewable energy resources include solar, water, wind, geothermal and gravitational energy (Figure 3.10). At present renewable energy resources are not exploited maximally, mostly because of high technological costs. In general, the role of renewable energy sources in the world energy balance is insignificant (under 0.7%, without water energy), but the primary energy generation exceeds 2% only as an exception. In 2005 the USA produced 6% of its energy from all renewable energy sources, including hydroenergy (45%), all types of biomass (46%), geothermal energy (6%), wind energy (2%) and solar energy (1%).

In 2005, the countries of the Organisation for Economic Cooperation and Development (OECD) generated 0.8% of all primary energy from geothermal, solar and wind sources, while 4.4% came from a combination of different biomass sources (including all types of waste) and 2.3% from hydroelectric power plants.

In 2006, the contribution of all kinds of renewable energy sources (including the energy for local consumption outside centralised transmission networks and as an addition to the traditional fossil energy sources and hydropower) in the EU countries

Primary energy resources	Type	Energy transformation in nature	Technical transformation of energy	Secondary energy
SUN	Biomass	Formation of biomass	Transformation plants	Thermal energy, electrical energy, fuel
	Water power	Evaporation, precipitation, melting	Hydroelectric power plants	Electrical energy
	Wind energy	Movement of the atmosphere	Wind turbines	Electrical energy
		Movement of waves	Wave power plants	Electrical energy
	Solar radiation	Ocean currents	Ocean current power plants	Electrical energy
		Heating the Earth's surface and the atmosphere	Heat pumps	Thermal energy
			Transformation of oceanic thermal energy	Electrical energy
		Solar radiation	Photolysis	Fuel
			Solar panels	Electrical energy
			Solar collectors, solar thermoelectric plants	Thermal energy, electrical energy
MOON	Gravitation	Tidal currents	Tidal power plants	Electrical energy
EARTH	Mainly disintegration of nuclei	Geothermia	Geothermal power plants	Thermal energy, electrical energy

Figure 3.10. **Renewable energy resources**

reached 6.38%, while the political aim is to increase the amount to 20% in 2020. According to experts, a further increase up to 25% before 2050 may prove unfeasible since energy consumption in the EU Member States is rapidly growing.

In the Baltic states, renewable resources have a significant share in the energy balance. The main sources are timber and hydroresources, to a lesser amount, also wind power, biogas and straw, which constitute nearly 30% of all exploited energy resources. The rest comes from imported energy resources: natural gas, oil products, coal and electricity. To ensure greater independence in energy management, it is necessary to raise energy efficiency, from energy generation to energy consumption. Households (heating of buildings) are of particular importance in this process. Besides, efforts should be made to develop energy production in the Baltic states in cooperation with other countries of the Baltic Sea Region. One of the principal solutions for energy independence is to increase the use of renewable energy resources.

ELECTRICITY FROM HYDROELECTRIC POWER PLANTS

For thousands of years, humans have used the kinetic energy of water for grinding, pressing oil and sawing timber.

The first watermill in the Baltic states was built in the 13th century, but already on the threshold of the 20th century, there were more than 700 watermills. In 1926, 26 small-scale hydroelectric power plants functioned in Latvia. At present, the greatest contribution to the energy balance from renewable energy resources comes from the hydroelectric power plants in Pļaviņas, Ķegums and Rīga. After the re-establishment of the independence of the Baltic states, many small-scale power plants had been restored or newly built. They were closed down in the 1960–1970s when the large-scale hydroelectric power plants were constructed and a centralised energy network was developed for the northwest region of the USSR. In 2008, Latvia's 138 small power plants generated only 2.4% of the total amount of energy. Theoretically, Latvia's small-scale power plants can produce up to 10% of the electricity generated by the big hydroelectric power plants.

Today only 20–25% of the hydropower potential of big and small rivers is used. However, the construction of reservoirs for hydroelectric plants is usually connected with inundation of river valleys, which may cause destruction of many rare and unique biotopes. Dams of hydroelectric plants hamper migration of fish, while the work of turbines creates frequent fluctuations of the water level and downstream flow during low-water periods, thus influencing water and coastal ecosystems. Therefore, a country cannot use all its hydropower potential, and the construction of a new hydroelectric power plant should be endorsed only after a comprehensive evaluation of its impact on the environment.

SOLAR ENERGY

Solar energy is the most widely available resource on the Earth. In an hour the surface of the Earth receives nearly the same amount of energy that the whole humanity consumes in a year. More intensive use of solar energy is limited by the costly technologies and their insufficient ability to absorb solar radiation, especially in the regions where the flow of solar radiation is less intensive, for example, Latvia. It has been forecasted that around 2015 the world energy development will see a rapid increase in the use of solar energy, while in 2050 it will have the leading role in the world's energy industry.

The duration and intensity of the Sun's radiation that reaches the Earth depend on the season, weather

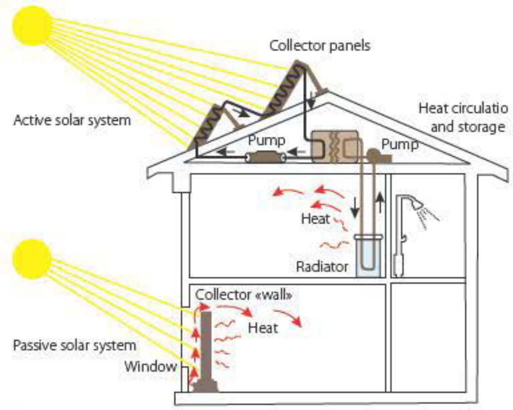


Figure 3.11. **Possibilities of using solar energy to heat buildings**

Figure 3.12. **Solar panels on the wall of a building in Germany**

Figure 3.13. **A solar power plant in the United Kingdom**

conditions and the geographical position of a country. The annual global radiation on a horizontal surface in deserts can reach 2 200 KWh/m². The optimal regions for using solar energy are the south-west of the USA, the Middle East and vast territories in Africa, Australia, Asia and South America. In northern Europe and the Baltic states the maximum power of solar radiation is 1 100 kWh/m² a year. However, considering heat transformation and the efficiency factor, only 400–450 kWh/m² can be actually used. In the Baltic states, solar energy can be mainly produced between the last week of April and the first week of September, when radiation intensity reaches 170 kWh/m². The regions with the largest number of sunny days are more prospective.

Solar energy can be used to generate both thermal energy and electricity, and exploited in two ways:

- passive use of solar energy – location of buildings, building materials that can maximally absorb solar energy;
- active use of solar energy – solar collectors, solar panels and power plants (Figure 3.11–3.13)

Active use of solar energy develops in two directions worldwide. Firstly, solar energy collectors and panels are mounted on buildings. In the collectors solar energy is converted into heat or electricity to be used for heating the rooms, swimming pools, drying kilns for grain. Several countries (Japan, Israel) pay great attention to the use of solar energy and many buildings are equipped with solar collectors. In the Baltic states, solar energy is used experimentally to heat several buildings and schools.

Secondly, solar energy is used actively in big solar power plants. In the very near future they will be built in China, Australia and the USA. The EU scientists and power companies have planned to launch a solar power plant in the Sahara, which could partly solve electricity supply problems in Europe and Africa.

GEOTHERMAL ENERGY

Geothermal energy is environment-friendly and sustainable in the long-term perspective as a thermal energy and electricity source. Heat in the interior of the Earth originated during the evolution of our planet, and it is being constantly replenished by the decay of radioactive elements. The use of geothermal energy is particularly topical in geologically favourable areas, mainly at the tectonic boundaries of plates (for example, in Iceland). The importance of geothermal energy also has been increasing lately in other countries and the EU (Poland, Germany, Hungary, France). Hot water (50–90 °C) is used to generate power and heat homes. Extraction of geothermal energy is environment-friendly as it produces no waste; only the amount of hot water is limited for the used water has to be returned to the water extraction sources. An overuse of hot water can cause a drop in the source water temperature since water does not heat up as quickly as it cools. However, the hazardous geothermal areas are sparsely populated, and transportation of hot water over long distances is unprofitable.

In Latvia, improved water extraction and use technologies can provide access to geothermal water resources for heating houses in the south west and in the south of the country where water temperature at the depth of 1 000 m reaches 38–40 °C. Without additional heating, water of this temperature can be used in swimming pools, for heating soil and fry nursery areas.

WIND ENERGY

Wind arises due to the Earth's rotation and differential warming of its surface. The role of wind the world energy production is rapidly growing. Wind power has been used since ancient times. In Europe wind power has been exploited for milling and water pumping for over 800 years. At present, thousands of wind generators in the world produce electricity.

The potential of wind power depends on wind velocity. Construction of wind generators is profitable in sites with dominating strong winds. The farther off the surface of the Earth, the stronger is the wind; this is why turbines should be built to the height of at least 120–150 m. However, a small-sized wind generator to satisfy the needs of a single household can be built in the yard as well, and it should not be too tall. So far, wind generators have been built mostly on land, but recently they have been sited offshore, where wind velocity usually is greater and there are more windy days.

It is now the world practice to create wind farms (Figure 3.14). The largest wind farm, with an electricity generating capacity that satisfies 230 000 households, was built in Texas, the USA, and comprises 627 turbines on an area of about 400 square kilometres.

Wind generators do not pollute the environment. According to a US estimate, a wind power capacity of 1 MW will annually diminish carbon dioxide emission into the atmosphere by 1 500 tons, sulphur dioxide by 6.5 tons and nitric oxides by 3.2 tons.

However, wind generators have an essential impact on the landscape and migration of birds. It has been calculated that in Altamont Pass wind farm, the USA, approximately 5 000 birds get killed by turbines or transmission lines every year. On the other hand, research in Germany shows that quails, corncrakes, curlews, golden plovers, herring gulls, cranes and several species of geese do not approach turbines closer than 200 metres. Also lapwings, bean- and greylag geese, tufted ducks, coots, pochards, golden-eyes and whooper swans dislike windmilling. Additional research in Lower Saxony, where a wind farm of 44 generators was built in 2000, proved that a peaceful coexistence also is possible: out of 21 migratory bird species, the number of birds has decreased in three species, birds of eight species occur in the former frequency, while the number of birds of ten species has even increased. To reduce the number of killed birds, experts advise that notes should be taken on bird migration height and routes when deciding on the placement of turbines.

OCEAN WAVE POWER

Electricity can be produced by exploiting the kinetic energy of the ocean and sea waves. If a one-metre high and 25-metres long wave crashes against the coast, the amount of the released energy is approximately 120 kilojoules. Converted into electricity, it would provide enough energy to light a table lamp for one hour. Wind capacity over a 5 km coastline is about 10 billion joules an hour, or 2.5 megawatts, which would satisfy the electricity consumption of 500 houses. Water does not flow with the wave; it only moves up and down. This motion is exploited to drive generators.

Ocean wave power can also be used in tidal generators, exploiting the rising and falling tidal waters in river estuaries. The use of wave power has been started comparatively recently by constructing experimental tidal power plants. Some generators are placed on the coast while others are submerged to capture much stronger wave energy.

Figure 3.14. **Latvia's biggest wind generator farm near Liepāja**

BIOMASS

During recent years, the issue of boosting the use of biomass energy is gaining attention in the world. Biomass is the biologically degradable part of waste and residue (including plant matter and animal waste) of agriculture, forestry and related industries, as well as the biologically degradable part of industrial and household waste. It consists of organic matter created in photosynthesis now, as opposed to fossil fuel that formed millions of years ago.

The main types of biomass are:

- firewood,
- by-products of forest use (woodchips),
- household waste,
- building waste,
- straw,
- plants (bushes, trees, crops) specially grown for harvesting biomass,
- biofuel (methanol, biodiesel),
- manure.

At present the EU generates only 4% of the required energy from biomass. If the EU used its potential fully, the countries could more than double the use of biomass, at the same time observing good agricultural practice, ensuring sustainable production of biomass, without causing any essential impact on local food production. A number of scientific and economic studies have brought out the following benefits of an increased use of biomass:

- diversification of energy resources in Europe by increasing the percentage of renewable energy by 5% and diminishing dependence on imported energy by nearly half;
- decrease in greenhouse gasses by 30 million tons of $CO_{2equiv.}$ emission a year;
- up to 300 000 workplaces, mainly in rural areas.

In rural areas of the Baltic states, houses are traditionally heated with firewood. In the last decade woodchips, residue of wood-working, shingles, granules and briquettes have been used more often. High-quality fuel, like wood granules and briquettes, is used for heating individual homes, while firewood, woodchips and wood-processing residue provide district heating. In the early 21st century, due to the reconstruction of many boiler-houses, firewood ranks second in energy production after natural gas in the fuel balance of the Baltic states.

The use of straw is not very popular in Latvia, but straw is widely used in Denmark, France, Sweden and Germany. Recently, some boiler houses in Latvia also started to use straw.

With the construction of new solid waste poligons, biodegradable waste has been recently used for energy generation. Organic waste (food scraps, plant waste from gardens, wood residue, sewage sludge) is converted by microorganisms. As a result, waste is partially or fully transformed, and biogas is formed, which consists mainly of methane (CH_4) and carbon oxides. Methane can be burned to generate thermal energy and electricity.

Many countries in the world pay ever more attention to the production of biofuel from biomass, which is a liquid or gaseous fuel for internal combustion engines. The most important type of biofuel is biodiesel, produced by esterification of vegetable oils, for example, soya oil, with alcohol (methyl alcohol, ethyl alcohol). Production of biodiesel is waste-free, and the eventual by-products – oil cakes, glycerol, sodium or potassium phosphates – can be further used in various other industries.

Production and use of biodiesel (a rapeseed oil methyl ester) is rapidly developing in the EU Member States because the EU directives stipulate that the consumption of biofuel should grow by 0.75% a year and should reach no less than 5.75% of the total consumption of vehicular fuels. Production of biodiesel is rapidly growing in France, Italy and Germany. At present France annually produces 200 000 tons of ethanol and 500 000 tons of biodiesel. Ethanol is produced from sugar-beet or crops, while biodiesel is mainly produced from rape. A hectare of rape plantation in France yields raw material for approximately 1.4 tons of biodiesel, a hectare of crops provides for 2.6 tons of ethanol, while a hectare of sugar-beet provides 5.8 tons of ethanol.

At the same time, rational use of energy is of prior importance – planning and economic use of energy, restriction of energy consumption, especially in heating and household use.

3.7 PROVIDING FOOD AND DRINKING WATER FOR THE HUMANITY

Land is undeniably one of the most important resources of nature for human life in all of the historically established stages of the social development of society. It has often been said that land gives all a human needs for existence: plants, animals, minerals and building materials. At human disposal there are 149 million square kilometres of dry land, while the total world area of land, with the exception of Antarctic ice-covered territories, is 134 million square kilometres. Not all of the terrestrial area is available for economic activities because some of it is occupied by mountains, rocks, deserts, coastal sands, tropical forests and marshlands; part of the territories are covered by terrestrial ice. This land fund differs by the structure of its use, by its regional distribution and by the amount of land resources per person.

In specialised literature, the notion of 'land' is explained as very wide and all-including; it represents the complex of all natural resources. The term 'land' refers to all the area not covered by the world's oceans and seas. Thus, land includes agricultural and forest lands, areas covered by marshes and glaciers, mountains, territories under industrial, traffic and communication objects, cities, as well as water reservoirs – rivers, lakes and ponds, canals, ditches and man-made water impoundments.

Agricultural land comprises intensively farmed arable land, natural meadows and pasture land directly related to agriculture. Arable land is extensively used everywhere in Europe and the Mediterranean regions as well as in south-east Asia. The vastest pasture territories are in central Asia, Australia, the southern part of South America and in certain regions of Africa. All in all, meadows and pastures occupy a larger territory than arable land. Such differences and territorial distribution are most often explained by the type of climate and fertility of land, population density, and other factors of the given region. The largest areas of agricultural land typically are in the temperate zone.

The character of land use has rapidly changed over the last centuries, exerting an ever increasing pressure on land and impacting the environment. For example, the main changes in Europe (with the exception of Russia) during the last 40 years include an increase in forest lands by 10%, a decrease in arable lands by 11% and a decrease in permanent pastures by 11%.

In general, the use of land is determined by several factors. Resources and infrastructure deserve special attention.

- Natural resources: climate, vegetation, water and hydrological conditions, soil and the actual use of land.
- Human resources: population, their age structure and education, land ownership rights.
- Capital resources: funds, private and municipal and state, to be invested in launching certain activities.
- Infrastructure: traffic, communications and other technical infrastructure.

In the Baltic states, long-term economic activities have essentially transformed the natural landscape; instead, a cultural landscape has appeared, reflecting different ways of land use. With the introduction of tilling, man had cleared deciduous forests to cultivate land for farming and, when soil fertility declined, the depleted fields were forsaken and left to grow over. In Latvia, agricultural lands occupy approximately 40% of the territory of the country. The largest areas of fields, meadows and gardens, including river valleys and the gentle slopes of elevations, are in the south of the country. Forests and shrubbery cover about 49% of the territory, mainly poor soils; marshlands constitute 10% of the territory of Latvia.

3.8 SOIL RESOURCES

One of the most important renewable natural resources is soil – the biologically active upper layer of land with a unique property – fertility. Soil development is a long-time, gradual and very complex process.

Soil is commonly understood as the uppermost layer of the Earth's crust formed by mineral particles, organic substances, water, air and living organisms. Soil is the contact and interaction zone for the Earth, air and water, and the habitat for most of the biosphere.

The fertility of soil is one of the principal factors that determine the use of land in a certain place. Soil properties determine the suitability of the place for:

- agricultural production, including the development of farming or cattle-breeding,
- development of forestry, including nursing of species of trees,
- laying out tourist trails,
- building playgrounds for sports.

The type and composition of soil can be an essential factor in regard to:

- type of crops to be cultivated,
- type of land use in dominating soils,
- alternative use of specific soils,
- land tilling and improvement,
- types of irrigation or drainage,
- type and amount of fertilizers,
- soil protection measures.

In rural areas, soil fertility determines the market value of land, and this factor is applied in many countries to determine the cadastral value of land.

Since the process of soil development is extremely slow, soil can be actually considered a non-renewable resource. Soil is the source of food, biomass and raw materials. It is the foundation of life; a landscape element and a store of cultural heritage. Many substances, including water, nutrients and organic carbon, accumulate, filter and transform in soil. Soil is the world's largest storage of the active part of the carbon cycle (1 500 gigatons), and its functions should be protected because of their social, economic and ecological importance.

One of the preconditions for successful and competitive development of agriculture is the fertility of soil. Although cultivation of different species of plants requires different conditions, all of the plants require a definite amount of moisture, nutrients, sufficient depth for roots and a suitable energy regimen for photosynthesis and production of biomass.

Soil is an extremely complex and volatile environment. In Europe alone there are over 320 important types of soil, and each of the types contains numerous variations of physical, chemical and biological properties. The ability of soil to perform its functions depends on its structure, while any damage to it affects other natural environments and ecosystems. Soil undergoes various degradation processes and hazards – it is affected by erosion, depletion of organic matter in soil, local and dispersed pollution, consolidation and subsiding of land, decrease in biodiversity, accumulation of salts, floods and landslides. Most of these factors or hazards take place simultaneously and, if the influence is serious, in arid or sub-arid climates it results in desertification of the affected territories.

Soil degradation directly affects the quality of water and air, biodiversity and climate change. It can cause deterioration of human health and create hazard to human and animal food safety. In the European Union, soil degradation processes and the ensuing hazards differ from country to country. Soil degradation is a problem for all EU Member States. Approximately 115 million hectares or 12% of Europe's total land territory are eroded by water, and 42 million hectares are eroded by wind. Nearly 45% of soils in Europe are characterised by a low content of organic matter, mostly in the southern regions, also in France, the United Kingdom and Germany. Furthermore, there are about 3.5 million potentially polluted sites in the EU Member States.

To provide the world's population with food, it is imperative that land degradation be reduced. At present, the total world territory of degraded land exceeds 1.9 billion hectares, which is more than the total territory of arable land. The largest areas of degraded land are in Asia (748 million hectares), Africa (495 million hectares) and Latin America (305 million hectares). In Europe degraded lands occupy 218 million hectares. In its report on land degradation, the World Resources Institute, the USA, points out that nearly 40% of the currently used agricultural lands suffer from various degrees of degradation, which presents a potential problem for the future concerning production of food for the population.

Numerous direct and indirect factors cause land degradation: deforestation, overgrazing, inadequate management of land, growth of human population in a certain region (Figure 3.15). Africa ranks among the first in the population growth and this creates a need for new agricultural lands and excessive clearing of forests and shrubbery. Trees and bushes are also used as fuel for cooking. Deforestation results in leaching nutrients from soil, changes in the moisture regimen and decline of the physical properties of soil, which further results in the loss of soil fertility. Deforestation and burning of bushes for agricultural lands facilitate desertification processes.

Desertification is a loss of natural vegetation which causes a rapid decrease in soil fertility and an eventual total extinction of the soil cover due to soil erosion. This process involves changes in the soil moisture regimen, and soil gets salinised and compacted. It is commonly believed that desertification is most characteristic of desert and temperate desert zones. Regular burning of savannahs ranks among major desertification causes. Natural fires are characteristic of savannahs; however, in our time most of them are consciously started by humans. The burning of vast grass and shrubland territories has affected soils in savannahs, they are often depleted, and fire in the regions adjoining deserts and temperate deserts has facilitated the advance of sands (Figure 3.16).

Overgrazing is another cause of land degradation. In arid regions, the nomadic cattle-breeding is traditionally practised, involving constant seasonal moving from place to place in search of new pastures. In this way ever new areas are affected by grazing. Besides, in our time it is the less fertile lands with loose ground vegetation unfit for tilling that are allotted to cattle-breeding. Along with the growing human population, the number of cattle also grows, leaving an increasing impact on natural ecosystems. With the ground vegetation degraded by overgrazing, soil in these

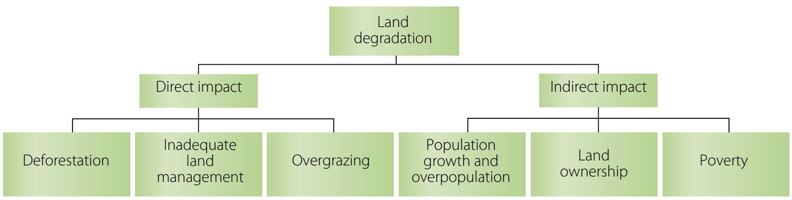


Figure 3.15. **Causes of land degradation**

Figure 3.16. **Advance of sands in the Africa's semi-arid zone**

regions is exposed to erosion and desertification. In the process of grazing, soil gets compacted, and it makes an essential impact on the air and water regimen of soil.

In the Mediterranean region, the considerable density of cattle, namely sheep and goats, caused the development of land degradation processes in Italy, Spain and Greece. The vegetation layer was destroyed, which precipitated wind and water erosion.

Desertification mainly affects developing countries where the rapid increase in the human population creates an excessive pressure on agricultural and forest resources which, in turn, leads to intensive deforestation and soil degradation. The situation is the most hazardous in Africa where 40% of the territory suffers heavily from human economic activity and is under the threat of desertification. Huge territories in Latin America, Asia and Australia are also endangered.

In the Baltic states, land desertification in its classical form is not typical; however, land degradation is evident in soil erosion (Figure 3.17) and pollution, mismanagement of agricultural lands and development of various recreation sites.

A further development of civilisation is viable if land degradation is restricted and the productivity of agricultural lands is raised without creating environmental damage. The basic factors for high yield capacity are the following: improved tilling practice, balanced plant nutrition elements, restriction of pests with the help of modern methods, protection of soil and water, and a high-level human responsibility. The improvement and use of pesticides and fertilizers has increased plant productivity, at the same time polluting the environment. The task for the future is to achieve a more efficient use of fertilizers and pesticides without creating hazard of environmental pollution.

Figure 3.17. **The fertile layer of soil decreases due to wind (a) and water (b) erosion**

3.9 WATER RESOURCES

Deterioration of the freshwater quality and depletion of its resources in certain regions of the world may become one of the most topical problems of society in the 21st century. In 2005, good quality drinking water was not available to two billion of the world's population. According to the UN prognosis, 2.8 billion people in 48 countries will suffer from the shortage of freshwater by 2025; 40 of these countries are in western Asia, northern Africa and the Sahel zone in Africa. For now, the international society does not have a solution to this problem, and a chronic freshwater deficit in 2050 is expected to affect as many as four billion people.

Although the Earth's freshwater resources are huge, many of them are not easily accessible for a variety of reasons (situated high up in the mountains or deep underground), or their quality is not suitable for human consumption. However, availability of water has already caused conflicts between people and countries alike. Experts warn that in the future water problems can create conflicts among Turkey, Syria and Iraq if Turkey builds dams on the Tigris and the Euphrates. In Africa, battles are going on for the waters of the Niger, in Asia for the Mekong, the Indus and the Ganges.

The use of water resources differs from country to country based on the level of development of the country and accessibility of water resources. In economically developed countries the average daily water consumption per person is 200–800 litres, while in developing countries it will hardly exceed 60–150 litres per day.

Freshwater has a variety of uses. According to the UN data, the household use of water accounts for 12% of water consumption, 8% is consumed by the power sector and industry, and agriculture uses nearly 70%. In agriculture, water is used for the daily intake of livestock, watering and irrigation of fields. For better harvest, farmers have turned to improved irrigation methods in many places. In Spain, for example, 14% of irrigated agricultural lands provide over 60% of the total agricultural produce. Because of the irrigation of agricultural lands, surface water resources are running short in certain places, groundwater stores are being depleted, and salt-water intrusion would make freshwater unsuitable for human consumption. Climate change and drier summers in southern Europe and elsewhere in the world have increased the use of water resources; therefore, water now has to be imported to the places which never had previously suffered from water shortage. Scientists consider that the pledge of the EU countries to increase the amount of biofuel up to 10% of the total amount of vehicular fuel by 2020 will result in a substantial increase in water consumption for agricultural needs.

The situation in Bahrain, Saudi Arabia and the United Arab Emirates is much more complicated. Due to a freshwater deficit, people in these countries and many other places of the world have to desalinate large quantities of sea or salt-lake water, or saline groundwater. The number of desalination plants in the world exceeds 15 000. Although the world supply of water for desalination is sufficient, the use of desalinated water for human consumption and in agriculture is restricted by the available electricity and by the high prime cost of desalinated water.

We have to note the fact that in the future freshwater will be increasingly extensively used, which may result in restrictions for the development of populated places, increased migration of the human population, growing pollution threats and other social, economic and ecological problems.

Figure 3.18. **Inhabitants of the Sahel zone in Africa currently suffer the greatest shortage of drinking water**

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CASE STUDY: ESTONIA
OIL SHALE DEPOSITS

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The Baltic Oil Shale Basin is about 50 000 km² in size and is situated mainly in northeastern Estonia, part of it extending eastward into Russia. At present, the Estonia deposit is the largest commercially exploited oil shale deposit in the world (total resources exceed 7 times 10^9 tons of oil shale) (Bauert and Kattai, 1997). The Estonia deposit has been mined continuously since 1916, altogether 1 billion tons of oil shale had been produced by 2006. The highest annual output of 29.7 million tons was reached in 1980. Production has decreased since then, and in 2009 the output was around 15 million tons. Currently, oil shale is mined in two underground and in two open-cast pits. Oil-shale mines cover 450 km², which forms 1% of Estonia's territory.

A simple explanation of oil shale is a rock that comprises so much organic matter that it burns. In Estonia, there are two burning rocks rich in organic content: graptolitic argillite and kukersite oil shale.

Graptolitic argillite, or Dictyonema shale, is a dark greyish-brown fine-grained claystone. The rock is named after the ancient marine organism – graptolite *Dictyonema* that lived in the Early Ordovician marine basin some 480 million years ago. The calorific value of this rock is low and therefore it has not been used for fuel. However, it contains several rare elements, such as molybdenum, vanadium and uranium. Graptolitic argillite was mined at Sillamäe for the production of uranium from 1949 to 1952 (Aaloe *et al,* 2007). Due to the very small yield, the production of uranium was stopped and the plant switched to processing imported raw material. More damage was caused in the phosphorite quarry near Maardu, where graptolitic argillite was removed and deposited in waste dumps. As a result of its self-combustion, substances harmful to human health reached the groundwater. This was one of the reasons to end the mining of phosphorite in Estonia.

To use oil shale industrially, the content of a solid organic matter kerogen, must reach at least 5–25% (maximum about 60%) (Bauert and Kattai, 1997). Besides organic matter, oil shale contains a non-combustible mineral part (carbonate and clastic material), which reduces the calorific value of oil shale. The mineral parts, mostly carbonates, disintegrate on combustion. Per thousand tons of oil shale, the combustible part forms 350 tons, water 100 tons and 550 tons remain as ash (Aaloe *et al,* 2007). Estonian oil shale is called kukersite, according to the German name of Kukruse Manor, to distinguish it from other kinds of oil shale in the world. Like coal, oil shale can be used as fuel without any preliminary processing.

The question about the formation of kukersite still remains unsolved, despite the efforts of geologists and oil-shale chemists. Most researchers agree that marine algae were the initial source of the organic matter in oil shale. Kukersite is believed to have been deposited in shallow coastal waters, where algae may have formed extensive mats. Calcareous material and clay particles accumulated along with the organic matter. This all happened at the end of the Middle Ordovician about 450 million years ago, when only algae thrived everywhere in water basins, as at that time there were no higher plants.

Kukersite forms thinner or thicker horizontal beds between grey limestone and is well-traceable because of its light-brown colour. The thickness of the productive bed is 2.5 to 3 m, of which oil shale forms 1.8 to 2.6 m and limestone 0.6 to 0.7 m. In the northern part of the deposit, kukersite seams are close to the ground, and oil shale can be mined in open-cast pits and shallow mines. Southwards the oil-shale seams descend lower (about 3.5 m per kilometre) – this is caused by the general southward dip of the Estonian bedrock. Therefore, kukersite is found already at a depth of 70 m at the southern edge of the deposits. All rocks in the productive bed contain many fossils or their crushed skeletal particles. Palaeontologists have found some 360 species of fossils (such as whitish bryozoans and well-preserved trilobites).

Oil-shale mining causes numerous negative changes in environmental conditions, some of which are unavoidable due to technological or economic reasons. Environmental impact and the resulting immediate hazards were the greatest during the Soviet period in the 1980s. Nowadays more attention is paid to the problems related to the environmental pollution caused by both excavation and further use of oil shale. Much has been done at the electrical power stations in Narva. For example, the emissions of carbon dioxide, nitrogen and sulphur compounds have been reduced substantially after the installation of new boilers and up-to date purification facilities.

Over the decades, scientists have developed various concepts to mitigate the environmental problems connected with mining (Punning, 1994; Liblik, Punning, 2005). Oil shale is mined in open-cast pits as deep as 30 m. Oil shale open-cast mining has affected around 120 km² of land in northeastern Estonia. Re-cultivation of this land is carried out in accordance with projects providing for elements of landscape architecture as well as species to be planted. As the greatest emphasis is placed on the economic reuse of abandoned open-cast pits, 85–90% of the reclaimed land has been afforested with Scots Pine, which is the optimal tree species in forestry. The re-cultivated area covers about 10 000 ha, incl. 160 ha of farmland. Research has shown that spontaneous

Figure. **Open-cast oil shale mine**

succession is also a useful technique for the reclamation of small areas. Planting broad-leaved tree species may enhance the performance of the herbaceous layer and increase overall biodiversity.

The main mining method used in underground mines is chamber mining. Ceiling rocks are fixed with column-supported roofs. Productive oil-shale layers (thickness 1.4–1.5 m) are excavated, ceiling rocks are let down with the help of hydraulic breaking-support device. When underground mining is completed, the mine is left hollow and it may collapse, thus also influencing the surface. Scientists have compiled a joint map of underground mining and the surface that describes the geodetic and geologic situation of all mines. Based on this information, it is possible to give a preliminary estimate of the impacts caused by the deformation.

The level of subsoil water is lowered below the level of the oil-shale layer due to mining technology. The water pumped out is discharged through outlet ditches and rivers mainly into the Gulf of Finland, but also into Lake Peipus. Annual water outlet of the mining amounts to 200–240 million m^3. The water pumped out of mines contains large amounts of sulphates; their concentration is up to 500 mg/l (Perens *et al*, 2006) because of the oxidation of pyrite occurring in Ordovician rocks. After mines are closed, a step-by-step restoration of the natural conditions of groundwater filling the mines begins – sulphates leach, oxidation of pyrite diminishes and the mineral content of the water pumped out decreases. Studies of mine waters have shown that five years after the closure of a mine, the content of sulphates and iron decreases below the maximum permitted level in drinking water, 250 mg/l and 0.2 mg/l, respectively.

The mining production excavated in the mines is enriched in special enrichment plants. Gangue from the enrichment process of oil shale in mines is placed into enormous heaps. Old heaps, or rather mountains so characteristic of the landscape of eastern Estonia, contain altogether 138 million tons of substance. In 2000, 3 million tons of leftovers from oil-shale enrichment were placed into the gangue-heaps of the mines. This substance is relatively inert and is not a direct threat to the environment. It is used for macadam production and road construction.

Most of the old gangue-heaps, called terricones, have transformed into green areas on their own, but trees and bushes have been planted onto younger ones. For example, 'Mount' Kukrus has become a popular tourism object. A rally course has been established next to 'Mount' Sinivoore, and its slopes have been fixed for skiing and sledging. Some of the old gangue-heaps are burnt, enabling the burning products to soak into surface and subsoil water. Nowadays, the danger of combustion has been reduced to a minimum.

Another set of complicated problems in this region is related to power production and the chemical industry. Compared to mine water, the substances leaching out of the production residues of these sectors affect the environment more seriously (Liblik, Punning, 2005).

More than 90% of the electricity produced in Estonia comes from oil shale. *Eesti Energia* (*https://www.energia.ee/*) is an international energy company offering integrated energy solutions, from production of electricity, heat and fuel to sales, customer care and additional energy-related services. After some mines will be closed in 2013 due to the exhaustion of resources, *Eesti Energia* will have to seek new mining opportunities to fulfil their oil shale delivery contracts and development plans. Continuing to mine at the current mining volumes (approximately 15 million tons per year), *Eesti Energia* would have sufficient oil shale resources for about 20 years. Resource use can be optimised by producing liquid fuels from oil shale. This emits less greenhouse gases than electricity production.

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4 HUMANS AND THE ENVIRONMENT

4.1 SYSTEMS OF THE EARTH: THE LITHOSPHERE, HYDROSPHERE, ATMOSPHERE AND BIOSPHERE

4.1.1 ENVIRONMENTAL SCIENCE – A SCIENCE OF ENVIRONMENTAL SYSTEMS

Everything is interrelated. All elements and processes in both organic and inorganic nature are interrelated – they influence each other in myriads of ways. However, among these innumerable interconnections, there are groups of individual elements or processes that can be marked out as more closely related, for example, clockwork parts, computer microchip components or members of one family. Each of these aggregates of elements has specific functions: clock shows time, computer processes information, family raises new members of society.

An aggregate of interconnected elements that performs specific functions is called a system (from the Greek word systema, which means 'a whole consisting of parts'). System theory classifies systems by their level of complexity. The natural systems comprising the Earth and everything on it are extremely complicated systems.

The Sun and its planets formed from the condensation of gas and dust clouds in the interstellar space about 4.6 billion years ago. The Earth functions by means of specific systems (spheres) – the atmosphere, hydrosphere and lithosphere – and the flows of substances and energy among these systems. The spheres of the Earth differ with respect to their composition, mass and processes taking place in them (Table 4.1), i.e. the processes of exchange of substances composing each sphere (e.g., water evaporation, condensation and runoff cycle) (Table 4.2).

Systems can be open or closed. In an open system, the flows of substances and energy are not confined. Ocean is an open system with respect to the Earth's combined mass of water – the hydrosphere. The Earth, on the one hand, can be considered a closed system with respect to the flows of substances (the Earth's mass is increased by a relatively small mass of falling meteorites, and a relatively small mass of substances leaves the upper layers of the atmosphere and dissipates into outer space); on the other hand, it is an open system with respect to the flows of energy (the Earth receives energy from the Sun and reflects part of the received energy into outer space). A characteristic feature of systems is their capability to react on various influences – feedback, which can be positive or negative. This feedback or counteraction is auto-regulative – it stabilises the system, maintains it in a relatively constant state. The feedback is positive when an impact on the system results in a further enhancement of the system's activity.

A typical example of negative feedback in an inanimate, technical system is Watt's Regulator (Figure 4.2). When the fly-ball rod rotation speed increases, the centrifugal force makes the system close the steam valve to the cylinder, thus ensuring that the engine always runs at the same speed.

Another factor that significantly influences the processes taking place on the Earth is the global sum of all living organisms – the biosphere. Life originated about 1.6 billion years after the formation of the Earth, and since then it has been substantially influencing the development of our planet. A great number of species of organisms have developed, flourished and disappeared since the times of the origination of life. Human beings have

Figure 4.1. **Earth viewed from space**

Table 4.1. **Main structural elements of the Earth**

	Chemical elements	Aggregative state
Atmosphere	N_2, O_2, H_2O, CO_2, Ar	Gaseous
Hydrosphere	H_2O (water, ice), substances dissolved in water (Na^+, Ca^{+2}, Cl^-)	Liquid, solid
Biosphere	Organic substances, H_2O	Liquid, solid
Lithosphere:		
Crust	Silicates, carbonates, sulphides, oxides	Solid
Mantle	Silicates (olivine, pyroxene)	Solid
Core	Iron and nickel	Fluid (inner core – solid)

Table 4.2. **Mass of the Earth's main components and the turnover period of substances in them**

	Mass, *kg*	Turnover period, *years*
Biosphere	4.2×10^{15}	60
Atmosphere	5.2×10^{18}	0.2
Hydrosphere	1.4×10^{21}	1600
Crust	2.4×10^{22}	$> 3 \times 10^{7}$
Mantle	4.0×10^{24}	$> 10^{8}$
Core	1.9×10^{24}	Permanent

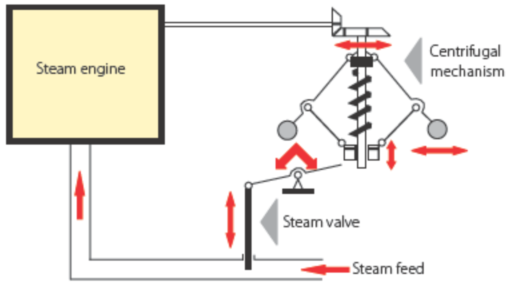

Figure 4.2. **Negative feedback principle exemplified by Watt's Regulator**

The more intensely the steam engine runs, the higher the rotation speed of the centrifugal mechanism; as a result, the steam valve gradually cuts off the steam feed. In this way, the regulation of engine operation is possible.

evolved during a very short period of the Earth's development process, and it is understandable that from the human perspective it appears as the most significant period. Hence, an understanding of how we can affect the environment around us is also significant. Nowadays human activities can influence the processes taking place on the Earth. Life affects the Earth's combined mass of water – the hydrosphere – troposphere and the upper layer of the Earth's crust.

Each scientific discipline has its specific object of study. Inasmuch as the object of environmental science is complex environmental systems, it can be defined as a science studying the systems of the Earth, their interactions and the influence of human beings on them.

4.1.2 ATMOSPHERE, HYDROSPHERE AND LITHOSPHERE

The atmosphere is one of the three system components (the atmosphere, hydrosphere and lithosphere) of the Earth, and life exists in all of them. The atmosphere is composed of gaseous substances (O_2, N_2), the hydrosphere consists of water and substances dissolved in it, whereas the structure of the lithosphere, which makes up a large part of the Earth's mass, is clearly heterogeneous.

The total mass of the atmosphere is 5.2×10^{15} tons or approximately one millionth of the Earth's mass, and it is relatively small compared to the masses of the hydrosphere and lithosphere (Table 4.2). Intensive processes of substance and energy cycling take place in the atmosphere, and it is the most mobile compared to the other spheres of the Earth. The atmosphere plays a vital role in climate control, preventing the Earth from becoming too hot or too cold. The atmosphere diffuses the energy from the Sun, thus maintaining the temperature balance and climate life-friendly. Water vapour and carbon dioxide in the atmosphere reflects part of the heat radiating from the Earth's surface, helping to keep up temperature on the Earth considerably higher.

The composition of the atmosphere has changed with the Earth's development, and presently it is in a certain state of dynamic equilibrium between the geochemical processes going on in the organic nature and the activity of human beings. At the same time, the atmosphere in its present state is a result of long evolution. After the Earth had been formed, the early atmosphere was composed of methane, ammonia, water vapour and hydrogen. This atmosphere did not shield the Earth even from short-wavelength electromagnetic radiation from outer space, and it was chemically reductive. Therefore, the first living organisms evolved in water, which protected them from the electromagnetic radiation of short wavelength and precluded the breakdown of organic substances (especially DNA and proteins). The development of photosynthetic organisms brought about further changes in the atmosphere's composition. These organisms are capable of absorbing carbon dioxide and water, producing carbohydrates and oxygen. Increasing concentration of oxygen in the atmosphere created the Earth's ozone layer, and the composition of the atmosphere became very much like it is today. During the atmosphere's evolution, the concentration of hydrogen decreased as it was bound up into chemical compounds as well as diffused into outer space. Hence, photosynthesis and the development of living organisms can be deemed as the combination of factors crucial for the formation of an oxygen-rich atmosphere as we know it today.

Even if the atmosphere's mass is relatively small (0.00009% of the Earth's mass, 0.044% of the mass of the Earth's crust, 0.6% of the hydrosphere's mass), its role is tremendous. The atmospheric gases are involved in an active substance exchange with the lithosphere, biosphere and hydrosphere, taking active part in all kinds of migration processes of substances and elements. The existence of the atmosphere is the precondition of possibility for life on the Earth, whereas the life processes themselves substantially affect the atmosphere's composition. Human activities cause changes in all systems of the Earth, and it is the atmosphere which is affected most. The specific properties of the atmosphere that significantly affect the processes on the Earth are its mobility and reactivity. The atmosphere can be regarded as a barrier that protects the life processes on the Earth, as far as it absorbs charged particles and a large part of high-energy electromagnetic radiation from the Sun, which would otherwise cause damage and destruction of living organisms. Radiation with a longer wavelength and weaker energy can reach the Earth's surface, while short-wavelength radiation (ultraviolet light, X-rays, γ-rays) is absorbed in the upper layers of the atmosphere. The atmosphere has an indispensable role in balancing the Earth's temperature. The atmosphere contains carbon dioxide and oxygen. Plants use the former for photosynthesis, while living organisms use the latter for breathing. Furthermore, the atmosphere plays a vital role in the global cycling of substances (carbon, sulphur, nitrogen, metals) and in the hydrological (water) cycle. In addition, a considerable part of meteorite mass coming from outer space burns out in the atmosphere.

The atmosphere's high mobility also supports transport of airborne pollutants from one area of the Earth to other regions and even their dispersion on a global scale. To be sure, a large part of the processes taking place in the biosphere depend on the composition of the air that is used for maintaining life processes, especially in the case of much more complicated organisms. Even microscopic amounts of toxic substances can cause adverse effects on human health if exposure takes place for longer periods of time.

Temperature and the atmosphere's chemical composition can also be quite different at different heights. The atmosphere has a layered structure; therefore, depending on the distance from the Earth's surface, many of its characteristics as well as composition are variable (Figure 4.3). The upper layers of the atmosphere have a considerably different composition than the much denser lower layers, in which the main mass of the atmosphere's gases is concentrated (the air mass within 30 km from the Earth's surface makes 99% of the total mass of the atmosphere). The Earth's atmosphere is in a state of dynamic equilibrium. The atmospheric pressure changes evenly depending on the distance from the Earth and other factors. However, the temperature decreases within the troposphere, then it increases again in the stratosphere due to the interaction of atmospheric gasses with solar radiation. High-energy electromagnetic radiation from outer space initiates ionisation in the upper layers of the atmosphere, splitting even stable molecules. Gas molecules reach high speeds as a result of collisions with the quanta of electromagnetic radiation in the rarefied air of the atmosphere's upper layers. At the same time, these processes govern the sorption of electromagnetic radiation, which is most intense at the top layers of the atmosphere, although it occurs, to a large extent, at lower layers as well.

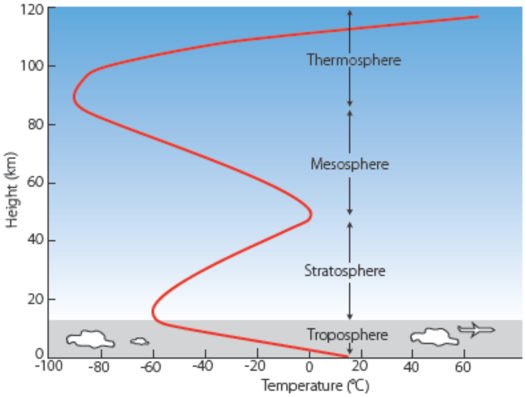

Figure 4.3. **Variability of the Earth's atmosphere and temperature depending on the distance from the Earth's surface**

The layer closest to the Earth's surface is called troposphere. The troposphere's height and processes taking place in it depend on the Earth's shape, movements of air masses as well as many other factors, including the anthropogenic ones. Since water vapour condensates at the upper limit of the troposphere, it does not reach the atmosphere's upper layers, where water molecules could be split in photochemical reactions, and the resultant hydrogen – diffused into outer space.

In the stratosphere, air temperature rises as the distance from the Earth increases. The rise in temperature is a consequence of photochemical reactions in the stratosphere – first of all, the formation and disintegration of ozone molecules, and also the intensive sorption of ultraviolet light.

The concentration of gases that form the upper layers of the atmosphere is considerably lower. These gases are in an ionised state, and they are subject to the influence of high-energy electromagnetic radiation coming from the Sun and outer space. Therefore, molecules move at much higher speeds in the rarefied air of the upper atmosphere. Reactions taking place in these parts of the atmosphere are rather different from those near the Earth's surface.

The hydrosphere is the whole of all water on the Earth's surface and in the Earth's crust near the surface. The World Ocean comprises the largest part of it. The cycling of substances is mostly associated with the Earth's hydrological cycle. The presence of water is a precondition for life on the Earth, and the existing forms of living organisms are to a great extent determined by water. Moreover, water is the main substance forming living organisms. Water is not only the main component of the hydrosphere; it also significantly affects the processes in the biosphere, atmosphere and – being a critical factor for many geological processes – the lithosphere. The role of water in the environment is decisive not only due to its total volume on the Earth but also due to its substantial properties.

The mass of the hydrosphere is 1.5×10^{18} tons, and its total area (ocean + glaciers and ice caps + lakes + rivers + swamps + wetlands) is 383 million square kilometres, which is 75% of the total area of the Earth's surface (510 million square kilometres).

The hard and rigid outer layer of the Earth – the lithosphere – is up to 200 km deep, and it comprises the Earth's crust and the outer part of

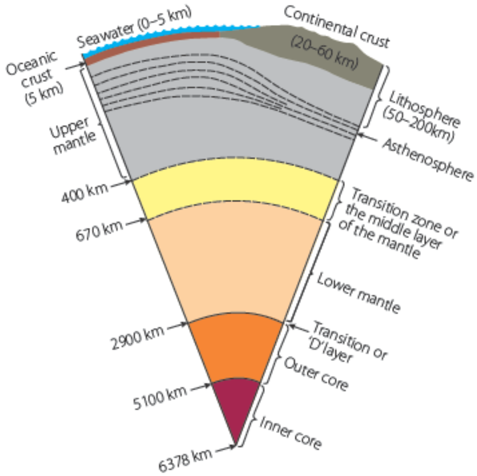

Figure 4.4. **Inner structure of the Earth**

the upper mantle. The lithosphere is underlain by the asthenosphere and the deeper part of the upper mantle made of magma that can come to the Earth's surface during volcanic eruptions. The Earth's outer core is liquid, and it makes up ~30% of the Earth's mass, whereas the inner core is solid and composed mostly of iron and nickel (Figure 4.4).

4.1.3 BIOSPHERE

The biosphere is the part of the Earth's environment in which living organisms are found, and it comprises the upper part of the lithosphere, the lower part of the atmosphere (troposphere) and the entire hydrosphere. The biosphere is simultaneously the entirety of all living beings (biomass) and their habitat environment. The biosphere is the space inhabited by living organisms in different concentrations. Whereas there are only a few bacteria per cubic meter in the upper layers of the atmosphere, there is not only high biological diversity but also a huge number of individuals within a specific unit area in the tropical rainforests of the equatorial zone. The biosphere is an extremely complicated and dynamic system which is affected by a multitude of different external factors, including contingent ones, such as the tectonic processes in the Earth's crust, ice covers and natural disasters.

The total number of hitherto known species of animals and plants reaches almost 3 million; from these, almost 300 000 are autotrophs, i.e. organisms producing the primary biomass. All other organisms are heterotrophs – they are the consumers of the primary biomass. Angiosperms have the largest number of species among plants, whereas insects, molluscs and vertebrates champion among animals. Fungi – being neither plants nor animals – have a special place among living organisms. They also are heterotrophs and have a vast number of species.

The total estimated global mass of living biological organisms is the biomass, and it ranges from 2.4×10^{12} tons to 1×10^{13} tons of dry matter, the largest part of which is phytomass (phytoplankton, trees, grasses), whereas the amount of zoomass is estimated from 2 to 10 per cent of the total biomass. The total of approximately 2.3×10^{11} tons of biomass is produced annually. Biomass constitutes 0.01% of the mass of the Earth's crust, and it would make a 2 cm layer if it were evenly dispersed over the Earth's surface. The largest amounts of biomass are concentrated in tropical rainforests – 65 kg/m^3 on average, whereas in boreal forests (taigas) it is 20–25 kg/m^3, in fertile zone steppes – 1 kg/m^3, in deserts – 0.25 kg/m^3. The concentration of biomass in the World Ocean at large is close to that of deserts, while in some places it is comparable to steppes and savannas. However, marine organisms have higher rates of reproduction and decomposition because their biological cycling is more intensive. Plankton is the largest and most significant community of living organisms on this planet. Although the mass of living matter is relatively small compared to the mass of the Earth's crust, the cycling processes there are much more intense. It is estimated that the biomass produced by plankton during the entire period of its existence on the Earth by far exceeds the mass of the Earth's crust.

Living systems – unlike the non-living ones – actively interchange with the environment, constantly taking organic and inorganic substances and energy from it and excreting the waste products of life processes back into the environment. The main categories of living systems are cell, organism, population and species community. Cells and organisms are excitable, i.e. they actively react on environmental changes, grow, develop and reproduce. The cell is the basic structural element of organisms, the organisms of one species make a population, while the species that are interrelated or have similar demands from the environment constitute communities of species. A species community and its non-living environment inhabited, used and transformed by the species together make a system of a yet higher category – an ecosystem, in which the components of both organic and inorganic nature are combined. Each species is unique, and it has specific and distinctive functions in the ecosystem. All species of organisms living on the Earth can be classified into four kingdoms: bacteria, fungi, plants and animals (viruses are not included in this classification). Even if the number of already classified species is overwhelming, it is deemed that scientists have not yet discovered the greatest part. It is estimated that the total number of species on the planet could be at least 13 million.

The living components of an ecosystem are made up of the organisms of different species that

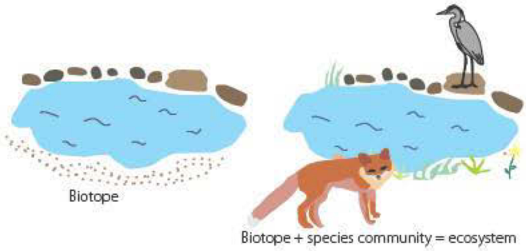

Figure 4.5. **An ecosystem is made up of a whole of elements of non-living nature (biotope) and a whole of living organisms (species community)**

Figure 4.7. **Boundary between the forest and meadow ecosystems makes a forest edge ecotone – brushwood, which contains both forest and meadow species**

populate the same habitat, usually interact and make a food chain. The whole of species within an ecosystem is called a species community. The whole of all components of non-living nature (rocks, water, air) that host a species community is called a biotope (Figure 4.5).

Ecosystems can be of different sizes, from micro-ecosystems, such as a rotting stump or a puddle, to meso-ecosystems and macro-ecosystems, such as a forest plot, a lake, the island of Madagascar or the Pacific Ocean. All the ecosystems of the planet constitute the mega-ecosystem – biosphere (Figure 4.6). Ecosystems are open systems, which means that they continuously receive and emit energy and different substances.

The main function of an ecosystem is to maintain life continually, synthesising organic substances with complex molecular structure – such as cellulose, sugars, proteins and fats – from elementary inorganic substances, such as gases, water, salts. When organisms die off, they decompose back into elementary substances.

Notably, ecosystems cannot be described in spatial terms only, because there are no exact boundaries between them – unless nature itself has demarcated such boundaries, for example, the line between dry land and water. Usually the transition from one ecosystem to another is gradual, and the transition area is called an ecotone (Figure 4.7). Therefore, the boundaries drawn on the ecosystem maps are quite relative – they often do not exist in nature.

Within an ecosystem, there are extremely diverse bonds or interrelations between different species and elements of inorganic nature. These bonds are much closer within a single ecosystem than between different ecosystems. There is no question that the most important of these relations are food or trophic (from the Greek trophe, 'food') relations, when one species consumes another species as food. For instance, there are trophic relations between herbivore species and plant species, between predators and their prey, between parasites and their host species. However, there are other forms of relations among species apart from the trophic bonds. These relations can be, for example, mutually beneficial or symbiotic (Figure 4.8), or they can be just the opposite – competition among species for food resources or a habitat.

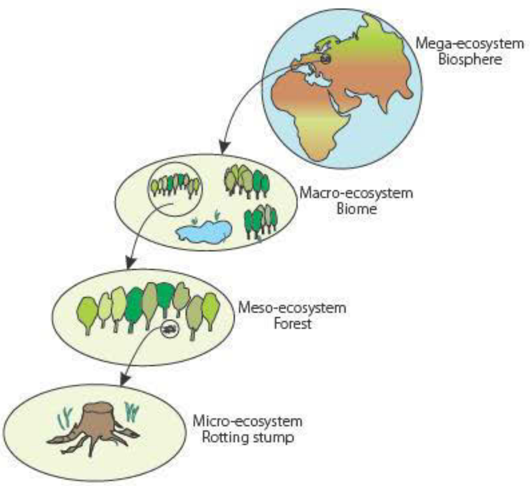

Figure 4.6. **Hierarchy of ecosystems**
Biosphere as the most comprehensive ecosystem is at the top of the hierarchy. Larger territories with homogeneous natural conditions can be singled out of the biosphere – they are called biomes. Meso-ecosystems, such as separate forest or grassland areas, swamps and lakes, in turn, can be singled out of the biomes.

Figure 4.8. **Lichen is a symbiotic association of alga and fungus**

There also are other types of inter-species relations: when one species subsists on the food leftovers from another species, finds habitation at places inhabited or forsaken by another species or just accidentally warns another species about imminent danger.

The trophic relations among species make the structural basis of ecological food chains and food webs (Figure 4.9). Energies and substances flow through ecological food chains. Green plants are the primary producers that make the first link of the food chain. Using the energy from the Sun, they produce organic substances from mineral substances, water and carbon dioxide by means of photosynthesis. The species within the other links of the food chain are unable to use solar energy directly; they can only consume the energy that is already enclosed in the matter of green plants. The organic substances produced by plants and their accumulated energy are first of all available to plant-eating insects, birds, mammals and other animals living on plant food. Plants are basically composed of cellulose – an organic substance that is hard to digest. Herbivores are able to digest cellulose with the help of micro-organisms that inhabit their digestive tracts as symbionts. In this kind of symbiosis, the animal provides shelter for the micro-organisms in its digestive tract, while the micro-organisms help the animal digest the swallowed plant food. Since cellulose has a low energetic value as food, herbivores have to eat frequently and in large quantities in order to acquire the energy they need.

The ecological food chain represents the feeding hierarchy of organisms in an ecosystem as well as the flow of substances and energy in it. The ecological food chain ordinarily consists of three to four trophic levels. The first level comprises autotrophic organisms that make their body matter by using solar energy and the inorganic substances taken from soil or water. All green plants are autotrophic, including the algae growing in waterbodies. The green plants produce their growth substances by means of photosynthesis. For this reason, they are called producers. There also are autotrophic bacteria, though they are less widespread in ecosystems. They synthesise their cell matter by means of chemical energy. All other levels of the food chain consist of consumers. The second level comprises herbivores that consume plants to obtain energy and the needed substances. The third level comprises the primary predators and parasites that use herbivores for food. In many ecosystems, the primary predators are also endangered, for they are eaten by the secondary predators in turn. The amount of solar energy available at each subsequent level of the ecological food chain is no more than 10–15%. This is because most of this energy is used for the metabolism, growth and reproduction of organisms at each level and some energy is lost as heat. For this reason, food chains are not long. A decrease in the amount of energy in the food chain is reflected by the number and total biomass of the organisms at each level. Usually there are more plants than herbivores and more prey than predators. The ecological pyramid of numbers shows this rule graphically (Figure 4.10).

The food chain also includes decomposers. They obtain the necessary energy and substances by decomposing the remains and excrements of organisms accumulated within the entire food chain. These organisms are called saprotrophs (from the Greek sapros – 'rotten', trophos – 'feeding'). It is

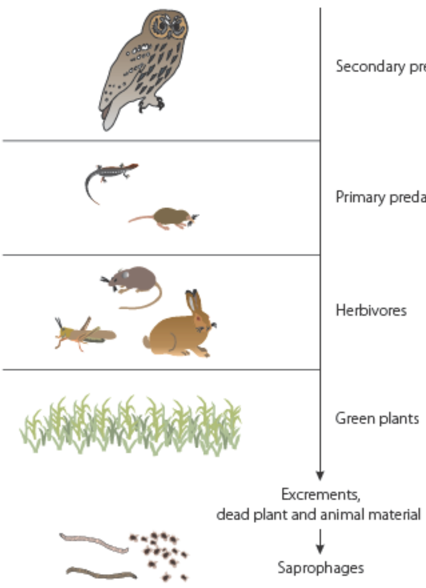

Figure 4.9. **Ecological food chain**

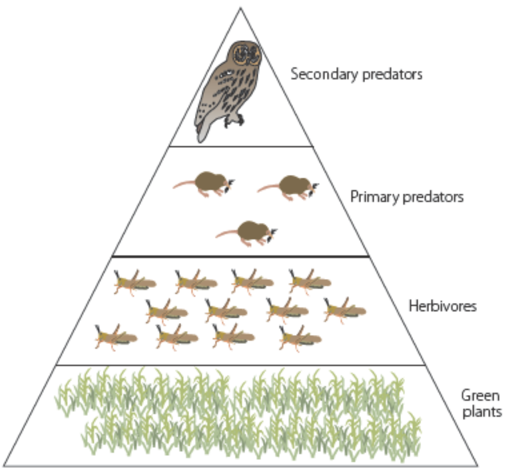

Figure 4.10. **Ecological pyramid of numbers**
Energy deficit and losses in the trophic food chain causes the situation when usually within an ecosystem there are more plants than herbivores and more prey than predators.

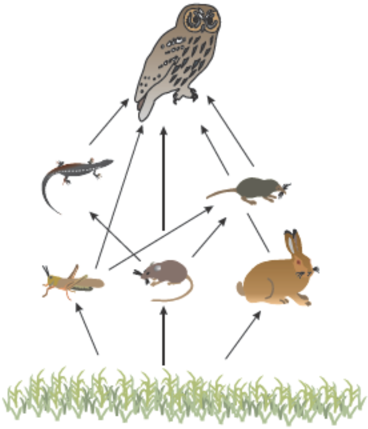

Figure 4.11. **Food web**
Species that act at different levels of the food chain make the nodes of the food web, whereas species that consume just one type of food are linked to the web with a single link.

worth noting that the ecological food chain is more of an abstract concept. In reality, many species use both plants and animals for food, for example, bears. Therefore, one and the same species can subsist at several trophic levels. Accordingly, a food web is a better way of representation of actual trophic relations among species (Figure 4.11). Each node of the food web denotes a particular species, whereas the links with other nodes indicate the trophic relations of these species with other species within the ecosystem. Thus, one can say that ecological food chains represent not so much relations among species but rather the flow of energy and substances within an ecosystem in general.

Ecosystems at different levels of hierarchy are not isolated from one another; rather, they are interconnected in innumerable ways. For this reason, processes taking place in a system at a lower level affect both the neighbouring systems at the same level and all the ecosystems at higher levels in the ecosystem hierarchy. Thus, the number of migratory birds of a particular species, for example, the Black Stork, in some regions of Latvia depends on the survival success of this species in Africa.

The Amazonian rainforest deforestation causes not just local climate changes; it also affects climate in the entire region of the Amazon Basin, South America and the Pacific Ocean, because the rainforest ecosystems, by means of intensive evaporation of water and release of specific substances into the atmosphere, determine the height of rain cloud formation above the region. Ultimately, these changes affect the global climate as well. Admittedly, today's knowledge on causal relationships in ecosystems is still incomplete. Theoretically it is possible that minor changes in one element of the system might cause significant changes in the whole system. This principle is metaphorically denoted as 'the butterfly effect', and it also applies to causal relations in ecosystems, as expressed by the saying that the flap of a butterfly's wings in the rainforest of South America can set off a storm in Europe. A small increase in the concentration of phosphorus-nitrogen compounds in a lake under favourable water temperature may cause an avalanche-like multiplication of algae and cyanobacteria (blue-green algae) that has a substantial effect on the whole ecosystem of the lake.

The hierarchic structure of ecosystems spatially manifests itself as the diversity of biotopes within a single ecosystem. A large diversity of biotopes is characteristic of natural landscape ecosystems, where all kinds of ecosystems alternate: different forest types, dry and wet meadows, peat bogs and marshlands, dunes, lakes. Landscape ecosystems with a low diversity of biotopes, in turn, in many cases are human-made: large tracts of human-planted forest, agricultural fields and pastures.

Species communities or biological communities represent the living components of the ecosystem. Biological communities consist of bacteria, fungi, plants and animals. These organisms depend on environmental conditions (temperature, moisture, soil fertility), at the same time transforming these conditions themselves. For example, plants with roots and litter as well as animals with digging and excrements transform non-living rocks into soil. Earthworms play an outstanding role in this process. The famous British natural scientist Charles Darwin once compared them with a farmer's plough because there are hundreds of earthworms per square meter of a field, and they continually feed on the soil, so that almost all of the field's topsoil passes through their digestive tracts within the period of one year. Earthworm castings are called coprolites, and they are chemically stable structural elements of the soil. In fact, they make the soil fertile by becoming the activity centres of the microbiological processes taking place in the soil.

A characteristic feature of a biological community is species diversity measured by the number of species within the community. The highest species diversity is found in the ecosystems of tropical rainforests and coral reefs. For example, the entomologist Terry Erwin has discovered that an average of 1 200 species of beetles inhabit the foliage of one species of tree in the Panamanian rainforest. Of course, the species diversity is much lower in the forest ecosystems of the northern and temperate zones, where the environmental conditions are more severe. For example, in coniferous forests, the number of species can be easily counted on the fingers of one's hand. Nevertheless, tens of different species of small arthropods and worms live in the forest soil.

Ecosystems constantly change and develop. Biological communities transform into different

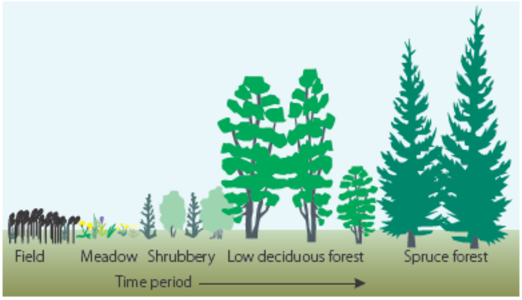

Figure 4.12. **Ecological succession in terrestrial ecosystems**
A field becomes overgrown and transforms into a spruce forest within a period of approximately 80–100 years. Several stages can be distinguished in this process. During each stage, there is a distinctive biological community with a specific composition of plant and animal species.

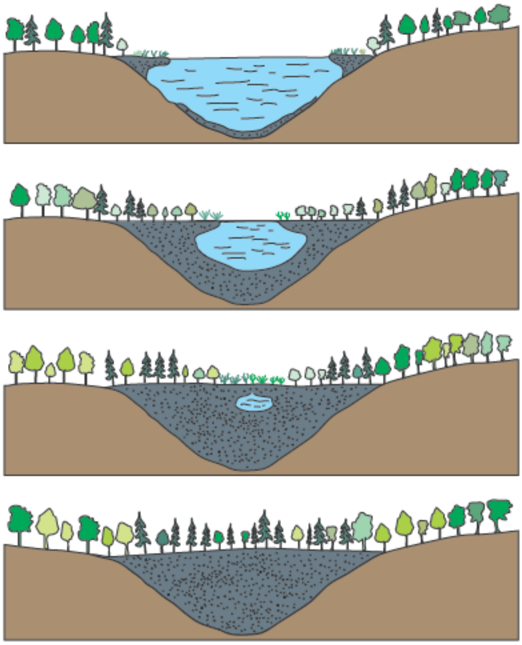

Figure 4.13. **Ecological succession in an aquatic environment**

ones, with a different composition of species. This development process of ecosystems is called ecological succession. A telling example of ecological succession is a field overgrown with weeds and grass, transforming into a meadow; then, the meadow is overgrown with shrubs; and, finally, the shrubbery transforms into a forest (Figure 4.12).

Ecological successions can be of different durations: from relatively short-term to very long. There can be short micro-successions that run for about a few weeks. In contrast, a gradual overgrowing of a lake and its transformation into a swamp may take thousands of years (Figure 4.13). The remains of aquatic plants and animals gradually settle on the lake's bottom; consequently, it becomes shallower and shallower. Overgrowing also takes place from the lake's shores; consequently, the open water area becomes smaller and smaller – until it disappears completely.

The main characteristic feature of ecological succession is the changing composition of species in an ecosystem. The total biomass of living plants and animals and its productivity within the ecosystem change with that. Parallel to that, the mass and productivity of organic substances produced in the ecosystem also change. Thus, another feature of ecological succession is changing amount of biomass produced within a specific unit of time. There are two main types of succession: primary and secondary. In the case of primary succession, the development process of an ecosystem starts on bare rocks, for example, on volcanic lava, in a sand dune or gravel pit. Micro-organisms, algae, lichen and moss appear first. When these organisms die off, organic substances gradually accumulate, and the soil is formed. After that, plant and animal species start to propagate, successively replacing one another along with the development of the ecosystem.

In the case of secondary succession, an ecosystem starts to develop following the impact of some forceful external factor, for example, forest fire, hurricane, deforestation, ploughing the soil and the like. In this case, succession takes place on pre-existing soil and with more or less developed or reduced biological community. In accordance with the theory of succession, an ecosystem in the process of development works its way towards a definite final goal – an ecological climax. Once the climax is reached, the ecosystem does not develop any further.

Humans also are part and parcel of an ecosystem – one of the species of living organisms. However, humans surpass any other organisms in their ability to influence ecosystems most, to use the biological production of these ecosystems, to change the composition of species as they consider necessary. Needless to say, to manage the ecosystems successfully, a good knowledge of their functioning, the organisation of species within them are required.

With their actions, humans are capable of sustaining or destroying the ecosystems of the planet. Since the destruction of the biosphere would bring the very existence of human beings to an end, humans should be objectively concerned with sustainable development of ecosystems. When there is no sufficient knowledge on some ecosystem, we should act by observing the precautionary principle. In accordance with this principle, if there is a suspicion that certain actions could have harmful consequences, the actions in question are inadmissible. If an interference with the ecosystem does take place, it should be done step by step, carefully assessing the consequences of each step before taking the next one.

4.2 CYCLING OF ELEMENTS AND ENERGY ON THE EARTH

The elements, substances and energy of the Earth are in the process of continuous cycling, which is described by the cycles of substances called biogeochemical cycles – because they encompass a variety of chemical conversions and geological processes, and living organisms take an active part in these cycles. The source of elements (for example, oxygen, sulphur, carbon) usually is the lithosphere. From there substances can make their way into the atmosphere and hydrosphere through volcanic eruptions and weathering of sedimentary rocks. Substances and elements also enter the atmosphere from the hydrosphere. Moreover, the processes related to water cycling in nature are crucial. Living organisms in the biosphere assimilate substances from the lithosphere, hydrosphere and atmosphere, and when they die, the substances return to the environments related with the biosphere.

The cycling of substances and elements is maintained by the flow of energy reaching the Earth from the Sun. The flows of energy govern the physical processes (for example, water evaporation and condensation and atmospheric circulation that creates wind) as well as chemical reactions occurring in the environment. The energy of the Sun makes the development of living organisms possible. Both chemical elements (for example, nitrogen, magnesium, sulphur) and substances (for example, water) are subject to biogeochemical cycling. Many elements that participate in the cycling of substances constitute the basic building blocks of living organisms. Carbon and oxygen make up to 80% of the mass of a human being. Other elements are found in trace amounts in the Earth's crust and in water; still, they are indispensable for sustaining life processes (for example, phosphorus, boron, copper).

Thus, both biological and geological processes govern the cycling of substances and elements, and, essentially, the concept of matter cycling discloses the nature of geological changes, physical processes and chemical reactions in the environment as well as transformations of biological systems (living organisms). The cycling of substances in the geological environment includes the processes that began after the Earth was formed. During the Earth's formation process, a solid crust was generated, and it was affected by periodic eruptions of the Earth's liquid inner, reaching the Earth's surface (Figure 4.14) and creating extrusive magmatic rocks. The composition of these rocks changed during the process of their erosion (disintegration), making sedimentary rocks. The latter, in turn, compacted, creating metamorphic rocks (for example, marble originated from the metamorphism of limestone).

Almost all the minerals on the Earth have originated in geological processes. The minerals that have formed in the Earth's interior or on its surface can remain almost unchanged for a very long time. If the physical and chemical conditions and composition of the environment undergo significant changes after the minerals have formed, their original properties and composition are transformed: they start weathering, new minerals and their aggregates are formed, and these new formations are more stable in the new conditions. These transformations of minerals take place constantly. There are minerals that change so slowly that these changes are not commensurable with the human lifespan or even with geological time. In contrast, there also are minerals that are unstable and can rapidly change under the influence of sunlight, air or moisture. Accordingly, different minerals have quite different roles in the formation of the Earth's crust. Some minerals are enduring and stable, and they have remained intact throughout

Figure 4.14. **Layers of sedimentary rocks (Devon, the UK)**
Sedimentary rocks have originated from the transformation of minerals from the Earth's solid crust. They moved with water flows and were deposited in waterbodies. The different composition of layers is evidence for environmental condition changes in the atmosphere, hydrosphere and biosphere.

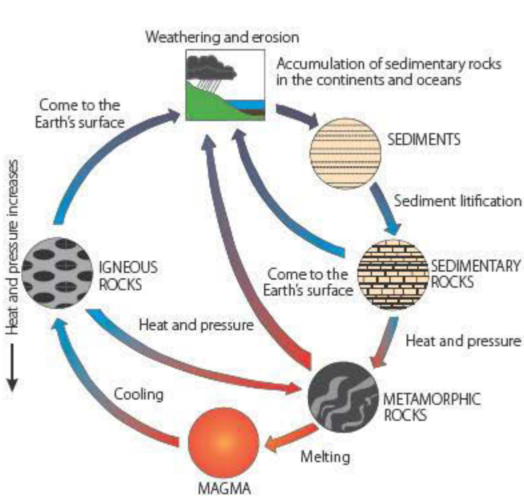

Figure 4.15. **Rock cycle**

the environment, pressure and temperature changes. Others, in contrast, are dynamic, have repeatedly changed their mineral form and play an active role in the transformations of the composition and properties of the Earth's crust. This process is called the rock cycle (Figure 4.15), and for stable minerals it can last for billions of years.

4.2.1 ENERGY FLOW AND THE EARTH'S CLIMATE

The main source of energy on the Earth is the Sun. The key factors that determine the extent to which the Sun's energy reaches the Earth are the following:

- distance covered by radiation;
- angle at which solar radiation reaches the Earth's surface;
- composition of the atmosphere and the interaction of solar and cosmic radiation with gases forming the Earth's atmosphere.

EARTH'S ENERGY BALANCE

Different types of radiation reach the Earth: the Sun's electromagnetic radiation and the flow of ionised particles (for example, oxygen or helium atomic nuclei) and elementary particles, as well as the flow of particles and radiation from outer space (cosmic radiation). The Earth's climate is mostly affected by the flow of electromagnetic radiation. The radiation from the Sun that reaches the Earth comprises the full spectrum of electromagnetic radiation: γ-rays, X-rays, ultraviolet radiation as well as the visible light, infrared radiation and radio waves. The energy of electromagnetic radiation decreases with the increase in wavelength; therefore, most of the radiation that reaches the Earth has high energy and a relatively short wavelength.

A considerable part of solar radiation (γ-rays, X-rays and ultraviolet radiation with short wavelength) does not even reach the Earth's surface because it is absorbed already in the upper layers of the atmosphere or is reflected back into outer space. High energy solar radiation transformations in the Earth's atmosphere are determined by the interaction of γ-rays, X-rays and short-wavelength ultraviolet radiation with atmospheric gases.

The visible light (wavelength approx. 0.40–0.70 μm) is essential for sustaining the life of green plants and most animals, as it carries the energy necessary for photosynthesis and regulates the animal reproduction times, migration and many other life processes. Infrared radiation (thermal radiation) has a much lower energy; nonetheless, it has a vital role in the Earth's climate formation, because it warms the lower layers of the atmosphere and the Earth's surface.

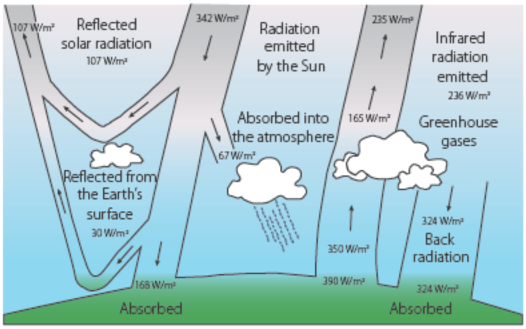

Figure 4.16. **Earth's energy balance**

The intensity of incoming solar radiation is approximately in equilibrium with the intensity of energy reflected from the Earth's surface (Figure 4.16). The flow of energy that reaches the upper layers of the Earth's atmosphere has an intensity of ~1370 W/m². Most of this energy is reflected back into space or absorbed as a result of interaction with gases in the Earth's atmosphere. The intensity of the flow of energy that finally reaches the upper layer of the troposphere is just 342 W/m².

Approximately 30% of solar radiation is reflected back into space. Part of this energy is reflected by cloud cover and small particles in the atmosphere. 51% of radiation from the Sun is absorbed by the Earth's surface, and this energy is spent for evaporation – as infrared radiation from the Earth and in convection and advection processes.

The theory that the composition of the Earth's atmosphere can affect the intensity of energy received from the Sun and the Earth's climate has been around for more than 100 years. Solar radiation warms the Earth's surface, and then the Earth reradiates this heat into the atmosphere. Since the temperature of the Earth's surface is by far lower than that of the Sun's surface, the intensity of energy emitted by the Earth also is much lower and the wavelength of this energy – much higher than that of solar radiation. The Earth's surface mostly emits infrared radiation that can interact with atmospheric gases.

Several of these gases can intensively absorb infrared radiation. These gases are carbon dioxide (CO_2), methane (CH_4), ozone (O_3) and water vapour, as well as nitrogen (I) oxide (N_2O) and the gases that are released into the atmosphere due to human activity – chlorofluorocarbons (freons).

Carbon dioxide, methane and also water vapour in the atmosphere work like greenhouse glass (Figure 4.17). They let solar radiation through, but hold up the infrared radiation reradiated from the Earth's surface. Due to this effect, these gases are called greenhouse gases. The higher their concentration in the atmosphere, the more infrared radiation is retained in the Earth's atmosphere and,

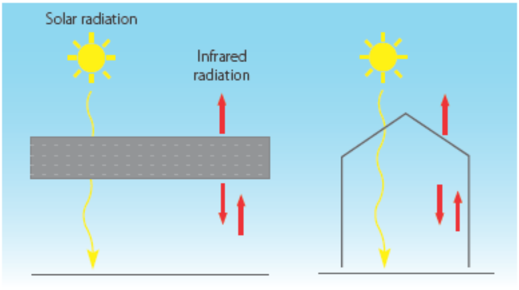

Figure 4.17. **Principle of solar electromagnetic radiation absorption in the Earth's atmosphere and in a greenhouse**

Table 4.3. **Variability of the greenhouse gas concentrations in the atmosphere and its effect on the Earth's energy balance**

Greenhouse gas	Gas concentration in the atmosphere, parts per trillion		Emission per year	Lifetime in the atmosphere, years
	1998	1750		
Carbon dioxide CO_2*	365	278	26.4 GT[1]	
Methane CH_4**	1745	700	600 Tg	8.4
Nitrogen (I) oxide N_2O**	314	270	16.4 Tg N	120
Perfluorethane C_2F_6	3	0	~2 Gg	10 000
Freon 11 $CFCl_3$	268	0		45
Freon 23 CHF_3	14	0	~7 Gg	260

* Concentration expressed in parts per million.
** Concentration expressed in parts per billion.

as a consequence, the higher the temperature of the Earth's surface. If the Earth's atmosphere were composed of nitrogen and oxygen only, i.e. the gases that do not contribute to the greenhouse effect, the Earth's average yearly temperature would be only +6 °C (now it is approx. +15 °C).

The Swedish chemist Svante Arrhenius proposed the hypothesis regarding the role of greenhouse gases – CO_2 in particular – in the Earth's climate formation as early as 1896. His calculation that doubling the CO_2 concentration in the atmosphere would cause a rise of the Earth's average temperature by 5–6 °C has been fully confirmed today.

Even the slightest changes in the concentrations of greenhouse gases in the atmosphere cause temperature changes on the Earth, causing further changes in the size of glaciers and ice shelves and caps, in the ocean level, patterns of currents, spatial structures of habitats and climate.

IMPACT OF GREENHOUSE GASES ON THE EARTH'S CLIMATE

Each of the greenhouse gases (Table 4.3) has a different capacity to capture solar radiation and reradiate it back to the Earth. The intensity of radiation is measured in watts per square metre (W/m^2), and the measurement shows the extent to which each of these gases affects the amount of energy that reaches the Earth's surface – thus also the extent to which it affects the climate. If the radiation intensity value is positive, the gas in question facilitates the rise in the Earth's temperature; if this value is negative – it facilitates the decrease in temperature. The natural greenhouse effect maintains the temperature which is just right for creating prime conditions for life on the Earth. Moreover, the greenhouse effect in not unique on the Earth. Astronomers think that other planets show the signs of the greenhouse effect as well. For instance, it is deemed that the temperature on Venus reaches as high as +450 °C largely owing to the greenhouse effect.

A characteristic feature of many greenhouse gases is their high stability with respect to the duration until they are chemically bound or emitted from the atmosphere (Table 4.3). Water vapour is removed from the atmosphere relatively quickly in the form of atmospheric precipitation. Methane oxidises photochemically into carbon dioxide and water. Carbon dioxide dissolves in water. Nitrogen (I) oxide (N_2O) is particularly stable. Many substances released into the atmosphere due to human activity – for example, freons – are exceptionally stable, and they will influence the atmospheric processes for a very long time.

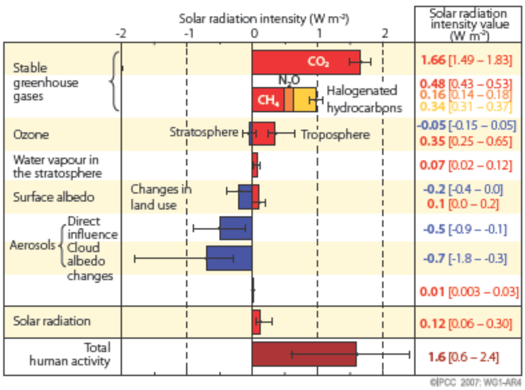

Figure 4.18. **Mean global radiation intensity for the main factors affecting the Earth's climate system**
The value of solar radiation intensity (radiation amount) indicates changes in reflected energy that would occur at the upper limit of the troposphere if the respective component were completely eliminated from the atmosphere.

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[1] Hereinafter the concentration of greenhouse gases is expressed in number of parts by volume (part-per notation) – correspondingly: ppm – parts per million; ppb – parts per billion; ppt – parts per trillion. This concentration notation shows the amount of substance per air volume. For example, 300 ppm means that a million of gas molecules in the air contains 300 molecules of the respective greenhouse gas or that a million air volume units (for example, cubic centimetres) contains 300 cm^3 of the respective gas.

Peta (P) – 10^{15} Tera (T) – 10^{12} Giga (G) – 10^{9} Milli (m) – 10^{-3} Micro (μ) – 10^{-6} Nano (n) – 10^{-9}

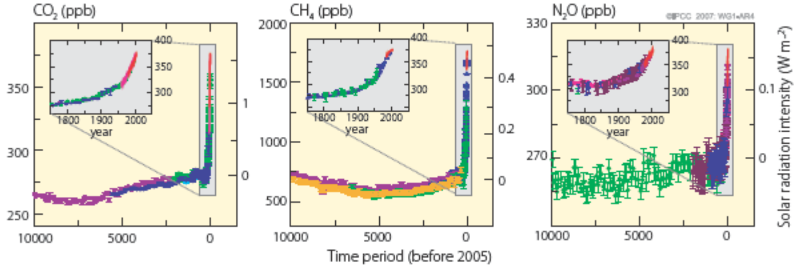

Figure 4.19. **Changes in greenhouse gas concentrations and the effect of these changes on the intensity of incoming solar radiation for the period of the last 10 000 years**

Different greenhouse gases can differently affect the Earth's climate in view of both their capacity to reflect infrared radiation and their concentration in the atmosphere. If we express the potential effect of CO_2 on the Earth's climate by 1 unit of measure, the relative potential of other substances that cause greenhouse effect to influence the Earth's temperature balance is significantly higher: for methane (CH_4) it would be 11, for nitrogen (I) oxide (N_2O) – 270 and for freon 11 (CF_3Cl) – 3 400. Knowing the amounts of radiation emitted by greenhouse gases, it is possible to forecast what kind of changes the increase in their concentrations in the atmosphere will bring about and what their overall influence will be (Figure 4.18, Table 4.3).

Within the last 10 000 years, especially in the last century, the concentration of the three major greenhouse gases has significantly increased in the Earth's atmosphere. Consequently, the intensity of solar radiation reflected back to the Earth's surface has also increased (Figure 4.19).

The biosphere (of both water and dry land) affects the composition of the atmosphere, assimilating carbon dioxide on the one hand and releasing oxygen and water vapour on the other hand. The biosphere plays a major role in the carbon cycle. Although the components of the climate system have different chemical compositions and physical properties and their effect on the Earth's climate formation is different, there is a constant exchange of matter and energy going on among them. Any changes in any climate system component – irrespective of whether they are caused by natural or by human activity – can affect the other components of the system and result in climate change. Climate change can occur as a result of both natural processes and human activity. The latter first of all affects the composition of the atmosphere as well as the ways of land use.

4.2.2 HYDROLOGICAL CYCLE

Water is a renewable natural resource that sustains life on the Earth. Water is the most important chemical substance for the existence of human beings and all other species.

Natural waters are categorised according to their overall level of mineralization (the proportion of mineral substances dissolved in water). The main types of water are the following: freshwater (its overall concentration of salts is up to 1 g/l), brackish water (1–10 g/l), saline water (10–35 g/l) and brine (35 g/l and more).

Freshwater makes a small part of all the water on the Earth – approximately 3%. Two thirds of freshwater is accumulated as ice and snow, one third is underground water, while rivers and lakes make just a very small portion of the total volume of freshwater on the Earth (Figure 4.20, Table 4.4).

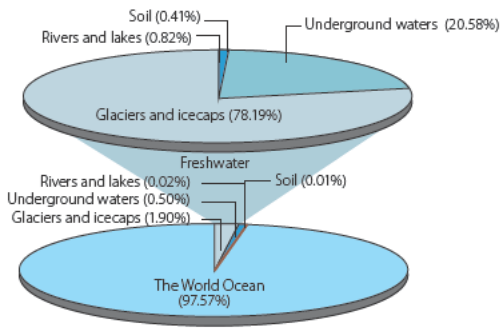

Figure 4.20. **Distribution of water resources on the Earth**

Table 4.4. **Water resources on the Earth**

Types of water	Volume, km³
The World Ocean	1 338 000 000
Groundwaters	23 900 000
incl. freshwaters	10 530 000
Moisture in the soil	16 500
Glaciers, icecaps, permanent snow	24 064 100
Freshwater lakes	91 000
Saline lakes	85 400
Rivers	2120
Water in the atmosphere	12 900

The hydrological cycle (Figure 4.21) represents the movement of water on the Earth. Five main sources of water are involved in the hydrological cycle: water in the World Ocean, the atmosphere, glaciers and icecaps, underground and freshwater sources. The hydrological cycle describes the relations among these main sources of water and shows the vital role of the processes of atmospheric

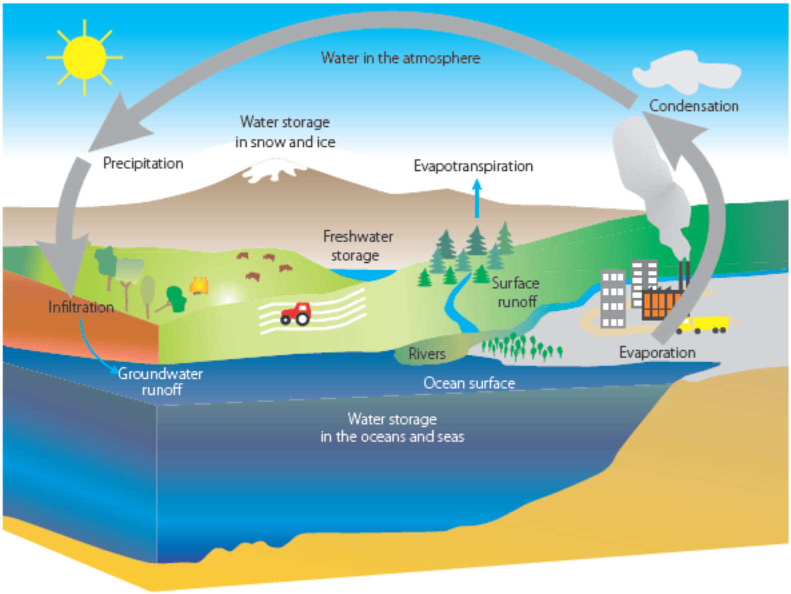

Figure 4.21. **Hydrological cycle**

evaporation and precipitation fallout for the planet's water balance. The Sun is the main source of energy, driving the global hydrological cycle as it warms the water masses on the Earth's surface, making them evaporate or sublimate: not only from the surfaces of seas and oceans but also from the soil, glaciers, icecaps and the Earth's snow cover. This water evaporates into the atmosphere, where the vapour cools down and condensates. The dust particles in the atmosphere become the condensation centres for water vapours. The particles formed from the impact of cosmic radiation can also cause water condensation. The condensation processes take place at the upper layers of the atmosphere as well as on the Earth's surface. Precipitation occurs in a variety of forms, including rain, snow and hail. When water evaporates in the atmosphere, it becomes subject to the atmospheric diffusion. Consequently, the water vapour, which is mostly formed above the surface of seas and oceans, can be carried to great distances along with the movement of air masses, until it finally falls out on the continents as well.

Atmospheric precipitation can form a snow cover, it can be assimilated by plants or absorbed in the soil, replenishing the underground water resources. Furthermore, one of the most important water movements is its accumulation in river basins and subsequent surface runoff with rivers. With this, the water cycle is complete. Water can stay in each of the abovementioned environments for a different period of time (water residence time). The duration of a water turnover period depends on the mass of water in the respective environment (for example, oceans contain most of the water mass that undergoes the hydrological cycle) and on the intensity of processes that the water is subject to in the respective environment. The duration of the period in which water completes a full cycle in the oceans and seas is estimated as approximately 4 000 years; in lakes – approximately 10 years; for underground waters – from a few weeks to 10 000 years; for glaciers – from 100 to 10 000 years; in the atmosphere – approximately 10 days.

An essential factor for the hydrological cycle is the character of the largest water mass – the World Ocean, particularly its water currents. Currents on the ocean surface are generated by the interaction of wind, the Earth's rotation (the Coriolis force) and thermal factors. The warm water surface currents move a huge amount of heat energy from the tropical zones of the World Ocean to the temperate and arid climatic zones. In effect, the climate becomes much milder in vast areas of dry land. The cold currents, in turn, chill the tropical regions.

Water is one of the substances most consumed by human beings – large amounts of water are used for household needs, production, especially in agriculture (Figure 4.22). Humans mostly use high-quality freshwater, but at the same time wastewater is produced as a by-product of human activities, and quite often it does not receive sufficient treatment. The highest water consumption rates in the world are in the following sectors: agriculture (69%), industry (23%), households and services (approx. 8%). Industrial consumption of water is mostly related to various technological processes. Considering the relatively large volumes of water required for industrial production, in many cases the availability of freshwater is the decisive factor for the placement of plants and factories at certain locations. Today, when many other economic factors also come to the

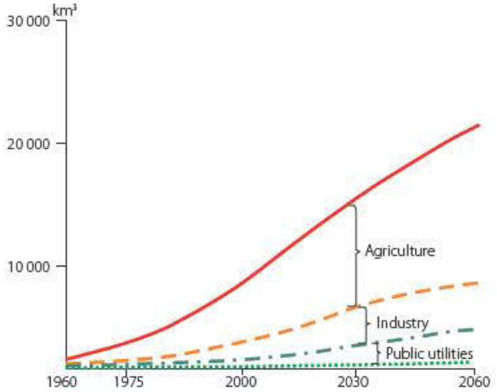

Figure 4.22. **Water consumption variability tendencies and forecasts in the main sectors**

fore, most industrial technologies reuse the water for production after proper treatment.

Households consume large amounts of water. It is generally known that a human being, depending on his or her weight and outdoor temperature, for personal consumption needs approx. 40 grams of water per weight kilogram daily. Calculations show that one city dweller in the temperate zone consumes approximately 200–220 litres of water daily. Even more, over 320 litres of water are consumed daily in order to satisfy all the needs of one person, including production of food and commodities and provision of services.

Due to the relatively high precipitation and low evaporation rates, sufficient freshwater supplies are available for people and economies in the Baltic Sea Region. Presently, because of the low population density, the availability of water is not an issue and does not in any way affect the quality of life and economy in the northern part of the Baltic Sea basin. At the same time, in Germany and Poland, the availability of water resources has already become the limiting factor for further development of agriculture. Poland, for example, now uses 18% of the total water runoff in rivers, which is considered to be the maximum amount of water that can be consumed without affecting the water ecosystems. The situation is even more critical in the Mediterranean countries. They do not have enough freshwater, and this deficit is substantially delimiting the development of traditional forms of agriculture. Therefore, these countries are reorienting their national economies to the service sector (mainly tourism)

Agriculture is the industry that consumes the largest amount of water. While in the developed countries this consumption does not exceed 20–25%, in the developing countries up to 80% of water or even more is used for irrigation.

The Baltic Sea is an inland sea. Therefore, its water exchange is limited, it has a relatively low salinity level, it is not deep, it has a large catchment basin and significant freshwater influence. Together these factors make the Baltic Sea particularly sensitive to pollution, for the harmful substances discharged into the sea remain there for relatively long periods of time, contaminate water and living organisms, form sediments.

Even though the water masses involved in the hydrological cycle are huge, human activity affects the flows of water. At present, the amount of water that humans consume is comparable to a substantial part of the runoff of the world's rivers. However, the consumption is expected to exceed the resources of natural water flows in the near future.

Figure 4.23. **Aral Sea in 2008**
The black line shows the area of the Aral Sea in 1960.

An illustration of the negative impact of human activity on water resource depletion is the desiccation of the Aral Sea (Figure 4.23) caused by the intensive use of water from the major inflow rivers for irrigation (mostly for cotton cultivation). In 1960 the area of the Aral Sea was 67 000 square kilometres, while by 2008 it has shrunk to 17 000 square kilometres. The prognosis for the future of the Aral Sea is bleak: it may completely disappear in a foreseeable future, leaving a vast salt desert in its stead.

4.2.3 CARBON CYCLE

Carbon is the most important element for living organisms. With an average concentration of 350 mg/kg, carbon is not so pervading on the Earth; yet, it has an exceptional role in the cycling of elements. In the carbon cycle (biogeochemical cycle), one carbon compound is converted into others, and this process occurs in the atmosphere, hydrosphere, lithosphere and biosphere. In the lithosphere, carbon is stored in carbonate sedimentary rocks (limestone – $CaCO_3$, dolomite – $CaMg(CO_3)_2$ and others), and it also forms fossil fuel sediments (coal, oil, bituminous shale). Furthermore, large amounts of carbon compounds (carbon dioxide and methane) are stored in the permafrost zone, and they also form waterbody sediments and the decomposition products of organic substances in the soil.

In the hydrosphere, carbon compounds are present in living organic matter, carbonate ions and hydrogen carbonate ions in the form of dissolved carbon dioxide and methane. The atmosphere contains approximately 760 billion tons of carbon in the form of such compounds as carbon (II) oxide (CO), carbon (IV) oxide (CO_2) and methane (CH_4). Carbon compounds have different cycling periods at each stage of the cycle: in the atmosphere it is quite short – 3 years, in the soil – 25 years, in the oceans – 350 years, while the cycling period of carbonate rocks is more than hundreds of millions of years.

The living, photosynthetic organisms of the biosphere that continuously absorb CO_2 from the atmosphere, forming organic compounds, have vital functions in the carbon cycle. CO_2 goes through a complete cycle in the atmosphere in a relatively short period of time – approximately four and a half years.

Not all dead organisms and plants decompose immediately. A small fraction of them reach the deep parts of inland waterbodies, seas and oceans and form sediments there. The organic material that decomposes slowly becomes part of the sedimentary rock formation process and can return into the atmosphere in a natural way (for example, in the process of erosion).

Carbon dioxide from the atmosphere can enter waterbodies and dissolve there. In water, algae absorb carbon dioxide in much the same way as terrestrial plants do. In addition, some aquatic life forms extract calcium and carbon dioxide from water to build calcium carbonate shells. When these organisms die off, their shells are deposited on the bottom of waterbodies, forming limestone. In this way, part of carbon becomes involved in the sedimentary rock cycle, which will possibly bring it as limestone up to the Earth's surface again in the future. After that, the erosion process and weathering will decompose this limestone, and dissolved it will return into the ocean, and then, from the ocean, carbon will be released back into the atmosphere.

The increase in carbon dioxide and methane emissions can become a factor that will adversely affect the environmental processes and carbon cycle. Estimates show that the amount of anthropogenic emissions of CO_2 have been increasing on average for 2.5% per year within the last hundred years

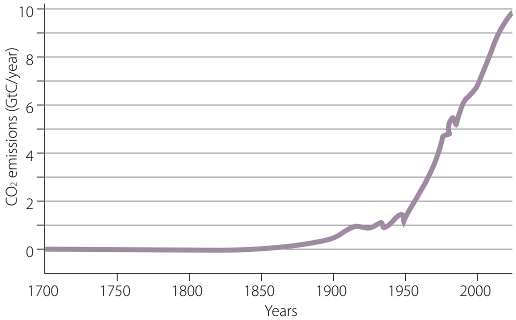

Figure 4.24. **Changes in carbon dioxide emission amounts over the last centuries**

(Figure 4.24). Shrinking of forest areas also affects the concentration of CO_2 in the air. The current amount of CO_2 anthropogenic emissions is 9.0 ± 0.5 GtC per year; however, depending on the World's population growth scenario, it is estimated that these emissions can increase up to 35.8 GtC per year by 2100.

Human economic activity changes the carbon cycle and enhances the release of the carbon compounds accumulated in the lithosphere into the atmosphere. Fossil fuel combustion and deforestation make CO_2 pass from the lithosphere and biosphere into the atmosphere much faster than it would occur in a natural way. At the same time, the return of CO_2 from the atmosphere in a natural way takes place much slower than when it is aided by human economic activity. In effect, the amount of CO_2 in the atmosphere irreversibly increases.

Methane plays a substantial role in the carbon cycle. Methane absorbs infrared radiation more effectively than CO_2; therefore, its increase boosts the greenhouse effect, even if methane's concentration in the atmosphere is lower than that of CO_2. Since the 60s of the last century, when the atmospheric methane concentration measurements began, its total concentration has increased for an average of 1% per year. Part of methane is generated as a result of rice and livestock farming, especially from cattle. Historically methane concentration changes, like those of CO_2, have been related to the climate changes during the ice ages and interglacial periods. However, in recent years research shows that geological processes can also be a significant source of methane. For example, such natural phenomenon as mud volcanoes is deemed to originate almost 10% of the atmospheric methane.

The concentration of carbon dioxide in the atmosphere has increased from 280 parts per million in the pre-industrial period to 385 parts per million in 2008 (Figure 4.24). Probing the composition of the air trapped in the continental glaciers has proved that the concentration of CO_2 today is significantly higher than it had been during the last

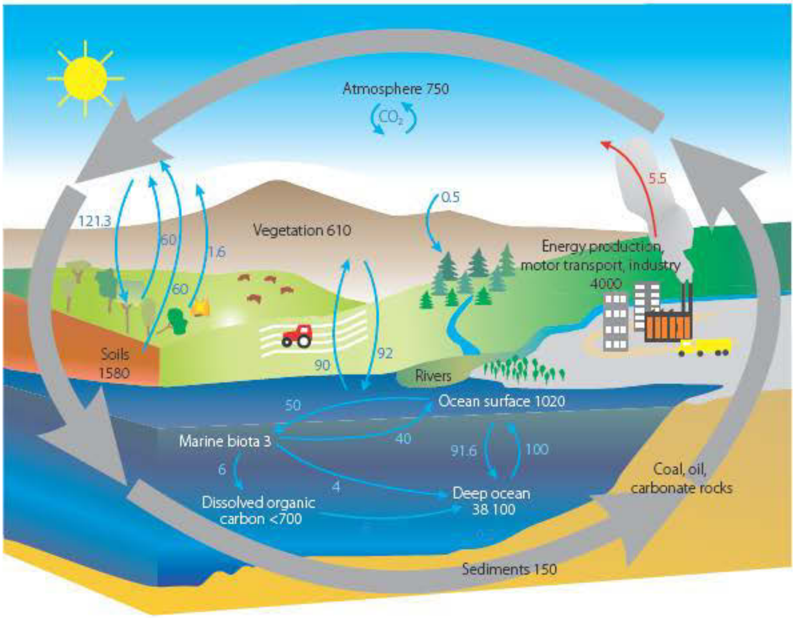

Figure 4.25. **Carbon cycle**
Amounts stated in PgC, flows – in PgC/y.

650 000 years (180–300 ppm). Human activity is the main factor contributing to the increase of CO_2 concentration in the atmosphere and affecting the whole carbon cycle.

4.2.4 NITROGEN BIOGEOCHEMICAL CYCLE

Nitrogen makes 76% of the atmosphere's mass, and it is one of the most important chemical elements in proteins and DNA; therefore, it is one of the elements necessary for the existence of living organisms. At the same time, the concentration of nitrogen compounds in the lithosphere and hydrosphere is quite low. Unlike oxygen, nitrogen is inert, and most living organisms cannot utilise it directly, because the bonds between atoms in nitrogen molecules are very stable. Processes in the nitrogen cycle ensure the bonding of atmospheric nitrogen (N_2) into such compounds that can be utilised by living organisms.

In the environment, nitrogen compounds are found as nitrogen (I) oxide (N_2O), nitrogen (II) oxide (NO), nitrogen (IV) oxide (NO_2), nitric acid (HNO_3), ammonia (NH_3) and ammonia salts. Other nitrogen compounds either form intermediate products in various reactions, or are unstable and decompose fast. Nitrogen compounds are interrelated, and they can be converted into one another (Figure 4.26). Reactions caused by micro-organisms play an important part in the nitrogen cycle, for these micro-organisms in the hydrosphere and lithosphere are involved in the conversion of most nitrogen compounds. In other words, they catalyse the synthesis of nitrogen compounds necessary for the existence of the biosphere's living organisms. It should be noted that only a small part of nitrogen compounds become involved in the nitrogen cycle, because nitrogen reacts with oxygen in the atmosphere, but these reactions require high energy that is generated only during the lightning discharges or is found at the top layers of the atmosphere.

The main process in the nitrogen cycle is its fixation (assimilation) – the reactions through which micro-organisms fix the atmospheric nitrogen, converting it into ammonium. Bacteria and blue-green algae are able to fix nitrogen. Micro-organisms produce 1–5 kg N/ha, nitrogen fixing bacteria – 100–300 kg N/ha.

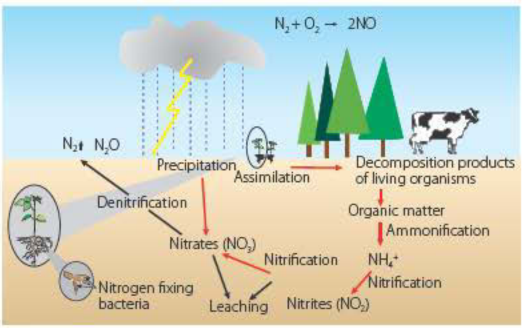

Figure 4.26. **Natural processes of nitrogen compounds in the environment**

Chemical reactions in the atmosphere and the activity of living organisms ensure nitrogen fixation (its conversion into chemically reactive and biologically available compounds).

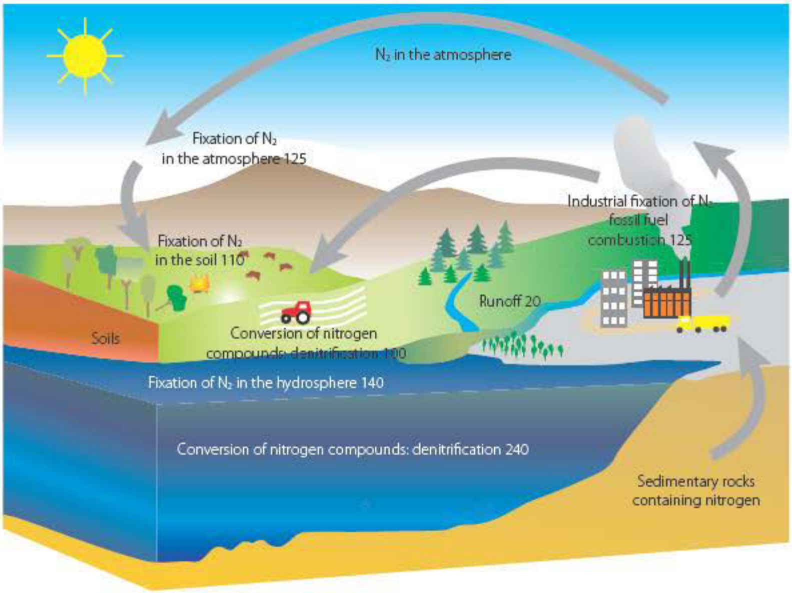

Figure 4.27. **Nitrogen biogeochemical cycle** Flows stated in PgC/year.

In the process of assimilation, nitrogen organic compounds are produced. They decompose and, in turn, produce ammonia or ammonium salts (ammonification). The latter are further converted into nitrates and nitrites (nitrification). Nitrification can also be considered to be the oxidation of organic and inorganic nitrogen compounds.

The final stage of the nitrogen cycle is its return to the atmosphere by means of the production of N_2 (denitrification). This process takes place in the soil. N_2O can also be produced in the process of denitrification.

Nitrogen (I) oxide (N_2O) is naturally found in the atmosphere as a product of various biological and photochemical transformations. The anthropogenic emission amounts of N_2O are small; therefore, nitrogen (I) oxide pollution – also taking into account its low toxicity – is not hazardous to living organisms. This substance does not have any odour or taste and is chemically inert. N_2O enters into the atmosphere mostly by means of denitrification processes, when the nitrogen compounds used in agriculture leach into the soil and waters, where they are reduced back into inert nitrogen gas. The amount of N_2O emissions is 100 million tons per year, and its overall amount in the atmosphere is 2000 million tons. The nitrogen cycle completes in 120 years, but the concentration of N_2O in the atmosphere has been increasing by 0.3% annually within the last hundred of years. Hence N_2O is considered one of the main greenhouse gases.

As with other key chemical elements, nitrogen cycling is graphically represented by its biogeochemical cycle (Figure 4.27).

In 1914, German chemists Fritz Haber and Carl Bosch developed an industrial method for the manufacture of ammonia from atmospheric nitrogen, commencing the development of a large-scale industrial production of agricultural inorganic fertilisers. Today the total amount of approximately 100 million tons of nitrogen fertiliser is produced every year, which roughly corresponds to the amount of nitrogen fixed by micro-organisms (100–200 million tons per year) (Figure 4.28). Thus, the amount of nitrogen produced by human activity is already comparable to the amount nitrogen fixed in the natural processes of the nitrogen biogeochemical cycle, and it is estimated that the former will exceed the latter in the near future.

Considering the large production amounts of nitrogen compounds, they can adversely affect not only environmental processes but also human and animal health.

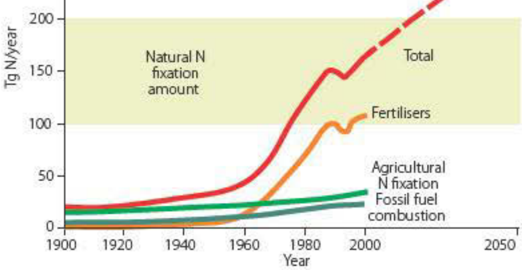

Figure 4.28. **Nitrogen fixation amounts in nature and by human activity on a global scale**

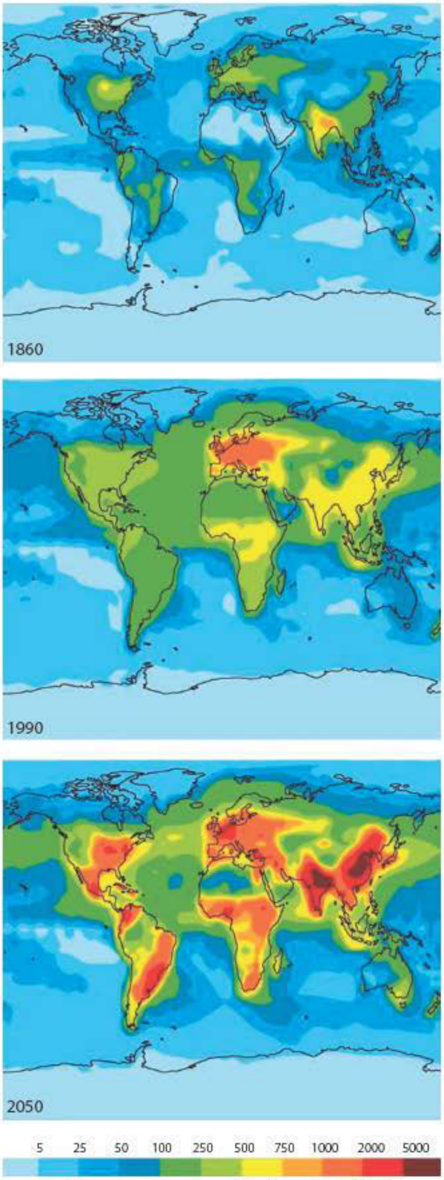

Figure 4.29. **Nitrogen compound fallout (mg N /m²/year) with atmospheric precipitation – changes in the amounts during the last centuries and a forecast**

Nitrogen compounds are among the basic nutrients needed for plant growth, and they are used in agriculture for soil fertilisation in order to promote the growth and yield capacity of cultivable plants. Unfortunately, a significant part of the nitrogen compounds used for fertilisation leaches into surface waters and groundwaters and, along with surface runoff – further into the seas and oceans. Nitrogen compounds also fall out with atmospheric precipitation (Figure 4.29). In effect, both water and soil become oversaturated, causing eutrophication.

In present-day Europe, the emission of nitrogen compounds has become one of the most hazardous environmental pollution factors. It is an urgent problem for the Baltic Sea Region countries, where the concentration of nitrogen compounds initiates many harmful processes, including the pollution in the Baltic Sea. Thus, the issues related to the flow of nitrogen compounds, their utilisation amounts and emission reduction become burning issues on the agenda.

4.2.5 PHOSPHORUS BIOGEOCHEMICAL CYCLE

The environmental processes and the quality of the environment depend not only on macro-elements but also on substances that occur only in very small amounts in nature. Examples of such substances include phosphorus, many metals and their compounds and other elements, such as iodine, bromine, arsenic, selenium and others. Phosphorus is particularly important for sustaining life processes in living organisms, as it is a component in the genetic information carrier molecules – deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), in many proteins as well as in the molecules responsible for cellular energy transport – adenosine triphosphate (ATP) and adenosine diphosphate (ADP). The phosphorus cycle (Figure 4.30) has a pivotal significance because phosphorus is often a limiting factor for the development of living organisms, i.e. the amount of phosphorus available for the development of organisms determines the intensity of their growth.

The phosphorus cycle differs from the cycles of other elements (carbon, nitrogen, sulphur and others) because it does not contain substances in gas phase as most phosphate compounds are non-volatile or solid. The amount of phosphorus compounds in the atmosphere is small, and they are usually extracted from the lithosphere's sedimentary rocks in the form of various apatites (mostly in the form of calcium phosphates) that have formed in shallow seas tens of millions years ago. When herbivores consume plants, phosphates enter the bodies of these animals. With their excrements or decay after death phosphates are returned to the soil and waters. Part of phosphorus compounds are bound as stable chemical compounds in the soil and marine sediments, forming phosphate sedimentary rocks. The natural cycling of phosphorus compounds is not intense; therefore, sedimentary rocks that contain phosphorus are concentrated in just a few regions of the world, and their weathering takes place slowly.

Phosphorus compounds are predominantly (~90%) used as inorganic fertilisers in agriculture. The estimated global utilisation of fertilisers is 15 million tons per year. The second major area of

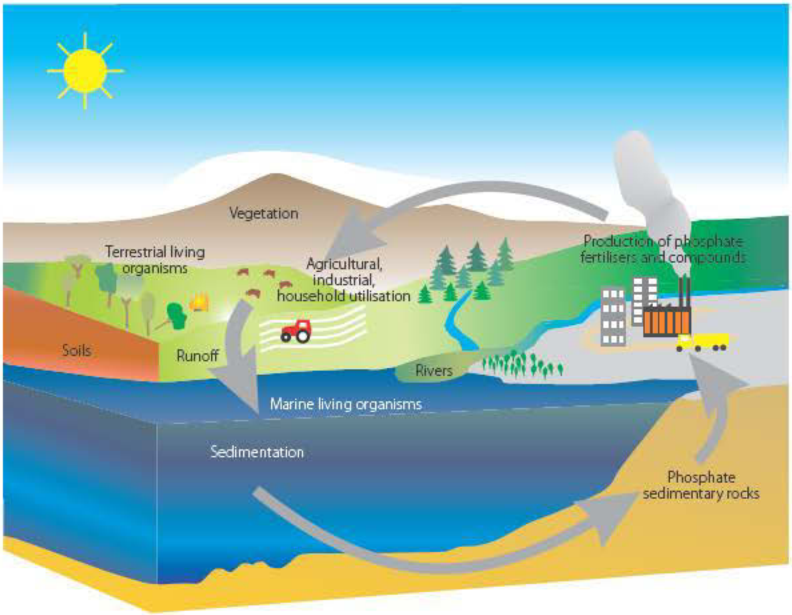

Figure 4.30. **Phosphorus biogeochemical cycle**

phosphorus compound utilisation is in detergents. Phosphorus compounds are added to detergents as water-softeners. Just like after the decomposition of living organic matter, virtually all areas of use of phosphorus compounds end up with their runoff into the hydrosphere after utilisation, intensifying the processes of eutrophication in waterbodies. In any case, human activity has cardinally changed the nature of phosphorus flow in its biogeochemical cycle.

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CASE STUDY: UNITED STATES

ECONOMICS AND LIMITS TO GROWTH: WHAT IS SUSTAINABLE?

Dennis Meadows
New Hampshire University

40 years ago I worked with others at the Massachusetts Institute of Technology to build a simple computer model that could offer insights into the impacts of limits to growth. We did not expect the model to be predictive – only that the scenarios would provide rough boundaries regarding what might happen in the future.

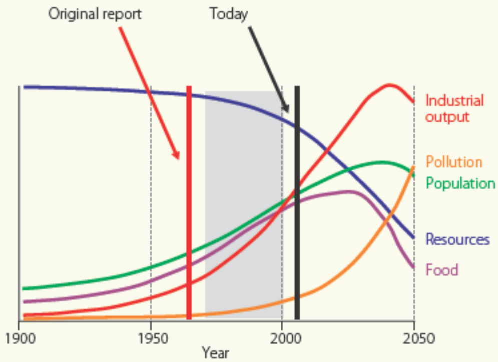


Figure. **Scenarios of possible changes of industrial production, pollution and resource consumption**[1]

Let us look at our reference scenario (Figure). The red line shows where we were when the model was first developed. The area until the black line illustrating the situation today represents the time period that might be changed by the policies we implement today.

In 1972, we expected another 40 to 80 years of growth in the various scenarios. The major difference I see when looking at the situation now is that things seem to be developing more rapidly than we expected. While some of the scenarios we looked at ended in orderly decline, most of the scenarios we modelled ended in collapse. Many people assume that technology may change things, but it does not prevent the end of growth or the decline. When we put together models using phenomenally optimistic assumptions, it just moved the decline date back a few years. Social changes are essential for a better outcome.

A key factor to understand is that what are normally considered problems today – for example, climate change, energy shortages and soil erosion – are not really problems. Instead, they are forces that will inevitably grow until they fully counteract our efforts to sustain continuous physical growth in a finite world. The problem is our addiction to growth.

In some ways, the situation is like if you have a friend who has cancer, and because of the cancer he has a headache. It is not nice to have a headache, so you give your friend pain relievers, but when the headache disappears you do not imagine you have cured the problem. The problem is cancer, and until you deal with the problem, there will be one or another manifestation. If you eliminate the headache, pain will appear in some other place.

We talk a lot about climate change today. I predict that in three or four years, climate change will not be the main topic. We will be talking about energy scarcity or food shortages or declining water supplies. This will occur not because we will have dealt with climate, but because they are of a large family of pressures which are going to mount until, finally, physical growth stops. Plus, politicians and the media get bored of a topic after they have focused on it for a relatively short time.

In the early days, we had only models to tell us that we were expanding beyond the planet's carrying capacity. Now we can look at the newspapers and get confirmation of the fact. It was astonishing to me in 1972 that people could believe that there are no limits. Initially, we assumed that people were just uninformed. If we could manage to give them the facts, they would change their opinion. Nothing I have seen in 40 years gives me support for that opinion. People who want growth will always find some reason to believe it is possible. There are an infinite number of rationalisations, so you will never manage to convince them.

Let me discuss some key assumptions in our model. There are three different ways we use space – one for extraction; one for activity; and one for disposing of wastes. The first and third of these have costs associated with them. When you have 100% of a given resource still available, you can start to use it up, and you do not perceive any significant cost increase. It is only when you get past maybe 50% or 60% depletion that you start to see a radical rise in the cost of extraction. There is an analogous curve for dumps where we dispose of our wastes – in the air, the earth, the water. As the fraction of the sink is occupied to a greater and greater extent, the cost of disposal goes up rapidly.

Industrial growth occurs because more capital gives you more output; more output permits more investment; and more investment lets you build up your capital stock. This is a positive feedback loop. As long as investment exceeds

[1] Adapted from Figure 4–12, page 172 of Meadows, D. H. *et al*, (2004) Limits to Growth. The 30-Year Update, White River Junction, VT, USA: Chelsea Green Publishing Company.

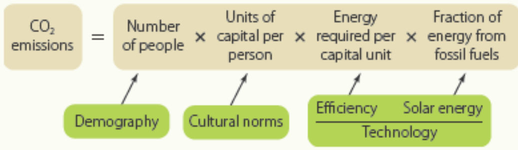
depreciation, you have growth – exponential growth, and rapid rates of increase. People get richer. If society is equitable, many people get richer.

However, as we start to draw down our resources and fill up our sinks, ever more of the capital has to be drawn off to provide for extraction and disposal; less is available for consumption. Eventually, you get to the point where you cannot sustain production around the industrial capital loop sufficiently to continue growth.

In our world model, it is the failure to produce enough output for capital reinvestment that tips the world's economy over into decline. The real economy is now moving into that period.

Some people now looking at our curves would imagine that the periods of greatest stress would be after the peak – once the declines have set in. I do not think that is true. Right now, around the globe, we (i.e., corporate, political, and religious leaders) are working as hard as we can to sustain growth. For growth to stop, negative pressures have to mount until they are strong enough to offset our positive pressures. That is the period that we are in now. So I anticipate the big stresses are the ones we are going to encounter over the next couple of decades.

Let me give one very quick example. CO_2 concentration in the atmosphere has been increasing at accelerating speed since our book came out. Why? Everyone in the world wants greenhouse gases to go down, but, by and large, they keep going up. The CO_2 emissions are a function of four factors: 1) the number of people; 2) the number of units of capital per person, which is a surrogate for living standards; 3) the amount of energy required to build and operate that capital; 4) the fraction of the energy that comes from fossil sources.



So far, our concern about climate change has manifested itself through efforts to improve efficiency and to implement alternative energy sources – the so-called technology options. But as long as we ignore demographic and cultural issues, the growth in the first two factors will continue to offset all of the improvement we make in Factors 3 and 4. Thus, until we can understand how to begin reducing the growth in the first two factors, climate change will continue.

5 ENVIRONMENTAL POLLUTION

5.1 ENVIRONMENTAL POLLUTION AND ENVIRONMENT QUALITY DEGRADATION

Life on the Earth is fragile, and every living being can continue to live only in the environmental conditions optimal for its life. Such factors as the rise or fall of temperature above or below the optimum, intensive flow of electromagnetic radiation (ionising radiation) or the action of chemical substances can annihilate living organisms and – in a wider context – life itself. Living organisms can also perish due to depletion of needed nutrients. Likewise, the impact of natural hazards and calamities can create unfavourable conditions for living organisms. Many times during the existence of the Earth, the number of species was reduced even by more than half as a result of various disasters. Moreover, living beings themselves can cause their living environment changes that have no less dramatic consequences.

The past, present and potential global threat of environmental pollution and degradation can to a great extent be considered one of the main factors that has an effect on the formation of society's environmental consciousness.

Pollutant is any substance released into the environment as a result of human activity or natural processes that has an adverse impact on living organisms. Environmental degradation means that the environment becomes unusable for its designed purposes or that the development of living organisms and their communities in the environment is impeded. Environmental pollution and degradation can be caused by chemical substances, physical factors or the development of undesirable living organisms (biological factors). Different substances or factors have different effects. Any chemical, biological or physical factor is called toxic if it causes an adverse biological reaction. All toxic substances are hazardous, but not all hazardous substances are toxic. Toxic substances can be either naturally occurring, or they can be human-made (xenobiotic) – produced by means of synthesis or as by-products in the process of production of other substances.

Environmental pollution is quite often associated with chemical pollution, and we will deal with that in a bit more detailed manner below. Pollution of the environment by chemical substances can be classified depending on the properties and structure of these substances. Environmental contamination with metals or their compounds (Cu, Pb, Co, Hg and others) and toxic trace elements (F, B, As, Se and others) can be marked out first. Organic pollutants, such as pesticides, can have a negative impact on the natural environment. Organic substances can be formed as a result of the decomposition of household products, pest control with pesticides and herbicides as well as industrial pollution. The environmental pollution threat increases if the organic substances that have been released into the environment are persistent (Persistent Organic Pollutants – POP), i.e., if they remain there for a long period of time (even several decades in the soil). Such substances as pesticide DDT, dioxins, polychlorinated biphenyls and others belong to POPs. More or less chemically inert compounds in a state of fine particles can also contaminate the environment. Particles may form dust and aerosols in the air and suspensions in water.

All kinds of chemical compounds are increasingly released into the environment (Figure 5.1). To date, there are approximately 10 million known chemical substances, and a large part of them do not exist in the natural environment. There are approximately 120 000 industrially produced chemical compounds that are widely used and 10 000 substances produced in the amounts exceeding 500 kg per year. Moreover, the number of types of industrially produced substances is increasing from approximately one to three thousand new ones every year.

Factors that cause environmental degradation can be classified depending on their nature. The quality of the environment can deteriorate due to physical factors, for example electromagnetic radiation, the influence of which can be quite different depending on the wavelength. Short-wavelength electromagnetic radiation (γ rays) actively affects living organisms, and its sources are radioactive elements or reactions in atomic nuclei. UV radiation, which has longer wavelength, may have a significant effect, for example, on the human skin or growth of plankton in surface waters. Noise pollution, i.e. high intensity noise

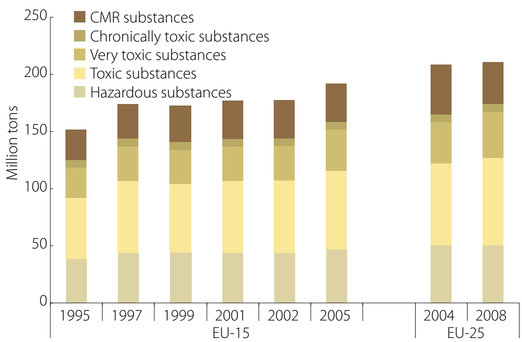


Figure 5.1. **Production amounts of hazardous chemicals in the European Union Member States**

CMR – carcinogenic (causing cancer), mutagenic (causing mutation) and reprotoxic (toxic to reproduction). The influence of CMR substances can increase the risk of formation of malignant tumours and mutations as well as cause reproductive system problems, affecting the offspring.

in the living or working environment, can be classified among physical environmental pollution factors. Increased amounts of heat (flow of energy) released into the environment may have quite a many-sided negative impact (thermal pollution). For example, the discharge of industrial cooling waters or warm water from thermal power plants into the environment has adverse consequences, affecting the growth of aquatic organisms. Last but not least, living organisms can also cause serious environmental pollution. They can be infectious agents, parasites as well as the living organisms whose metabolism or decay products are harmful to humans or other living organisms.

5.2 AIR, WATER AND SOIL POLLUTION

5.2.1 AIR POLLUTION

Protection of air and water from pollution is a matter of great importance. Air is one of the essential factors making life on the Earth possible. Depending on the body constitution, a human being consumes 6–13 cubic metres of air daily or even more in cases of heavy physical loads. Consequently, trace amounts of harmful substances in the air may have an adverse effect on the human health.

Pollutants spread rapidly and to far distances in the atmosphere; therefore, the problem of atmospheric pollution should be dealt with on a global scale, and international cooperation is vital in this regard. Air cleanness in dwelling premises and working environment is a special air pollution problem because today people become increasingly exposed to hazardous and toxic substances at home or work. The air pollution problem has been accompanying us already since the times the ancient people discovered fire. From today's perspective, there is no doubt that the ancient people's health or even life were endangered by high concentrations of such pollutants as carbon monoxide (CO) released from incompletely burnt firewood and other compounds emitted during burning. Furthermore, the ancient Romans already knew about lead and mercury poisoning in mines.

Air pollution hazard has sharply increased since the development of Industrial Revolution and the mining industry. Industrial development in the last century came into view first of all with smoke tails from factory chimneys (Figure 5.2). Some production processes, for example soda production, entailed the release of a large number of aggressive and toxic substances into the environment. The first victims of air pollution were factory workers and people living near factories. In addition, many workers became industrial accident victims. Since labour safety was among the issues actively dealt with concurrently with other workers' social protection issues, a certain progress was achieved in this field in the course of time. Yet the overall industrial development and emission of hazardous substances reached such levels that labour protection at workplaces alone could not safeguard them against health damage. The London Great Smog caused by adverse weather conditions in 1952 lasted for several weeks and took its toll: about 4 000 people had died prematurely and 100 000 more were made ill due to the smog's effects. Around this time, photochemical smog began to occur in the USA (Los Angeles) and Japan. In the 1970s the attention turned to precipitation pH changes, but at the beginning of the 1980s – to stratospheric ozone layer changes.

Although a range of air environmental protection measures are being implemented today, it is estimated that the losses incurred by the effects of polluted air on the human health – medical expenses, loss of working capacity – still amount to hundreds of millions of euros per year just in the European Union countries.

Industrial pollution mostly occurs in the industrially developed regions of North America, Europe and Asia. The main sources of anthropogenic pollution that also affect the quality of air are energy production, heating, transport, industrial production and agriculture, whereas the main air pollutants are a) sulphur compounds; b) nitrogen compounds; c) carbon compounds; d) halogenated organic substances; e) metals and their compounds; f) aerosols and dust; g) radioactive elements.

Both industrial processes and heating contributes to air pollution. Incineration of household waste pollutes air significantly. From traditional fuels,

Figure 5.2 Oil refinery plant (Italy)

Crude oil, coal processing and petrochemical refinery plants are among the major sources of environmental air pollution.

coal is the most polluting. Another considerable pollution source group is motor transport – as motor exhaust gases contain various harmful substances. The exhaust gas composition may differ depending on driving habits, engine operating conditions, fuel supply and quality. In the process of incomplete combustion of fuel hydrocarbons, they are transformed into carcinogenic substances – polyaromatic hydrocarbons. According to the total emission amount of some pollutants, motor transport has become a major pollution source in today's cities.

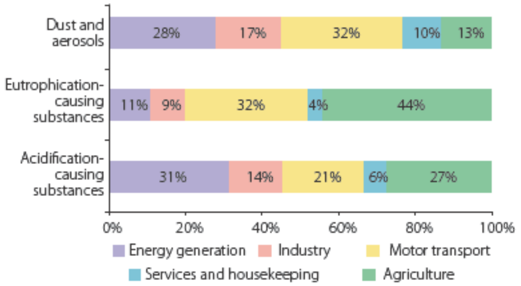


Figure 5.3. **Main air environmental pollutants and their sources**

Many production processes are characterised by the emission of specific pollutants. Nowadays countless very harmful substances are used in both industry and housekeeping, and they can enter the air of a work area or the atmosphere in the form of gas, vapour, aerosols or dust. To protect both workers and residents, several criteria (limit value) have been established in order to limit the maximum permissible concentrations of various harmful substances in the air.

Air quality measurements for air pollution analysis are usually made in ambient air. However, air pollution in the human living environment – dwelling premises and workplaces – may affect the human health considerably more. All kinds of local sources – such as kitchens, stoves, furniture, polymers, painted surfaces, domestic animals – can cause serious indoor air pollution. Room ventilation also affects the air pollution level. Ventilation should be balanced with the need to maintain the optimum temperature in dwelling premises.

5.2.2 WATER POLLUTION

Water is considered to be polluted if certain substances or physical factors affect the quality of water and functioning of ecosystems and, as a result, the use of water for particular purposes is restricted.

Water pollution is classified into two types:

- point source pollution;
- non-point source pollution.

Typical water pollution point sources are

- pipage for draining treated or untreated urban or factory wastewater into reservoirs, rivers, lakes and seas;
- agricultural wastewater;
- oil and oil product pipelines.

Non-point water pollution sources are dissipated, and it is much more difficult to identify and assess them. Typical non-point pollution sources are: surface runoff from agricultural fields and building areas, rainwater runoff from urban territories, runoff from abandoned and active mining sites and quarries, fallout of substances with precipitation, drainage from landfills. Non-point source water pollution is more hazardous than point source pollution.

The main aquatic environment pollutants are nutrients (nitrogen and phosphorus compounds), surfactants, metals and their compunds, and toxic trace elements.

Pollution of natural waters with crude oil, oil products and other persistent substances is particularly hazardous. Persistent organic pollutants (POPs) have a special place among these hazardous substances. POPs can be divided into 3 groups according to their usage type and origination: a) plant protection products – pesticides (aldrin, DDT, dieldrin, endrin, hexachlorbenzene, heptachlor, chlordane, mirex, toxaphen); b) chemical products for industrial use (hexachlorbenzene, polychlorinated biphenyls); c) y-products (polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, polyaromatic hydrocarbons) of production processes.

5.2.3 SOIL POLLUTION AND DEGRADATION

Pollutants quite often penetrate soil, affecting the organisms that live there. However, the effect of the presence of pollutants in soil or the lithosphere on both terrestrial animals and ecosystems is much more considerable as these substances accumulate in food chains. The main specific feature of the pollution of the lithosphere and soil is its rather limited dispersal from the sources, determined by the properties of materials that compose the soil and lithospheric rocks. At the same time, the mobile component of the soil environment – water, or, more exactly, the underground water – can disperse the pollutants quite quickly. Thus, the soil and lithosphere environmental pollution concentrates at its outlets yet can quickly dissipate, and it intensively interacts with the soil-forming rocks. Another significant specific feature of the soil environment is that the degradation processes of pollutants there take place relatively slowly because the availability of nutrients, water and oxygen indispensable to the life of micro-organisms is often quite limited. The soil environment and the

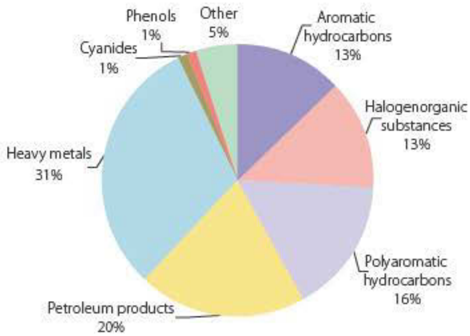


Figure 5.4. **Main groups of substances – most typical pollutants of the EU cities and soils of industrial use**

lithosphere can be contaminated by substances that have entered them directly or through atmospheric precipitation or water. Sulphur and nitrogen oxides, entering soil with atmospheric precipitation, can substantially change its composition and affect even groundwaters.

Waste dumping is a significant source of soil degradation, and it may cause soil contamination not only locally but also on a regional scale, and even in deep groundwater. Underground disposal of pollutants – for example, pumping them more than one kilometre deep into the ground – may delimit their immediate action; however, the consequences may come about in the more distant future.

Virtually all groups of major pollutants – including organic compounds (volatile organic and halogenated organic compounds, oil products, easily degradable organic substances) and inorganic compounds (radioactive elements, heavy metals, toxic trace elements) – cause the soil and lithosphere contamination.

Soil pollution with nutrients and plant protection product residues occur as a result of agricultural activity. Since the soil composition affects the plants, and people use plants for food, it may have a considerable effect on the human health. The amount of trace elements that humans ingest with food depends on the soil composition. Consider, for example, such a trace element as selenium – its shortage or excess in human food may cause specific diseases. Likewise, the content of fluorine, arsenic and boron in soil may adversely affect the human and animal health in the respective region. There is evidence that stomach cancer can be related to the soil composition factors in particular cases.

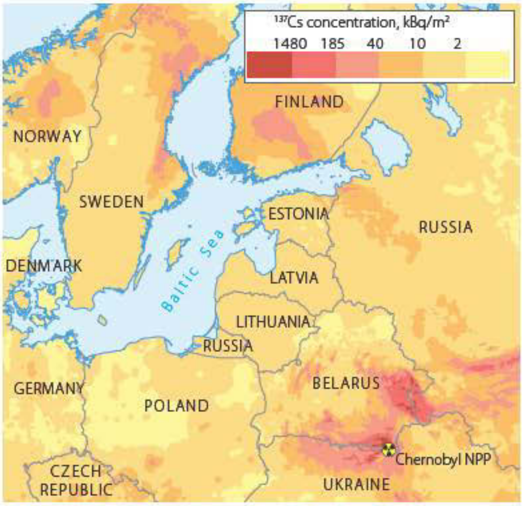


Figure 5.5. **Soil contamination in central and northern Europe after the Chernobyl nuclear disaster**

After the nuclear reactor accident, the fallout of radioactive isotopes (as seen in the ^{137}Cs example) occurred for the most part in the region of the accident site, whereas a significant part of radioactive elements was carried away with air masses and reached even the Scandinavian countries.

The soil contamination caused by human activity can be not only local; it may also affect vast territories – as it happened, for example, as a consequence of the Chernobyl nuclear disaster (Figure 5.5), and the radioactive contamination also gradually permeates the groundwaters.

5.3 GLOBAL ENVIRONMENTAL POLLUTION PROBLEMS

5.3.1 EARTH'S OZONE LAYER AND THE CONSEQUENCES OF ITS DEPLETION

Ozone (O_3) is one of the oxygen molecule forms composed of three interconnected oxygen atoms. Ozone is a pale blue gas that has a higher density than air. Ozone is formed when energy – for example, electromagnetic radiation – splits the oxygen molecules. As a chemical substance, ozone is a powerful oxidant. The presence of ozone in the atmosphere, its formation and disintegration reactions are vital for the absorption of the UV radiation from the Sun.

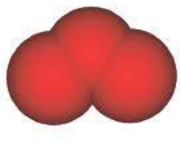


Figure 5.6. **Ozone molecule is composed of three interconnected oxygen atoms**

The ozone concentration near the Earth's surface is ~0.001% by volume, whereas in the stratosphere its concentration may be even more than 100 times higher. Nonetheless, the ozone concentration in the stratosphere is relatively low because the air in this layer of the atmosphere mostly consists of nitrogen (78%), oxygen (21%) and argon (~1%). The ozone layer (its thickness in the atmosphere under normal conditions is approximately 2.5 mm if only the dispersed ozone molecules were gathered together) protects the biosphere from the ultraviolet part of the solar radiation spectrum. The ozone concentration in the atmosphere mostly depends on the latitude, season, solar activity and other factors. The ozone layer is thickest at the height of 25–30 kilometres in equatorial regions and 15–20 kilometres around the Earth's poles (Figure 5.7).

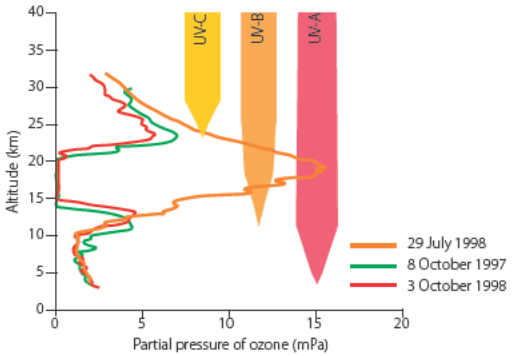


Figure 5.7. **Variability of the ozone concentration over the Antarctic and the absorption of UV radiation in the atmosphere depending on the UV radiation wavelength**

The ozone concentration in the atmosphere is expressed in gas concentration units of measure (mg/m³, µg/m³) or in a special unit of measure called the Dobson unit (DU) in honour of Gordon Miller Bourne Dobson, who was one of the first scientists studying the atmospheric ozone. One Dobson unit is a 0.01 mm thick ozone layer under standard temperature and atmospheric pressure.

In the first stage of ozone molecule synthesis, an oxygen molecule is excited by absorbing the UV radiation energy (Figure 5.8). The excited oxygen molecule splits into two oxygen atoms that are free to react with another oxygen molecule to form an ozone molecule. In this way, UV radiation is absorbed during the ozone molecule formation process, and the new ozone molecule also is capable of absorbing it. At the same time, UV radiation that has a shorter wavelength (and higher energy) splits the ozone molecules. As a consequence, the concentration of ozone is decreasing in the upper layers of the atmosphere. Thus, the Earth's ozone layer is a region in the atmosphere where the reactions of ozone molecule synthesis and

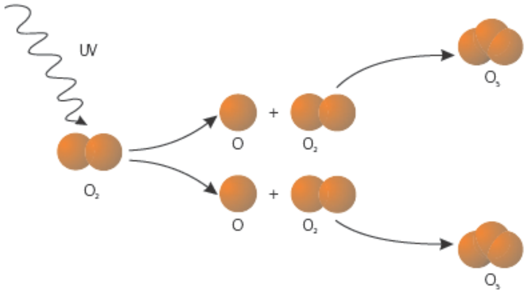


Figure 5.8. **Ozone molecule formation induced by UV radiation**

destruction are in a state of a certain equilibrium (destruction reactions prevail in other parts of the atmosphere), whereas higher concentrations of ozone are present in the stratosphere.

Several factors affect the concentration of ozone: the movement of air masses, natural, seasonal and other processes. The anthropogenic contamination of the atmosphere has a crucial role in the ozone layer destruction processes. The atmospheric contamination with halogenated hydrocarbons, produced in relatively large amounts, is considered to be particularly hazardous to the environment (Table).

Table. **Main substances that affect the ozone layer**

Substance	Usage	Lifetime in the atmosphere, years
Freons, CFC – 11 $CFCl_3$	In aerosols, refrigerant	55
CFC – 12 CF_2Cl_2	In aerosols, solvent	116
CFC – 22 $CHFCl_2$	Solvent	400
Chloroform, $CHCl_3$	Solvent, reagent	0.7
Carbon tetrachloride, CCl_4	Solvent, in firefighting	4.7
Nitrogen oxides, NO_x	In industry, energy	A couple of days
Methane, CH_4	In agriculture, industry	10.5

Halogenated hydrocarbon molecules are composed of carbon, hydrogen and halogen (F, Cl, Br, I) atoms. Those halogenated hydrocarbons whose molecules contain one or two carbon atoms and have their remaining hydrogen atoms replaced by fluorine or chlorine atoms are called freons. Considering the wide range of industrial use of these substances, their production in industrial quantities began in the 30s of the 20th century. Initially freons were used as a replacement for such hazardous and toxic gases as ammonia (NH_3) and sulphur dioxide (SO_2) in refrigerators. Since freons had low toxicity and were non-combustible, they were found useful in a wide range of other applications as well. At the end of the 1980s, the total production amount of freons reached 1.2 million tons per year.

Freons are emitted into the environment as a result of specific features of technological processes (e.g., refrigeration systems), after use of products (e.g., aerosols) and in technological processes (e.g., microchip cleaning). The lifetime of freons in the atmosphere is from 29 to 500 years. After entering the stratosphere, freons interact with UV radiation, releasing chlorine or fluorine atoms that can subsequently become involved in ozone degradation reactions.

The reduction of the ozone concentration (the ozone layer depletion) was observed for the first time over the Antarctic, where natural processes initiate an especially intensive breakdown of ozone molecules (Figure 5.9). At the beginning of the 1970s, the size of the Antarctic ozone hole was a few million square kilometres, while now it exceeds 25 million square kilometres.

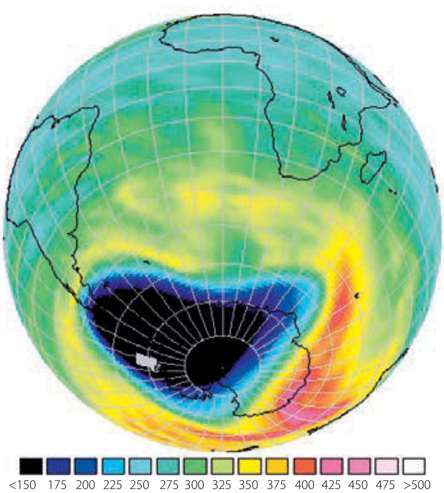


Figure 5.9. **Profile of the ozone hole over the Antarctic (ozone concentration in Dobson units)**

The decrease in the ozone concentration in the stratosphere increases the intensity of UV radiation reaching the Earth's surface. UV radiation is divided into three radiation ranges with different wavelengths according to its biological effect: UV-C (wavelength λ < 290 nm); UV-B (λ = 290–320 nm) and UV-A (λ = 320–400 nm). UV-A and UV-B radiation reaches the Earth's surface. Window glass, for example, absorbs most of this radiation. UV-C and a significant part of UV-B radiation is absorbed in the stratosphere.

The depletion of the ozone layer by 5% will substantially increase the intensity of UV-B and UV-C radiation reaching the Earth's surface. It is estimated that the mortality rate from malignant skin diseases will increase by 20%. Increased UV radiation can affect the immune system, vision, cataract may become pervasive. The intensity of UV radiation may have an effect on the agricultural production and on the reproduction of living organisms in the World Ocean, especially plankton. Reduction in the growth of plankton, in turn, will affect the fish feed base. Furthermore, the impact on the Earth's thermal balance may also be considerable.

The depletion of the ozone layer and increase in the intensity of UV radiation reaching the Earth's surface have far-reaching consequences. Diminishing the negative effects of UV radiation has become one of the central objectives of environmental protection policy. Suntan has for a long time been regarded as a sign of a healthy lifestyle and good health in general. However, today views about the healthfulness of sunbathing have radically changed. The production and use of various sunscreen cosmetic products and sunglasses that protect the skin and the eyes from UV radiation has been increasing.

Several legislative acts have been adopted with the aim to reduce the destructive effects of pollution on the ozone layer. The drafting of legislation pertaining to the ozone layer protection began in 1985. The most important international treaty in this regard is the Montreal Protocol on Substances That Deplete the Ozone Layer (a protocol to the Vienna Convention of 1985 for the Protection of the Ozone Layer) designed to restrict the production of these substances.

To a considerable extent, the legislation restricting the ozone layer depletion had laid the foundations for further development of an effective environmental law system. The environmental legislative acts drafted for the purpose to restrict the use of substances that destroy the ozone layer provide for various activities carried out on an international level, such as the ozone layer study and monitoring, phasing out the production of these substances, compensations to developing countries for the losses incurred due to the high costs of alternative technologies. The implementation of the relevant

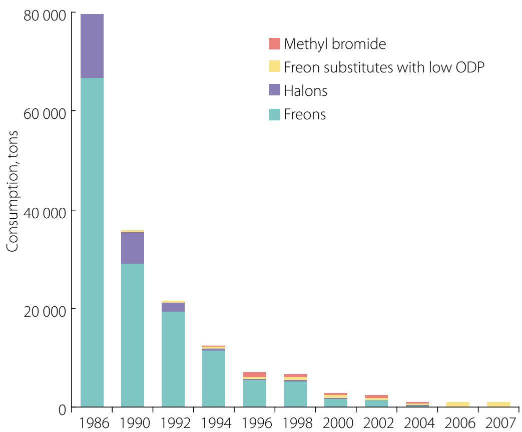


Figure 5.10. **Changes in the production amounts of ozone-depleting substances in the EU Member States**

international laws has been successful – the use of ozone-depleting substances has been significantly reduced (Figure 5.10), and alternative solutions have been developed in the sectors where the use of substances with properties analogous to freons is necessary. There are reasons to believe that the ozone layer recovery has already begun (this is also confirmed by recent measurements of the ozone layer), and the concentrations of ozone-degrading substances in the atmosphere may noticeably decrease in the future.

5.3.2 GLOBAL WARMING

Climate is the statistical summary of weather and meteorological phenomena and occurrences over a long period of time, ranging from a few years or decades to thousands of years. Climate is expressed in averaged long-term atmospheric physical parameter values characteristic of the Earth as a whole (global climate) or of a specific territory (a country or region). Like many other issues relating to climate change, the extent and character of human influence on climate are still studied and analysed, but, to say the least, there is no doubt that human activities do influence climate.

There is conclusive evidence that the consequences of human activities – such as air, water and soil pollution, overpopulation – also cause climate change. However, it is quite difficult to distinguish clearly and unambiguously the climate change processes stimulated by human activities from those that are part of natural development. A sharp increase in the concentration of various gases (their source is human activity) in the atmosphere is indicative of the increase in anthropogenic influence (Figure 5.11). It is evident from the diagram that the concentrations of gases were considerably lower in the period when industrial production was not yet intense, while they have substantially increased during the last centuries.

The concentration of greenhouse gases has increased just within the last 300 years – beginning with the Industrial Revolution. There are reasons to believe that the sharp increase in environmental pollution since the beginning of industrialisation has been affecting climate change. Consequently, the current climate change process could be untimely and unnatural, and it may also lead to many global climate problems that we already witness today.

The phrase 'global warming' denotes not only the increase in the Earth's average temperature (Figure 5.12), usually measured as the average temperature per year, but also substantial changes in the entire climate system.

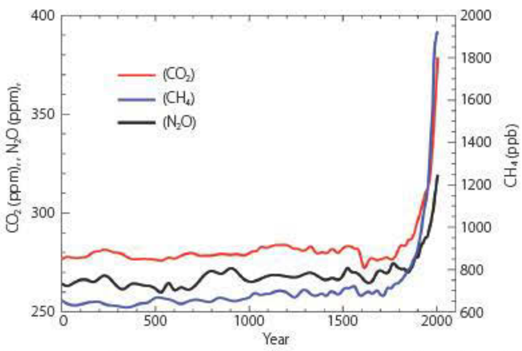


Figure 5.11. **Changes in the concentrations of carbon dioxide (CO_2), nitrogen (I) oxide (N_2O) and methane (CH_4) in the atmosphere during the last 2 000 years**

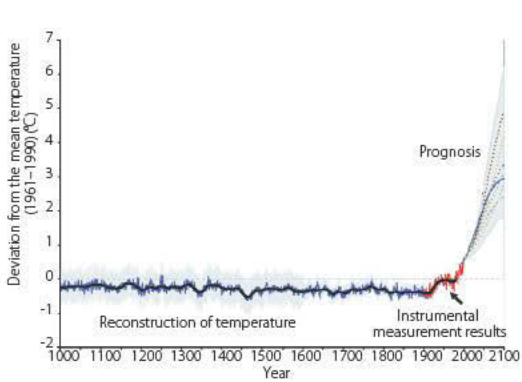


Figure 5.12. **Temperature changes in the Northern Hemisphere during the last 1 000 years and a prognosis of possible changes in the future**

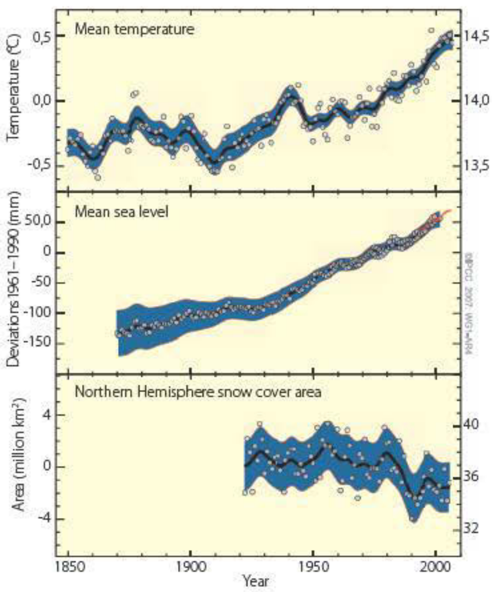


Figure 5.13. **Changes in the air temperature, sea level and snow cover area within the last 150 years**

The climate in the Baltic countries has become warmer over the last years. Winters have become shorter and the snow cover thinner. The warm period has become longer, and there are fewer days with low temperatures. The average temperature on the planet has increased for approximately 0.7 ± 0.2 °C (Figure 5.13). Long periods of draught occur in summers. Air warming takes place not only over the continents but also over the seas and oceans. With the increase in temperature, the snow cover duration is decreasing. Air warming is related to the reduction of permafrost areas. Mountain glaciers recede to higher elevations and become smaller and shorter, affecting the mountain rivers. As glaciers melt and the snow cover diminishes, the global sea level is rising.

Temperature rise in the Northern Hemisphere and particularly in the Baltic Sea Region does not occur evenly throughout the year; for the most part, only the winter months have become warmer (Figure 5.14).

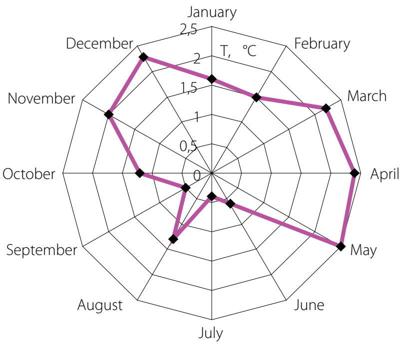


Figure 5.14. **Average monthly temperature rise in Rīga (1851–2008 I–XII)**

The effects of global warming are not equally intense in all regions of the Earth. Global warming has affected the rainfall patterns – they have recently become more irregular, leaving some regions with almost no precipitation and causing long drought periods, while elsewhere rainfalls have become much more frequent than before. In some regions, such as China, long drought periods alternate with severe floods, seriously impeding the agricultural production.

Precipitation is the source of freshwater which flows into the seas and oceans, changing the freshwater and saltwater proportion. These changes, in turn, affect the warm ocean current patterns. The mean sea level rises due to the increased precipitation and the melting of glaciers, ice cups and ice sheets. As a consequence, the habitable dry land areas decrease. Global warming and the related climate change can also cause serious economic problems. Climate change can seriously impede the agricultural production. The mean air temperature increases and unstable winters affect the plant kingdom. Due to the warm weather, many plants start to bloom earlier in spring and are destroyed by sudden frosts. Although late frosts have also occurred before the major climate change, in present-day warm winters the plants break into leaf well before spring begins. Many countries of the world that base their economies mostly on agriculture incur losses and may even face an economic crisis due to climate change. The irregularity of rainfall also causes serious damage, since both heavy rains and draught badly affect crops. The developing countries that have not accumulated sufficient reserves for emergencies may experience even greater problems with providing living means to their residents.

Variability of climate systems can be projected with the help of climate models used when it is impossible to study an object or phenomenon directly.

All the issues related to the Earth's climate change are interrelated – when the air temperature changes, the rainfall and global sea level will also change, and each of the factors will affect the others. This principle is underlying climate change modelling.

The increase in global warming largely depends on greenhouse gas concentrations and emission amounts. Therefore, to forecast the temperature, we need to forecast the gas emission amounts, which, in turn, depend on the lifestyle of humans. The United Nations Intergovernmental Panel on Climate Change has developed several alternative models for the prospective development of society and climate change:

- Scenario A1 ('zero' growth). Greenhouse gas concentration in the atmosphere remains at the level of 2000; there is no economic and population growth, and climate change is driven by the climate system inertia only.
- Scenario B1 (sustainable development). Natural growth continues until the middle of the 21st century, then the population declines; the economic development continues.
- Scenario A2 ('business as usual'). This scenario describes a differentiated world, in which each nation relies on its own powers and resources; the population is constantly growing; economic development is regionally-oriented.
- Scenario A1B (technological progress). This scenario describes a world of rapid economic development, population growth and technological progress that allows to reduce the consumption of material resources.

The climate change future scenarios predict that the air temperature will rise by 1–8 degrees on average, and the warming rate is projected to be higher than it was in the 20th century (Figure 5.15). Global warming will definitely affect the average rainfall on the Earth (Figure 5.16). Along with the increase in temperature, the moisture concentration

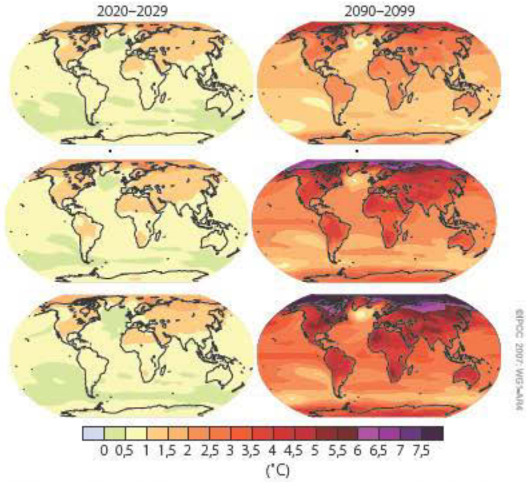


Figure 5.15. **Modelled mean air temperature on the Earth**
The mean air temperature on the Earth is modelled for the periods between 2020 and 2029 and between 2090 and 2099 vis-à-vis the temperature in the period between 1980 and 1999, depending on the potential society development and climate change scenarios: B1; A1B; A2 (from top to bottom). The figure shows how the air temperature on the Earth can change depending on the society development scenario.

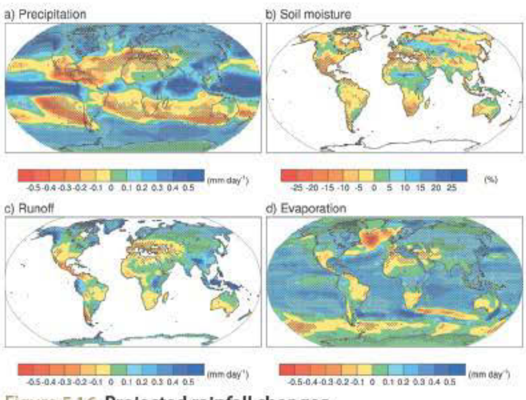


Figure 5.16. **Projected rainfall changes**
Mean changes in (a) precipitation (mm day^{-1}), (b) soil moisture content (%), (c) runoff (mm day^{-1}) and (d) evaporation (mm day^{-1}). Changes are annual means for the A1B scenario for the period 2080 to 2099 relative to 1980 to 1999. Soil moisture and runoff changes are shown at land points with valid data from at least 10 models.

and hence rainfall will also increase. Precipitation will not be regular, and there will be a risk of drought periods in many regions of the Earth. Rainfall changes can affect the Earth's processes, for example, heavy precipitation in polar regions may affect the stability of glaciers and ocean currents.

Both rainfall changes and global warming affect the global sea level. It hardly needs saying that, as the Earth's temperature rises, the ice sheets of the polar region begin to melt, and it turns out that the permafrost boundary is not permanent at all. This melting causes the water level in oceans to rise. The climate change models project that, until 2100, the water level in seas and oceans will have risen by 0.09 to 0.88 metres (Figure 5.17).

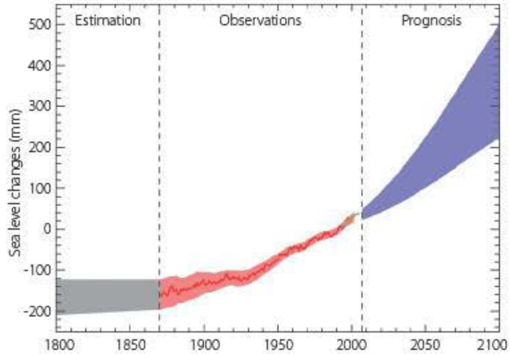


Figure 5.17. **Confirmed and projected sea level changes**
This figure shows the actual and possible changes in the water level in seas and oceans in the period between 2000 and 2100.

The mean water temperature in the oceans and seas will also increase, which means that the melting of glaciers and ice sheets and the rise of the sea and ocean levels will continue for hundreds of years after the stabilisation of greenhouse gas concentrations. With that, the inhabitable dry land areas will decrease. With the melting of polar ice, large amounts of freshwater will flow into the oceans and seas, affecting the marine fauna, ocean currents and thermal balance.

It is worth noting that climate change cannot be projected accurately because there is also a possibility that these processes occur faster, by leaps, causing global cataclysms.

5.4 REGIONAL ENVIRONMENTAL POLLUTION EFFECTS

5.4.1 SULPHUR COMPOUNDS

Today the main source of sulphur compounds in the atmosphere is human economic activity. In 2006, it created approximately 65% of the total amount of sulphur compounds in the atmosphere, and sulphur dioxide (SO_2) made up 90% of this amount.

Sulphur is quite a widespread element on the Earth, and most of the sulphur compounds are found in the lithosphere and hydrosphere.

The emission of sulphur compounds into the environment has considerably increased since the beginning of intensive human economic activity associated with the industrial revolution. The main processes in which sulphur compounds are released from the lithosphere are ore extraction (several metals are found in the form of sulphide and sulphate ores), fuel (coal, oil, peat) combustion and fertiliser production. The main source of sulphur dioxide emission is energy production, i.e. energy production by combusting different fuels. Both the combustion process and fuel quality can significantly affect the intensity of pollution. Coal combustion releases into the atmosphere about 70% of the total anthropogenic emissions. In the Baltic states, the main sources of sulphur dioxide are the so-called stationary emission sources or power plants, of which the Narva Power Plant (Estonia) complex is the leading one. Although in the European Union countries the total SO_2 emission levels have considerably decreased in recent decades, they are still comparatively high (Figure 5.18).

The main anthropogenic source of sulphur dioxide is fossil fuel combustion (Figure 5.19).

Sulphur dioxide is a colourless gas with a very strong, pungent odour. It is easily liquefiable and soluble in water, making a medium-strong acid – sulphurous acid (H_2SO_3). Sulphur dioxide oxidises easily in the atmosphere, reacts with atmospheric water vapour, and sulphuric acid solution is the end-product of these transformations. The fallout of compounds formed as a result of sulphur dioxide oxidation occurs in the forms of rain and snow (wet deposition) as well as dust (dry deposition).

In high concentrations, sulphur dioxide causes severe respiratory irritation. Since sulphur dioxide is soluble in water, when breathed in, it can already be sorbed by the nasal and airway mucosa, whereas sulphur dioxide penetrates the lungs. This is one of the factors causing the harmful effects of smog, as it is formed in humid air and has a high dust content.

When the daily average concentration of sulphur dioxide reaches 500 μg/m³, it aggravates the condition of people suffering from asthma and pulmonary diseases, whereas an increase in hospitalisation rate has been observed at concentrations reaching 750 μg/m³. The sulphur dioxide concentration in the air reached 4 000 μg/m³ during the London Great Smog of 1952.

Sulphur dioxide also adversely affects plant growth. High concentrations of sulphur dioxide can cause necrosis or death of plant tissue, while chlorosis – pale, yellow or yellow-white leaves because of insufficient chlorophyll – is characteristic of chronic exposure. The harmful effects of sulphur dioxide are amplified with increasing humidity. Sulphur dioxide inhibits the photosynthesis and respiration process in plants and causes damage to cell membranes. The extent of plant damage depends on the balance of nutrients and trace elements and also on the presence of alkaline compounds in the soil in which the plant is growing. The indirect effects of sulphur dioxide – causing environmental acidification because of a drop in the pH level of precipitation – affect the condition of plants and forests, as well as aquatic ecosystems and processes taking place there.

5.4.2 NITROGEN COMPOUNDS

Nitrogen makes up approximately 76% of the mass of the atmosphere. Several nitrogen oxides can also be present in the atmosphere as air pollutants: nitrogen (I) oxide N_2O, nitrogen (II) and (IV) oxides NO, NO_2 and even nitric acid HNO_3.

Nitrogen (I) oxide N_2O is formed mainly through natural processes, and human activity affects its concentration only indirectly. This substance is odourless, tasteless and chemically inert. It is used as an anaesthetic agent in medicine and as an inert gas in technological processes. No toxic effects of this substance have been found.

From the environmental pollution standpoint, special attention should be given to nitrogen (II) oxide NO and nitrogen (IV) oxide NO_2. Nitrogen (II) oxide NO is a colourless, odourless and non-flammable gas. Since it is easily oxidised to NO_2 in

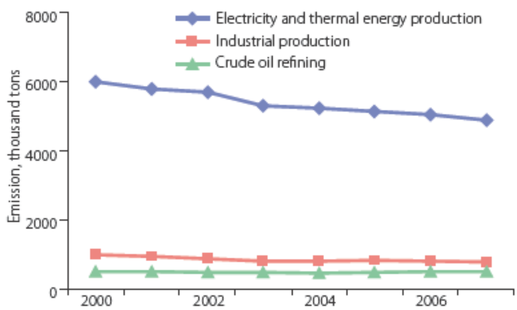


Figure 5.18. **Changes in the total sulphur dioxide emissions in the EU Member States**

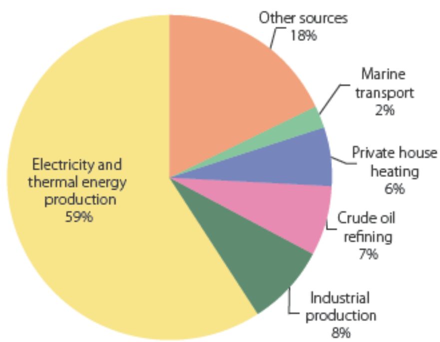


Figure 5.19. **Sulphur dioxide emissions according to their sources in the EU Member States (2007)**

the air, usually the combination of these two oxides resulting in NO_x or flue gas is considered. Nitrogen (II) and nitrogen (IV) oxides are highly toxic. Nitrogen (II) oxide is formed when the gases constituting the atmospheric air mutually react at increased temperatures. The rate of this reaction depends on the temperature, respectively, on the amount of energy supplied. NO is already forming, for example, when reaching incandescence. The reaction of NO, N_2 and O_2 molecules is in a state of equilibrium at a temperature of 2 000 °C. The intensity of the NO formation process is affected by how soon the created molecule leaves the reaction zone. In any case, nitrogen oxides are formed in all processes that take place at high temperatures, e.g. in plasma and in combustion and explosion processes.

Nitrogen oxides are also formed in the combustion processes of motor vehicle engines. Intensive release of nitrogen oxides during the process of electrical welding, especially in confined premises, is unsafe from the viewpoint of work safety. Emitted in the stratosphere, nitrogen oxides can participate in the ozone breakdown cycle. Supersonic aircraft exhaust is a significant source of nitrogen oxides in the stratosphere.

The oxidation of nitrogen oxides in the atmosphere forms nitric acid HNO_3, fallout of which occurs with precipitation mainly in the forms of acid and salt. Nitric acid, together with sulphur compounds, causes the acidification of precipitation and the environment. Since the transformations of nitrogen oxides and their elimination from the atmosphere occur quite swiftly, the acidification of precipitation caused by nitrogen compounds significantly affects the areas near the contamination sources.

Today the emission of nitrogen oxides as well as another environmental pollutant – ammonia – has become, overall, one of the most hazardous environmental pollution factors in Europe. Although the emission levels have been notably reduced, they are still high (Figure 5.20).

The issue concerning the reduction and control of the emission of nitrogen oxides becomes particularly

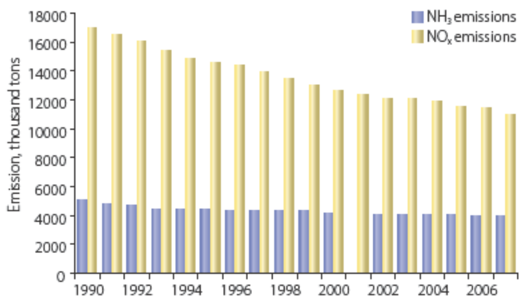


Figure 5.20. **Emission amounts of nitrogen oxides and ammonia and their changes in the European Union Member States**

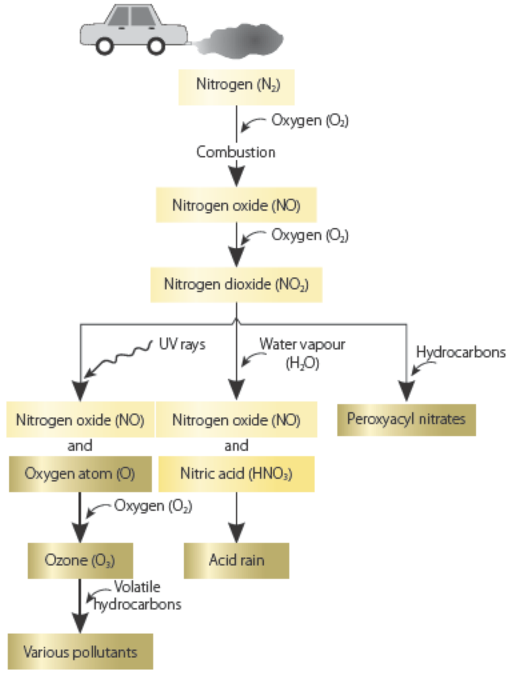


Figure 5.21. **Role of nitrogen oxides emitted with motor vehicle engine exhaust in the reactions of formation of smog, acid rain and ozone**

acute in the Baltic Sea Region countries, where the concentrations of nitrogen compounds stimulate many negative processes occurring in the region.

Motor traffic is considered one of the major sources of nitrogen oxides which directly affect the air quality in cities (Figure 5.21).

5.4.3 DUST AND AEROSOLS

Atmospheric air contains particles of every sort, size and composition. Their sizes may vary from micron to millimetric parts. The finer particles (size < 10 µm) are called aerosols, whereas the coarser are called dust. Liquid micro-droplets (haze) are also counted as aerosols. The main sources of dust and aerosol formation are various natural processes – soil and its constituent mineral particles entering the atmosphere with wind, dust storms (Figure 5.22), volcanic eruptions, forest fires, and evaporation from the sea and ocean surfaces (forming sea salt aerosols). Admittedly, today human activity causes the discharge of many aerosols and dust into the air. The main anthropogenic sources are such processes as the generation of energy, the production of building materials, mining, agriculture, air transport and others.

Aerosols can be formed and the composition of particles in the air can vary as a consequence of different chemical reactions. Sulphur and

Figure 5.22. **Sand storm in the Sahara**

nitrogen oxides play a considerable role in these processes. Since the airborne solid particles form the condensation centres for water vapour, all these reactions take place in the atmosphere in the presence of water. Acid rain formation is a typical example.

As aerosols and dust particles have a relatively large surface, they can sorb atmospheric gases, chemicals, micro-organisms and water vapour, and this sorption process determines the rather complex composition of aerosols.

Atmospheric aerosols and dust can significantly affect the Earth's climate, as evidenced by long-term climate change analysis and the increasing effect of dust from volcanic eruptions on the climate.

An important group of aerosols are those of organic composition. Their source can be both natural processes (plants, forest fires, organic matter decay) and anthropogenic processes. The presence of metal compounds (Pb, Hg, Cu, Ni, Be), radioactive isotopes and organic substances in the composition of aerosols can particularly adversely affect the human health. The exposure to aerosols is most hazardous in case of inhaling such particles that are retained in the lungs (coarser dust particles are captured in the nasal cavity and upper airways, whereas finer particles can be exhaled). The aerosols containing such particles are called respirable aerosols. Their particle sizes are often smaller than 2.5 μm. These aerosols are designated $PM_{2.5}$ (PM stands for Particulate Matter). The effects of these aerosols can be as follows:

1) the substances adsorbed on the surfaces of aerosol particles may desorb and enter the circulatory and lymphatic systems. Such an effect is typical of various combustion products. Combustion product aerosols contain carbon, and on the surface of these aerosols, usually there is quite a high concentration of different organic substances originated from incomplete combustion or in the process of thermosynthesis;
2) ultrafine particles, such as asbestos fibres, can penetrate the blood or lymphatic system from the lungs;
3) aerosol particles can remain in the lungs and calcify, causing constant irritation. The aerosol effect of this type is characteristic of occupational diseases – asbestosis and silicosis, caused by inhaling the air polluted with mineral particles;
4) micro-organisms, bacteria or fungi residing on the aerosol and dust particles may cause allergic reactions as well as illness.

The dust of pollen, wood, flour and other organic substances can be considered a special group of aerosols. Since these substances are organic, their composition differs significantly from the traditional dust composition; yet, these aerosols can cause allergies.

Since the effects of aerosols on humans, animals, plants and buildings can be detrimental, and aerosols and dust can be considered, by their mass, the largest group of atmospheric pollutants, it is crucial to limit their emission in the main sectors responsible for this kind of pollution, namely the production and energy industry.

5.5 INDOOR AIR POLLUTANTS

Air pollution is usually associated with the quality of outdoor urban air. However, the health of humans may be much more affected by air pollution in their living environment – dwelling and working premises (Figure 5.23).

There are several factors that determine indoor air pollution. First, there is the air pollution in human living environment caused by the external air inflow. An example of such a situation is an excessive concentration of lead and polyaromatic hydrocarbons in dwelling premises near motorways. Second, different local sources – such

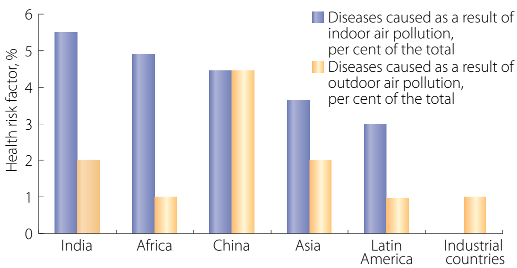


Figure 5.23. **Relative impact of indoor and outdoor air pollution on the human health in different regions of the world**

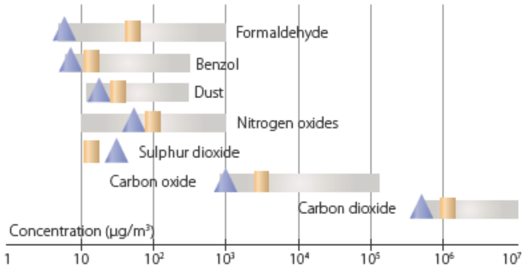


Figure 5.24. **Comparison of typical concentrations of indoor ( ) and urban environment ( ) air pollutants and the concentration intervals in the indoor air ( )**

as kitchens, stoves, furniture, polymer materials, painted surfaces, animals – may also cause serious indoor air pollution.

Another factor that affects the indoor air quality is the production of new materials and substances. In this way, increased quantities of new substances are brought into the human living environment, contaminating it. For example, new insulation materials, cleaning agents, cosmetic products, solvents, plant protection products expose humans to the substances whose toxic properties have been proved. Pollution of human living environment can cause a variety of adverse effects, including instant death. Quite often people die from poisoning with carbon monoxide emitted from stoves, fireplaces and gas heaters. Even in developed countries indoor pollution may be fatal, as evidenced by the deaths from legionellosis.

However, long-term effects of living environment pollution on the human health are considerably more common. These effects can manifest themselves after longer periods of time, even decades; hence, it is difficult to prove them using today's research methods (such as epidemiological study results). Such effects are characteristic of such substances as radon, asbestos, formaldehyde and others. Moreover, today the air pollution in dwelling premises is considered one of the main causes of certain illnesses, for example, lung cancer.

Air environmental pollution can be caused by both organic and inorganic substances as well as micro-organisms. Legionnaires' disease – a more severe form of the illness known as legionellosis – is a typical illness caused by the living environment air pollution with micro-organisms, in this particular case – by the bacteria *Legionella pneumophila*, which is one of more than 20 similar bacteria that cause legionellosis.

Outbreaks of legionellosis have occurred in 1981, 1985, 1988, 1992 in the USA as well as other countries, and, having regard to the high fatality rate from this disease, it has been studied quite extensively. Legionellosis is a lung disease caused by environmental pollution (it does not spread from person to person) with the bacteria. These bacteria thrive in water, particularly in closed water circulation systems, ponds, also in air conditioning systems, and they can be inhaled in the form of aerosols when water is disseminated, for example, by showers, garden sprinklers, humidifiers and other equipment. As aerosols bacteria can be transmitted to relatively long distances. To prevent legionellosis, it is important to set up and operate water circulation systems properly. Practically, it means preventing the reproduction and growth possibilities for bacteria.

Allergic alveolitis can also be caused by micro-organisms in the air. Alveolitis in its acute form begins six to eight hours after exposure, and it has the symptoms of an acute respiratory illness, such as fever, shortness of breath, cough and muscle pain. The sickness may last just a few days if exposure to the provoking antigen ceases. The chronic form of the disease is more common in the presence of a constant low-level pollution source, for example, domestic animals. This disease is caused by the fungi, which, for that matter, also cause an allergic reaction to hay, especially if it is mouldy. The same micro-organisms can also thrive in air-conditioning and ventilation systems.

The presence of fungi, bacteria and other micro-organisms in the indoor air can also cause such diseases as asthma, allergic rhinitis and the sick building syndrome. The latter has a number of different symptoms that people may experience while they are living or working at particular premises and that cease when they leave these premises. Typical symptoms of this syndrome are irritated and watering eyes, running nose, headache and sometimes asthma. Air conditioning and humidification systems can also cause infectious diseases.

Since people in developed countries spend indoors approximately 70% of their time, the indoor air quality should be given special attention. The living environment air pollution with asbestos has been widely studied, proving its adverse effects on the human health. However, the artificially produced fibrous materials (glass wool, glass fibre, rock wool), especially when they have deteriorated, may cause similar pollution. Air contamination in living rooms with the chemicals typical of outdoor air pollution – such as sulphur oxides, heavy metals, aerosols – also is a matter of great concern.

Air pollution with asbestos typically occurs only in the human working and living environment. Asbestos is a generic term for fibrous silicate minerals. The environment can be contaminated by using asbestos cement, asbestos fabrics and asbestos as a heat insulation material. The hazardous effects of exposure to asbestos are caused by its mechanical action on the living tissue with which it comes into contact. In the case of inhaling the air contaminated with asbestos, a relatively large part of its fine fibres is lodged in the lungs. Prolonged exposure to asbestos dust may cause asbestosis – a pulmonary fibrosis caused by asbestos inhalation, associated with pleural calcification and a possibility of developing into lung cancer. Asbestosis has a very long latency period – 14 to 35 years.

Another pollutant affecting, first of all, indoors and working environment is radioactive radon (Rn). Radon is a colourless noble gas, denser than air, formed naturally as an intermediary product in the decay process of such radioactive elements as uranium (^{238}U) or thorium (^{232}Th). Condensed radon has a blue glow. As gas radon is an inert substance, which is not retained in the human body. Radon is hazardous due to the action of atoms separated in its breakdown process while the gas is in the lungs. Radon decay products are reactive metals that form oxides and other compounds that are deposited in the human body. Since these compounds are unstable and disintegrate further, in this way the human body becomes exposed to internal ionising radiation. In most cases, the effect of this radiation is the development of malignant tumours (primarily lung cancer). Swedish scientists estimate that in Sweden up to 25% of death occurrences from lung cancer are caused by radon. Indoor radon contamination is a typical human living environment pollution problem, because high concentrations of radon can occur only in confined spaces with limited air circulation. Up to 80% of radon emission comes from soil and the rock weathering process. Since radon as gas is very penetrating, it enters into the human living environment through cracks and openings in building foundations. Drinking water can also be a major source of radon.

In conclusion, considering the substantial effect of indoor air quality on the human health, the range of issues associated with air pollution in human living environment deserves special attention.

5.6 MAIN WATER POLLUTION PROBLEMS

As a result of human activities, substances different from those formed in natural processes get into water and significantly affect its composition and properties. These substances are inorganic (nutrients, inorganic salts, toxic trace elements, radionuclides) and organic (biodegradable substances, oil products, pesticides, surfactants). In addition, the physical effects of human activities on water are considerable. In Latvia, contamination with nutrients and organic substances is quite substantial and wide-ranging, whereas other types of pollution and elements are typical of the local point sources of pollution. The subsequent sub-sections will provide a more detailed description of the major water pollution types and elements.

5.6.1 WATER POLLUTION WITH NUTRIENTS

The main nutrients found in waters, considering their significance for the life processes in water bodies, are the following: nitrogen compounds – inorganic ions (NH_4^+, NO_2^+, NO_3^-) and organic compounds; phosphorus compounds – inorganic (PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$, polyphosphate ions) and organic compounds; and iron and silicon compounds in different forms and oxidation stages.

Ammonia (ammonium ions) is formed in water bodies, when heterotrophic bacteria decompose the organic nitrogen-containing substances, although its concentration more often depends on the inflow of organic waste (slurry, sewage, excrements) and municipal and industrial waste into water bodies, where nitrogen may be present in the composition of organic substances (proteins, amino acids, amines, nucleic acids). When organic substances decompose, a relatively large number of various nitrogen compounds are formed as intermediate products; however, owing to low biological stability, their accumulation in waters does not occur. Ammonium ions are toxic, especially their effects on fish.

Nitrite ions (NO_2^-) are mostly formed as intermediate products of nitrogen compound transformation – through the oxidation of NH_4^+ or reduction of NO_3^-. In uncontaminated waters nitrite ions are found in trace amounts (> 0.001 mg/l NO_2^-), and the increase in their concentration is an essential indicator of pollution.

Nitrate ions (NO_3^-) can be found in all types of water bodies. The concentration of nitrate ions in clean surface water normally is 0.4–8 mg/l, whereas in contaminated water it may be as high as 50 mg/l. The main pollution sources are fertilisers leaching from the soil and organic and inorganic substances in their conversion and transformation processes. The forms of nitrogen compounds are interdependent, and they can transform into one another. The cycling of nitrogen compounds is determined by the activity of micro-organisms.

The significance of *phosphorus compounds* for reactions taking place in the aquatic environment is related to their role in the metabolism of aquatic organisms and to the fact that only relatively small amounts of phosphorus are present in the hydrosphere. Compared to other elements whose presence is indispensable to the development of living organisms (C, H, O, N, Fe, S), phosphorus is much less common. For this reason, it is the availability of phosphorus in particular that often limits the growth of living organisms in water bodies.

Phosphorus in water can be found in the forms of numerous compounds. Increased amounts of *phosphate ions* (PO_4^{3-}) are discharged into waters mostly due to human economic activity. Phosphorus compounds play a significant role in the eutrophication processes taking place in water bodies. The content of phosphates in industrial wastewaters may reach high levels, and special technologies are needed for their disposal. When phosphorus compounds are discharged into water bodies, they are assimilated by aquatic organisms, and after the decomposition of biota, phosphorus compounds are released, and they accumulate in sediments. In changing environmental conditions, this accumulated phosphorus can be released, creating the so-called internal pollution load.

5.6.2 EUTROPHICATION OF WATERS

On hot summer days, when looking for a place to enjoy a refreshing swim, we discover that the banks of many lakes and rivers are so overgrown that it is difficult to access water, whereas beaches are often covered with rotting algae mass. Why do such circumstances develop?

Larger or lesser amounts of nutrients enter surface waters all the time, and they provide the necessary conditions for the formation of organic substances in aquatic organisms using energy from sunlight. These are photosynthesising plants and include different algae, higher aquatic plants – such as reeds, rush, pondweed, duckweed and others – as well some bacteria. If the inflow of substances containing nutrients increases, obviously, their concentration in water increases, in effect boosting the growth of plants, mostly algae, thus increasing the overall live mass of aquatic organisms. This process is called eutrophication (from the Greek – *eu-* 'well' + *trophē* – 'nourishment' = 'well nourished').

Several signs indicate that an intensive eutrophication process is in taking place in water. Some of them are easily noticeable, for example, if there is an abundance of nutrients, algae thrive, making the water cloudy, so that you cannot see through it deeper than 0.5 m; rocks and plants have periphyton and filamentary algae on them; fish are choking even in summer and under ice in winter; gas bubbles come to the surface from rotting plants and animal remains. The other signs are: the concentration of oxygen in water decreases, or it can even be absent in deeper water layers; animal species adapted to living in clean, nutrient-poor water – for example, the salmon fish family – die out. However, the most conspicuous sign of eutrophication is the overgrowing of water bodies.

Eutrophication is a global problem, and it has heavily affected the Baltic countries as well – their lakes, rivers and the sea. The main consequences of anthropogenic eutrophication are the overgrowing of lakes (Figure 5.25) and rivers (Figure 5.26) and the proliferation of algae in the Baltic Sea.

Knowing that nutrients flow into water continuously, a question arises: What can be done to limit the inflow of these substances? We should remember that the primary causes of anthropogenic eutrophication are related to the way the drainage basin land is utilised and managed (e.g., for agriculture, forestry); processes in the water bodies; the inflow of substances from the atmosphere. Understanding the causes and process of eutrophication has led to the drafting of environmental legislation aimed at limiting it – especially since the 90s of the 20th century. Although there is an extensive legislative framework pertaining to water protection, large funds are allocated for this purpose and environmental protection institutions take pains to improve the situation, only a quite insignificant decrease in the actual concentrations of eutrophication-causing

Figure 5.25. **Mass proliferation of the green alga *Enteromorpha intestinalis* L.**

Figure 5.26. **Overgrown section of the Lielupe River between Bauska and Mežotne**

substances in European surface waters (rivers) has been reached during recent decades.

Since nutrients flow into water from the whole drainage basin, the key eutrophication control measures come down to managing the drainage basins of all rivers and lakes in such a way as to reduce the inflow of nutrients into waters. The management and protection of all water resources in the European Union are based on this principle. The main eutrophication control measures are: to improve wastewater management systems, preventing the discharge of untreated sewage into water; to implement good agricultural practices, for instance, reducing unnecessary use of fertilisers by drawing up fertilisation plans and keeping with them; to set protective zones with limited economic activity near water bodies. Since trees, shrubs and caulescent plants growing along the watercourse retain nutrients and contaminants, vegetated buffer strips should be maintained, for example, tree felling should be limited on the slopes.

Understanding what eutrophication is, how it comes about and how it can be reduced is important for everyone. We can mitigate eutrophication even in the course of our everyday activities, for example, by choosing environment-friendly washing powder (without phosphorus compounds), by making fires on the river and lake banks only at designated places, by avoiding trampling the ground vegetation in dune areas and river and lake shores, and so on.

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TOWARDS COOPERATION BETWEEN SAINT-PETERSBURG UNIVERSITIES AND THE CITY OF SAINT-PETERSBURG IN ENVIRONMENTAL ACTIVITIES


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The biggest city of the Baltic Sea Region – Saint-Petersburg – has many environmental issues to deal with: water and air pollution, soil re-cultivation and waste management. Saint-Petersburg is situated in the delta of the Neva River on the eastern coast of the Gulf of Finland and has access to river and sea waters. Thus, the most important issue that has been a problem for long is sustainable water management. Therefore, raising awareness of the new generation of environmental problems connected with water and cooperation with city administration towards sustainable solutions are very important.

The city of Saint-Petersburg takes many measures to improve the environmental situation with water management to make it more sustainable. For example, nowadays, after another stage of the Northern Tunnel Sewer construction finished in December 2009, the company *Vodokanal* Saint-Petersburg that belongs to the Russian Federation purifies 91% of the wastewaters and claims it will purify all the wastewater by 2011. A unique project – the construction of the largest wastewater enterprise in the city, the Southern-western Wastewater Treatment Plant – was completed in 2005 with the support of Scandinavian countries that provided state-of-the-art technologies. It was done in accordance with the HELCOM recommendations and awarded the Baltic Sea prize for the contribution to improvement of the environmental situation. This water treatment plant alone purifies more than 330 thousand cubic metres of wastewater from a territory with over 700 thousands settlements of people.

Another good example: on 26 June 2009, the last chlorine bottle was removed from the premises of the Saint-Petersburg *Vodokanal's* Northern Water Treatment Plant. Now Saint-Petersburg is the world's first megalopolis to stop using liquid chlorine for water disinfection. Sodium hypochlorite is a substitute for chlorine. Chlorine was used for disinfection purposes at waterworks in Saint-Petersburg in the period between 1911 and 2008. Disinfection is a key element of water treatment. Chlorine compounds have a long-lasting disinfecting effect, and in the cities with long water distribution networks, there are no other means of maintaining epidemiologic safety of water on its way to consumers. Sodium hypochlorite (NaClO) is a sodium salt of hypochlorous acid, stable in water solutions. The water-disinfecting effect of chlorine and sodium hypochlorite is the same. However, sodium hypochlorite is non-hazardous.

Every day 2.5 million cubic metres of wastewater are delivered to the general system of wastewater treatment of Saint-Petersburg, which consists of 20 facilities. In 2010 the *Vodokanal* Saint-Petersburg presented the innovative water supply management system for the city and became the first Russian enterprise in housing and water sectors to be awarded the certificate of the European Foundation for Quality Management (EFQM) 'Recognized for Excellence' of five stars.

To get an impression on this environmental solution for a megalopolis and to learn more about how wastewater treatment facilities operate in practice, students of the

Figure 1. **Students at the Saint-Petersburg Wastewater Treatment Plant**

Figure 2. **Students are ready to combat pollution**

Baltic University Programme at Saint-Petersburg State University visit the enterprise as part of their Master's level course 'Sustainable Water Management' (Figure 1).

Oil traffic mainly takes place by maritime and river transport. The majority of such dangerous goods as oil products come in through the north-west region of Russia and especially Saint-Petersburg. That increases pressure on the overall transport infrastructure and the city, mainly the seaport. Growth of the transport loads reinforces the negative influence on the water quality and the environmental situation in and around the city.

Some of the students get a better understanding of wastewater treatment technologies and are inspired to take part in practical environmental activities. They can try being environmental volunteers and participate in the oil combating training and cleaning of oily birds in the coastal zone of the Gulf of Finland, organised by the Environmental Committee of the City of Saint-Petersburg.

The environmental volunteer movement has gathered many students from several universities of Saint-Petersburg. During their training, environmental volunteers work together with experts from government authorities responsible for oil combating operations in Saint-Petersburg, and international organizations like the WWF. There are two fields of activities – work in oil combating in the coastal zone and cleaning and rehabilitation of oiled birds (Figure 2). Students of environmental sciences and ecology can choose the activity. Both are very important for protection of nature in the coastal zone and the improvement of the environmental situation in the city. Cooperation between environmental authorities and universities is beneficial to both sides. Involvement of the new generation in nature protection and ecological safety management at a regional level allows to prepare new experts with experience in improving of the environmental situation in large cities.

6 ENVIRONMENTAL HEALTH

6.1 ENVIRONMENTAL HEALTH CONCEPTION

The existence and development of humankind has become dependent on the quantity of chemical substances that are used in various production processes and households. Substances essential for everyone are polymers, plant protection agents and medications. They are used in clothing manufacture, construction, agriculture, household, and their use has made it possible to improve the human life quality and to extend the lifespan significantly. We can argue that the production of any chemical substance is associated with both the benefits from its use and the risk that may be caused by its adverse properties. Human health can be affected not only by the use of chemicals but also by various physical factors, such as electromagnetic radiation, noise and heat. The electromagnetic radiation of high energy and short wavelength (γ-radiation) can destroy the structure of cells, influence the bio-molecules which determine reactions taking place in the body. Therefore, exposure to high doses of this radiation is lethal to humans. Electromagnetic radiation of longer wavelengths (200–400 nm) (ultraviolet radiation) can cause skin pigmentation (tanning), but lasting exposure to this radiation can promote skin cancer. Another physical factor of environmental pollution – noise – can cause discomfort, earache or hearing impairment; prolonged exposure can affect a person's mental health. Living organisms (biological environmental pollution) can also affect human health and ecosystems.

Consequently, an increasingly urgent need arises to assess the effects of substances and different factors on people who produce and use them as well as other living organisms and their communities – ecosystems, and to forecast their content in the natural environment in the future and to estimate their concentrations.

6.2 HOW TO ASSESS THE HAZARDOUSNESS OF SUBSTANCES?

The effect of any substance or factor on living organisms depends on the nature of this effect (toxicity) as well as on the quantities of substances that enter the body. Most substances are harmless if the dose affecting the organism is sufficiently low, whereas even any well-known and widely used domestic substance in high doses may become hazardous to the human organism. The amount of substance that a living organism takes in over a given period of time is called the dose. Several types of doses are distinguished:

- contact dose – the amount of a substance taken in from the environment;
- absorbed dose – the actual amount of a substance that enters the body;
- total dose – the sum total of separate doses.

The assessment of the hazardousness of a substance and risk of its exposure is based on the correlation between the dose of the substance and the body's response. The study of this correlation allows to evaluate the toxicity of a substance, for the toxic reaction usually depends on both the dose of the substance under study and the concentration of the substance in the part of the body affected first. Usually exposure to a substance is toxic if there is an interaction between the compound and a certain receptor in the body. The receptor might be an enzyme whose activity is inhibited. The binding to the receptor can be both reversible and irreversible; hence, the duration of exposure to the toxic substance is crucial. Although the concentration of the substance in tissue is directly proportional to the dose of the compound, several factors may influence the amount of the substance that actually brings about the toxic effect. The absorption of the substance, its distribution in the body, metabolic processes and discharge mechanisms can affect its concentration when molecules reach the receptor.

In order to assess the body's reaction to the amount of the substance taken in, other factors and conditions should also be taken into account. The key factors affecting the action of the substance are the number of doses, the nature of intake (continuous, in specific doses), the frequency of

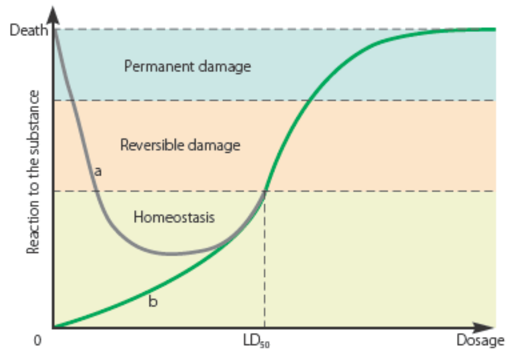

Figure 6.1. **Reactions in living organisms depending on the quantity of the substance taken in: a) the substance is necessary for the functioning of the body; b) the substance is not necessary for the body**

intake and the total time of action. Breakdown of the amount of the substance into separate doses, as a rule, reduces the toxicity of its action because the substance is transformed or eliminated from the body as a result of metabolism.

Curves in Figure 6.1 show reactions in the body depending on the quantity (dose) of the substance taken in.

The effect of a substance on a living organism depends on the properties of the substance, the age and sex of the organism affected by the substance, the duration of action and recurrence of dose, the way the substance enters the body and the transformation of the substance in the environment and the body. For example, the effect of such a toxic substance as dioxin on different organisms varies greatly, and the nature of its toxic action depends on the sex of the organism used for testing purposes.

The effects of a substance can vary within quite a broad range in one substance test group (population) – some individuals may have a high resistance against the effects of the substance, whereas this resistance may be low in other individuals.

The understanding of the effects of substances is based on the study of the reactions of living organisms in response to changing doses or concentrations of the substances studied. At the same time, the toxicity of a substance is considered to be one of its properties determined by its molecular structure (a property similar to the substance's molecular weight, volatility or the capacity to adsorb on solid surfaces). Consequently, the study of correlations between the toxicity of the substance and its composition can also be used for toxicity assessment.

The toxic effects are caused by the presence of a substance in the body. It can be taken in at one time, or its effects may add up. In the latter case, it may be necessary to assess the doses that can be taken in over a longer period of time. The simplest criterion of toxicity evaluation is mortality (lethality) although this indicator provides little information about the processes that determine the toxic effects.

One of the most widely used methods for toxicity assessment consists of the determination of the lethal dose of a toxic substance. Lethal dose (LD) is the amount of a substance that causes the organism's death.

The dose that causes death in a fixed part (usually 50%) of an animal testing group following the contact with the analysed substance over a given period (usually 24, 48 or 96 hours) is denoted as LD_{50}. Lethal dose is expressed in milligrams per kilogram of live weight (mg/kg). For toxic substances, LD_{50} is usually less than 15 mg/kg (Table 6.1). The LD_{50} value may vary depending on the duration of the action and the nature of the population.

Table 6.1. **LD_{50} value for some substances**

Substance	Testing animal	LD_{50} (mg/kg of body mass)
Ethanol	Mice	10 000
Sodium chloride	Mice	4 000
Morphine sulphate	Rats	900
Phenobarbital	Rats	150
DDT	Rats	100
Strychnine sulphate	Rats	2
Nicotine	Rats	1
Tetrodotoxin	Mice	0.1
Dioxin	Rats	0.001
Botulinus toxin	Rats	0.0001

Acute toxicity can be defined as the total negative effect caused by a toxic substance taken in a single dose. Analogous to acute toxicity, chronic toxicity can be defined as the total negative effect caused by a toxic substance affecting a living organism over a longer period of time.

The effects of physical or biological factors can be assessed and studied like the effects of toxic substances, i.e. analysing the correlations between the doses (action intensity and amount) and the organism's responses.

6.3 EFFECTS OF POLLUTANTS AND PHYSICAL FACTORS ON HUMANS AND ECOSYSTEMS

6.3.1 TYPES OF TOXIC EFFECTS

Depending on the type of damage caused to organisms, the effects of toxic substances can be categorised as follows:

- direct toxic effects: tissue damage;
- changes in biochemical reactions;
- neurotoxic effects;
- immunotoxic effects;
- mutagenic effects;
- genotoxic effects;
- carcinogenic effects;
- effects on the endocrine regulation processes.

Although the changes that can be caused by the action of a toxic substance vary, it is possible to highlight some of the prevailing forms of toxicity.

The normal functioning of a human body is closely related to the environment. The prerequisites for life are twofold: a continuous exchange of substances, energy and information between the organism and the environment and the organism's ability to distance itself from the environment to such an extent that the changes in environmental physical and chemical parameters cannot significantly affect the basic life processes.

Any living organism (including a human being) is an indivisible unity of cells, tissues and organs. Regulatory mechanisms provide for the functional unity of various tissues and organs, and specific defence mechanisms are responsible for the organism's relative independence from the effects of various external environmental factors:

- homeostasis – the organism's ability to maintain the internal environment and various bodily functions in a stable state in the changing internal and external environmental conditions. Homeostasis is regulated by the complex self-regulatory mechanisms of the organism;
- adaptation – the ability of living organisms to adapt to changing circumstances of existence developed in the evolutionary process. The organism's adaptation processes comprise various systems of organs, but the regulatory mechanisms of the nervous and hormonal systems are the most significant.

Although several stages can be distinguished within the adaptation process, when the environmental conditions drastically change, bodily function disorders followed by complex adaptation reactions mostly occur first. The organism is actively looking for a suitable state to meet the new circumstances. After that (in a favourable situation), the functions stabilise because the adaptation has taken place.

If foreign chemical substances enter the body, the adaptation process reinforces the activity of enzymes – they transform and destroy the chemical substances.

If the effects of environmental factors exceed the organism's adaptive capacity, it is broken down, initiating the exhaustion phase in which compensatory mechanisms start their action against the onset and progression of a pathological process. The effects of adverse environmental factors and pollution depend mainly on the organism's health condition, age and sex. Children and elderly people are much more sensitive to the harmful effects of pollutants than adults. This also applies to pregnant women and their unborn children, sick people and people with different pathological conditions, such as nutritional deficiency diseases and avitaminosis.

To fight the effects of adverse environmental factors, the body has developed several defence systems that ensure its ability to resist these adverse impacts. The skin and mucous membranes, the organs located on the boundary between the environment and organism (respiratory and digestive systems, the lymphatic system and urinary tract) as well as the immune system, mononuclear phagocytic system and defence reflexes perform the barrier function.

The purpose of immunoprotection is the organism's defence against genetically foreign cells and substances. The lymphatic tissue and organ systems perform the organism's immunoprotection.

The defence functions of the respiratory system are as follows: ciliary movement in the bronchial epithelium and excretion of mucus from the bronchial glands, bronchial muscle contractions, activity of the pulmonary macrophage system, secretion of immunoglobulins from the airway mucosa and stability in the pulmonary alveoli provided by a complex system of self-regulating surfactants.

In the process of evolution, the organism's defence system has effectively developed to combat naturally toxic substances and other adverse factors. However, the environmental pollution also contaminates the internal environment of the human body. Dust accumulates in the lungs, metal compounds are deposited in the bones, soft tissues and organs. Contamination in the human body initiates changes in the physical and chemical parameters of the organism's internal environment. A considerable contamination of the environment and organism can disturb the functioning of the organism's defence system.

If the harmful environmental conditions are excessively hazardous or persist for longer periods of time, exceeding the organism's adaptability, they become the risk factors for a variety of pathological conditions, illnesses or even death.

6.3.2 EFFECTS OF ENVIRONMENTAL POLLUTANTS AND FACTORS ON HUMAN BEINGS

Pollutant chemicals and biological factors (living organisms) might be present in the air, water, soil and food, and they can enter the body through the respiratory tract, gastrointestinal tract, skin, eye conjunctiva and placenta. The ways of entry depend on the aggregative state of substances and physical and chemical properties of compounds. Whatever the mode of absorption, all chemical substances enter the bloodstream and, from there, into various organs and tissues.

Bacteriologically contaminated water is the main cause of the diseases of the digestive system, skin, eyes and many other. Approximately 80% of diseases recorded on a global scale and more than a third of death occurrences in developing countries are directly related to the use of contaminated water.

The most representative physical pollutants of the environment are noise, vibration, non-ionising and ionising electromagnetic radiation.

The action of pollutants mostly affects those organs and systems that perform the barrier functions on the boundary between the environment and organism, preserving the organism's internal environment uncontaminated.

Diseases can develop from the effects of pollutants due to human susceptibility. Although the pathogenic effect always depends on the intensity and duration of exposure, persons who are more susceptible to diseases may fall ill even after a minor contact with a hazardous factor. Susceptibility depends on the biological factors (age, sex, heredity, other diseases), lifestyle (dietary regime, smoking, alcohol, stress), change of the environment if it was different in the previous place of residence or work.

Differences in susceptibility decrease with increasing exposure – in extremely hazardous conditions, both more susceptible and less susceptible persons may become ill. Children and the elderly are more sensitive to environmental pollutants.

The human population's biological responses to the effects of environmental pollutants can be represented by means of a pyramid (Figure 6.2). The base of the pyramid is the widest part. It reflects the weakest response – the accumulation of pollutants in the body. The narrowest upper part of the pyramid corresponds to the smallest part of the responses – death. The figure shows that not all of the population is equally sensitive to one or another environmental factor. In response to the effects of pollutants, most of the population develop a variety of physiological, biochemical, immunological and morphological changes and preliminary stages of disease. Such changes can usually be detected only in targeted studies, while practical medicine usually establishes only illness or death.

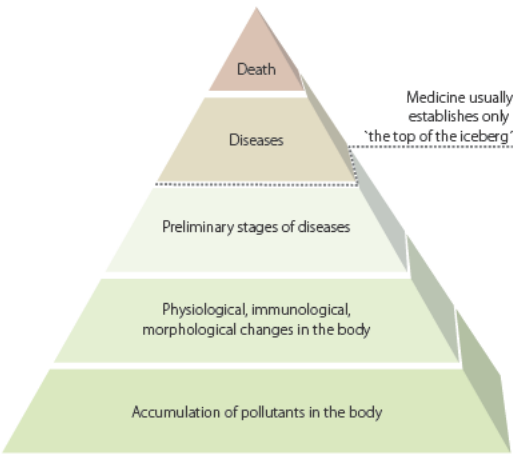

Figure 6.2. **Population's biological responses to environmental pollutants**

The contemporary development of medicine and other sciences has enabled the discovery of a wide range of ways how environmental pollutants affect the human body, such as

- pathologies of various organs and systems (respiratory, gastrointestinal, circulatory, nervous and endocrine, immune, urinary and reproductive system abnormalities);
- sensitisation of the organism and a variety of allergic diseases;
- skin, mucous membranes and dental abnormalities;
- oncological diseases;
- infectious diseases;
- effects on genes.

From the chemicals occurring in the environment, the effects of heavy metals – especially mercury and lead compounds – are particularly notable. Furthermore, pesticides are very serious environmental pollutants that can cause central nervous system disorders. Persistent chloro-organic pesticides circulate in the air, enter the food chains and substance cycles.

Effects on the nervous system are a major cause of acute poisoning cases. Animals are highly sensitive to the effects of such substances as the nervous system plays a fundamental role in various vegetative processes. In addition, nerve cells are sensitive to any damage, including metabolic. Nerve cell damage often is irreversible. Often the death of an individual is ultimately determined by the effects of toxic substances on the nerve cells, even if another group of tissues is affected. For example, cardiotoxins (atropine) or substances that affect breathing (CO, HCN) are fatal because of the disruption of oxygen supply to the neurons.

6.3.3 EFFECTS OF ENVIRONMENTAL POLLUTANTS ON THE ENDOCRINE SYSTEM

The endocrine system is composed of internal secretion glands, regulating many body functions through the hormones synthesised in these glands (Figure 6.3). Female organisms produce estrogenic hormones, whereas male organisms – androgenic hormones. The endocrine glands of the human body are the thyroid gland, parathyroid glands, the thymus, gonads, the adrenal gland and pancreas. The placenta, kidneys, the liver, fat tissue and the endothelium also have endocrine secretion functions.

Hormones are specific substances that are synthesised in different tissue cells (endocrine gland cells) and released from there into the intercellular solution, spreading through (or with) this solution and regulating target cell functions and processes throughout the body.

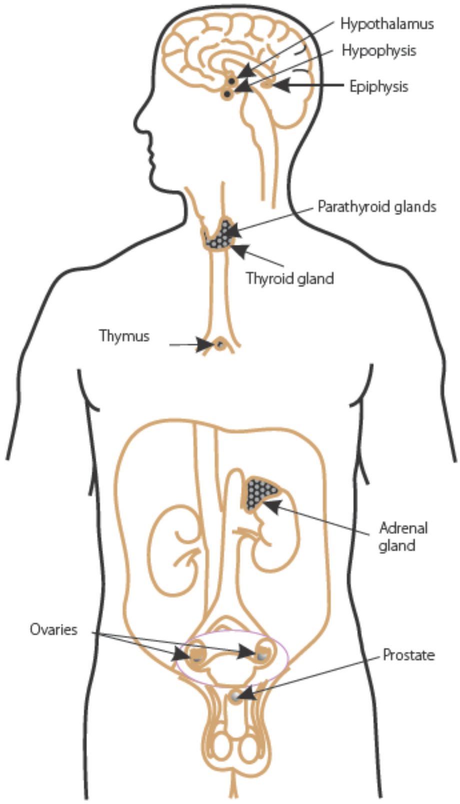

Figure 6.3. **Hormone-producing glands in the human body**

Hormones regulate the body's development and growth; they influence behaviour, regulate the reproductive cycle (the menstrual cycle, onset and progress of pregnancy) and significantly affect the functioning of the body (the functioning of skeletal, circulatory and immune systems as well as brain performance). Typical examples of reproductive hormones are estradiol, estrone and estriol.

There also are many substances whose structure and properties are similar to those substances that may actively affect the functioning of the endocrine system. Such substances may affect organisms in embryonic or foetal development stages as well as the reproductive system, central nervous system, immune system and endocrine regulatory processes. A typical characteristic feature of such substances is that their effects are initiated by low concentrations and may become manifest only in future generations. Just as carcinogenic substances, the substances affecting the endocrine system do not belong to one particular group of substances; the effects come about as a result of the action of various structurally different substances.

The most widely studied group of substances affecting the endocrine system are environmental estrogens or exoestrogens. These substances, acting on living organisms,

- simulate the action of estrogen synthesised in the body. The substances affecting the endocrine system are capable of producing effects similar to those caused by endogenous steroids.
- block, eliminate or modify the bonding of hormones with their receptors, thereby affecting the quantity of hormones and type of effect on the cell. Such substances are called anti-estrogens or anti-androgens;
- alter the rate of production or decay of naturally formed hormones;
- affect the structure of hormone receptors or their formation in the body.

Usually, the intensity of natural reproductive hormone action is significantly higher than that of environmental estrogen (except for diethylstilbestrol and contraceptives). It has been proved that many structurally different substances have the capacity to affect the endocrine system. Environmental estrogens typically have both synergistic and antagonistic effects.

Natural hormones are unstable and disintegrate within a period ranging from a few minutes up to several hours after the formation. Unlike naturally occurring substances, environmental estrogens are persistent and may even accumulate in living tissue.

The main difference between the hormones produced in human or animal organisms and the substances that degrade the endocrine system is their origin and possible ways of assimilation. Considering the extensive use of various exoestrogens, their high concentrations in the environment have been proven (Table 6.2). The high environmental concentration of substances that degrade the endocrine system is also attributable to their high persistence as a result of metabolic transformations and chemical and biological degradation processes. Many substances that degrade the endocrine system are quite volatile; therefore, they may be disseminated with air masses although usually they are spread by water. Examples of such substances are the pesticide DDT, a substance that is widely used in the production of polymers – bisphenol A, a synthetic estrogen diethylstilbestrol as well as a variety of substances of a natural origin (Table 6.2).

Table 6.2. **Substances with estrogenic activity and their typical concentrations in the environment**

Substance	Concentration	Environment
Estrone	$(1.4–76) \times 10^{-9}$ g/l	Wastewater
Oestradiol	$(2.7–48) \times 10^{-9}$ g/l	Wastewater
Nonylphenol	$(0.15–2.8) \times 10^{-6}$ g/l	Wastewater
Pthalic acid esters	3.2×10^{-6} g/l	Gull eggs
Polychlorinated biphenyls (PCBs)	14.1×10^{-3} g/kg	Wastewater

Environmental estrogens are

- pesticides – the estrogenic activity of many pesticides has been proven (DDT, endosulphan, dieldrin, kepone, dicofol, toxaphene, chlordane, alachlor, atrazine, nitrophen, benomyl, mancozeb, aldicarb);
- substances used in manufacturing polymers (bisphenol A, phthalates);
- therapeutic substances (diethylstilboestrol, cimetidine);
- chemicals of domestic use (surfactant degradation products – nonylphenol and octylphenol);
- many environmental pollutants (polychlorinated biphenyls, dioxins, polyaromatic compounds);
- heavy metals and their compounds (lead, mercury, cadmium).

Food may be considered to be the major source of intake of substances affecting the endocrine system: food products that contain these substances, food additives and food packaging.

Endocrine system regulation disorders, in turn, can affect the central nervous and immune system. These disorders may occur already in the embryonic development stage, and they can cause sexual behaviour changes, slowdown in the development of secondary sexual characteristics, prostate disorders, decrease in sperm production and sexual activity, reproductive function disorders, male feminisation, formation of malignant tumours.

The thyroid gland is particularly susceptible to the adverse effects of environmental factors. Studies show that elevated concentrations of heavy metals – lead, manganese and mercury – in the environment cause pathological changes in the thyroid gland.

The proven effects of substances that affect the endocrine system manifest themselves in the form of reproductive system abnormalities and development delays. These effects have been proved by both laboratory studies and cases when these substances entered the environment, affecting the development of living organisms. It is believed that these substances contribute to malignant tumour development. For example, diethylstilboestrol was used as a medication to reduce premature birth risk, and a considerable increase in the cancer mortality rate in the daughters of women who used this medication was proven only much later. From the ecotoxicological point of view, the impact on wild animal populations has been acknowledged as particularly substantial. It is believed that the substances that have an effect on the endocrine system have affected, for example, the populations of fish and birds of prey in the Great Lakes Region, the population of alligators in Lake Apopka (Florida, the USA) and the population of otters in western Europe.

6.3.4 GENOTOXIC EFFECTS OF ENVIRONMENTAL POLLUTANTS AND FACTORS

According to the mechanism of toxic effects, three groups of substances can be distinguished: mutagens, carcinogens and teratogens. Their effects are related to cell metabolism processes and impact the transmission of genetic information (Figure 6.4).

Mutagenic substances or factors cause mutations – heritable changes in the cell genotype. They can be chemical substances or physical factors, such as ionising radiation. Mutations that occur in generative cells are generative mutations, and they result in mutant organisms. Mutations in somatic cells occur in few body parts.

Mutations can also occur when a substance becomes 'trapped' between the chains of a DNA double helix. This situation may either destroy the conformation of the DNA double helix, or cause an erroneous reading of information from it.

6.3.5 CARCINOGENIC EFFECTS OF ENVIRONMENTAL POLLUTANTS AND FACTORS

A major adverse effects of environmental pollutants is associated with their role in malignant tumour development. Malignant tumour is a generic term for more than 200 diseases characterised by uncontrolled cell division. Malignant tumours that develop in connective tissues are called sarcomas, whereas those that develop in epithelium tissue – cancers. Tumours develop not only in humans but also in animals and plants. Benign tumours grow slowly, moving the surrounding tissues. They are often

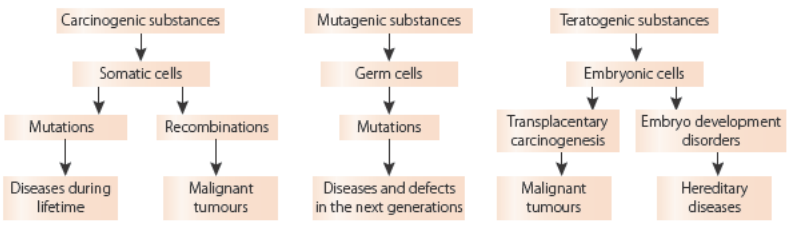

Figure 6.4. **Effects of mutagenic, carcinogenic and teratogenic substances on living organisms**

encapsulated, do not form metastases and do not recur. Usually the forms of tumours are classified according to the location of the tumour in the body or certain organs, for example, the circulatory system cancer, lung cancer, brain cancer. Different forms of cancer have different causes. A range of cancer risk factors have been definitely proven, for instance, smoking, radioactive radiation, unhealthy diet. Heredity is considered one of the main risk factors. There are families that have a significantly higher risk of developing cancer than others. For example, a woman's risk of developing breast cancer increases from 1.5 to 3 times if her mother or sister had it. Sometimes breast cancer is associated with specific gene mutations, which are prevalent among certain ethnic groups or families. The possibility that women with such a gene mutation will develop breast cancer is significantly higher.

In addition, the effects of physical factors can cause cancer. These factors include ionising and ultraviolet radiation. Usually the physical factors cause specific forms of cancer; therefore, by reducing their harmful impact, it is possible to reduce significantly the spreading of certain forms of cancer. People working in certain professions can be exposed to ionising radiation, for example, operating X-ray equipment or nuclear reactors. Uranium mining workers have a very high risk of cancer; for those who smoke, the risk increases several times. The most common diseases caused by ionising radiation are lung and blood cancer. Lung cancer is caused by inhaled radioactive dust. This dust accumulates on the lung surface and, in long time, may cause a malignant transformation of cells. People who survived the Hiroshima and Nagasaki bombing were at considerably increased risk of developing leukaemia.

Humans are exposed to UV radiation while outdoors. Long and intensive UV radiation can cause skin cancer. The intensity of radiation depends on the geographical location, climate and thickness of the layer of the stratosphere. The UV radiation exposure is increased in the countries with high proportion of clear days as well in the territories over which the ozone layer has been depleted. Exposure to substantial doses of UV radiation can also take place in specific industries and occupations, for example, colour coating and printing, medicine (sterilisation with UV lamps), welding.

Smoking and tobacco use are risk factors that have the second highest mortality rate. The incidence of lung cancer in smokers is 50–20 times higher than in non-smokers. The death rate related to lung cancer has been growing steadily since the beginning of the 20th century and is not expected to fall in the foreseeable future. Cigarette smoke contains around 4 000 chemicals. There is evidence that many of them are carcinogenic. Smoking also significantly increases the incidence of mouth, larynx and bladder cancer.

Unhealthy eating habits also are a very important risk factor for cancer. People who are not on a proper and healthy diet are prone to the effects of carcinogenic substances. This risk may be reduced by means of a balanced diet and proper food preparation.

The incidence of cancer and mortality rate from several of its forms are high in the Baltic countries, compared to the mortality rate from lung cancer in men of northern Europe (Figure 6.5).

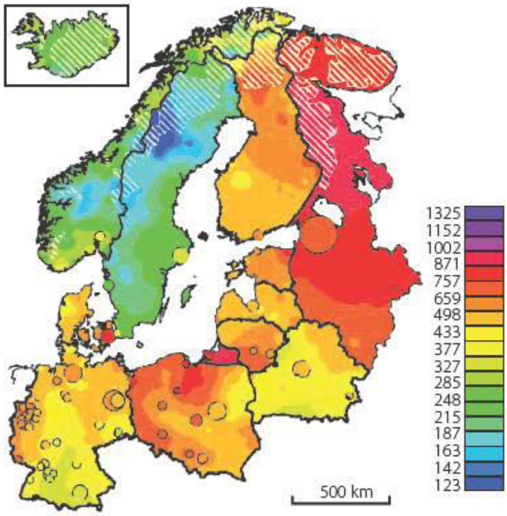

Figure 6.5. **Male mortality rate from lung cancer in northern Europe (per million inhabitants)**

Factors that can cause cancer are:

- inherited susceptibility. It is believed that only 5% of cancer incidences in the USA are attributable to hereditary genetic mutations in the human genome. In early childhood genetic factors determine the development of cancer, but it is not the main cause of incidences;
- environmental carcinogens;
- inherited susceptibility heightened by the effects of substances that cause cancer. These factors are the main cause of cancer today, accounting for 60–90% of cases;
- unknown factors.

Several carcinogens significantly increase the risk of malignant tumour development by acting on cells, more precisely – directly on separate segments of the genome.

Of the various causes that affect the mortality rate from malignant tumours, food and smoking are the dominant ones, and substances that enter the body through smoking or are ingested with food are the main sources of carcinogenic effects (Figure 6.6).

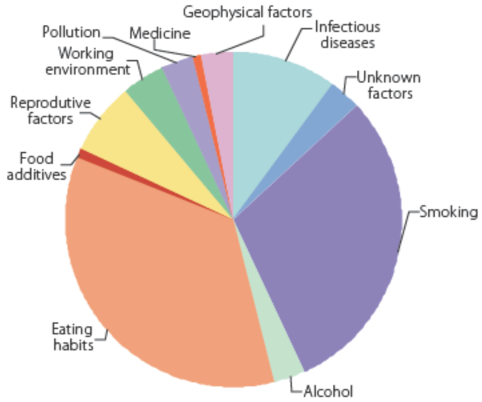

Figure 6.6. **Effects of various causal factors on the mortality rate from malignant tumours**

The development of malignant tumours is to a large extent determined not only by genetic factors and the predisposition of an organism but by the action of substances on particular elements of the human genome. Arguably, if the action of substances and factors that promote the development of cancer were prevented, the number of cancer occurrences would decrease, even though it is not easy to prove the effects of hazardous factors and substances because there is often a considerable time span between the action of a substance and tumour development.

The most common carcinogens are substances of anthropogenic origin, but also natural substances. Aflatoxins are an example of such a natural substance; they originate from moulds and contribute to liver cancer development.

Malignant tumours can be caused by

- any substances or factors that cause DNA damage: chemicals (carcinogens), ionising radiation;
- substances, organisms or factors that stimulate cell division. For example, hormones that stimulate cell division, viruses (the papilloma virus, which is a risk factor for cervical cancer, hepatitis B and C viruses, which can facilitate cancer development in the liver, herpes viruses).

However, when the cells stimulated in this way are not subject to mutation, they do not transform into cancerous cells.

Food and substances used for intoxication (e.g., alcohol, tobacco, drugs) can be a source of carcinogens. Tobacco smoke contains many carcinogens. Alcohol and foods with a high fat and low fibre content may also increase the risk of developing malignant tumours. Mould growing on protein-rich products (e.g., rice, peanuts) may contain aflatoxin. Contact with carcinogenic substances and factors such as benzene, tar products and radiation may take place at the work environment. Furthermore, viruses can be quite an important factor contributing to the development of cancer – for example, the Epstein-Barr virus, which belongs to the *Herpesviridae* family.

6.3.6 TERATOGENIC SUBSTANCES

Teratogenic substances affect the reproductive function of living organisms. These chemicals cause foetal (embryonic) defects. This phenomenon occurs both in humans and in animals and plants. From Greek, the words '*terat-*, *teras*' mean 'monster, monstrosity'.

Hereditary pathology studies have shown that it occurs in 2–3% of newborn children. 25% of the pathologies are genetically inherited, including mutagenic pathologies, 50–10% are caused by teratogenic effects, while the remaining 60–65% have unknown causes – most likely, it is a joint effect of both genetic and environmental factors. There are about 25 known chemicals that have teratogenic effects on humans and up to 800 – on animals. Many of the latter can also be potential human teratogens.

There are several risk periods in the development process of an embryo. For a human embryo such a period is the 18th to the 55th day of pregnancy, when the organs are developing (Figure 6.7) During this period, the embryo is especially sensitive to chemical factors. Contact with teratogens can reduce the size and number of cells, which can lead to the retardation of vital organs or foetal growth in general. In the 1960s, the sleeping pill thalidomide was the cause of incompletely formed limbs in neonates (e.g., a shorter arm or no arm at all). Mothers had been using this drug during the first months of pregnancy.

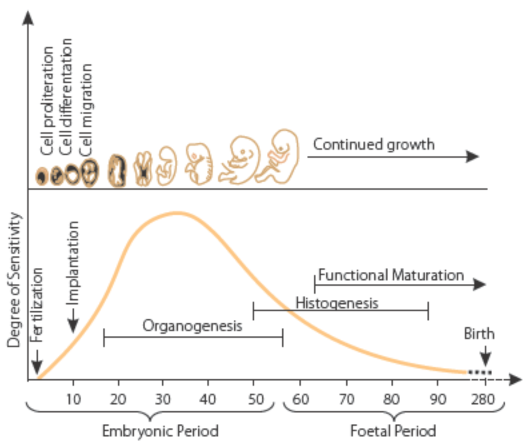

Figure 6.7. **Main phases of the development of the human body**

The effects of teratogens were also observed from large doses of vitamin D and the use of drugs for treating certain malignant tumours. Tests on animals have shown that even relatively common environmental pollutants, such as carbon monoxide CO (from car exhaust and smoking), have teratogenic effects. Carbon monoxide can diffuse through the placenta and increase the concentration of carboxymethyl-haemoglobin in the embryo's blood. Cadmium, lead and mercury are also teratogenic. The chemical mechanism of teratogenicity has not been fully researched yet. The most important groups of substances that have teratogenic effects are summarised in Table 6.3. Compounds of various classes can be teratogenic, but their common property is the capacity to diffuse through the placenta.

There is a close relationship between the substances with carcinogenic and mutagenic effects, whereas teratogens cannot be likened to any of these groups.

Table 6.3. **Main substances with teratogenic effects**

Substance	Effect
Metals and their compounds	
Lead	Facilitates spontaneous abortion and nervous system disorders
Methylmercury	Teratogenic effect on the nervous system
Lithium	Teratogenic effect on the heart
Aluminium	Teratogenic effect on the nervous system
Arsenic	Teratogenic effect
Medications	
Diethylstilbestrol	Adenocarcinoma
Thalidomide	Teratogenic effect
Retinoids	Teratogenic effect
Chemicals	
Ethyl alcohol	Intoxication of the foetus
Chloro-organic pesticides	Facilitate spontaneous abortion
Polychlorinated biphenyls	Teratogenic effect
Ethylene oxide	Facilitates spontaneous abortion
Dioxin	Teratogenic effect

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INTERNET RESOURCES

A Small Dose of. Accessible: *www.asmalldoseof.org/*

Agency for Toxic Substances. Accessible: *www.atsdr.cdc.gov*

European Centre for Ecotoxicology and Toxicology of Chemicals. Accessible: *www.ecetoc.org/*

Hazard Database. Accessible: *www.evol.nw.ru/~spirov/hazard/*

Information Toxicology International. Accessible: *www.infotox.com/*

Pollution Information Site. Accessible: *www.scorecard.org/health-effects/*

Toxicology Source. Accessible: *www.toxicologysource.com/*

CASE STUDY: SWEDEN

NOTES FROM A STUDENT

Isak Stoddard
Uppsala University

The immense challenges that our societies face, now and in the near future, cannot be taken lightly. Sustainable development is about us, how we choose to relate to each other and to the planet, and our ability to envision society that does not destroy its own resource base. Being a student in this day and age is a tremendous opportunity, but it also comes with great responsibility. We have the privilege of being part of creating the future we wish to see for ourselves and our children, and drive the transition of our societies to sustainability – a transition so profound that it is being compared to the agricultural and industrial revolutions. These are exciting times.

During our lifetime, we will have to come up with the social and technical innovations, as well as artistic and spiritual invention, that will make this transition possible. Organisations, businesses, governments and other societal actors are now realising this fact and are increasingly demanding for people who have the knowledge and skills required to work in society that is rapidly retreating from overshoot. Our window of opportunity is closing fast. During our time as students, we have to make sure to acquire the skills, knowledge and networks we need to shape our own future. We will have to fight for it too, since much of what we need is not available through conventional academic channels.

The present horizontal university structure – divided into disciplines and departments – has been very effective in accumulating detailed knowledge on the physical environment and driving the development of new technologies. It is, however, not appropriate, or even able, to deal with the most critical questions of our time. Universities, through both their research and education, therefore need to realign their priorities to better contribute to the betterment of our societies and the environment. This process has already started, and many countries are pushing for Education for Sustainable Development (ESD) in their education and university legislation. As students, we need to demand that our teachers and universities live up to their commitments. We need to take the opportunity to rediscover the connection between what we learn at universities and the rest of the world.

The transition to sustainability will require every kind of human talent in what will need to be a celebration of creativity and ingenuity. The system modeller authors of *Limits to Growth*, based on their understanding of the dynamics of complex systems, have proposed a set of seemingly soft tools that can help drive the transition. They are: networking, visioning, truth-telling, learning and loving. When deployed effectively, they can be profoundly powerful in transforming the structure of our societies.

So, how do we build our own capacity to use these tools to change the world? A large number of student initiatives are already helping us increase our capacity to take on the challenges ahead. We will give you some examples. Several of them are described more in detail further in the book.

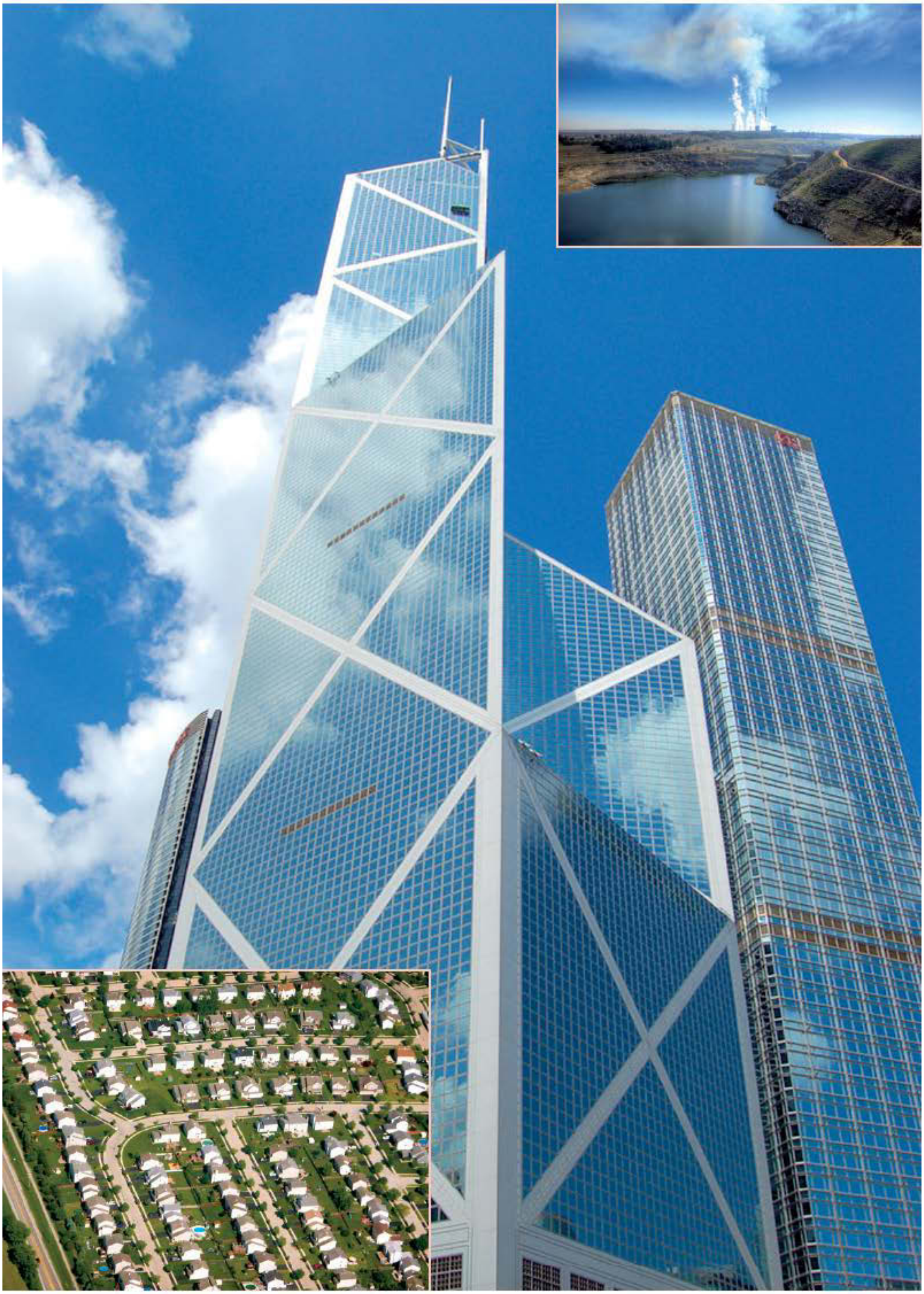
In the Baltic Sea Region, networking between students is quite active. Through the Baltic University Programme (BUP), students from all over the Baltic Sea Region, with diverse cultural and educational backgrounds, collaborate and build their team-working skills by participating in a number of different student activities. Student conferences, sailing courses and workshops focused on issues of sustainable development are organised on a yearly basis throughout the region. Education for sustainable development is in focus.

Many student groups do practical projects. Workshops, summer camps for youth, campaigns to support local, small-scale farming and making Rīga a bicycle-friendly city are some of the activities. Born of the dreams of environmental science students and faculty teachers in 2006, Eco-club Green Wave, a student organization at the National University of Kiev, Ukraine, creates opportunities for students to gain practical experience and unite the student community around sustainability issues.

To establish learning for sustainable development at universities is particularly hard. At Uppsala University, students themselves took on the challenge to define what they needed to learn and how their education should be organised in order to be able to deal with the complex and challenging issues of our time. This resulted in the Centre for Environment and Development Studies (CEMUS) – a centre for student-run education which is part of both Uppsala University and the Swedish University of Agricultural Sciences. Since its establishment in the early 1990s, CEMUS has grown and is now the size of a regular university department, specializing in student-run, interdisciplinary education for sustainable development.

There are many reasons for concern when it comes to the future of human life on this planet. The non-linear dynamics of the thresholds of planetary boundaries, combined with a global poverty crisis, makes our future uncertain and hard to predict. However, it is clear that we need to act urgently to steer clear of dangerous tipping points in the Earth's ecological and social systems. Humans are quick to adapt, as a species we have been through rough times before, but the scale of the crisis and the sheer amount of people on this planet puts us in a new situation. The time to act is now. We need to connect with like-minded people to create an attractive, fair and sustainable future. Being an agent of change and working for a more sustainable world means facing consistent scrutiny, being wrong at times, learning from our mistakes but always remembering our goals. The journey towards sustainability will be very difficult at times, but it will also be lined with joy and a sense of meaningfulness. What could be more exciting and inspiring than being part of – and possibly shaping – the greatest transition in the history of humanity?

7 ECONOMICS – THE ENVIRONMENT – GROWTH



7.1 ENVIRONMENT, ECONOMICS, DEVELOPMENT

Existence of human beings relies on the use of ecosystem services. Humans – society – nature: in the course of time this trinity has caused many problems which are especially topical nowadays. The conflict between environmental protection and the technological progress and growth of society exists in the industrialised part of the world. A thought-out environmental policy helps reduce activities dangerous to the environment. The development of technologies is directed towards attaining desirable standards of living. In recent years, this opinion has significantly changed in favour of environmental protection. People have understood that not all resources can be renewed; they have understood that clear water and air is an integral part of human survival. Up to the second half of the 20th century, the understanding of mutual interaction between humans and nature was limited. Nowadays we know that natural resources are not inexaustible and that any activity of humans has both long-term and short-term effects on nature. The society and business world have changed their attitude towards the environment – environmental issues have become serious arguments in decision-making. Many enterprises, especially small and medium-sized, implement environmental requirements more; however, there is lack of information and resources.

Raising the quality of life of the people cannot happen without the improvement of the surrounding environment. If environmental quality is reduced, both society and the national economies are losing; furthermore, deterioration of environmental quality negatively affects human health, the stability of natural ecosystems, as well as the availability and quality of natural resources. Degraded environment also profoundly affects the awareness of society in general. In order to reduce unfavourable impact on the environment, the ways of decision-making in the national economy and the attitude towards the environment in general should be cardinally changed because environmental quality and unaltered nature are inalienable preconditions for a wholesome life of human beings and sustainable development of states and society.

Implementing environmental policy, economic instruments are of ever-increasing importance. They work especially efficiently under market economy conditions and affect the possibilities of producers or the behaviour of consumers in the market.

The objectives of economic instruments are to limit uneconomical use of natural resources, to reduce the production and consumption of products which pollute the environment, facilitate the introduction of new and improved technologies in order to reduce environmental pollution, as well as to fund environmental protection measures.

Sustainable development cannot be imagined without considering joining the economic and environmental objectives. Methods for sustainable agricultural production, use of energy, management of natural resources and industrial production hold a great potential, but they should be used more widely. Sustainable global economics also indicates indirectly the restriction of the population and consumption of materials. The assessment of sustainability of economic activities and their implementation has become the main guideline, and it will become more important in the next decades.

Economics provide significant contribution to understanding and solving environmental problems the today's society is facing. People pay more attention to the economic value of the environment and the effects of economic activities on the environment. Partly it is determined by the increasing concern regarding such environmental problems as climate change and depletion of cultural and historical landscapes, or by the increasing interest of politicians regarding benefits and losses from implementation of certain environmental protection policies.

7.2 ECONOMICS AND SUSTAINABLE DEVELOPMENT

7.2.1 ECONOMICS AND SUSTAINABLE DEVELOPMENT OF ECONOMY

Economics is frequently understood as a science of satisfaction of material needs, the ability to earn money. It is a rather incomplete opinion.

From Greek, the word 'economics' means 'house order'. Economics is a science of the ways how to obtain order in a house so that the people have a good life there. Satisfaction of material desires and money is necessary but it is not a sufficient condition for human beings to feel good.

Economy is a set of economic activities and the environment where they take place. The objective of economy is to achieve happiness and well-being of all people; yet, the good life of today must not endanger a good life in the future.

How can we endanger welfare in the future by increasing welfare today? Mainly we do it by deteriorating the quality of the environment – in ecological, ethnical, social, cultural and other aspects. Most often it occurs by confusing the objective and instruments – considering the rapid growth of economy and the reduction of inflation and the state budget deficit to be the main objectives.

Sustainable development does not mean that the present generations must ensure the welfare of the future generations – each generation has to take care of its own welfare. If we do it instead of the next generation, how will it be able to take care of the welfare of the subsequent generations? However, our generation can put the next generation in a better starting position by not damaging the environment, not making it to pay off our debts.

The notion of sustainable development appeared in the second half of the 20th century when the attitude towards material goods changed, taking purchasing them for granted. At the turn of the 19th and 20th century, the eminent American economist Thorstein Veblen formulated the term 'conspicuous consumption', indicating that people are purchasing material benefits not only because they need them, but to prove themselves and others that they can afford to buy them, as an act of self-assurance. The things have lost the respectful attitude towards them and the work put in them; therefore, things are thrown away lightly. Thus, natural resources are turned into waste without creating true growth of welfare. Probably this is the main reason why in the second half of the 20th century the mankind started to acknowledge that its development has lost sustainability.

Sustainable development may remain a beautiful and utopian objective if society and each individual do not understand this objective, accept it as their own and subject their everyday activities to this objective. Even if the largest part of society does it, the activities of some individuals not complying with the objective are sufficient to endanger the objective. What are we to do in order it would not happen? It is unlikely that rigour of law or upbringing and good example will be sufficient.

Each person has his or her own system of priorities. How to achieve that activities of that person to attain his or her objectives are not in conflict with the interests of society?

Activities of humans in order to achieve an objective can be explained using the basics of game theory – the concept of Pareto efficiency and Nash balance. Such approach is typical of society because the benefit of an individual depends not only on his or her own behaviour, but also on the behaviour of all the members of society.

The situation when none of its participants is able to find any other situation in which his or her benefit would increase concurrently not reducing the benefit of any other participant is called a Pareto-efficient situation.

The situation when none of its participants is able to increase his or her benefit by changing his or her labāk: attitude (if others do not change their behaviour) is called a Nash balance situation.

Every day we see a bounty of Nash balance situations that are not Pareto-efficient. Each of us has once judged, 'I understand that what is happening is wrong. However, if I change something, I will suffer myself. Therefore, I will better keep silent. Let somebody else undertake the role of initiator of changes'.

If the situation (the set of behaviours of members of society) is not Pareto-efficient, it is always possible to find some better situation. So, the set of behaviours of members of society, which complies with sustainable development, should be Pareto-efficient. At the same time, not any Pareto-efficient situation will comply with sustainable development. Pareto-efficiency is necessary but insufficient condition for the situation to comply with sustainable development.

The first basic theorem of the welfare economy declares – free market ensures that the use of resources in economics will be Pareto-efficient. Sometimes it is mentioned as an argument that the free market itself is a mechanism that ensures sustainable development of economics. Nevertheless, the explanation is false due to the following reasons: 1) the theorem is applicable to an ideal model of total competition only, which does not exist in today's economics, 2) the indicator of profit in financial terms is considered to be the efficiency criterion, which is too simplified and is not correct from the point of view of sustainable development.

Let us assume that a Pareto-efficient situation that complies with sustainable development can be found. Let us assume that the majority of members of society would acknowledge it as correct and undertake to follow the sustainability principles. Would it be sufficient to implement such Pareto-efficient situation in real life? The liberal paradox of the welfare theory declares that counting only on free action of humans and achieving a Pareto-efficient situation are incompatible. Pareto efficiency is endangered by Nash balance – if at least one of the members of society withdrew from a Pareto-efficient state because his or her individual benefit would increase this way (although the benefit to other members of society would decrease), seeing that, other members of the society would start to think, 'If this is what the others do, why shall I be the honest fool?' Thus, the society would fall into Nash balance, when each member of society understands that the situation is wrong; however, if anybody started to change it, they would only suffer for it.

The question therefore is, how to attain that the Pareto-efficient state is retained and there is no Nash balance?

The American economist Thorstein Veblen has discussed such concepts as 'instincts' and 'institutions' in his works. Institutions are sets of norms created in the course of centuries, which are observed not because of the penalties but because the impossibility of violation of these norms is instiled in a human from an early age. We do not do things we would do in a bedroom on the street and vice versa. By means of law, institutions restrain individuals from such activities that may endanger society. If institutions are lost, the welfare of society is significantly endangered.

Supposedly, the safest way that has justified itself in the course of centuries is to instil certain principles in society in the form of generally accepted norms. The presently dominant arrogant attitude towards values, which facilitate observance of such norms, e.g. a family, the nation, the state, morality, religion, seriously endangers progression to the objective – sustainable development.

7.2.2 INTERACTION OF ECONOMICS AND THE ENVIRONMENT

Economic activities always affect the environment. The tendency in the developed countries of the world is that mankind is consuming ever more resources than it is necessary to satisfy its basic needs. The reason is the correlation between a higher standard of living and a greater purchasing power. People consume heat, energy, food, clothes, furniture and modern technologies in order to satisfy their needs. Natural resources are used to make products and provide services. Because of irrational economic activities, resources may become depleted for the next generations. The environment is endangered by the waste originating from production and consumption; the amounts of waste are increasing because of the increasing number of inhabitants on the Earth. Figure 7.1 shows the flow of materials between the environment and economics.

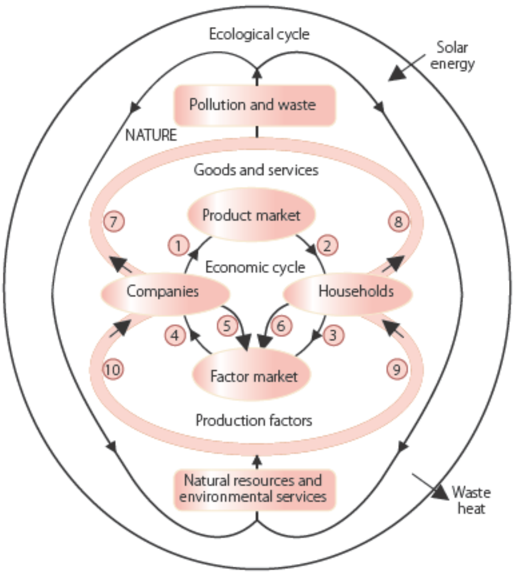


Figure 7.1. **Model of interaction between economics and the environment**

1 – supply of goods and services; 2 – demand for goods and services; 3 – supply of resources; 4 – demand for resources; 5, 6 – reuse, recycling and renewal; 7 – waste from production; 8 – waste from consumption; 9, 10 – natural resources

The interaction between humans and the environment may be categorised as follows:

- interaction between a human and the environment,
- interaction between humans.

The services provided by the environment are important for the economics:

- the environment as the source of resources,
- the environment as the space for disposal of waste, and
- the environment as the living space and provision of existence.

In economics, the environment has been traditionally perceived as the source of renewable and non-renewable resources and the place for disposal of waste. That is an explicit environmental exploitation approach. In economics, it is important that the resources which have an owner and have a cost are accounted for. Part of environmental resources was and is free of charge. It is essential to understand that resources are used intensively, as well as the fact that resources have a value, even if they do not have an owner.

Since the middle of the 20th century, intensive use of the environment for economic activities has led to the situation when environmental changes have become a serious issue on the global scale. It has become apparent as an increase in external costs.

In order to ensure sustainable development, each process should be assessed according to the three basic principles:

- *needs* – emphasising the vital needs of the poor parts of the world (developing countries and the poor members of society), which have to be the highest priority. It is the *principle of equality and fairness* – all people have equal rights to food, home, education, attention and love;
- *limited possibilities of the environment* to ensure the present and future needs of an adequate level of modern technologies and social organisation. It is the *precaution or long-term vision principle* – never take more then necessary, do not underestimate the possible risks. Before we purchase something, let us think it over whether we really need this thing, before we introduce a new technology or product – whether it is really safe in all aspects, before we break or hunt something – whether we need it and whether the joy of the moment of our omnipotence is really more significant than the diversity of nature which the next generations would also like to enjoy;

- *systematism* – interaction between the environment, society and the economy, which is usually reflected in the model of three capitals, including the nature capital, the human capital and the capital created by humans.

Sustainable development means solving any economic, public or environmental issue so that the decision is favourable to the development of any involved sector or at least as little unfavourable to it as possible. The concept of sustainable development includes physical conditions, policy visions, the notion of the quality of life or welfare and an optimised impact on the environment in order to ensure availability of its resources to the future generations.

7.2.3 IMPACT ON THE ENVIRONMENT – DETERMINING FACTORS AND PRINCIPLES

The growth of material welfare determines the impact on the environment. It means a larger flow of materials and energy, reduction of which would, in turn, mean less impact on the environment. The requirement to perform environmental impact assessment (EIA) of potentially dangerous objects of economic activities is determined by law; it is one of environmental protection policy instruments. EIA is a procedure that helps assess the possible environmental impact of the intended activity and prepare proposals for prevention or reduction of adverse impact.

In contrast to legislation that regulates a particular environmental sector, for example, the use of water or air, EIA is directed towards assessment of all activities that affect the environment. This assessment process should be commenced the earlier the better – in the stage of planning, designing and decision-making regarding the intended activity. EIA assesses possible direct or indirect changes in the environment due to the intended activity that may affect:

- humans, their health and safety;
- biologic diversity;
- soil, air, water and climate;
- landscape, cultural and nature heritage;
- material values;
- interaction of all above-mentioned fields.

Society has a significant role in the EIA procedure; an individual is given wide opportunities to co-operate in assessment of environmental issues as well as to affect the course and result of decision-making.

Environmental impact assessment is a tool to ensure progress towards the economic and environmental aims. There is a close connection between the environment and economics when economic solutions are based on the principles of rational use of resources and environmental protection. Interaction of environmental and economic objectives is presented in Figure 7.2.

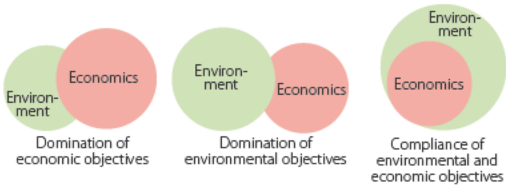


Figure 7.2. Interaction of environmental and economic objectives

In the case the *economic objectives* are dominating, the environmental requirements are adopted only to the extent stipulated by law. In the case *environmental objectives* are dominating, economic interests are deliberately restricted, including income and competition. Environmental economics means reconciling the conflicts between economics and ecosystems, combining the use of environmental protection measures with changes in production, production itself and the management processes.

The notion of sustainable development means a change in the traditional economics, humanisation of its main principles, coordination of the development of economic and environmental systems and search for common approaches. One of the main differences of environmental economics from the traditional economics and ecology is a larger–scale, sustainable approach to activities of humans in time and space. It includes a network of interacting economic and ecological systems of different levels. Traditional economics is oriented towards individual consumers and depends on their taste and choices. Due to technical progress and replaceability, natural resources are considered to be unlimited. The concept of environmental economics is based on other principles – humans are considered to be only one of the components of the united environment – economic system, although a very important one.

Several socio-economic factors determine the impact on the environment: the numbers of the population, affluence and the technology used. It is the IPAT formula:

$$I = P \times A \times T,$$

where

I – impact on the environment;

P – number of population;

A – affluence, which may be expressed as GDP per capita;

T – technology.

If the population does not increase, affluence and technologies become of greater importance. Affluence is traditionally expressed as GDP per capita. The growth of affluence has been and is still considered a significant indicator of successful functioning of a state. Since such approach is typical of the countries of the market economy, the growth of affluence is characterized by all deficiencies of the market. The market mechanism determines the prices, including the costs of the business, but not including losses of society caused by the process of production and distribution of goods. The most significant deficiency of the market is external effects, which may be assessed as external costs that providers of services and producers of goods impose on society. Thus, economic activities have negative impact on the environment (external factors) and the users of the degraded environment must cover the losses.

External costs are losses which the subject A causes by his or her activity to the subject B or subject C without set purpose and without compensating for those losses.

Analysing the condition of the environment and impact of economic activities on the environment, the environmental indicator system describing the interactions between the environment and society is useful. It is shown in Figure 7.3.

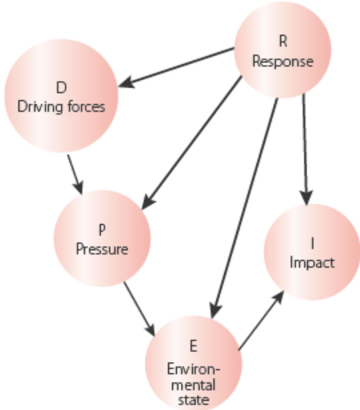


Figure 7.3. **Environmental indicator system**

D – driving forces – socio-economic forces driving human activities, which increase or mitigate pressures on the environment; P – pressures – stresses which human activities place directly on the environment (amount of emissions, waste production, amount of catch); S – state – the condition of the environment (the concentration of pollutants, number of species); I – impacts – the effects resulting from the condition of the environment (changes of ecosystems, the number of extinct species, sickness rates); R – responses – responses by society to the environmental situation (policies, regulations for the improvement of the environmental quality, reduction of emissions, penalties.

7.2.4 ENVIRONMENT AS CAPITAL: ECONOMIC GROWTH AND DEVELOPMENT

Economic growth has become the central problem of economic analysis, because, taking into account the increase in the world's population, economic growth has to provide for the increase of the standard of living. Some economists affirm that the economic growth increases the standard of living of all the world's population in any case. However, the real economics shows that it does not increase substantially the standard of living of the poor in many countries.

In sustainable development, the notion 'development' denotes not only the increase in production, gross national product, welfare, but also the development of the social and economic sphere, which ensures the preservation of natural ecosystems and the environment for human life.

Why is growth not the same as development? Economic *growth* is an increase in economic activity measured with the increase in percentage of the real gross domestic product within a particular time period. *Development* is a wider notion that includes increase in the standard of living and decrease in poverty. The economic growth ensures the increase in the standard of living only to a small part of the population, but the majority is sinking into poverty. The way the economic growth affects different sections of the population determines the level of economic development.

Therefore, the economic growth is possible without development or with little development. We can estimate the development of a state by analysing its economic indicators. Historically, GDP was used as the main indicator to assess development. GDP is used as the indicator of the standard of living in order to compare it in different countries. GDP might be larger in the countries with a larger population, but it is not a rule. In order to compare the standard of living in different countries, GDP per capita is used (Latin 'per each head'). As the price level differs in different countries, GDP per capita is re-calculated.

Exceedance of limits is a stage when delayed environmental signals are not strong enough to stop growth. In this stage society can still act to return within the limits of the environmental capacity and avoid the collapse (Figure 7.4).

In order to ensure a significant increase in the welfare of the population, stable and sustainable economic growth is necessary, but it is strongly affected by the consumption of resources and environmental pollution.

Figure 7.4. **Possible consequences of economic growth**

Gross national product (GNP) is the total value of the end-products created in a year with the means of production owned by the citizens of a country.

The difference between GDP and GNP constitutes the net income acquired by foreigners. If GDP exceeds GNP, the citizens of a country earn less in foreign countries than foreigners earn in the respective country.

Economists have put forward the idea that there are three sectors of economy:

- primary sector includes acquisition of raw materials by way of agriculture, fishery, forestry and the mining industry. The countries with low levels of income represent this group;
- secondary sector includes industrial production related to manufacturing and construction. The countries with medium levels of income represent this group;
- tertiary sector includes provision of services (e.g. education, tourism). The developed countries dominate this group. If a country has a large proportion of the tertiary sector in its economy, it means it is in the stage of maturity and in the process of growth.

The development of the economy of countries starts with the primary sector of production, then transfers into the secondary sector and the tertiary sector. Along with economic growth and increase in income, demand for agricultural products increaases rapidly in proportion, and the secondary sector grows. With further increase in income, the demand for services also increases; thus, the secondary sector grows and develops. In some developing countries the tertiary sector is very significant because of tourism, yet the secondary sector is undeveloped. Economists deem such situation risky for a country.

7.3 SUSTAINABLE DEVELOPMENT OF ECONOMY AND THE ENVIRONMENT

The most difficult thing in the assessment of economic development is to choose unified indicators which would best reflect the progress towards sustainable development, as well as the economic processes and their impact on the environment. Monetary units usually serve as economic indicators, physical units – as environmental indicators (area of logged forests in ha, number of endangered species, amount of pollution), but social indicators usually concern the conditions of real life (level of employment, poverty) or human values affected by cultures, morals and religions. Many indicators allow to assess the achievement of different objectives of sustainable development.

Several complex indexes have been developed that broaden environmental, social and economic indicators and unify them in one scheme, thus facilitating the assessment of the progress towards sustainable development.

Analysis of environmental management allows to conclude that the procedures for determining and regulating the economic efficiency of the environment must be improved so that environment-friendly decisions can be made in companies and in the economy in general.

Each production process can be divided into three parts:

- *input* – raw materials, additional materials, energy resources, labour;
- *production process* – mechanical, chemical or other type of processing of materials;
- *output* – the product (also waste, emissions into soil, water and air, noise, dust, smells).

From the point of view of the environment, it is especially important to assess the output. Although pollution is created in the process of economic activities, it is not always a significant risk for certain stages of production. There is a greater risk of emissions into air, not in water, in certain production processes. If the possibility the emissions would form is approximately equal, the impact on the environmental must be assessed, finding out whether emissions into water may cause more serious environmental effects than emissions in air. Using such scheme in a particular company, it is easier to find those parts of the production process where there are deficiencies and the economic activities violate the conditions specified in a pollution permit.

As to investments, the adoption of a decision regarding the use of investments is an especially important stage. The time of payback of investments and prospects of the development of the object of economic activities depend on careful and correct preparation of the investment plans. Different methodological approaches and basic principles are used for the assessment of real investment project efficiency in international practice, depending on the type of projects. They can be classified into two groups:

- methods which do not intend the use of the concept of discounting:
  - assessment method for the profit margin,
  - assessment method for the payback period of investments,
- methods based on the use of the concept of discounting:
  - assessment method for the net present value,
  - assessment method for investment profitability,
  - assessment method for internal rate of return.

Building on the research on the standards of the Global Energy Efficiency and Renewable Energy Fund for the mobilisation of public and private financing, which intend to ensure global access to low-cost and safe energy services favourable to climate, the International Energy Agency forecasts that the worldwide demand for energy will increase by over 60% up to 2030. It is estimated that in order to satisfy this demand, approximately 12 trillion euros must be invested in the energy sector during the next 25 years. Serious financial difficulties will arise if the usual investment attraction plan is used; moreover, this plan will not provide a sustainable future.

Investments in renewable energy and energy efficiency are typical public advantages with significant local and global benefits, for example, low emissions of greenhouse gases and pollutants. They help improve the safety of the energy supply using such local energy sources as wind, sun, geothermal and biomass energy. Ever wider use of efficient technologies of renewable energy resources will reduce the impact of fossil fuels on the environment and health as well as relieve the strain on the markets of energy resources. They will also promote local employment and provide income, for example by ensuring efficient use of energy, especially in remote regions where to increase the energy supply is not economically profitable.

If the public advantage is fully taken into account, projects regarding renewable energy resources and energy efficiency frequently become lucrative, especially in the countries where energy production is usually inefficient and pollutes the environment more than in industrialised countries, where up-to-date environmental regulations are in force.

In order investors would not consider the time of payback an additional risk factor, the calculation and assessment of the time of payback of investments is mandatory. It is recommended to link measurements of the environmental quality with the approach of the life cycle analysis, which identifies the main problems and impact of a product on environment. It is problematic to decide in which stage of the life cycle a product is when assessing pollution caused by economic activities and analysing the cycle. A rubber tire can serve as an example. We can discuss the process up to extraction of oil in order to create synthetic rubber. We can include the production of the necessary drilling equipment in order to extract the oil, or even discuss the equipment that services the drilling devices.

Using input-output (I-O) analysis lets us analyse the circulation cycle of a product or production technology. I-O analysis can also be used to calculate direct or indirect effects of the use for different technologies. In order to use I-O analysis, the information regarding costs, output and pollution is necessary; therefore, it is not widely used in the stages of analysis of the product circulation cycle although the I-O method is attractive in theory. Even a simplified I-O method shows the significance of effects during the life cycle:

- technologies which comprehensively reduce the use of resources always belong to clean technologies;
- technologies which replace an unclean process with a cleaner process (replacement technologies) are not always clean technologies.

In practice, the I-O method is still unusable to clarify detailed matters, for example, whether production of a damask fabric is cleaner than a disposable material. The I-O method is used to clarify broader matters, for example, use of resources and reduction of pollution in some sector of economy.

7.4 ENVIRONMENTAL ECONOMICS AND THE MARKET MECHANISM

7.4.1 COMPETITIVE MARKET MECHANISM

The functioning of the market is determined by demand and supply. Demand shows how many goods people are willing and able to buy, supply – how many goods producers are ready to offer on the market for different prices. Interaction between buyers and sellers helps determine an equilibrium price at which the amount of goods in demand and supply is equal.

The demand line shows graphically the correlation between the amount of goods in demand and their price. The law on demand determines – if other conditions are equal, the amount of goods in demand reduces if the price increases. The supply line shows graphically the correlation between the amount of goods in supply and their price. The law on supply determines – if other conditions are equal, the amount of goods in supply increases if the price increases. Another condition that affects the demand of goods is the income level of buyers, prices of supplementary and substitute goods, the preferences of buyers and future forecasts. In turn, the supply is also affected by the costs of raw materials and labour, the availability of technologies and the number of sellers. Market eqilibrium is shown graphically in Figure 7.5.

Perfect competition is a market condition when there is competition of both buyers and sellers, but

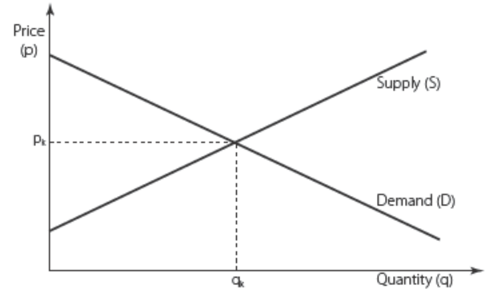


Figure 7.5. Market equilibrium under perfect competition
The market equilibrium is achieved when the amount of goods in demand and supply is equal. In the diagram, the specified equilibrium price is p_c and the amount – q_c.

there is no mutual agreement of sellers regarding the price of goods, and the situation is characterised by the following:

1) there are many buyers and sellers none of which is capable to affect the market price;
2) buyers and sellers have a possibility to commence or terminate the trade;
3) uniform, undifferential goods are offered;
4) buyers and sellers are familiar with complete market information;
5) it is possible to buy and sell any amount of goods in the market.

Perfect competition is an important precondition for self-adjustment of the market. However, conditions of perfect competition are rare in real life, and there are situations when division of resources is inefficient and it is possible to improve the situation of some market participants without making the situation of any other participants worse.

7.4.2 ENVIRONMENTAL PROBLEMS AS A RESULT OF MARKET FAILURE

The fact that environmental problems arise proves that the market mechanism has not ensured the most efficient allocation of resources regarding the environment and resources, as it is stated in theory.

The situations in which the price formation mechanism does not provide allocation of resources efficient for the society are called market failures.

The main market failures are the following:

- difficulties to determine demand for public goods;
- positive and negative externalities;
- imperfect competition (monopolies, oligopolies, monopolistic competition);
- information asymmetry.

Public goods are commodities and services simultaneously available to many individuals, and the consumption by one individual does not reduce consumption possibilities for others. Examples of public goods are clean air or water, parks, provision of public order available to many consumers, and it is impossible or very difficult to prevent people from using them even if they have not paid for them.

Considering reduction of pollution a service to which the conditions of the free market apply, an economically efficient level of environmental pollution could be found. In order to determine the equilibrium, demand and supply lines should be designed. As improvement of the environmental quality is a public good, it is difficult to determine its demand with different price levels. Public goods are not being actually sold and people do not disclose how much they are willing to pay for them if they can use them without paying. However, economists have found methods with which it is possible to determine at least approximately the demand for improvements of environmental quality.

Similarly to other goods, the supply line S shown in Figure 7.6 shows marginal costs of pollution reduction – costs of reducing pollution by one more unit at different levels of environmental quality. As in the case of other goods, the supply line is a graph of a rising function because it costs less to reduce such amounts of pollution with which nothing has been done by one unit – it is sufficient to install a simple purification plant. However, when the environmental quality improves, reduction of pollution by one more unit costs more because more complicated technologies must be introduced to do it.

The environmental quality demand line D represents a decreasing function because the benefit from the reduction of pollution is greater if the amount of pollution is large. When the environmental quality improves, there are fewer benefits from reduction of pollution by one more unit. If the air or water quality in a town is already good, people will not be ready to pay for small improvements as they would do if the quality of environmental services was bad because there are fewer benefits

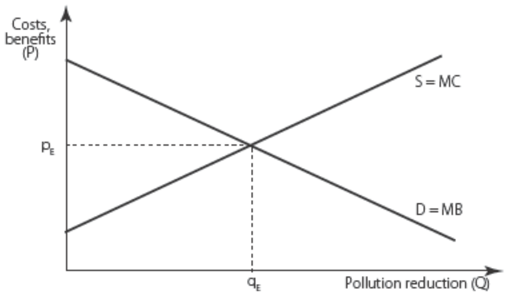


Figure 7.6. Economically optimal level of pollution reduction
S = MC supply – marginal costs of society; D = MB demand – marginal benefits of society. Market equilibrium is the point of intersection of the demand and supply line, where the marginal costs of pollution reduction are equal to marginal benefits of society from pollution reduction – q_E is the economically efficient pollution reduction level, and p_E is its costs.

from these improvements. Thus, the willingness to pay for the improvements of environmental quality and the benefits of society related to a cleaner environment, improved health, better-functioning ecosystems, aesthetics and the increase in property value can be considered a demand function.

In economics, an efficient pollution level is the point at which pollution reduction costs do not exceed the benefits of society from pollution reduction. It is not the so-called 'zero pollution' because at the present technological level the so called 'zero emission technologies' are rather an ideal solution than a real possibility, which the present technologies could help to achieve only by completely ceasing to use electricity and the transport system, different goods and services.

We can also search for solutions to environmental problems by modelling demand and supply for different goods and services that couse environmental pollution. In this case the market failures are externalities and imperfect information.

Externalities arise if additional costs or benefits to a third person who is neither buyer nor seller of goods occur while goods are produced or consumed. If there is a factory in the city which produces cement and hazardous emissions, additional costs to residents arise – they might fall ill more frequently, go to general practitioners and buy medications. It is a negative externality which causes costs not included in the price of goods, and too much of these goods are produced because the market price does not reflect the costs to all society (Figure 7.7).

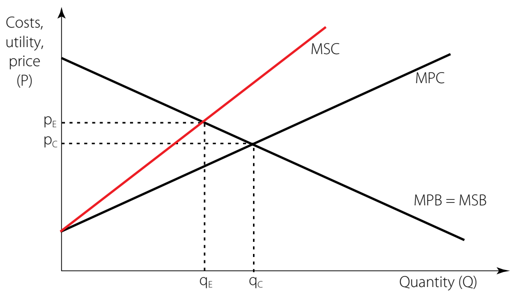


Figure 7.7. **Impact of externalities on the competitive market equilibrium**

MPC – marginal private costs; MSC – marginal social costs (private costs plus external costs); MPB – marginal private benefit; MSB – marginal social benefit; q_c – quantity of competitive equilibrium; q_E – quantity of efficient equilibrium; p_C – competitive equilibrium price of goods; p_E – efficient equilibrium price of goods.

In competition conditions, the quantity of balance of demand and supply would be q_c and the price – p_c. If the costs which arise due to a negative external effect are added to marginal private costs, the line of marginal private costs MPC diverges towards MSC. We can see that the balance efficient for society is with less goods q_E and higher price of goods p_E.

If the factory introduces a new technology or installs purification devices which reduce pollution, an additional benefit arises for the third persons – the health of the residents is improving, labour productivity is increasing, people can earn more – this is a positive externality, and too little of such goods are produced because the market price does not reflect the benefits to all society.

Market failures are also caused by incomplete information. Consumers frequently are unaware of the external effects and costs consumption causes to society at large. For example, plastic bags decompose extremely slowly, excessive consumption of surface water and groundwater adversely affects the quality and amount of water as well as the ecosystems depending on the water. Purification of air or water and elimination of pollution have positive external effects, improving the health of residents, increasing the yield of agricultural products, preserving biological diversity. By ensuring the society with information regarding the consequences of consumption, the demand or readiness to pay for the improvements of environmental quality could increase.

Pollution reduction is a policy instrument via which the governments try to solve market deficiencies – to regulate demand and supply or to ensure reduction of environmental pollution. However, intervention of the government does not always provide an efficient result – the market failures are not completely eliminated.

7.4.3 POLLUTION REDUCTION METHODS

The means and methods at disposal of governments fall into three principal groups: institutional approaches, legislative instruments and methods of economics.

The institutional approaches are granting property rights of public goods to some of market participants, reduction of transaction costs and provision of availability of information.

Legislative instruments are laws, regulations or standards approved with specific procedures which determine the requirements to the production process, goods or pollution – quotas, prohibitions, non-tradable permits, pollution zones.

Economic methods (taxes, targeted subsidies, tradable emission quotas) are policy initiatives which allow a polluter to choose an economically profitable method for the reduction of pollution.

Transaction costs are related to negotiations between a polluter and representatives of society suffering from this pollution – legal consulting, negotiations, premises and information.

The institutional approach is described in theory by the Coase theorem. In 1960 the outstanding work 'The Problem of Social Cost' written by the American economist of British origin, the Nobel Prize winner Ronald Coase (1910), was published. Coase stated that by clearly determining property rights, the market mechanism will ensure an efficient solution to a problem regardless of which of the parties the property rights have been granted. Low costs for obtaining information and transactions are mentioned as necessary conditions.

If the property rights have been defined, Coase shows that, the parties involved, for example manufacturers who cause pollution and residents who are suffering from this pollution, will start trading, offering the other party a compensation (Figure 7.8).

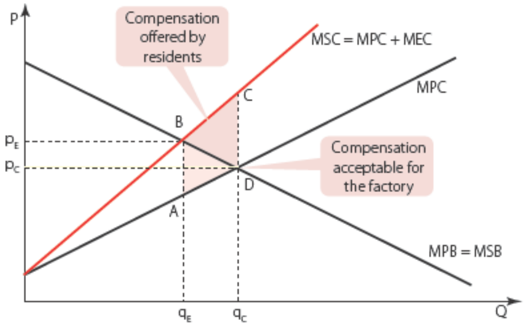


Figure 7.8. **Trading in the case the property rights belong to the factory**

For example, there is a factory on the shore of a lake, which dumps its wastewater into the lake; therefore, damage is caused to local residents and vacationers, who want to swim, fish and go boating in the lake. If the property rights belong to the factory, trading will start with a certain amount of manufactured goods q_C, which reflects competition balance. With such quantity of goods, additional costs arise for vacationers due to negative external effects shown by the line segment CD. By offering compensation to the factory in order it would reduce production volumes, vacationers are winners as long as the amount of the compensation is less than the damage caused to them shown as the square ABCD in Figure 7.8. The factory will be interested to reduce the production volumes if the compensation received for the production reduction shown with a triangle ABD in Figure 7.8 is larger than the unearned income (MPB – MPC). Yet the vacationers will agree to offer only such compensation that does not exceed the damage caused to them (MSC – MPC). As shown in Figure 7.8, the reduction of production volumes is from q_C to q_E, which coincides with efficient balance because at this point the amount of offered compensation coincides with the amount of unearned income and nobody has the possibilities to improve their conditions.

If the property rights belong to vacationers, trading will start with a statement that the factory has no right to pollute the lake. The factory will start trading with vacationers, offering compensation in order to commence production of the goods. In such case the factory will be a winner with any amount of compensation less than the profit, but the vacationers will be ready to receive any amount of compensation if only it exceeds the damage caused to them. As in the previous case, the balance will be achieved with quantity of goods q_E, when neither factory nor vacationers are able to improve their conditions.

The condition regarding low costs for obtaining information and transactions is essential because such trading requires information on amount of damage caused and the equivalent of it in financial terms as well as information to organise negotiations between the involved parties and to solve legal matters. It needs time and money.

However, it is not always possible to determine the number of people affected by pollution, their geographical distance and time. Pollution is often imperceptible, but it accumulates in the course of time, and sufferers will be the future generations.

Nevertheless, pure environment is not enough for sustainable development. In order to ensure welfare, we cannot do without production and agriculture. Therefore, negotiations between polluters and sufferers are a search for compromise. The critics of the Coase theorem mention the extremely rare examples of such trading in real life as a major drawback of the theorem. However, there are cases when investors who want to build industrial enterprises, facing resistance of local residents, try to agree via investing in the development of the local infrastructure, improving the environment or establishing purification devices.

The public discussion of polluting activities facilitates trading with polluters. The necessity of public discussion is determined in regulations in relation to environmental impact assessment (EIA).

Legislative instruments determine the standards, quotas, prohibitions or limitations of use of certain substances in order to ensure environmental quality necessary for the health of the population. However, these instruments do not promote search for the most efficient pollution reduction measures in terms of costs. Form the point of view of total costs of society, legislative instruments have several imperfections.

First, the pollution level determined in the standard can be not the economically efficient pollution level at all. Either the standard is too high and pollution reduction expenditure exceeds social benefits or the standard requirements are too low, and larger social benefits could be achieved by investing additional resources in pollution reduction. When the responsible institution sets the standards, precise information is not available either regarding functions of demand or supply. The standards are modelled only approximately; therefore, a mistake in determining the economically optimal pollution level is very likely.

Secondly, regional differences are not taken into account when the national standard is set. The optimal pollution level is determined by the location of marginal social benefit and marginal social costs, and at least one of these functions differs in different regions. The social costs and benefits may differ due to income, education, as well as density of population. For example, reduction of pollution, which is labour-intensive, in a district with high unemployment and low salaries is cheaper than in the capital city. Even then, if the standard is efficient in a particular region, it does not mean it would be efficient in the whole country.

Thirdly, provision of the standard does not provide an efficient solution if the emissions of pollutants do not have an equal effect on the environment. It happens if impact on the environment does not change proportionally to amount of emissions. Differences in pollution also arise if polluters are at different distances from the residents or ecosystems even if pollution sources are identical. The further the pollution source is located from the residents, the lesser damage is caused because part of pollution disappears thanks to the assimilation ability of the environment.

The first economist who proposed a tax as appropriate means for inclusion of costs caused by external effects in the price of goods to reduce their demand was Professor of Cambridge University, Arthur Pigou (1877–1959).

The proposal of Arthur Pigou was to impose a tax on each unit of goods causing negative external effects so that by adding a tax to marginal private costs, the competition balance would diverge to efficient balance. In practice the main problem is

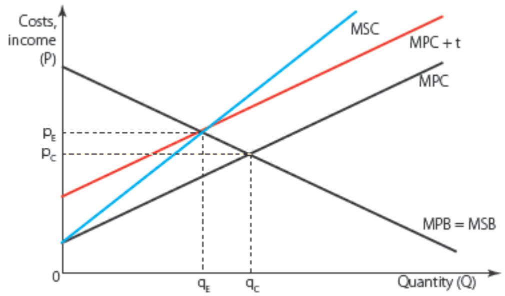


Figure 7.9. **Graphic explanation of the Pigou tax**

Under conditions of competition, the quantity of balance of demand and supply would be q_C and the price – p_C. If the manufacturer pays a tax t, the straight line of marginal costs MPC moves up to MPC + t. If the amount of tax is specified exactly as large as the not-included costs which have arised due to external effects, the new balance is with efficient quantity of goods q_E and the price of goods p_E.

to assess in financial terms how large are the not-included costs and what should be the amount and price of the goods of efficient balance. The gist of the Pigou tax is used in introduction of different pollution fees.

A fee or tax on pollution is a payment with the main purpose of including external effects in the costs of the product. That corresponds to the principle 'the polluter pays'. A tax and fee differ: a tax is paid into the state budget, but a fee is received by a service provider or the local government. Part of pollution fees are changed according to the quantities of emissions, but others are specified as user fees regardless of the actual amount of pollution (Table). If a fee for pollution is introduced, a polluter can choose the economically most profitable option – to reduce emissions using environment-friendly technologies, to reduce the amounts of production and thus pollution, or to continue to emit pollution and pay the pollution fee for it. In case of use of standards, there are no such possibilities to choose from.

Subsidy is a payment or tax relief which ensures financial support for reduction of pollution or plans to reduce it in the future. Subsidies are granted either for purchase and installation of equipment that reduces pollution or for actual reduction of pollution. Similarly to the Pigou tax, a subsidy has to be equal with marginal benefits of society to make efficient pollution balance. Several EU Member States subsidise the purchase of environment-friendly cars, installation of solar batteries, use of biofuel, construction of wastewater treatment plants or other activities helping to protect the environment.

The system of deposits and repayment is a system in which one has to pay for the potential pollution. The money is repaid if the product is handed over for destruction or recycling. This market instrument joins initiatives similar to pollution fees, but it facilitates the control mechanism because the buyer of the polluting goods is interested in

Table. **Pollution fees – types and examples**

Type of payment	Taxable object	Examples
Fee for emissions or leakage	Amount of pollution discharged into the environment	Fee for the use of landfills Carbon taxes Nitrogen taxes in France and Sweden Taxes for chemical fertilizers and pesticides
Fees for natural resources or user fees	Amount of resource use or costs of public services	Fee for collection of municipal waste Fee for noise caused by airplanes Fee for sewage Fee for traffic jams in cities
Fees for products	Products that are source of pollution	Tax on batteries Tax on the use of plastic bags Tax on packaging Fee for waste of electric and electronic devices

ensuring appropriate use of the goods to receive repayment. Most often the system is used for packaging of drinks, lead-containing batteries, car tyres and other products whose waste is dangerous for the environment.

The pollution permit trading system is establishes a market for pollution permissions. Knowing the desirable pollution reduction level, the market mechanism is given a possibility to determine the price for pollution reduction.

Pollution permit trading systems use tradable pollution credits, when a polluter obtains credits only if they emit less pollution than the specified standard, or pollution permits, which give the right to emit a certain amount of pollution. A certain number of permits are issued in a region, and trade in issued permits is ensured among owners of polluting sources in this region.

Polluters can choose the cheapest way – to buy a pollution permit or to reduce pollution. In the example regarding two polluters with different pollution reduction costs, the first would be ready to buy pollution emission permits from another enterprise, for which it is profitable to reduce pollution due to advantages of costs.

The most significant disadvantage of this method is that only the total amount of pollution is being controlled in the region. It may cause situations when separate 'hot points' with heavily concentrated pollution arise.

7.5 ECONOMIC VALUE OF THE ENVIRONMENT AND ITS ASSESSMENT METHODS

7.5.1 NECESSITY TO DETERMINE ENVIRONMENTAL VALUE

Economic assessment of the environment is always performed for a certain objective:

- to choose the economically most profitable option to achieve a specific aim, comparing costs and benefits of different environmental projects;
- to assess efficiency of resources invested in environmental protection;
- to assess the damage caused to the environment;
- to assess the costs or benefits caused by external effects;
- to determine priorities in environmental protection and conservation projects;
- to determine demand for the environmental quality, which would allow to reach an efficient pollution level and determine the standard and tax rates.

7.5.2 COMMON ECONOMIC VALUE OF THE ENVIRONMENT

Determining the value for different nature objects, we have to take into account that varied functions are to be assessed. In a complex economic assessment of the environment, one of the possibilities is the concept of the common economic value of ecosystems. Using it, the types of benefits provided by different ecosystems can be assessed, including benefits not expressed in financial terms. In accordance with this concept, the common economic value of ecosystems consists not only of costs of resources, but also of incomes provided by the use of ecosystem services. Components of the common economic value show the value society grants to different features of nature objects.

The main components of the common economic value are the following:

- use value, the sum of the value of direct and indirect use;
- value unrelated to use, the sum of the option value, existence value and bequest value.

The value of direct use depends on the actual use of the environment – it corresponds to the value of a nature object and features of a nature object which make it possible to provide profitable services. For example, the value of direct use of the Baltic Sea includes income from fishery, tourism and shipping.

The value of indirect use is related to the functions of ecosystems – physical, chemical and biological processes that ensure self-preservation of ecosystems, flood protection, climate stabilisation, retaining of nutrients, absorption of carbon dioxide, supplementation of underground waters, and also benefits from cultural and historical landscapes, attractive places and protection of untouched nature. These functions support economic activities, protect property and health for they preserve the environmental quality and stability of the place. The value of indirect use of the ecosystem of the Baltic Sea lies with such services as pollution assimilation, climate

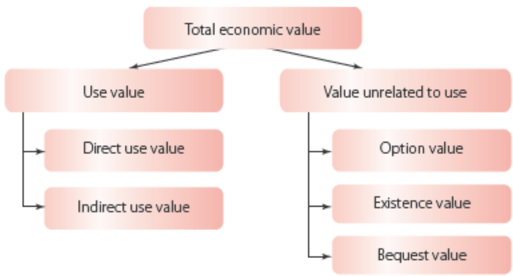


Figure 7.10. **General economic value of the environment**

Figure 7.11. **Environmental value is determined not only by material but also by aesthetical values of nature**

regulation, recreation and recovery services, provision of habitats for valuable and rare bird species.

The option value, which is also called the deferred alternative value, is related to alternative use of environmental objects and their undiscovered potential. For example, oil is not extracted in the basin of the Baltic Sea at the moment; however, it is possible that it could be extracted in the future using more advanced technologies. Such a possibility certainly increases the general economic value. In the future many nature objects could be used so that they are more useful to society than they are now – diversity of habitats and preservation of the genetic fund are mandatory preconditition s for further development of society and new scientific discoveries.

The existence value means that people value the fact that the existence of habitats and species is ensured. The awareness that such places exist is valuable even if a person himself or herself would never see or use them in any way. It means the social significance of nature objects for the purposes of science, education and learning, the aesthetic and cultural value of nature objects and the value of ecosystems *per se*.

The bequest value means society values preservation of environmental objects for the future generations just because such nature objects exist. This value stems from the readiness of people to pay for the existence of a nature object regardless whether a person himself or herself will be using it or not. When unique nature objects are lost, their actual value could probably never be regained, the genetic information and possibilities of future evolutionary changes could be lost.

7.5.3 METHODS FOR ECONOMIC ASSESSMENT OF THE ENVIRONMENT

Having seen the wide range of benefits provided by ecosystems, it is clear that it is almost impossible to assess many of them in financial terms. In order to assess different development alternatives, efficiency of investments and demand for the environmental quality, it is necessary to clarify, at least approximately, these benefits in financial terms. Using the results of the assessment, the opinion of society regarding values and gradation of values has to be heeded. Values of society can change in the course of time due to scientific discoveries and increasing understanding. The assessment results are affected to a large extent by the chosen method and the attitude of assessors towards the assessed object, their opinions on life and attitude towards the environment.

In order to express in financial terms the values consumers assign to different nature services and benefits, economists use the following criteria:

- market price;
- willingness to pay (the amount which a consumer is ready to pay for improvement or preservation of the environmental quality);
- willingness to accept compensation (the amount which a consumer is ready to receive for refusal from goods or services).

The market price is the lowest limit of the benefit assessed by a consumer, because part of buyers would also buy goods if the price was higher than the price specified in the market. The market price does not reflect the readiness of all consumers to pay. The economic value of environmental benefits is better revealed by readiness to pay or accept compensation.

Methods based on market assessments use the data on transactions carried out in real markets to assess benefits or losses regarding changes of the environmental quality. This group of methods is used in assessing marketed ecosystem products. In such cases the market prices of raw materials and products, which reflect the demand and supply ratio, can be used. The methods based on the market assessments can only be used to determine the value of direct use of the environment and only regarding such benefits as market goods.

The most frequently used methods based on market assessments are:

- replacement method,
- method of productivity and income changes,
- method of restoration expenditure.

The replacement method uses costs which arise to compensate a function of the ecosystem with the cheapest substitute which is considered the value of the environmental service. For example, if a family uses water from a private well and, due to pollution with wastewater from the nearby factory, the water becomes unusable for drinking, the family is forced to buy water or install water treatment facilities. Using the replacement method, the costs of consumed water or installation and use of treatment facilities are calculated for a selected time period. Furthermore, if the quality of water had become unsuitable for survival of fish in a natural water reservoir, the replacement costs would be related to fish breeding in nursery.

The method of productivity and income changes is used if the environmental resources are used in the production process. Any changes of resources may change productivity and thus also the income. The method can be used in order to calculate additional income when the anticipated catch is increasing, new technologies of water treatment are introduced, with the increase in grain yield, when air quality is improved, higher air quality standards are envisaged in regulations. This method can also be used to assess additional costs which arise by enlarging the area of a nature reserve because the tree logging and extraction of resources will decrease in that area.

The method of restoration expenditure is used as the measure of the value of an ecosystem for calculating the costs to restore the ecosystem to the desirable quality, for example, costs necessary for purification of a lake or costs to restore fertility of soil affected by erosion.

Methods of indirect choice are used in order to assess the environmental services which are not marketed but whose value is determined by prices of market goods related to the assessed environmental benefit:

- hedonic pricing method,
- travel cost method.

With the help of the hedonic pricing method, the value of ecosystems or environmental services is determined using their direct effect on the price of some other good. The method is most commonly applied to variations in housing prices related not only with different features of housing but also with utilities and infrastructure of its surroundings. This method nesures that the prices of the property market, also including housing prices, reflect the value people assign to the quality of the environment.

Let us assume that there are two houses with equal features of consumption (the number of rooms, year of construction, level of decoration, distance from the city centre), except for the environmental quality – atmospheric air pollution, the noise level, surrounding landscape, proximity of a forest, park or water reservoir. The prices of these houses would differ because of the environmental quality.

Using the hedonic pricing method, the following has been found out:

- the extent to which the difference of propery prices is affected by differences of environmental parameters;
- how much people are willing to pay for improvement of environmental quality and what is the social value of the improvement.

The limitation of the hedonic pricing method is that it assesses the environmental benefits related to prices of housings or other goods used in the assessment only. Moreover, it is possible to measure readiness to pay only for studied differences of the environmental quality and their direct effects. If people are unaware of the relation between any characteristic feature of the environment and their benefits, the environmental value will not be reflected in prices of goods.

The travel cost method is mainly used to assess nature objects, parks or protected areas used for recreation. The value of services of such places cannot be measured only according to their fee for use, which usually is low or even free of charge. Analysis of expenditures for time and transport to see national parks, nature monuments and other specially protected nature territories and to enjoy their beauty is the basis of this method. The method can be used to calculate an adequate entrance fee in such places to regulate the number of visitors and invest in the development of the park.

Methods of direct choice:

- contingent valuation method,
- contingent choice method.

Methods of direct choice use different polling techniques to study the readiness of people to pay for a service of an ecosystem. The advantage of these methods is that it is possible to assess both the value of use and use-unrelated value of the ecosystem.

7.5.4 COST AND BENEFIT ANALYSIS AND DISCOUNTING

In order to ensure welfare, it is necessary to invest in production units which provide goods and services. In economics the efficiency of investments is assessed using cost and benefit analysis. Choosing the right project for investments, benefits and losses have to be compared in financial terms. Money investments in the relevant project and income (benefits) are compared. Since benefits are mostly expected in the future, they are assessed considering the present market situation. The expected benefits or losses may be summed up and the obtained sum may be considered the assessment of profitability of investments. If benefits are greater than losses, the project is acceptable.

Figure 7.12. **Correct investment policy is a precondition for a good choice of investments and decision-making**

Simple comparisons of benefits and costs are considered unacceptable in theory and practice of due to several reasons. Today's income is considered more valuable than benefits of tomorrow. As the well-known proverb goes, a bird in the hand is worth two in the bush. Therefore, the factor of time – discounting – is taken into account. 100 euros today are more valuable than 100 euros in a year or two because they can be invested and the amount of income increased by the interest. Investments into the particular project and alternative investments, for example, deposits in a bank, are compared, or the investment in a certain project, for example, buying government bonds with fixed interest of profitability. If the benefit from the project is greater, the project is profitable.

In a real-life situation, several problems may occur, especially if environmental protection is taken into account. First, all benefits and losses have to be expressed in financial terms, and in many cases it causes additional problems. Second, using the described methodology, the future damage is assessed as low because many benefits or damages to the environment may appear after several years. Discounting moves aside the costs of society closer to the initial period, but the future costs and benefits are assessed lower than the costs and benefits of the initial period. Thus, the main principle of sustainable development – equality of generations – is violated. Discounting causes several problems for the future generations because a high discount rate facilitates faster use of renewable and non-renewable resources. The costs and benefits of projects and new technologies are also assessed too low (for example, waste caused by the nuclear power industry). Therefore, valid projects may be refused as unacceptable.

Benefits or losses of the investments into socially significant projects with large benefits for or damages to the environment are more difficult to assess than of private investment projects. The main reason is that there is no adequate price system. It is not always possible to find prices similar to the prices in private projects, the losses or benefits for objects that do not have market prices have to be assessed. It is not possible to assess all benefits and losses, hypothetical prices are used.

Assessing investments in socially significant projects, a lower discount rate is usually used – a rate intended for risk-free investments, for example, the interest rate of long-term government bonds.

7.5.5 INSURABLE RISKS

The insurance possibilities of environmental risks have to be viewed as the interaction point of two sectors – the environment and insurance – the place of the environmental risk among others and preconditions for identification of an insurable risk.

Insurable risks are twofold:

- the case of risk occurrence peril;
- the conditions of risk occurrence hazard.

To illustrate the environmental risk in insurance, the case of a risk occurrence would be a possible yield of cereals (the insurance object), but the conditions of a risk occurrence – storm, wind, hail, incessant rain, losses caused by the third person.

An individual's attitude towards risk differs from the perception of professional risk signatories of the insurance company. The level of uncertainty of a particular risk depends on the attitude towards the risk and other parameters. If a person assumes the risks of earthquake, floods, hurricane as the uncertainty degree of the third level – the highest, the experts of insurance companies and risk management experts of the government will assign nature elements to the second – medium – level of uncertainty within the real competence. The differences between individuals and private insurers or the government in the attitude towards one and the same risk arise due to different economic capacity levels of risk management. The economic capacity of risk management is characterised by financial, informative and risk management parameters – the available resources for compensation of possible losses.

The global economic depression, hurricanes, floods, earthquakes, possible losses of yield of cereals affected by nature elements are among such risks. Losses in certain geographical regions correlate positively and depend on each other because, for example, an earthquake will necessarily cause heavy losses in medical and property insurance. It is not possible to identify and merge these risks. In accordance with theory, if a risk is not identifiable and mergeable, it is not possible to diversify the risk. Thus, the risk is not insurable in the form of classic insurance. The main task of insurance is to clear a risk or possible losses in the insurance fund. The insurance fund is created by the insurers, merging many similar units which characterise the risk. The insurance fund may be defined as mutual agreement between insurers and insurants – holders of similar units characterising the risk – on insurance of a certain type, undertaking the compensation of possible losses of similar units characterising the risk because only a small part of participants of the insurance fund usually suffer losses.

The worldwide experience indicates the use of new insurance forms by insuring the fundamental risks which are difficult to insure (systematic risks).

A risk whose frequency is not predictable, yet a substantial part of the world's population is subject to the influence of it, is considered a fundamental risk.

Classification of fundamental risks:

- nature risks (earthquake, storm, flood),
- risks caused by society (nuclear power, climate change).

The influence of small risks manifests itself in one unit (object) characterising a risk or to several units (objects) characterising a risk, for example: 10 road transport vehicles having suffered in the fire in a factory or in a road traffic accident at the same time are included in the category of losses of small risks.

Classification of small risks:
- nature risks (wind, hail, drought, incessant rain),
- risks caused by the third person.

Insurable risks that do not affect society as a whole but a person's property, real estate, health or business, for example, road transport accidents or road transport thefts or a fire in a private property do not cause global problems. These risks are identifiable and they can be merged. These risks can be diversified and are insurable.

In an ideal case, the insurance risks correspond to several requirements:
- risk can be assessed in financial terms,
- insurable risk is represented by many units,
- purchaser of insurance is a neutral person towards a risk,
- risk is small,
- losses are accidental,
- losses caused by risk are identifiable,
- compensation is economically justified.

The choice of administration of insurance determines the character of insurance:
- private insurance – the private sector (small risks),
- public insurance − the public sector (fundamental risks),
- combined insurance − the private and public sector (small risks and fundamental risks).

Both in theory and practice, it is best to choose the administrative model of combined insurance – insurance scheme – to manage environmental risks. Communication forms among the participants to insurance scheme.

7.5.6 NATIONAL TAX POLICY AS A TOOL FOR FUNDING AND IMPLEMENTATION OF ENVIRONMENTAL PROTECTION PROJECTS

Traditionally, tax policy is an aggregate of national measures guided to stimulation of economic growth, achievement of high financial results, taking into account the interests and rights of taxpayers. Such definition of tax policy corresponds to two of three sustainable development dimensions referred to in the report of the UN World Commission on Environment and Development, excluding the environmental dimension for the main function of taxes as mandatory payments to the state is fiscal – to ensure the state with funds and sources of financial resources accumulated in the form of a budget and used to

Figure 7.13. **Environmental risks (coastal erosion, landslide risks) may be a significant obstacle to any development, even to seemingly safe**

ensure implementation of the general functions of the state (protection, maintaining of public order, education).

The regulating function of taxes is reflected in differentiation of imposition of taxes. Collecting taxes, the state influences the behaviour of natural and legal persons – economic subjects. When the state stipulates different conditions for different groups of taxpayers or different territories, the capital and production concentration is being stimulated or hindered, the economic activities of subjects are facilitated or impeded.

Natural resource tax on the extraction of water resources and pollution of waters, as well as rates of water supply and sewerage and fees for the use of water resources to natural and legal persons are determined taking into account:
- that natural and legal persons cover all the costs related to the use of water resources and pay for water resources and damage caused to the environment,
- the principle that the polluter pays,
- that water resources are to be used rationally,
- geographic, geologic and climatic conditions, as well as evaluating the social, ecological and economical consequences of the application of payments and fees.

Society is not ready yet to change its consumer behaviour regarding the environment; nevertheless, ever more enterprises are trying to reduce environmental pollution using environment-friendly materials because the rates of the natural resource tax are increased year by year. Thus, the purpose of natural resource taxes is achieved: to promote economically efficient use of natural resources, restrict pollution of the environment, reduce manufacturing and sale of environment-polluting products, promote introduction of new, environment-friendly technologies, support sustainable development of the economy and fund environmental protection measures.

In support of taxpayers, the state allows to use all funds obtained from tax payments (tax income) only for financing of measures and projects directly connected with environmental protection, rehabilitation, recultivation, use or recovery of hazardous waste, as well as research or renovation of resources.

Present exploitation of the world's natural resources is not sustainable. Improvement of welfare of society has to be achieved in accordance with environmental preservation and protection. The new model for environmental development reflects degradation of the environment caused by the consumer society and negative consequences of climate change in the world today and invites us to strengthen the fields of science and education and co-operation among the government, academic, private and society sector in promoting sustainable development at a local and global level.

In economics, taxes are means for allocation and redistribution of national income and macro-economic stabilisation which reflect the existing economic and financial relations.

Since the beginning of the 1990s, the possibility to achieve the objectives stipulated in the field of environmental protection via taxes is widely discussed; however, the natural resources tax still is not regulated at the EU level, unlike excise duty for oil products – another payment related to restriction of environmental pollution, which is harmonised.

Excise duty for oil products, fuel and cars is also considered economic means for environmental protection. Although not all income of this tax is directed towards environmental protection, the differentiated tax rates for fuel promote the use of a better quality and environment-friendly fuel. In the EU excise duty is included in the group of environmental taxes.

The purpose of excise duty for oil products, like the purpose of natural resources excise duty, is to limit consumption of oil products due to harmful impact on the environment, as well as to fulfil its fiscal function – provide income for the national budget.

Figure 7.14. **Environmental values of landscape are a significant factor for facilitating investment**

The natural resources tax consists of the fee for use of natural resources and pollution fee to the extent specified in limits and of sanctions for pollution exceedance and consumption of resources.

Taxable objects may be classified into groups:

- natural resources, including water and biological resources,
- the Earth's interior, pumping natural gas or greenhouse gases into geological structures,
- waste dumps and sanitary landfills, where waste is disposed, and emission of pollutants in air and water,
- greenhouse gases emitted by technological equipment not included in the issued emission quotas,
- goods harmful to the environment,
- packaging of goods and materials and disposable dishware and tableware,
- radioactive substances,
- vehicles,
- coal, coke and lignite (brown coal).

The natural resources tax is calculated pursuant to the classification of rates and actual quantity or weight of resources.

7.6 IN SEARCH OF ENVIRONMENTAL PROTECTION AND BALANCE OF ECONOMIC GROWTH

Solving national and global environmental problems is the main task of the mankind in the 21st century. The cause of the majority of problems is the economic growth and trying to increase the level of material welfare constantly. Hence, we have to search for solutions in the field of economics. Environmental protection policies usually assess costs and benefits, and these aspects are often decisive. In some cases the compromise between economics and preservation of the environmental quality is required. Environmental risks must not be forgotten. Complete exploration and evaluation of them is essential to preparation of strategies for the development of economy.

In order to co-ordinate the relations between economics and the environment, several methods of economic control based on market control methods are used. However, they show that previous experience is not sufficient for solving ever more environmental problems caused by economy.

The method of comparison of benefits and costs is the basis for economically important decisions.

Its use in activities concerning the environment is insufficient.

Comparing the benefits and costs, the environmental losses and benefits caused by the economic activities have to be evaluated in financial terms because all decisions in economics are made by evaluating benefits and costs in financial terms. Further development and wider use of these methods is essential in formation of economic development strategies. The role and place of the environment must be clearly formulated in economics. Unfortunately, for the time being, the importance of the environment does not manifest itself so strongly in theory as it does in the real world.

Figure 7.15. **Understanding of welfare that includes environmental quality is the basis of sustainable development**

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CASE STUDY: DENMARK

WIND ENERGY USE IN THE BALTIC SEA REGION: SOCIETAL AND IDEATIONAL CONTEXTS

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Wind energy has been used for more than five millennia for sailing boats, pumping water and milling grain. However, industrial production and consumption of wind energy started a little more than 100 years ago. Yet it is the focus on renewable energy resources in approx. the last 50 years that has aroused an intensified interest in wind energy. Currently the most frequent form of the use of wind energy is production of electricity. In 2009, the capacity of wind-powered generators was about 2% of worldwide electricity production, and it is growing rapidly. This is also the case in the Baltic Sea Region; e.g., Germany has experienced an increase from 5% to almost 7% within the last three years, in Denmark currently around 20% of energy production is wind-powered.

Denmark has been a world leader in the production and use of wind power. Wind energy constitutes a higher proportion than in any other country. Denmark pioneered commercial wind power during the 1970s, and today almost half of the wind turbines around the world are produced by Danes. After a setback in 2005, the Danish wind turbine industry is again the world's largest today.

THE DEVELOPMENT OF WIND ENERGY IN DENMARK

This case story focuses on the history of wind energy use in Denmark. It will show that natural as well as societal conditions are important, and so are policies, actors and institutions together with political culture and ideas.

NATURAL CONDITIONS

Denmark did not originally have any known fossil fuel deposits. Thus, when the 1973 oil crisis hit the Western world, Denmark was totally dependent on imported oil. Only after the United Nations had declared in 1958 that continental shelves were part of the neighbouring countries, oil and gas was found in Denmark, namely in the Danish part of the North Sea, and oil and gas production was started in 1972. In 1991, this development had led to a situation that Denmark was self-sufficient in oil and gas and later, in 1997, self-sufficient in energy. This was the result of the energy policy implemented after the oil crisis with the aim to intensify exploration and extraction from the North Sea, to increase collective heating based on cogeneration and the introduction of natural gas as an alternative to imported coal, to increase efforts to save energy, and, finally, to intensify research on and use of renewable energy sources. Wind power became an obvious choice since the conditions for using wind energy are favourable in Denmark.

SOCIETAL CONDITIONS

It is important to recognise the development of wind power use as conditioned by the lack of natural energy deposits and the result of historical circumstances and policies. The historical developments produced the conditions for the introduction of alternative energy sources. The First World War and the Second World War were events that generated the need for alternative energy sources due to the lack of possibilities to import coal and oil. It caused a boom in the production of wind power made possible by large industrial enterprises like F. L. Smidth.

Furthermore, the oil crises in the 1970s were obvious occasions for considering alternatives to fossil fuels and development of wind energy for reasons such as the increase in oil prices, danger of supply safety and concerns about the environment, including concerns over climate change due to excessive carbon dioxide emissions. Growing concerns over global warming were the case especially in the 1980s, since the number of coal-fired electricity power plants had increased drastically after the 1973 and 1979 energy crises. That led to a boom in wind energy production, e.g., the Riisager Windmill produced since 1978 as part of a governmental programme for improving windmills and counselling the emerging windmill industry.

Additionally, the Chernobyl Nuclear Power Plant catastrophe in 1986 was an event that certainly begun the concern over the dangers of nuclear power production. Following other countries, the Danish Parliament passed a law forbidding building of nuclear power plants in 1988.

Renewable energy became the natural choice, since it was a probate remedy for reducing the risk of global warming as well as for the dependence on import from other countries.

ACTORS AND INSTITUTIONS

Although the best-known pioneers of modern wind power technology are the the Scotsman James Blyth and the American Charles Brush, it is worthwhile to mention the Danish pioneer Poul la Cour. In 1891 he built a test windmill at the Askov Folk High School in southern Jutland that revolutionised the effectiveness of wind power and made it possible to decentralise electrical supply and bring electricity to rural areas by establishing small electricity production units in small villages and individual farms. Poul la Cour was a physicist and meteorologist and had a record as an inventor. However, his main drive for performing wind power tests was social.

Figure 1. **Middelgrunden Windmill Park in the Baltic Sea east of Copenhagen**

He noticed that the invention of electrical applications drew many people from the countryside into towns and he wanted to help people stay in the countryside.

The Second World War and the following years saw industrial enterprises entering the scene, such as F. L. Smidth. The oil crises in the 1970s also called big companies to the fore, such as Vestas that started wind turbine production in 1979 and is the largest producer in the world today with a 28% share of the world market and more than 39 000 wind turbines placed in 63 countries on five continents. At the end of the 20th century, wind power was no longer a business for individual pioneers, as at the end of the 19th century, but for large industries.

Governmental policies and institutions also played an important role by performing tests and offering advice for private entrepreneurs. Not only governmental research and development but also tax schemes benefitted the private wind power sector. Thus, the successful development of wind power in Denmark is caused by the close collaboration between publicly financed research and private industry in key areas. The expansion of the Danish wind power industry to the United States market in the 1980s was a joint effort by small Danish companies that developed the wind turbines and Danish governmental laboratories that provided test facilities and secured reliable products.

In addition, the production of large-scale wind power facilities left a room for civil society and social movements, as was already the case with the pioneer Poul la Cour who himself was part of the folk high school movement. The most famous example of this is the Tvind windmill built in 1978 by the teachers and students at the Tvind folk high school. Both technically and politically this wind power construction had immense importance as a grassroots activity and as part of the political struggle against nuclear power. Today the public is represented in the wind energy production sector through investments and active involvement in cooperatives.

To encourage investment in wind power, the government offered tax exemption for people generating their own electricity connected to the public electricity grid. Some households actually invested in their own wind power turbine, but most bought shares in wind turbine cooperatives which invested in community wind turbines. The wind turbine cooperatives invested in either single turbines or in wind mill parks. A successful example is the offshore MiddelgrundenWindmill Park in the Baltic Sea just outside Copenhagen with 20 turbines built in 2000 as the world's largest. This windmill park is a good example of community wind energy – it is owned by a cooperative formed by a group of local people in cooperation with the Copenhagen municipality and the local public electric power company. 10 000 private investors own 50% of the enterprise. By 1996, there were around 2 100 such cooperatives in Denmark. By 2004 over 150 000 persons had shares in wind turbine cooperatives and 5 500 or 75% of the wind turbines in Denmark are installed by cooperatives. This cooperative model for wind power development has spread to other countries in the Baltic Sea Region, for example, Germany.

POLITICAL CULTURE AND IDEATIONAL DEVELOPMENT

As we have seen, the outstanding example of the Danish wind energy production and consumption can be explained as a result of a fruitful combination of private enterprise, civil society or NGOs and governmental policies and institutions. However, the explanation would not be complete without mentioning the political culture and the ideational development that provided the basis for this success history.

The pioneer Poul la Cour was part of the folk high school movement and placed great emphasis on engagement of the civil society in the development and use of wind power at the end of the 19th century and the beginning of the 20th century. So did the activists who initiated the Tvind experiment in the 1970s with the slogan 'you can do what you will do', expressing a belief in the power of the people when they act together.

Furthermore, the Tvind experiment was part of the anti-nuclear movement that arose after the end of the Second World War. As part of the peace movement, it initially favoured the peaceful use of nuclear power but developed into a movement against any use of nuclear power due to the potential danger of nuclear power production and due to concerns over the safety of waste disposal. When the organisation NOAH, a discussion group at the University of Copenhagen that had met once every week since 1969 (Danish acronym 'Natural Science Faculty Wednesday Evening Meetings'), founded a section for nuclear power, it became the inspiration for the formation of OOA, the Organisation for Information on Nuclear Power, in 1974. OOA's goal was to hinder the construction of nuclear power plants in Denmark. It also initiated several popular protests against the Swedish nuclear power plant in Barsebäck since its location only 14 km from the city of Copenhagen was considered a potential danger for the two million residents of southern Sweden and the Copenhagen area.

In 1997, negotiations between the Danish and Swedish governments resulted in a decision to close down the Barsebäck nuclear power plant.

OOA had an immense popular backing as a protest movement. The sister organisation OVE, the Organisation for Renewable Energy, was established in 1975 to inform the public on alternatives to nuclear power. The direct involvement of the public helped the popularity of wind power turbines. Opinion polls show that 86% of Danes support wind energy compared to fossil fuels. Today OOA has been closed down because its goals have been achieved by the passing of the Danish law forbidding construction of nuclear power plants in Denmark and by the decision to close down the Barsebäck nuclear power plant across the Øresund in Sweden. With the growing interest in nuclear power as part of the global warming debate, this may be a premature decision; however, 'nuclear power is not the answer to global warming or anything else' (Helen Caldicott).

The development of wind power in Denmark is ultimately conditioned by the strong ideas and practice of the 'you can do what you will do' thinking and direct involvement of the civil society.

Figure 2. **OOA sticker soon spread worldwide and became the most commonly used image in the global anti-nuclear movement**

8 NATURE PROTECTION

8.1 HISTORY OF NATURE PROTECTION

There have been diverse nature protection traditions in the world for a long time, ranging from hunting bans imposed by the ruling class on certain species at specific time periods to the establishment of forest areas where tree logging is prohibited. Awareness of the close relationship with nature has manifested itself in the ancient religions of all peoples as the worship of various natural objects and phenomena. The role of religion in building society's attitude towards nature has diminished with the development of society; at the same time, the importance of relevant legislative documents has increased.

Figure 8.1. **Latvian rural landscape, also typical of the other Baltic Sea Region countries**

The need for protection of nature values appears to be embedded in everyone's subconscious. For example, even today many Latvian land owners leave scenically beautiful tree clusters in the midst of agricultural lands although such a requirement is not included in any legislative provision.

Two main directions of nature protection have emerged since it began: first, establishment of protected territories that host picturesque landscapes, rare plant or animal species or are rich in cultural heritage; second, sustainable use and conservation of natural resources.

A law on forest protection and a list of protected plants can be found already in the Code of Laws of the ancient Babylonian king Hammurabi (1792–1750 BCE). More information on nature conservation became available at the 18th and 19th century. In the 19th century, good forestry practice was based on the experience of the 17th – and 18th – century French and German foresters who explored and managed forests in colonies. Later on that forestry practice was also developed and introduced in the USA. Nature protection in the modern sense began in the USA in 1872, when Congress established the world's first specially protected nature territory – Yellowstone National Park. The geologist Dr Ferdinand Vandeveer Hayden was the initiator of the establishment of the national park; he was the one who persuaded Congress of the need for such an action. The park area is 8 980 km^2 of lakes, canyons, rivers and mountain ranges. Unsustainable use of natural resources, including poaching, was the main threat to this unique area. 1872 can also be considered the year nature management institutions came into being because the first national park manager was appointed that year.

In the following years, national parks apeared in other parts of the world: the Royal National Park near Sydney, Australia, in 1878, Banff National Park in Canada in 1885 and Tongariro National Park in New Zealand in 1887.

The leading country in nature protection in Europe at the turn of the 20th century was Sweden. In 1909, it issued two laws pertaining to nature protection. The first law provided for the protection of a variety of outstanding natural monuments (such as large and old trees), and the second law for the establishment of national parks. Nine national parks were established in Sweden in the same year. They became the first national parks in Europe. Other European countries soon followed Sweden's example. The 1st International Nature Protection Conference held in Berne (Switzerland) in 1913 was very significant for this process. The concept of 'nature protection' was introduced at this conference.

Due to uncontrolled human actions, many unique flora and fauna species had become extinct at that time. Therefore, urgent development of the nature protection concept was in order. The conservation approach adopted was based on the discontinuance of any economic activity in the protected nature areas. Its practical outcome was the worldwide establishment of national parks and nature reserves, thus preserving unique ecosystems and remarkable natural monuments.

Figure 8.2. **Protection belt of the Baltic Sea coast**

Figure 8.3. **Yellowstone National Park in the USA is famous for its unique geological objects**

The next important step in the development of nature protection in the world was the establishment of the UN International Union for Conservation of Nature (IUCN) in 1948. The purpose of this organisation is to facilitate the preservation of natural diversity and promote sustainable use of resources. In the year of foundation, the Union published its Red List of Threatened Species. The Red List included information on the distribution, biology and current status of endangered and rare animals (mammals, birds, reptiles, amphibians and fish) and higher plant species, as well as possible causes of their extinction. The Red List is not a closed document, and it is updated on a regular basis. Nowadays all the species included in the Red List are classified into seven categories.

The inclusion of species into the Red List does not mean that they are protected by law. The Red List is mostly information for society on threatened species and specific measures necessary for their protection.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) also plays an important role in nature protection in the world. In 1970, UNESCO approved the international programme 'Man and the Biosphere' (UNESCO – MAB), whose purpose was to foster interdisciplinary research in environmental science. Due to the initiatives of UNESCO, biosphere reserves were created with the aim to achieve and demonstrate a certain balance between the protection of natural diversity, economic development and preservation of cultural values. Currently there are 482 biosphere reserves in 102 countries worldwide.

There are longstanding traditions of nature protection in the Baltic Sea Region. For ancient peoples, nature protection was the way of living, while nature itself was an object of worship. Folk songs, legends and widely occurring sacred springs, groves and trees speak volumes for this attitude towards nature.

Little is known about nature objects and regulations on the use of nature resources in the early mediaeval period; however, it is known that in the 16–17th century, owing to the influence of German forestry schools, there were strict hunting and tree-felling regulations in Latvia. Hunting and fruit-tree protection laws were adopted in the part of Latvia under Swedish governance in the 17th century.

In the first half of the 19th century, under the rule of tsarist Russia, intensive tree logging took place along the coast of the Baltic Sea. As a result, shifting dunes formed, which buried the coastal villages. Hence, the tsarist Russian government issued a decree establishing a protective belt that was on average about 320 metres wide. In particularly dangerous places, this protective belt was as wide as 510 metres, in some places reaching even 2 versts (2.13 km). This decree may be considered the first legislative measure towards environmental protection in the Baltic Region.

The establishment of protected nature territories in the Baltic countries began at the beginning of the 20th century, and this process was largely driven by different organisations that brought together the representatives of creative intelligentsia. The first specially protected nature territory in the three present-day Baltic countries was established in Väike Islands, Estonia, on 14 August 1910. The idea of establishing a nature reserve on these islands belonged to Karl Reinhold Kupffer, a member of Rīga Naturalist Society, who, travelling on the Estonian islands, became fascinated by the diversity of bird species. Today, Väike Islands are included in Vilsandi National Park. The first specially protected nature territory in Latvia, Moricsala, was established in 1912 – also on the initiative of Karl Reinhold Kupffer. Since 1957, Moricsala has been granted the status of a strict nature reserve.

8.2 WHY ARE BIODIVERSITY AND NATURE PROTECTION SO IMPORTANT?

The term 'biodiversity' includes a wide variety of forms of life on the Earth, including the diversity of genes, species, ecosystems and landscapes.

Summarising the different views as to why biodiversity conservation is needed, three shared insights can be pointed out:

1) biodiversity provides conditions for the physical existence of the present generations (air, water, food);
2) biodiversity gives reasons for hope to solve various problems in the foreseeable future (e.g. new medications);
3) biodiversity conservation is necessary for aesthetic, cultural and religious reasons.

Environmental philosophy, policy and law usually operate within a broad spectrum of philosophical views regarding the interrelations between humans and nature. These views can be either anthropocentric or ecocentric. In anthropocentrism, nature has value only insofar as humans have imparted this value onto it; i.e. nature has value because it provides for human well-being. The anthropocentric views on why environmental protection is needed and to what extent it should be ensured are derived from this basic principle. From the anthropocentric perspective, nature protection is necessary for human existence – nature gives food, air and ensures human well-being. Everything that contributes to human well-being should be supported. If it is better for humans that air and water are clean, humans should take measures to make air and water clean. If beautiful nature makes humans feel happier, this is a sufficient reason to preserve it. Humans do not have any other motivation for nature protection besides their own satisfaction.

The difference between ecocentrism and anthropocentrism lies in the understanding of value. In ecocentrism nature has its own intrinsic value, and it has the right to exist regardless of whether it does or does not provide any service or benefit to humans. For example, the cod catch control in the Baltic Sea represents a typical anthropocentric approach, since up to now the responsible authorities have not expressed an opinion that the species has a value in itself. Cod is considered only food for humans, and there is a concern that increased catching will make this food unavailable.

Biodiversity conservation became a key nature protection priority in the world after the UN Convention on Biological Diversity was signed in Rio de Janeiro in 1992. The Convention aims at protecting the global ecosystems, plant and animal species and their genetic diversity, at the same time allowing sustainable use of natural diversity and fair and equal distribution of the benefits acquired by means of the use of genetic resources.

8.3 BIODIVERSITY LOSS WORLDWIDE

The total number of species in the world reaches about 10 million. Only 1.5 million species have been described and identified so far, most of them insects (950 000 species) and plants (287 655 species). New species are discovered every year, and the exact total number of species on the Earth is unknown. Tropical rainforests are the richest in species, and a huge number of organisms dwell in soil and the deep sea. Many of them are so tiny that their identification is difficult. All kinds of forms of life are found everywhere – from tundra to tropical rainforests and from alpine areas to the deep sea – and they subsist interacting both among themselves and with abiotic factors. Ecosystems are formed as a result of this interaction.

Over the past 10 000 years, the growing human intervention in natural processes has caused the extinction of certain species as well as many disasters, such as flooding and landslides that occur more and more frequently. Since human knowledge of the natural processes is not sufficient, humans should not interfere with them, as these changes in the long run might affect humans themselves. Moreover, changes in the natural processes pose a threat to the quality of human life as the ecosystems lose their capacity to serve human needs effectively.

Figure 8.4. **Common Toothwort (*Lathraea squamaria*) is a parasite that takes nutrients from the roots of deciduous or conifer trees**

Figure 8.5. **A small area of tropical rainforest may harbour more than 200 species of trees**

Figure 8.6. **Due to the shrinking area of the Aral Sea, its fleet has been abandoned in the desert formed in the place of the desiccated sea**

For example, the channelling of water from the rivers flowing into the Aral Sea, Amu Darya and Syr Darya, for the irrigation of cotton plantations has caused a major ecological and economic disaster in the 20th century: most of the Aral Sea has dried up, leaving empty plains covered with toxic waste. The hazardous waste is moved by sandstorms, causing an increased incidence of cancer and lung diseases in the region.

The main causes of biodiversity loss are changes in natural habitats, which often manifest as a decrease in size or the deterioration of natural habitats such as forests and mires. These changes are caused by either intensive agriculture or over-exploitation of forests, oceans, rivers, lakes and soils, also by invasion of alien species, pollution and, increasingly, global climate change. Of equal significance is the growth of the human population and natural resource consumption, lack of knowledge on species and ecosystems, international trade and unequal distribution of resources. In most cases, humans are responsible for the decline of biodiversity in the world at the level of species, inter-species and ecosystems. Loss of biodiversity can be illustrated with various indicators and figures showing changes in sizes of areas and numbers of species. The Global Biodiversity Outlook shows that the only large-scale positive tendency is an increase in specially protected nature territories, while other tendencies are distinctly negative.

8.4 BIODIVERSITY CONSERVATION MEASURES

There are different ways to promote biodiversity conservation in the world today, and in the developed countries they are integrated into national laws and regulations. The main methods used are as follows:

- to establish specially protected territories,
- to restore habitats,
- to regulate obtaining of protected species,
- to restrict trade in species,
- to limit the introduction of alien species,
- integration of biodiversity conservation issues in other sectors.

Although the establishment of specially protected nature territories is one of the oldest methods of environmental protection, this method does not always ensure the preservation of nature values, because even the largest of these territories are influenced by the processes and activities around them; they are not isolated. For example, although a source of river pollution may be located outside the specially protected nature territory, it has a direct negative impact on the river's ecosystem within the specially protected nature territory.

Specially protected nature territories are established in accordance with national laws and fall into several categories which differ in the aim of their establishment, area size, degree of protection, activities permitted or prohibited,

Figure 8.7. **Grīņi Nature Reserve in Latvia was established in 1936 in order to preserve rare, protected plant species; Cross-leaved Heath (*Erica tetralix*)**

the expected management and the purpose of protection. Generally the law provides for special state protection of rarities and unique features as well as typical natural ecosystems and characteristic landscapes:

- the aim of **strict nature reserves** is to ensure an undisturbed development of the natural processes, and to protect and study rare or typical ecosystems and their components. Strict nature reserves are established in the areas of almost untouched nature. Human presence is allowed only with special permits for research purposes;
- **national parks** are vast areas separated for the purpose of protection of nature and landscape values and cultural heritage. National parks are established to promote environmental protection, facilitate scientific development, environmental education and for recreation purposes;
- **biosphere reserves** are large areas where natural and landscape values of international significance are preserved, at the same time ensuring the sustainable social and economic development of these areas;
- **nature reserves** are established to protect rare or disappearing species or biotopes. Usually they are minimally affected by human activity, and their management is strictly controlled;
- **nature parks** preserve the natural and cultural values of particular areas, and they are established to maintain site-specific landscapes, educate society and provide a place for recreation, at the same time maintaining biological diversity;
- **marine protected areas** are established in territorial waters, exclusive economic zones or continental shelves to protect marine animals, including migratory birds, and marine biotopes;
- **protected landscape areas** are large territories with particularly beautiful and diverse natural landscapes;
- **nature monuments** are subdivided into:
  - protected trees,
  - dendrological plantations,
  - alleys,
  - geological and geomorphological formations.

Specially protected nature territories often have administrative bodies that manage them, ensure the observance of protection measures and deal with economic, educational and environmental communication issues. Laws and regulations also provide for the protection of these areas, their management and conservation of their natural values.

General regulations are effective in all specially protected nature territories, except those for which individual protection and use regulations have been established. General regulations mean uniform conditions for economic activities and the code of conduct in all specially protected nature territories according to the category they belong to.

Specific requirements for individual specially protected nature territories as well as deviations from general regulations can be provided for by individual protection and use regulations. Legislation can also provide for a possibility that local municipalities establish nature reserves, nature parks and nature monuments important to preserve the natural or cultural heritage in the respective territory.

Although it is significant for nature protection to establish specially protected nature territories, it is not sufficient to ensure the preservation of dispersed species and biotopes because they are not concentrated in large areas or in high numbers in one locality. Hence, a relatively small part of protected objects are found in specially protected nature territories. A typical case is all the bird species for whose protection Latvia bears an international responsibility, such as the Lesser Spotted Eagle, Black Stork and Corncrake.

To favour protection of dispersed species, several measures can be taken. In Latvia, in accordance

Figure 8.8. **Skaņaiskalns cliff on the Salaca River bank**
One of the numerous geomorphological nature monuments in the North Vidzeme Biosphere Reserve, Latvia.

Figure 8.9. **Forest Pasqueflower (*Pulsatilla patens*)**
Forest Pasqueflower grows in dry pine forests, is one of 231 specially protected plant species in Latvia.

with the Law on the Conservation of Species and Biotopes of Latvia, micro-reserves can be created to protect specially protected species or biotopes. A micro-reserve to protect the habitats of specially protected bird species can be created if inhabited nests or mating-places are found in a territory with adequate nesting or mating conditions for the species in question. A micro-reserve to protect the habitats of other specially protected animal, plant or mushroom species or specially protected biotopes can be created according to the following criteria:

- no more than ten habitats of the individuals of the respective species or specially protected biotopes are found in the country's territory;
- from ten to fifty habitats of the individuals of the respective species or specially protected biotopes are found in the country's territory or their number is rapidly decreasing, which may cause the extinction of this species or biotope.

The lists of specially protected species and biotopes usually include endangered, disappearing or rare species and biotopes or species that inhabit specific biotopes, and they are protected by the state.

The second measure – restoration of natural habitats – is a rather new measure taken in response to the rapid decrease in natural habitats and their deterioration. It is often time-, money- and labour-consuming. Restoration of the water level in mires, river re-meandering and grassland restoration are the most common activities carried out in the Baltic states.

Another measure of biodiversity conservation is the prohibition to obtain wild or rare plant and animal species. The individuals of specially protected species can be obtained in limited amounts in compliance with the procedure established by the law, on condition that such acquisition is not detrimental to the preservation of the population of the respective species at a favourable conservation status within its natural distributional range. Obtaining of protected species is regulated by the Law on the Conservation of Species and Biotopes.

Figure 8.10. **Wolf's-foot Clubmoss (*Lycopodium clavatum*)**
Wolf's-foot Clubmoss is one of 24 specially protected species of limited use in Latvia. A special permit is required to acquire it.

During the last century, trade and tourism have rapidly developed and the standards of living have improved over most of the world. There is a wide range of wild species products, from live animals and plants used for trade to their products, including food, leather articles, game trophies, timber, tourist souvenirs, traditional Oriental remedies. It is estimated that the trading volumes of these products fluctuate around 0.75 billion euros per year. The USA and the EU have the biggest consumer markets. Many wild animal and plant species are consumed in large quantities, and this, along with the decrease in the number of suitable habitats, poses a threat to the survival of the species or leads to their extinction.

In order to prevent the extinction of wild animal and plant species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was signed in Washington in 1973. The need for such a convention arose in the 1960s, when a number of developing countries turned to other countries for help to protect their natural resources that had been excessively exploited. Trade knows no boundaries, and people in developed countries had begun consuming large quantities of exotic goods from developing countries – ivory, wood and leather products. Many wild species subject to international

Figure 8.11. **Sosnowskyi Hogweed**
Sosnowskyi Hogweed (*Heracleum sosnowskyi*) was introduced in the Baltic countries from the Caucasus as a forage crop in 1948. It spread rapidly and is very difficult to eradicate. Its juice is toxic, and even touching this plant may cause skin burns and sores.

trade are not specially protected, or are even reared and propagated in captivity for production (crocodiles, snakes). CITES ensures that the use of endangered wildlife and plant species is sustainable, so that these resources would be preserved for future generations as well. Regulation of trade in species is a biodiversity conservation measure that requires international cooperation.

The fifth measure of biodiversity conservation is concerned with alien species. National legislations on the protection of species and biotopes usually prohibit the introduction or release of alien species. However, to satisfy pressing economic or social needs, a limited introduction of species may be allowed only with a permit issued after the environmental impact assessment. Unfortunately these laws came into force much too late. Some species such as the Raccoon Dog, American Mink and Sosnowskyi Hogweed are some of the most glaring instances of introduction that have caused irreversible consequences in the Baltic countries.

The last but not least biodiversity conservation measure is the integration of biodiversity conservation in other sectors, such as forestry, agriculture, fishery, hunting and mineral extraction. Biodiversity conservation planning should take place in all of these sectors on a global scale down to national, local and individual responsibility.

8.5 NATURE PROTECTION PLANNING AND ACTIVITIES

Four stages can be distinguished in nature protection: 1) collection of information (on nature objects), 2) monitoring, 3) planning of activities, 4) implementation of activities and monitoring of their effectiveness. Each stage comprises a number of activities that are the same in most developed countries. Nature conservation laws, providing a legal framework for the implementation of measures, have an important role in nature protection.

Nature protection is based on the studies and inventory of species and biotopes, ecosystems, forms of terrain, geological objects and landscapes mainly carried out by experts in the field. In every developed country there are scientific institutions and NGOs that carry out various research projects and compile inventories. Data on the distribution of nature objects in the country are collected, and from the data it is possible to figure out which nature objects are to be considered rare and endangered. However, this is only the starting point of environmental protection. It is essential to obtain information on the population structure, vitality, dynamics of species and the main factors influencing their populations, as well as on the distribution of species habitats and the factors influencing them.

Monitoring means regular, focused studies carried out at specific locations and with definite time intervals, using approved methodologies. The purpose of biodiversity monitoring is to provide environmental and nature protection authorities and society with information on the status and changes of biodiversity in the country. The tasks of biodiversity monitoring are the following:

- to obtain information on the areas and status of specially protected biotopes and to forecast their changes;
- to follow the condition of populations of specially protected, biotope-specific or invasive species;
- to determine the impact of natural and anthropogenic factors on biotopes and species.

The planning of nature protection activities takes place at several levels – national, regional and local. Planning at the national level includes the preparation of various programmes and guidelines, action plans of national significance and a legal framework, as well as the establishment of specially protected nature territories. Action plans for specially protected species and biotopes or biotope groups are developed at the national level, and these plans are prepared by experts and are usually approved by the government authorities. At the regional level, the environmental protection measures and requirements are laid out in the plans for administrative division units, such as regions. At the local level, the planned activities mainly pertain to specially protected nature territories and preparing nature conservation plans for them.

The implementation of activities also takes place at all three levels. At the national level, it means

Figure 8.12. **Plant species counts in sampling plots are a labour-consuming but precise method for detecting even slight changes in species composition, and are often used for the assessment of grassland management activities**

Figure 8.13. **To make an artificial nest structure for a White-tailed Sea-eagle is a difficult and complicated task that requires knowledge, courage and skills**

that the legal basis and planning documents are regularly reviewed, correcting them in line with the situation in the country and the world, and that new specially protected nature territories are frequently created in collaboration with non-governmental organisations and experts in the field in developed countries. At the local level, mostly in specially protected nature territories, various management activities to protect nature values are implemented in accordance with management plans or species or biotope action plans. It is important to monitor the effectiveness of the management activities in order to assess whether they have been successful.

8.6 MAIN REQUIREMENTS OF THE EUROPEAN UNION NATURE CONSERVATION POLICY

The European Union nature conservation policy is defined in two EU directives: Council Directive on the Conservation of Wild Birds, also known as the Birds Directive (2009/147/EC, 30.11.2009) and Council Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora, also known as the Habitats Directive (92/43/EC, 21.05.1992). Both directives require protective measures for plant and animal species and habitats, including prohibited activities, requirements for monitoring, research, as well as the competence of the Member States and the European Commission in the field of nature conservation. The annexes to the directives contain the lists of plant and animal species and habitats (both terrestrial and marine) covered by specific EU policies, as well as other technical requirements.

The Habitats Directive aims to achieve a favourable conservation status for the species and habitats listed in the annexes to the directive. Favourable conservation status means that the natural distribution range of a species or habitat does not decrease and is not expected to decrease in the near future. Data on species population dynamics indicate that a species provides for its own long-term existence, and a proper habitat size is a sufficient condition for the long-term survival of the species. A habitat, in turn, should have all the characteristic structures and functions, as well as a favourable conservation status for the habitat-specific species.

The Birds Directive aims to ensure the protection, conservation and acquisition of all wild bird species that occur naturally in the territories of the EU Member States. Both directives set out specific endangered species and habitats whose protection requires the establishment of protected areas. Since these areas are established throughout the EU, together they form a single network of protected areas known as *Natura 2000*.

Figure 8.14. **Lady's-slipper Orchid (*Cypripedium calceolus*)**

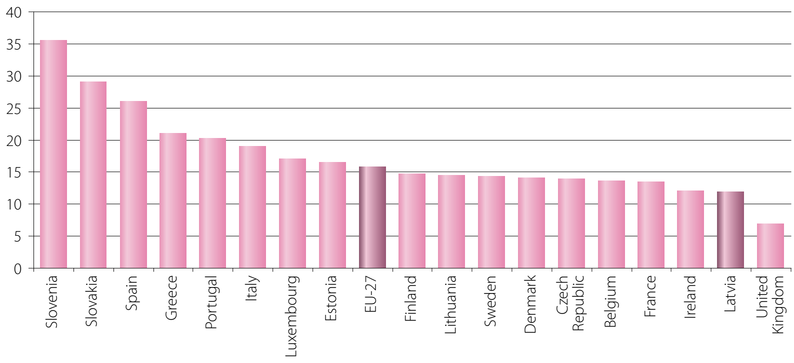

Figure 8.15. **Size of terrestrial territories of the *Natura 2000* network in the EU Member States, % of the territory**

The EU-wide network *Natura 2000* has been founded for the purpose of protection of the habitats listed in Annex I to the Habitats Directive and species listed in Annex II to the Habitats Directive, as well as bird species listed in Annex I of the Birds Directive and migratory bird species. In the network of *Natura 2000,* protected areas are established only on the basis of scientific criteria, and the area boundaries are set irrespective of any socio-economic considerations.

8.7 INTERNATIONAL COOPERATION IN NATURE PROTECTION

Globalisation affects both economics and environmental protection, as the correlation between the consumer markets of developed countries and preservation of natural diversity in Asian, African and South American countries has proven. The economic development gap between developed and developing countries has affected many international negotiations in the area of environment and nature. Yet both parties agree that national economic development cannot go on in a degraded environment, and, conversely, it is impossible to restore and recuperate the environment without national economic development. Today international cooperation takes place at the level of ratification of international treaties and implementation of international projects. International nature protection organisations, such as the International Union for Conservation of Nature (IUCN), World Wide Fund for Nature (WWF), Wetlands International and others, founded and located in developed countries, invest heavily in the implementation of various nature protection projects in developing countries. Unfortunately, projects alone cannot solve national or even regional problems of environmental protection.

The main environmental and nature problems in developing countries are: a rapid decrease in natural forest areas, desertification, water and air pollution and poaching. Moreover, developing countries are the countries with the highest population densities in the world. Poorly developed agriculture based on unsustainable practices such as 'slash-and-burn' farming, global business based on clearing natural forests and cultivating monoculture plants instead of forests are the main causes of ecosystem degradation and the extinction of many species. Some of the other causes are poor environmental management, ineffective legislation, the high risk of corruption, political instability and the influence of large companies on the governments.

The originally good idea to produce biofuel as an alternative to fossil fuels and the subsidies of developed countries to this sector unfortunately led to deforestation in Indonesia, Brazil and elsewhere. Large areas of natural forests were cut in order to establish soya and oil palm plantations for the purpose of biofuel production.

Figure 8.16. **Tea plantations in a former natural forest site**
By purchasing coffee or tea not grown in an environment-friendly manner, we are at risk of promoting clearing of tropical rainforests to make plantations.

Figure 8.17. **Oil palm plantation in Indonesia**

Deforestation in developing countries is for the most part caused by the demand for timber, biofuel, minerals, meat and various crops in the global market, which is determined mainly by developed countries. For example, the largest part of the Amazon rainforest in Brazil is converted into cattle pastures because there is a high demand for Brazilian beef in the European market – explained by the fact that foot and mouth disease has been eradicated almost in the entire territory of Brazil. Thus, the direct link between natural resource consumption in developed countries and nature protection in developing countries becomes apparent. Moreover, developing countries have huge international debts, extending to billions of euros. Consequently, a large part of the income from the export of natural resources can be used to extinguish the country's external debt. This scheme indirectly contributes to further depletion of natural resources in these countries.

One of the ways of international cooperation in nature conservation is the ratification of various conventions. A convention (a multilateral treaty) is an international agreement on solving a specific problem, determining the mutual rights and obligations of the participating countries. Conventions are signed by sovereign states and international organisations. The weakness of nature and environmental protection conventions is that the responsibility for their implementation rests with the participating parties. Since the participating parties have no penalties for the non-fulfilment of the commitments of conventions, they fulfil these commitments 'according to their capabilities and needs'. The fact of ongoing biodiversity loss worldwide is also indicative of the insufficient effectiveness of conventions. The Baltic Sea Region countries have ratified all major nature and environmental protection conventions, including the six UN environmental protection conventions:

- **The Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat** (1971).
- **The Convention on World Heritage** (1972) obliges the participating countries to ensure natural and cultural heritage study, protection, preservation, promotion and transfer to future generations.
- **The Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES** (1973) aims to protect certain endangered species from over-exploitation in trade. The number of species covered by the Convention exceeds 34 000. Annex I comprises the species threatened with extinction; Annex II – the species that are not yet threatened with extinction but will likely be threatened if trade in the specimen of these species is not restricted. Annex III comprises the species identified by any of the participating countries as an object of control within its jurisdiction in order to prevent or delimit trade in these species, whose control requires help from other countries. It is important to remember that there are always alternative souvenirs – i.e. made without depriving animals of their life – that can be brought with you from trips, such

Figure 8.18. **Salaca River**
The Salaca River is the heart of North Vidzeme Biosphere Reserve – it is one of the most scenically beautiful rivers and a major salmon river in Latvia.

Figure 8.19. **Komodo Dragon (*Varanus komodoensis*)**
Komodo Dragon lives on only a few small Indonesian islands, and it is included in the CITES Annex I list of species as very rare and endangered.

Figure 8.20. **Corncrake (*Crex crex*) is an endangered species worldwide**

Corncrakes migrate to south-east Africa in winter, and to preserve this species, it is necessary to preserve its habitats in the Baltic countries and Africa, and to ensure many other preconditions related to agricultural land management.

as local craft items. At the very least, you can always take pictures of your adventures. The airport customs authorities regularly detain passengers who have purchased products made from endangered wildlife or plant species and who do not have a CITES permit.

- **The Berne Convention on European Wildlife and Natural Habitats** (1979) aims to preserve wild flora and fauna and their natural habitats, especially those species and habitats whose protection requires cooperation between several countries, as well as to promote such cooperation. The provisions of the Convention and its Annexes are included in the Law on the Conservation of Species and Biotopes and the regulatory enactments related to this law.
- The main objective of **the Convention on the Conservation of Migratory Species of Wild Animals**, also known as **the Bonn Convention** (1979), is to protect migratory bird species. To this end, the participating countries should:
  - encourage, support and participate in research related to migratory species;
  - provide for immediate protection of the migratory species included in Annex I of the Convention;
  - enter into agreements on the conservation and management of the migratory species listed in Annex II of the Convention.
- The overarching objectives of **the Convention on Biological Diversity** (Rio de Janeiro, 1992) are:
  - biodiversity conservation and sustainable use of its components;
  - fair and equitable distribution of benefits from genetic resource consumption, including both adequate access to genetic resources and appropriate transfer of technologies, taking into account all the rights to these resources and technologies, as well as adequate funding.

  The essence of this Convention is to reveal a global need for a broader outlook on the issues of nature protection and to integrate environmental protection requirements in all sectors.

8.8 ROLE OF CITIZENS AND NON-GOVERNMENTAL ORGANISATIONS IN ENVIRONMENTAL AND NATURE PROTECTION

Non-governmental organisations (NGOs) are established to represent citizens' interests in various fields. Since as early as the middle of the 19^{th} century, a variety of NGOs have been founded all over the world, and their establishment has always reflected the world's progress and current events. Over 100 000 non-profit organisations acting on an international level have been founded since 1850. The most active formation of NGOs began after the Second World War – at an average of 90 organisations per year.

Nature and environmental protection is aimed at improving the welfare of society as a whole, satisfying individuals' rights to live in a favourable environment. During the last decades, the number of NGOs aimed at protecting the environment has increased dramatically both in the EU and worldwide, and their role and functions have been expanding. Their actions directly affect the development of the environmental protection sector.

Environmental protection emerged as an international problem in the 1970s, when society started to become aware of such problems as nature resource depletion, climate change, pollution and environmental quality degradation. Today, the focus is on such problems as global warming and sustainable development. The mission of environmental NGOs is to find solutions, to urge for active involvement of society, to supervise agreements at all levels and to follow the fulfilment of commitments.

Society at large is quite aware of the environmental issues, supporting the efforts of NGOs in such areas as waste and water management and nature conservation. For all that, society does not always clearly understand the goals of NGOs acting in the field of environmental protection, and this

Figure 8.21. **Information boards are a way to inform society about nature values and their conservation measures**
A – an information board in the centre of Rīga; B – information boards in Gauja National Park.

shortcoming is largely due to the lack of knowledge on nature protection issues.

As a result, society's support for NGOs of environmental protection varies depending on the degree of understanding of the urgency of the specific issues to be addressed. For example, society will definitely support the efforts of NGOs to limit forest logging volumes and will keenly engage in activities related to nature-watching. Nevertheless, such activities as the establishment of specially protected nature territories and land transformation bans along the sea coast in order to preserve coastal biotopes are often not understood, and the majority of society perceives them as unnecessary constraints.

The World Wide Fund for Nature (WWF) (formerly named **the World Wildlife Fund**) was founded in 1961 in order to build a future in which humans and nature live in harmony. Since those early days, the WWF has developed into one of the largest environmental organisations in the world. Currently there are over 1 300 WWF conservation projects underway around the world. Most of these projects focus on local issues. They range from school nature gardens in Zambia to initiatives that appear on the packaging in local supermarkets, from the restoration of orangutan habitats to the establishment of giant panda reserves.

A traditional way to involve NGOs in national administration is to participate in drafting and implementation of legislation and to supervise these processes.

Freely accessible and comprehensible information and a successful sustainable development policy are essential prerequisites for a civil and democratic society to develop. The Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters defines the rights and responsibilities of society and governing bodies in the area of environmental protection.

Ever more information on environmental issues appears in the mass media. Specialised television and radio programmes and periodicals as well as regular publications in magazines and newspapers are essential to the development of environmental consciousness. Unfortunately, there are few analytical publications that help people better understand the environmental and nature protection issues and environmental, economic and social correlations.

Both NGOs and government institutions educate the public. Experience shows that success in nature protection can be achieved with timely, targeted and intensive education.

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CASE STUDY: SLOVAKIA

BIOLOGICAL INVASIONS OF PLANTS IN SLOVAKIA

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According to the European Strategy on Invasive Alien Species, an alien species is a species, subspecies or a lower taxon introduced outside its natural former or present distribution; this includes any part (seeds, eggs) of such species that might survive and subsequently reproduce (Genovesi, Shine, 2004). Introduction and/or spread of an invasive alien species threaten biological diversity. We here discuss invasive (naturalised) alien plant species the distribution and/or abundance of which in the wild increases regardless of their habitat. Archeophytes are species introduced before 1500 (sometimes considered native species), and neophytes are naturalised aliens introduced since 1500 (expanding native species – apophytes – are not considered invasive alien species). The most important invasive plants in Slovakia are, for example, the Common Ragweed (*Ambrosia artemisiifolia*), North American Daisy (*Aster novi-belgii* agg.), Canadian Horseweed (*Conzya canadensis*), Japanese and Czech Knotweed (*Fallopia japonica, Fallopia bohemica*), Jerusalem Artichoke (*Helianthus tuberosus*), Giant Hogweed (*Heracleum mantegazzianum*), Himalayan and Small Balsam (*Impatiens glandulifera, I. parviflora*), the Canadian and Early Goldenrod (*Solidago canadensis, S. gigantean*) and Annual Fleabane (*Stenactis annua*). Many invasive plant species occur almost exclusively as weeds in arable land or at other sites with frequent disturbances (Feher, 2007).

Slovakia is at the southern periphery of the Baltic Sea Region and only a small part of it belongs to the Baltic Sea waterscape. One of the most important factors that influence biological diversity is expansion of alien (allochtonous) plant species due to transportation, agriculture and trade of goods. The exotic species have expanded in Slovakia since the late Neolithic and Eneolithic, but an exponential growth of their distribution is evident since the 20th century. Invasive plant species were abundant near bio-corridors, mainly along watercourses, roads and railways. On the banks of the rivers both nitrophilous high-herb plant communities with alien species and regularly mown meadows relatively resistant to the invasive species can be found. By evaluating 197 field records, we have proved that expansive weeds occur in human-made habitats and invasive plant species prefer natural and semi-natural plant communities. The group of expansive agricultural and other ruderal weeds consisted of *Abutilon theophrasti, Ambrosia artemisiifolia, Amaranthus powelli, Artemisia annua, Cannabis ruderalis, Helianthus annuus, Iva xanthiifolia, Panicum miliaceum, Rumex patientia* and *Sorghum haleppense*, the group of invasive species of natural and semi-natural habitats consisted of *Aster lanceolatus, Aster novi-belgii* agg., *Bidens frondosa, Fallopia japonica, Fallopia bohemica, Helianthus tuberosus, Impatiens glandulifera, I. parviflora, Solidago canadensis* and *Stenactis annua*. The classification of *Conyza canadensis*, *Lycium barbarum* and *Solidago gigantea* species remained contentious. Some neophytes (e.g. *Impatiens glandulifera, I. parviflora*) almost do not penetrate the farmland. Attention should be paid to *Stenactis annua* that has spread especially along dikes. A dangerous field weed, *Iva xanthiifolia*, sometimes occurs in riparian high-herb nitrophilous phytocoenoses. In contrast, the shore species *Solidago gigantea* and *Aster novi-belgii* agg. sometimes penetrate the farmland. In order to evaluate the invasiveness of species, it is important to know the properties of species which determine their successfulness in invasions. A very important feature of invading species is the formation of a large number of generative organs. Seeds of all invasive species we studied also spread by hydrochory (swim on the water surface), only two species had heavier seeds. They develop at the bottom of the water bodies (e.g., *Impatiens glandulifera, I. parviflora*). *Helianthus tuberosus* had low seed formation and germination ability, this species expanded mainly by means of tubers. The representatives of the *Compositae* family also expanded by means of anemochory. Removal of plant vegetative propagules has an important role in vegetative reproduction. All the examined plants, after their separation from the bank, swam on the water surface or were partially immersed in water, whereby they were able to root on the bank and establish a new population there.

For some species, vegetative reproduction by the means of rhizomes (e.g. *Fallopia japonica*) or by rhizomatous tubers (*Helianthus tuberosus*) dominated, while their generative reproduction (although germinating seeds were generated) was not proved in the field. Plants without rhizomes had a good rooting capacity from the stem nodes (e.g. *Impatiens glandulifera*). Well-canopied stands expanded fast and enlarged their area, but the intensity of the growth of individual invading species varied. Clonally growing species were most successful in expanding locally because ramets of the population can be supported by the whole polycormon (invasive species of the *Fallopia, Aster, Solidago* genera). Non-clonally growing plants with the strategy of generative reproduction could successfully expand within larger distances because they were not limited by the length of ramets but invaded canopied communities with difficulties because propagules could not have support from the mother plant (e.g. invasive species of the *Impatiens* genus) (Feher, Koncekova, 2005a, 2005b).

The European Strategy on Invasive Alien Species was adopted in 2003. It states that invasive alien species are the

Figure. **Czech Knotweed (*Fallopia bohemica*) forms dense canopies and threatens the local biodiversity**

second cause of global biodiversity loss after direct habitat destruction, and have adverse environmental, economic and social impacts (Genovesi, Shine, 2004). Some of the European countries have prepared legislation and/or their own national strategies on biological invasions. In several countries there are 'black lists' interlinked with legislation. It is forbidden to introduce or release species that are on the black list. The National Biodiversity Strategy of Slovakia includes an article dealing with invasive species which states that it is necessary to prevent the introduction of invasive species and control or eradicate those alien species which may threaten ecosystems or native species. The issue of biological invasions is also solved in the Slovak legislation (the Country Act No. 543/2002 of the Collection of Laws and the Regulation No. 24/2003 of the Collection of Laws). In 1997 a group of experts was assembled to deal with the problem of invasive plant species working under the Slovak Environmental Agency. The National Committee of the Scientific Committee on the Problems of Environment, in co-operation with other organizations (for instance, Slovak Ecological Society of Slovak Academy of Sciences), has been organising scientific conferences about biological invasions regularly. There are several prevention possibilities to control or regulate biological invasions, e.g. interception (regulations and their enforcement with inspections and fines), treatment (treatment of goods and their packing) and prohibition (trade prohibition based on international regulations).

The whole process of invasions is very dynamic; therefore, its research appears to be a long-lasting process.

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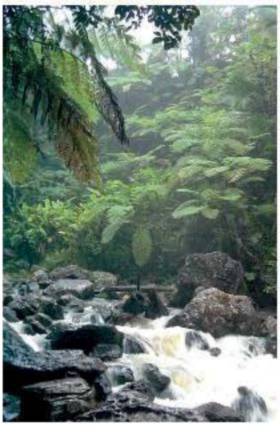
9 INTERNATIONAL COOPERATION IN ENVIRONMENTAL PROTECTION AND SUSTAINABLE DEVELOPMENT



9.1 MUTUAL COOPERATION AND DEVELOPMENT

The concept of mutual cooperation and development was initially used in biology in relation to evolutionary interaction of two mutually connected species when typical genetic features determine a better fitness of one of the species; however, the dominating genetic features of this species leave a considerable impact on other species. Explaining the essence of mutual development, it is assumed that there is an interaction between the essential features or part of the features which then influence further evolution. Within the systems of common development the proportions may change unpredictably.

According to the economist R. Norgaard, the development of a society can also be considered to be a common development of the systems of culture and ecology. He calls it a paradigm of common evolution and predicts that the progress and harmony of the development of different cultures in future will be determined by the potential of the 'patchwork' principle.

We can imagine the Baltic Sea Region, its countries forming a colourful patchwork quilt. The pieces hold well together in the southern and western parts of the Baltic Sea Region; however, the stitches appear looser in the direction from the east to the west. Each particular 'patch', e.g. Latvia, develops its culture and economy in its own way, while common development implies ties with the neighbouring countries, too. Besides, new ties are being formed with European Union Member States, and the earlier ties with the former Eastern block are retained.

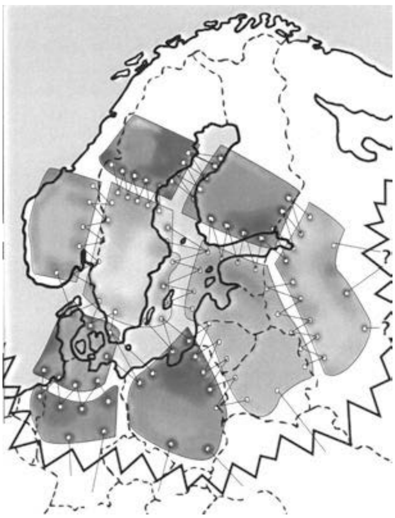


Figure 9.1. **'Patchwork' of the Baltic Sea Region**
The 'patchwork' metaphor implies that the Baltic Sea coast countries should engage in a common development process, using their local knowledge accumulated over the centuries. By preserving the local specifics and cultural diversity in the modern and dynamic world, the countries of the Baltic Sea Region will be able to ensure sustainable development.

Today the more developed countries jointly evolve, using the achievements of Western science and fossil hydrocarbon fuel (oil, natural gas and coal). People use the same or similar chemical fertilizers and pesticides for cultivating similar varieties of corn. However, the idea of common evolution should be based on the idea of sustainable development. Thus, it would be for the common benefit of all peoples, even if the development patterns of individual countries were different. Earlier cultural diversity was possible because individual cultures had more space; representatives of different cultures did not meet as frequently as today, and communities depended on their own resources, labour and technologies. The modern world is going through the process of globalisation: expansion of the market economy and advance of the developing countries towards the common market, thus facilitating an increasing uniformity in the world.

However, ever fewer languages are used on intercontinental flights, mobile telephones and the Internet. If fast-food restaurants and supermarkets take over the market of corner shops and small cafés, is this a road to sustainability? Is the road of sustainable development secured if we all speak, although some difficulty, one language and eat the same food (with minor local differences)?

Knowledge, values, technologies and institutional structure – all of it is connected with a common environment in each particular country as well as in the whole of the Baltic Sea Region and the European Union in general. Sustainability can be ensured only by considerate activities in each particular place. 'Traditional knowledge has local peculiarities that have evolved as a result of a unique common development of particular social and ecological systems,' says D. Orr. Sustainability should be based on not only revival and preservation of traditional knowledge in each country and in the 'patchwork' countries, but also on exchange of knowledge on a much larger scale – not only within the Baltic Sea Region but also within the European Union and worldwide.

The metaphor of the 'patchwork quilt' is based on the idea that all countries around the Baltic Sea have been historically closely interconnected and their application of the local knowledge has ensured their centuries-long success. They are not afraid or shy to be distinctive and different. The preservation of local peculiarities and cultural diversity in a dynamic and unevenly changing world could be an important feature of sustainable development in the Baltic Sea Region.

9.2 INTERNATIONAL ENVIRONMENTAL ISSUES

Many environmental issues are of an international character, at times becoming global in a political sense as they involve larger territories than the frontiers of countries mark. This refers to such major environmental systems like the Earth's atmosphere and the World Ocean; nevertheless, scientifically speaking, the biosphere, too, is common for the whole of the world. Although it is divided into the ecosystems of different countries, the loss of balance within an individual ecosystem may have a negative impact on other ecosystems and even entail risks to the existence of the biosphere. It also causes problems in international relations since sovereign states are rather biased when defending their independence and caring for the quality of their environment and natural resources. Thus, individual countries are guided by their interests in assessment of international environmental issues and their solutions.

According to the classification of the United Nations Environmental Programme (UNEP), the quality of environment and its trends of change can be divided into four categories:

- atmosphere (climate, ozone depletion, air pollution – local or transboundary),
- water (inland, coastal and sea ecosystems),
- earth (forests, desertification, use of land, soil),
- biological diversity.

Considering the complex nature of international diplomatic relations, attempts are being made to distinguish global and transboundary environmental issues, or to seek solutions for global and transboundary issues separately.

In some cases – climate change, ozone depletion, trade in endangered species – the principles of environmental protection are logical and internationally imperative. In other cases complications arise, for example, concerning transportation of toxic waste across borders. Since globally the amount of toxic waste is rapidly increasing, it seems plausible that there are many countries which cannot afford building safe toxic waste recycling enterprises and landfills, which is why toxic waste is transported to other countries. However, the UN stand on this issue is unequivocal: the disposal of toxic waste in developing countries, as practised by developed countries, should be banned.

The most important global environmental issues concern the atmosphere, especially climate change and excessive catch in the World Ocean. They are truly issues of the whole of humanity since everybody uses the air and resources of the sea. The prospective exploitation of the Antarctica also belongs to these issues, as everybody might benefit from it.

G. Hardin proposed the metaphor of 'the tragedy of the commons' because such world natural resources are very sensitive to overuse or pollution. Nobody owns these resources – neither an individual state nor a corporation nor a physical person. This explains the fact that no restrictions have been imposed: there are no private property borders or exploitation quotas. Consequently, everybody can go on exploiting the commons for one's needs up to the depletion of the resource or the collapse of the system. Any country may emit an unlimited amount of greenhouse gasses into the atmosphere or deplete all the fish in a particular fishing area.

As a result, the common resources are being depleted at an alarming rate. The tragedy, according to G. Hardin, is inevitable since the world resource reserves, limited as they are, are being devastated. He compares the problem to a lifeboat: 'We cannot have everybody on board the lifeboat because there are a limited number of seats.' To avoid such a tragedy, each individual must support the implementation of an authoritative management of the common resources. Hardin proposes to appoint a leader who would see to the exploitation quotas.

Doubtlessly, the society must take it into consideration and make provisions for preservation of these common resources. However, it is a complicated international task for there are too many culprits as well as victims, and it is difficult to determine their respective responsibilities and duties. At present the only solution is to reach an international agreement and adopt international binding multilateral treaties.

The prospective exploitation of the Antarctica is also considered a problem of common environmental significance as many might benefit from it.

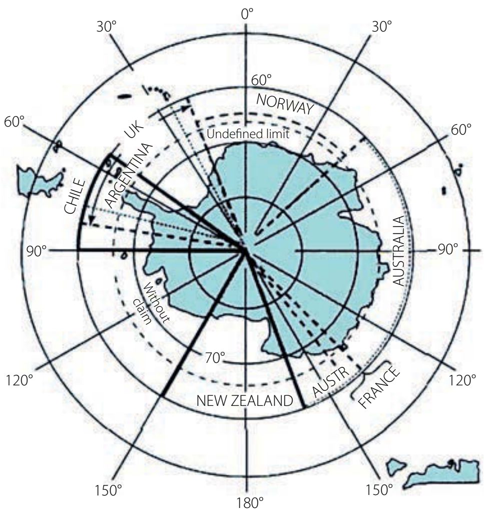


Figure 9.2. **Potential territorial claims of the countries to the Antarctica**

Territorial claims to the Antarctica are being contested although they are not adjudicated because the Antarctic Treaty of 1959 is still in force. This international treaty obligates the signatory countries to preserve the Antarctica and the surrounding seas south of 60° S latitude free for scientific research to any country of the world. The Treaty established this territory as a demilitarised zone free of nuclear weapons, also stipulating measures of nature and environmental protection.

While the Antarctic Treaty was still relatively flexible, it was under considerable pressure since there was an immense interest in the exploitation of the resources (oil, industrial minerals, shrimp, fish). This conflicted with the environmental protection demands. Today increasingly pressing demands are being voiced to modify the Antarctic Treaty, coming from non-member countries as well (in fact, these countries are not able to carry out any essential scientific research on the territory of the Antarctica). Non-governmental organisations, too, call for UN mediation to transfer the control over the Antarctica to all countries of the world, not just the member states of the Treaty. There are certain tendencies that might lead to the mitigation of the 1988 Convention on the Regulation of Antarctic Mineral Resources. Up to now the Convention stipulates that the use of mineral resources might be permissible only upon a very rigid evaluation of the impact on the environment which is confirmed by the member states of the Convention. The conflict between the United Kingdom and Argentina over the Falkland Islands was a clear warning that the lucrative Antarctic mineral resources may call forth territorial claims.

As a measure of the World Ocean protection, the 1954 International Convention on the Prevention of Pollution of the Sea by Oil was adopted to minimise the discharge of oil and oil waste from tankers and other vessels. To secure the efficiency of the protection of oceanic waters, it was necessary to adopt restrictions on pollution of rivers, on wastewater, air pollution since these types of pollution also lead to the pollution of the ocean.

In 1958, the first conference on the Maritime Law took place, but in 1959 the UN established the International Maritime Organisation, which was entrusted with the improvement of security measures at sea, facilitation of the development of regulations and decreasing of pollution.

In the early 1970s maritime countries began declaring their coastal waters part of their jurisdiction on an increasingly larger scale. First, it was 3 nautical miles, then 12 and now even 200 nautical miles.

However, the 1950 Convention on the Continental Shelf was less ambitious although with time there was a growing interest in shelf resources. To tackle these issues, the Third Conference on the Maritime Law was held in 1974.

The Regional Seas Subprogramme of the UN Environment Programme brought together maritime countries to discuss the situation. The conference resulted in a number of regional maritime agreements that referred to the Mediterranean, the Persian Gulf, the Western Africa region, South-East of the Pacific, the Red Sea, seas of Eastern Africa and South Pacific. These agreements laid the foundation for environmental action plans and cooperation towards reduction of pollution.

In 1977, the North Sea ceased to exist as an open sea as fishing and extraction of mineral resources was restricted when the European Union determined the new zoning of the continental shelf. Thus, the North Sea as well as the Sea of Japan, the Baltic Sea and the Mediterranean became subjects of conventions or international agreements. The UN also set additional demands regarding the territories of these seas to ensure an effective control of pollution.

The 1982 conference in Jamaica adopted the Convention on the Maritime Law, stipulating that the Convention refers to the areas up to the depth of 2 500 m from the shore.

In the late 1960s, researchers identified a hazardous and growing water pollution and reduction of the oxygen concentration in the Baltic Sea. All the seven Baltic Sea states – Denmark, Finland, the Democratic Republic of Germany, the Federative Republic of Germany, Poland, Sweden and the USSR – agreed on taking immediate measures to reduce the pollution of the sea. The Convention on the Protection of the Marine Environment of the Baltic Sea Area was adopted in 1974. Within its framework, the Helsinki Commission (HELCOM) was established to ensure the implementation, monitoring and development of a programme of common activities. At the time it was a unique attempt to agree on cooperation in addressing common environmental problems in East European and West European countries

Figure 9.3. **Shipwreck of the tanker *Amoco Cadiz* off the coast of Brittany (France) on 16 March 1978**

simultaneously. In this way cooperation ties were established for joint efforts towards measures for environmental protection and general security.

In 1984, during the first meeting of the ministers of the Baltic Sea Region countries, an action plan was adopted concerning four spheres: reduction of pollution, scientific research, navigation safety and prevention of oil leakage. The plan could be viewed as a political support for the development of the scientific and technological strategy. Solutions for problems of national character or implementation of projects were not discussed, neither were any binding documents adopted. In the second meeting of the ministers, in 1988, 78 projects were endorsed although many important problems were left unresolved. Much criticism was levelled at no tangible progress, and demands were made for actual measures and concrete results.

On the whole, many developing countries wished to see the World Ocean as a free-for-all territory, like the Antarctica, rather than have the huge area *de facto* taken over by the states which had the most up-to-date technology for exploiting the oceanic resources at their disposal.

A common tendency can be traced in the conventions adopted and treaties signed: to allot an increasingly significant place to the principle of precaution. The countries of the world are called upon to prevent pollution in case of emergency situations and accidents. Such policy was caused by the catastrophic accident in Chernobyl, on the tanker *Amoco Cadiz* and similar cases.

9.3 INSTITUTIONS INVOLVED IN INTERNATIONAL ENVIRONMENTAL PROTECTION

The number of institutions and persons involved in international environmental protection is very large; however, by an attempt to group them, the most significant units are:

- states,
- international environmental organisations,
- global environmental movements,
- industry and business,
- experts,
- society at large,
- individual talented personalities.

Of all the above-mentioned, it is only governments, or states they represent, that have the right to take internationally binding decisions. Only governments of sovereign states can ensure participation of their citizens in the implementation of international regulations. It is the states that manage the use of their resources for economic development or military aims; moreover, by using their political rights, they ensure that the welfare and social goals of their people are attained.

In accordance with the principal theoretical concepts concerning international relations, states undertake international cooperation only if there is any prospective benefit for their countries otherwise unachievable. In fact, countries desire to reap maximum benefit from international cooperation compared to other countries irrespective of their status in the international convention of countries. On individual occasions states can hope for some indirect benefit, for example, by promoting good international relations with other countries. However, a higher level of socialisation and friendliness are highly appreciated, which makes it possible to claim a larger portion of the common world reserves. Sometimes countries, in the name of their interests, make rather blatant attempts at a profitable bargain, even at the expense of other countries – by asking an inflated price for their participation, inadequate compared to the real potential of the respective state.

Different conceptual approaches, national interests, the level of own responsibility and abilities, as well as the efficiency of work become essential elements in the development, adoption and implementation of multilateral international agreements.

Governments establish various executive institutions, including environmental agencies. They are exposed to different kinds of pressure from the local entrepreneurs or businesses who would like to enjoy certain privileges or benefits related to the exploitation of natural resources or environmental pollution. At times these pressures make a government present itself in the international arena less as an environmental problem solver but more as a petitioner, which can leave a considerable impact on the environmental efforts of other countries, to the point of rejecting otherwise necessary solutions.

In many cases, individual ministries or even agencies represent their countries in international work groups or meetings, and on certain issues they may hold views that differ from those of the country. Sometimes the official state delegations find themselves under pressure – on the basis of their democratic rights, local interest groups (producers or active environmentalists) seek to attain an internationally binding decision that would benefit them. Besides, decision-makers need to consider general public sentiments as well.

States of the world are very different, have different historical heritage, environmental conditions and natural resource reserves. Some countries can be considered advocates of the modern environmental protection ideas. They include Europe's Nordic countries, which pursue strict demands in the sphere of international environmental management and protection, call on other states to participate in discussions and even take on unilateral additional obligations to encourage other countries and peoples to follow suit.

The European Union also supports a more rigorous international management of environment by allotting considerable funds for this aim. However, with the EU expansion, differences in the opinions on the future perspective can be observed among member states.

The position of the USA on environmental problems of global significance, especially on restricting climate change and a tougher international management of environment, has been severely criticised.

Nevertheless, several blocks of similarly thinking countries have formed. The 'northern' block includes the industrialised welfare states of North America, Europe and other continents. The 'southern' block is larger, represented by the developing countries of Asia, South America and Africa. The former Second World (socialist) countries together with the South-East Asian countries form the block of the developing countries. The situation in the 'Fourth World' countries (mostly African) is the gravest. These states suffer from extreme poverty, wars, unrests, diseases, lack of food and social care. The block of developing countries has grown from 77 states (G77) to 130 states, and it has a significant proportion of say in making international decisions.

The 'northern' block focuses more on such environmental problems as climate change and ozone depletion, whereas the priorities of the 'southern' block are the lack of drinking water and desertification.

Of great importance are the funds that have been used to attain the aims of environmental policy. Individual countries have a significant influence on which problems are raised for discussion, on negotiations and making political decisions, signing conventions and protocols. Sometimes a group of countries united by common interests, international organisations or even talented and purpose-driven individuals assume the role of the leader in negotiations. Leaders should be distinctly positive to be able to steer countries towards adopting more rigorous demands for the preservation of the global environment. There are also countries which, due to different reasons, oppose the treatment of a particular environmental issue; several countries which share such a stand can form a 'veto coalition' and sometimes achieve that the issue is removed from the international environmental political agenda.

A situation like this has developed around the preparation of an international document concerning the protection of whales: Iceland, Norway and Japan are strictly against imposing a moratorium on whale hunt. Similarly, the exporting countries of genetically modified corn – Canada, the USA, Argentina – weakened the Cartagena Protocol on Biosafety to the Convention on Biological Diversity, which came into force in 2003.

However, sometimes groups of countries can achieve imposition of stricter demands, like in the case of the Basel Convention, when African countries called for a total ban on transporting toxic waste from the countries of the 'northern' block to the countries of the 'southern' block. African countries had the crucial role in the development of the Convention to Combat Desertification.

9.3.1 INTERNATIONAL ENVIRONMENTAL ORGANISATIONS

In the majority of cases, international environmental organisations have been set up by mutual agreement of countries for practical measures to tackle global environmental issues. International environmental organisations have been extremely good at organising broad discussions to prepare projects of environmental policy planning, funding and implementation. At present there are about 250 international environmental organisations, most of them specialising in preparation and implementation of conventions on both global and local scale. The origins of environmental organisations date back to the time after World War II when the world faced the necessity to create a system to prevent wars, to restore the demolished economies and prepare solid ground for successful development. Thus, the United Nations (UN) was established, as well as the International Bank of Reconstruction and Development (the World Bank) and the International Monetary Fund. The General Agreement on Tariffs and Trade (GATT) later became the World Trade Organisation.

Several massive regional organisations came into being: the European Union, the North American Free Trade Association (NAFTA) and the Association of South East Asian Nations (ASEAN). All these organisations play an important role in tackling global evironmental issues up to this day.

However, the leading role belongs to the UN and its environmental organisations. The UN was founded in October 1945, when 50 countries signed the UN Charter in San Francisco, the USA. Today the number of its member states has grown to 192, and the UN is recognised as the world's most influential international organisation. Its initial task was to promote peace in the world, prevent conflicts between states, control armament, protect human rights, facilitate economic and social development and preserve the global environment.

To accomplish the tasks regarding the environment and development, the UN has set up

Figure 9.4. **Signing of the UN Charter (26 June 1945, San Francisco, USA)**

Figure 9.5. **UN Headquarters in New York, USA**

the following programmes: the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP) as well as the Commission on Sustainable Development (CSD). These organisations work under the auspices of the UN Secretariat, but their budget is endorsed by the General Assembly of the UN.

The necessity of the UN Environment Programme was confirmed during the United Nations Conference on the Human Environment in Stockholm in 1972 as a response to the signals of the alarming deterioration of the quality of the environment. The headquarters of the UN Environment Programme is in Nairobi, Kenya, but there are also offices in Switzerland (Geneva) and other countries. Among the tasks of the Programme are: the control of the fulfilment of international agreements and decisions on environmental issues; urging discussions on new initiatives of environmental protection, also by aggregating environment-related information from the countries of the world and by rendering support for the required scientific research.

Together with the UN Development Programme and the World Bank, the UN Environment Programme maintains the Global Environment Facility (GEF), which, in turn, funds projects that tackle the most topical environmental issues.

However, the possibilities of the UN Environment Programme are rather limited. Therefore, the countries of the world deliberate on substitution of the Programme with the Global Environment Organisation (GEO), which would have wider powers and better funding.

9.3.2 ENVIRONMENTAL ACTIVIST GROUPS

Environmental activist groups usually come out against slow and low-quality measures aimed at tackling environmental issues, and they often attract the attention of the society to lesser-known environmental issues. Thus, they present an important force in the global environmental management. There are numerous environmental activist groups and they have different interests because of their differences in ideology, strategy, institutional structure and goals.

Global environmental protection groups have manifested themselves to the world in various ways. Their principal activities are aimed at global protection of the environment. Among these groups are the World Wide Fund for Nature (WWF), Greenpeace and the Climate Change Network. Some organisations specialise in data collection

Figure 9.6. **UN Assembly Hall.**
The speaker is Ban Ki-Moon from South Korea, who assumed office as the Secretary General of UN on 1 January 2007

Figure 9.7. **Emblem of the UN Environment Programme**

that testify to the degradation of the world's environment, for example, the World Resources Institute in Washington prepares regular surveys of all kinds of impact on the environment caused by anthropogenic activities.

Many environmentalist groups are extremely active at the venues of important negotiations on the problems of the world's environment or sustainable development and also at world environmental congresses. The protesters often wear masks of animals or birds, stick up protest slogans on tall buildings, and actively lobby leaders of official delegations or delegates. Of late they also organise parallel conferences and environmental forums.

Figure 9.8. **Greenpeace protests against the company Esso/ Exxon Mobil**

Such activities cannot be ignored, especially because the majority of the society support the environmentalist groups and take their side. Consequently, many protesters' demands are included in official agendas and even reflected in the concluding documents. There are new tendencies that global environmentalist groups cooperate and work out alternative concluding documents, make them known to wide public, collect signatures in support of such documents and demand their consideration along with the official concluding documents. For example, the International Union for the Conservation of Nature (IUCN), consisting of a network of nature protection groups, prepared the Draft Convention on Biodiversity.

Participation of environmentalist groups in the implementation of international conventions and decisions as well as monitoring is of great importance. Usually these issues are within the competence of member states; however, the states not always have the necessary potential and funds. Therefore, environmentalist groups enjoy strong support. They raise the alarm if their countries do not fulfil their international duties or their activities fail to meet the requirements of the international documents they have signed and ratified.

The global society has a decisive role in all future processes, including environmental protection and sustainable development; nevertheless, the political process is being steered precisely towards the needs of the population of the world. The global and local groups of environmental protection have also come from the grassroots to demonstrate public discontent with environmental degradation, and their activities facilitate dissemination of democratic principles in the society as well as public participation in the management of the global environment.

9.3.3 INTERNATIONAL CORPORATIONS

The world economic system, which includes individual enterprises, companies, joint-stock companies and international corporations, exploits natural resources, and the result is environmental pollution. This is a cause of constant complications and even conflicts between economic development and environmental protection. It is widely believed that it is the large corporations, exercising a disproportionate influence on political processes, that should be held responsible for the current degradation of the environment and depletion of the world resources. At the same time, corporations and the business world make efforts to diminish their negative impact on the environment by working out and implementing standards of good management practice; they also attempt to present themselves to the society in a 'greener' light.

However, facts show that there is a close connection between sectors of industry and global environmental issues.

The industry and service sectors have great influence not only on the environment but also on the respective national governments and the development of their policies and development plans. However, large companies seldom get directly involved in politics. Usually this is the sphere of specific non-governmental organisations connected with industry and trade. One such major organisation is the World Business Council for Sustainable Development (WBCSD), representing over 170 sectors of industry. This organisation was founded in 1991, shortly before the UN Conference on Environment and Development, to summarise and publicise the opinion of the business world on future tendencies.

The International Chamber of Commerce (ICC) also integrates different and diverse organisations to join in the discussions on international environmental issues.

Table 9.1. **Global environmental issues and the associated sectors of industry**

Global environmental issue	Primary production	Secondary use
Climate change	Extraction of fossil fuel	Energy production, provision of transport system
Flow of toxic waste	Waste recovery and disposal	Use of recycled materials
Decrease in biodiversity and biosafety	Agricultural, biotechnological and pharmaceutical industries	Use of mineral fertilizers, pesticides and modified organisms in farms
Ozone depletion	Chemical industry	Production of refrigerators, electronic goods and aerosols
Spread of stable organic compounds	Chemical industry	Agriculture
Decrease in forest areas	Chemical and forestry industry	Timber industry
Pollution of the World Ocean	Oil extraction and transportation	Sectors that use oil products

The activities of organisations for international environmental management include participation in global environmental forums or lobbying in their own countries. Sometimes organisations try to influence governments as they participate in the drafting of international regulations or standards to corner the market for their goods or services as well as to secure other advantages and increase their capacity to compete in global markets.

In many cases the industry and trade sectors want to achieve adoption of universal international standards in order to exclude competitors.

It is noteworthy that tackling many global environmental issues is even unfeasible without drawing in the industry and trade sectors, principally in relation to environmental pollution which underlies unwelcome climate changes and ozone depletion. Many sectors feel under threat as they are found co-responsible for causing environmental problems; others are ready to offer solutions along with reaping huge profits for themselves.

Undeniably, producers have an increasingly powerful say not only in the development of the environmental policy in their countries but also in the development of a new kind of relations with the public. Voluntary commitments concerning environment-friendly production and an appropriate mechanism of control of certification and compliance featuring distinct eco-labelling win public acclaim.

9.4 ROLE OF SCIENCE AND SCIENTISTS IN IDENTIFICATION AND TACKLING OF ENVIRONMENTAL PROBLEMS

Scientists definitely play a prominent role in the development of international documents pertaining to environmental policy. Although it was traditionally believed that scientists were not directly involved in the process, the UN Conference on the Human Environment in Stockholm, 1972, actually brought out their special role.

At the intellectual level, problems are identified and scientifically described. In this regard, J. Evelyn's research is notable; he announced that the quality of air in London was poor in a publication in 1661. Similarly, the French engineer Jean-Antoine Fabre (1748–1834), after having carried out research in the mountains, informed the public about soil erosion in the Alps.

J. A. Fabre's observations concerning soil erosion did not offer solutions to the problem. The same can be said about the talented and versatile polyglot George Perkins Marsh, ambassador of the USA to Italy, who in his book *Man and Nature* (1864) explained, in the scope of contemporary knowledge, the role of rivers, banks and surrounding wetlands in the origin of floods in continental Europe. He predicted the possibility of floods as long as humans would continue industrialising and adapting rivers to their needs. However, he did not solve the problem either.

In the early 20th century, the Swedish scientist Einar Naumann explained the principles of eutrophication. He discovered that an excessive amount of nitrates and phosphates causes biological activity. The results turned out to be correct although no one gave careful attention to them until the problem gained topicality in connection with a massive loss of fish. Consequently, scientific research was necessary, yet it had been insufficient.

Speaking of scientists as discoverers of problems, the name of the Swedish chemist Svante Oden (1924–1986) is often mentioned. He discovered the complex and large-scale acidification mechanism and studied it in relation to burning fossil fuels. Indeed, for about a century scientists had had some general knowledge on it, but S. Oden's article, which was published in the Swedish newspaper *Dagens Nyheter* in 1967, turned out pivotal in tackling the situation in practice. The novelty was the more recent and precise data; yet most importantly, this information could be introduced to politicians who used it in decision-making. As a result, the concept of environmental protection was worked out in the 1960s, and practical tasks were outlined. 'Acid precipitation' became an issue to be discussed in political circles, but the problem formulated by S. Oden became an environmental problem as well.

Figure 9.9. **The Swedish chemist Svante Oden (1924–1986) was the first to study the consequences of burning fossil fuel**

He realised that sulphurous compounds in fuel can be oxidised in the process of burning and later might turn into sulphuric acid, which has a devastating impact on the environment. It was tested by the International Meteorological Institute in Stockholm, which since the 1950s has carried out measuring of atmospheric pollution.

Figure 9.10. **Major contribution of the outstanding Swedish chemist Svante Arrhenius (1859–1927) to science was his electrolytic dissociation theory**

However, Arrhenius was a pioneer in many different spheres. Already in 1896 he had advanced the theory that the rise of carbon dioxide concentration in the atmosphere was going to cause the effect of global warming. He may have got interested in this problem after it was widely discussed in relation to the discovery of the recent Ice Age. He calculated that doubled concentration of carbon dioxide would result in a temperature rise by five degrees. His calculations are very close to our present-day notions.

In the 19th century, global warming had not yet become an environmental problem. However, there were scientists who saw a link between the temperature rise and human activity. Svante Arrhenius (1859–1927), a physico-chemist at the Stockholm Högskola, had put forward the theory of the greenhouse effect already in 1896, but in 1938 the British scientist Guy Stewart Callendar (1898–1964) published an article in which he demonstrated a connection between this phenomenon and burning of fossil fuel. As a result of burning, carbon dioxide is emitted, and with its concentration in the atmosphere rising, the air temperature also rises. However, even G. S. Callendar himself did not consider that to constitute an environmental problem because it was not socially recognised. It did not gain recognition up to 1960 when the concept of the greenhouse effect was already in wide use and the global temperature rise had become a topical environmental problem. The process of global warming was gradually progressing, and the problem had to be included in the programme of human activity.

Environmental problems are not new, they have existed for hundreds of years and have arise in many places of the world. Yet they have been problems of local importance, dispersed and isolated in both time and space. They have emerged in various places and evaluated as well as tackled differently – by individuals and by society at large. Scientists and government officials have been involved, but sometimes these problems were left untreated, as was the case of the London smog. Londoners had complained about it already in the 13th century, but practical measures were taken only in the 1950s – 700 years later.

When these social problems surfaced and were explained, their nature changed. People's inconsiderate attitude to their environment was reflected in these problems. Along with the idea of the possibilities of nature and opportunities of environmental protection, a convincing interpretation method was created and introduced to journalists, scientists, international organisations and individuals concerned about environmental problems. Scientists created environmental models, concepts and theories; to the general public, scientists were the activators of environmental problems; it was only scientists who could use their methods to identify the borderline between what was 'normal' and 'problematic'.

The scientist as a discoverer of environmental problems performs other important functions in the modern society. The scientist is a teacher who disseminates knowledge on research and thus carries out the mission of educating the public about the questions of nature and the environment. The scientist is also a consultant who helps decision-makers to prepare optimum solutions; as a creator of new knowledge, the scientist works out the best technical and social solutions for the problems of nature and the environment. The scientist also assumes the role of a responsible intellectual by entering discussions and explaining the interrelation between environmental and political issues in the mass media.

Application and scientific interpretation of data on the environment are instrumental in assessing global tendencies and developing future tendencies. The case of the Danish scientist Bjorn Lomborg is an enlightening example. In 2001 he published the book *The Skeptical Environmentalist* to prove that the existing state of the environment was not as bad as other scientists found it. Lomborg was severely criticised for a methodologically unjustified selection of separate environmental data to draw general conclusions inconsistent with the reality. However, he was not the only one to take a stand against the propagators of environmental problems. Such has been the case with the problem of ozone depletion, the currently topical climate warming and other issues. This urges the environmentalists to work even more assiduously and consider the complex and intricate nature of the phenomenon as well as be better prepared for the eventual attacks by sceptics and critics.

Science can take pride in being the driving force behind activity programs for nature and environmental protection. However, its history has not been a linear process, clearly outlined and progressive. It has rather been a meandering advance, with numerous attempts, failures and the significant achievements of the second half of the 20th century in creating models of nature and the environment. Science is also responsible for huge disasters, including harm to nature; yet future without science in inconceivable. Science remains a consequential factor in tackling problems of nature and the environment the humanity faces worldwide and in the Baltic Sea Region in particular.

9.5 DEVELOPMENT OF INTERNATIONAL COOPERATION

Policy of environmental protection (at least in its first stages) has been directed towards specific events. It is easy to attract the attention of the public by pointing out obvious and easily comprehensible problems such as acid rains, seal hunting in order to obtain furs and pollution caused by pesticides. However, when it comes to problems that become evident after a longer period of time, such as the global changes of temperature, expansion of deserts and depletion of biological diversity, it is considerably more difficult. The point of view of scientists regarding critical and problematic issues does not always coincide with that of the governments and international organisations.

For a government, an issue becomes critical only when it has attracted the attention of a great part of the public, its more prominent members, or when the attention of the mass media has also been attracted. That is why the international policy of environmental protection is concerned both with the growth of the movement of environmental protection and the development of scientific thought regarding important ecological processes. The 20th century has seen the most achievements of this kind.

In international political relations, the emergence of environmental protection issues as problems can be divided into four phases. The first phase began in the 19th century with the signing of bilateral fishery agreements and ended in 1945 when new international organisations were established. The second phase began with the foundation of the United Nations and reached its peak during the United Nations Conference on the Human Environment in Stockholm, 1972; the development and establishment of the movement of environmental protection took place during this phase. The third phase (1972–1992) witnessed an explosion of new environmental protection institutions and agreements. The fourth phase began with the United Nations Conference on the Environment and Development in Rio de Janeiro in 1992. The last phase is markedly characterised by integration of environmental issues in nearly all public and private spheres, and the impact of these issues on the activities of the humankind.

9.5.1 FIRST PHASE: SEA RESOURCES

In the beginning international environmental protection focused on systematising the issues of jurisdiction and ensuring the administration of international watercourses by passing laws for transboundary rivers and lakes. Attention was drawn to the populations of migrating wildlife as well due to the fact that no state could single-handedly take care of its protection when the growth of industry threatened to destroy many species; for example, the government of Switzerland proposed (albeit unsuccessfully) a formation of an international committee to protect migratory birds of Europe as early as in 1872. However, different governments had begun taking measures to protect nature even earlier than that; they were mostly to do with the interests of local economies – protection of forests, inland waters, mineral fields and certain wildlife species.

With the exception of the seal protection treaty (adopted in 1911), all the other early attempts to regulate the use of joint natural resources required so much debate that in the end they turned out to be inefficient and had to be postponed. Dealing with environmental problems was difficult due to the fact that there was no clearly defined ground and strict political approach; moreover, there were cultural differences, and all the aforementioned aspects led to different approaches. The attempt to ensure international whale protection turned out to be an especially unavailing episode in the history of international environmental protection. The Convention on Restrictions of Whaling was signed in Geneva in 1931, and 24 states had either ratified or joined it up to 1935. However, the Soviet Union and Japan – the two states most involved with whaling – did not sign the convention. In addition, the states that had signed the document had few duties to attend to. The International Whaling Commission was established in 1946 due to the initiative of the USA; a whaling code was adopted, and the commission could make amendments without holding official conferences. Yet, despite the authority given to the commission, the short-term interests of whaling were impossible to overcome, and the commission did not heed even its scientific advisors.

During the Conference on the Human Environment, whales were mentioned as a symbol of the antiecological behaviour of humans. A procession was organised for the protection of whales and a decision was passed to recommend a 10-year moratorium on commercial whaling, which was supposed to enhance the activities of the International Whaling Commission; yet it took 10 more years to authorise the moratorium.

The North Pacific Fur Seal Convention managed to protect seals from a direct impact of human activities by providing that hunting as well as the population of seals both on land and sea territories were to be controlled. In this case, international cooperation was more successful because the fur seals are a particular subspecies whose behaviour is easily predictable – they have localised territories for breeding their young; thus, the territories can be controlled by the state governments. Whales, on the other hand, have different subspecies that populate different oceans; their behaviour is not easily predictable, resulting in difficulties to determine their numbers and regulate the size of the population. The differences in political, economic and geographical factors only contributed to complications of the process.

Nevertheless, in 1982 the International Whaling Commission finally voted for halting commercial whaling, setting a period of transition of three years. The states concerned with whaling – Japan, the USSR, Brazil, Peru, Norway, Iceland and North Korea – still opposed the vote. However, in 1990, when the five-year moratorium had ended, in a conference held by the International Whaling Commission, most of the members voted to prolong the moratorium. The states against it accepted the vote since refusing to do so would have cost them their political and business reputation.

9.5.2 SECOND PHASE: ACTIVITIES OF THE ENVIRONMENTAL PROTECTION MOVEMENT AND THE UNITED NATIONS

Many non-governmental organisations concerned with protection of the environment came into being after the end of World War II, supported by the governments on both national and international scale. During that time the global problems were related to four important spheres: 1) the ban on distribution of nuclear, biological and chemical weapons, reduction of military costs, and prevention of a new war, 2) reduction of poverty, 3) the nature and environment crisis that manifested itself in depletion of resources and biological diversity and in increasing amounts of waste, 4) recognition and ensuring of human rights.

However, the events that took place on an international scale had different impact regarding the social and environmental protection movement in each state based on the national political culture. For example, the environmental protection movements in Denmark, Sweden and the Netherlands had certain national peculiarities resulting from specialisation and the professional standard.

Some of the movements had attracted a great number of members whereas others consisted of a small number of groups of experts; similarly, some of the movements were concerned with solving general problems of environmental protection and development while others focused on particular environmental issues.

During the 60s, there was a significant interest in nature in scientific and economic aspects; the decade left an impact on how environmental problems were viewed in intellectual and political circles.

In 1962, Rachel Carson published her book *Silent Spring* which criticised the overly extensive use of pesticides and stressed their negative influence on human health and ecosystems. Although the scientific community criticised the work as being over-emotional, almost all of the pesticides mentioned by R. Carson are banned now.

In 1962, the actual state of environment was uncertain; however, 1970 arrived with a many-voiced and unyielding public opinion. Groups of concerned scientists, administrators and environmental protection enthusiasts initiated

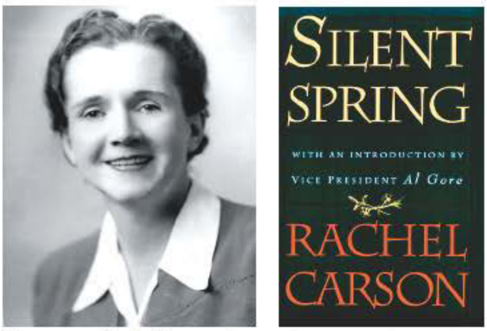


Figure 9.11. **Rachel Louise Carson (1907–1964), a marine biologist and writer**
Her most significant work is ***Silent Spring***, republished in 2002 to commemorate 30 years since the publication of the first edition

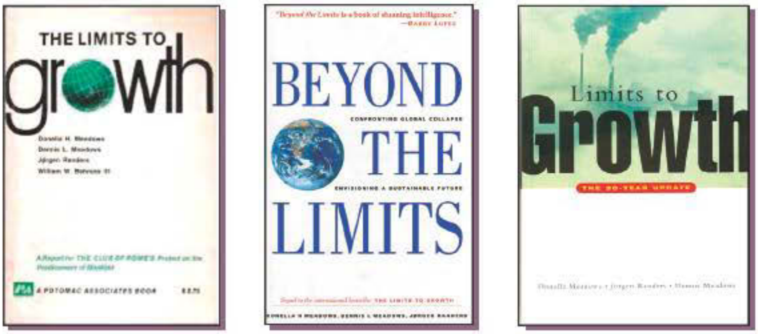


Figure 9.12. **Three editions of *Limits to Growth* (1972, 1992 and 2004)**

an explosion of a mass movement, which spread in the industrialised world. The later movement of environmental protection came more from the grassroots, was much more active and politically responsive compared to the earlier organisations of nature protection.

Significance of environmental organisations in the international relations of environmental protection begun to increase. Environmental organisations increased pressure on the governments to make them formulate and carry out efficient environmental protection policies. Non-governmental organisations collaborated via a regional and global network in order to obtain information and work out the strategy needed for environmental protection. On the local scale the organisations established groups and enlisted individuals to solve particular immediate problems in their vicinity. These organisations were grassroots movements with influence on the international policy of environmental protection, and several organisations of significant standing and a particularly scientific or professional approach, such as the International Council of Scientific Unions and the World Conservation Union, grew out of them. They actively participated in the preparation of the United Nations Conference on the Human Environment in Stockholm, 1972.

Among the institutions and centres concerned with environmental information, education and consultations, the International Institute for Environment and Development, the Institute for European Environmental Policy and the World Resources Institute stand out.

During the 50s and 60s, the global economy experienced growth; however, afterwards fundamental problems began to develop, resulting in the oil crisis of 1973. The crisis coincided with the awareness of the 'limits to growth', explained to the world by the Club of Rome.

The Club of Rome was established as a free association of European scientists, technical employees and politicians during the time when the liberal democracy of capitalism was shaken by crises, and issues of civil rights, peace and environment were beginning to dominate. The Club of Rome published the report *Limits to Growth*, based on the research carried out by the Massachusetts Institute of Technology (USA) led by D. Meadows.

Limits to Growth was based on the outcomes of prognoses regarding the constant depletion of resources, increase in pollution and population. The goal of the report was to promote awareness of the economic, political, social and environmental components of the global system as well as to aid the development of new opinions regarding the political means of solving problems. *Limits to Growth* exposed the probable global development up to 2100, examined the use of computer-created models in system analysis (which had been unprecedented before), and extrapolated based on the growth experienced from 1900 to 1970. The conclusion was that if structural changes were not introduced, the world could experience grave difficulties around 2100.

The model examined five interdependent spheres of development, namely industry, resources, pollution, food and population. Changes that affect only one sphere could still cause problems in others, and technological innovations dealing with the expansion of a particular sphere would not affect the general tendency towards a collapse. The report severely attacked the widespread view that the development of technology could improve the environment. Although the report was criticised for its focus solely on the analysis of the Western system as well as the application of the system dynamic method, *Limits to Growth* set the preconditions for a new way of thinking and an awareness of global action programmes and helped to form a new comprehensive view on the global environment.

9.5.3 THIRD PHASE: FROM STOCKHOLM (1972) TO RIO DE JANEIRO (1992)

Two international conferences took place in 1968 and 1972, during which the problems of global environmental protection were discussed; moreover, specific solutions to improve the state

Figure 9.13. **Opening of the United Nations Conference on the Human Environment in Stockholm, June 5, 1972**

were proposed. The first was the Biosphere Conference in Paris, which was in a more scientific vein and in which such problems as the human influence on the biosphere, the effect of air and water pollution, overgrazing of green areas, deforestation and the drainage of wetlands were discussed. The same problems were analysed in more detail during the next meeting – the Biosphere Conference in Stockholm, which attracted international attention to many global problems of nature and the environment.

The United Nations Conference on the Human Environment in Stockholm in 1972 undoubtedly was a turning point and the most important event regarding the establishment and expansion of an international environmental protection movement. It was the first time when environmental problems were discussed and analysed in connection with economic and social development in an international forum. A direct outcome of the conference was the establishment of a new United Nations agency: United Nations Environment Programme (UNEP), which marked the transition from the environmental protection form of 1960 to the establishment of a movement that dealt with the environment protection politically and globally – a much more serious movement of the 1970s, thus confirming the trend towards emphasising a human-inhabited environment affected by humans and underlining the importance of a marked conservation and protection of nature. At the beginning of the 1980s, there were about 13,000 non-governmental organisations in the developed industrial states (30% had been established in the previous decade) and 2 230 in the developing countries (60%). The environmental non-governmental organisations in the developing countries provided an alternative to the corrupt governments.

The environmental protection movement was a significant force in the struggle for independence in eastern Europe and the Baltic states – Estonia, Latvia and Lithuania. The rapid expansion of the movement probably was fuelled by the objections to the decisions made in Moscow regarding the development of industry and the use of natural resources; moreover, it was generally confirmed that extensive pollution is a significant factor contributing to the deterioration of human health.

The conference in Stockholm triggered many international initiatives and activities.

The Geneva Protocol on long-range transboundary air pollution (adopted in 1986) proposed quantitative goals. The document in question was reconciled with the European Commission and the North Sea Declaration. It was decided to reduce the amount of pollution caused by heavy metals, toxic and volatile organic substances and biogenic substances by half up to 1995.

The Baltic Sea Declaration signed in Ronneby in 1990 was an important step to ensure the implementation of environmental protection measures agreed upon internationally on a local scale. An action programme was approved coordinated by national and international experts and financial institutions, including the International Bank for Reconstruction and Development, the European Investment Bank, the Nordic Investment Bank and the European Bank for Reconstruction and Development. Programmes and regulations to cut the pollution were adopted on a local scale. In 1992, the plan was backed by the Baltic Sea Environment Declaration, which ensured the possibility to further guarantee the economic strategy of financing environmental actions.

In accordance with the United Nations General Assembly Decision of December 1983, the World Commission on Environment and Development was founded, and the position of chair was entrusted to Gro Harlem Brundtland.

Figure 9.14. **Gro Harlem Brundtland, ex-Prime Minister of the Kingdom of Norway and Chair of the World Commission on Environment and Development**

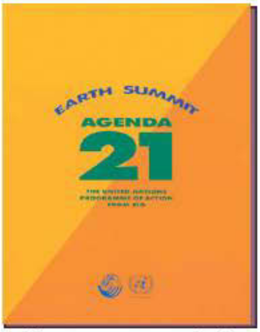


Figure 9.15. **United Nations publications are issued in huge editions worldwide**

The task of the Commission was to single out critical problems and formulate their solutions planned as a renewed research to ensure the emergence of multilateral solutions and restructure international economic corporation. The commission organised public conventions in all five continents, and the report *Our Common Future* prepared by the Commission was published in 1987. The report was widely used by the United Nations and others in order to emphasise the possibilities of implementing the set goals in each state. The definition of sustainable development was an agreement on political principles, arrived at through a difficult process, which would serve as basis for a careful and responsible monitoring and use of the resources of the Earth.

'Sustainable development is development that meets the needs of our generation without compromising the ability of future generations to meet their needs.'

The process of founding Green Parties took off – as early as 1972 in New Zealand, later in 1973 – in Great Britain, 1974 – France, 1978 – Belgium and West Germany, 1979 – Switzerland and Luxembourg, 1980 – Finland, 1981 – Sweden, 1982 – Austria and Ireland, 1983 – the Netherlands and 1984 – Italy. In the elections of the European Parliament in 1984, Green Parties from seven states took part.

The Green Party of Latvia was founded in January 1990 as the first new political party in Latvia before the Declaration of Independence on May 4.

A new ideological turning point in the environmental protection movement was needed in order to be able to formulate the new philosophy of life, like the Club of Rome had done before. In *Gaia: A New Look at Life on Earth* by James Lovelock, published in 1979, the general arguments were accompanied by a new comprehensive view, namely that the humankind is only part of a much greater natural system as the processes that take place on the Earth are influenced by all living organisms that inhabit the planet. They are inseparable, interrelated and form a unity – the biosphere.

9.5.4 FOURTH PHASE: THE PERIOD OF INTEGRATION

The United Nations Conference on Environment and Development that took place in Rio de Janeiro in June 1992 was the most diverse and large-scale conference ever organised by the United Nations. 179 state representatives and 120 state leaders partook in the Conference. Preparations for the conference took two and a half years, and its progress was widely reported by the press. Many national delegations with representatives of governmental, municipal, business, scientific, non-governmental and other organisations took part in the debate with the institutions of the United Nations. The discussion touched upon issues of international importance – protection of the atmosphere; the use of the oceans, freshwater and land resources; preservation of biological diversity; careful application of biotechnology; and problems regarding toxic and solid waste and hazardous chemical substances. Five documents were signed at the end of the conference, signifying joint national interests and the reached unanimity. This conference was very significant for the future development of the debate on sustainable development, negotiations between developed and developing countries and for the process of explaining the relations between environment and development.

At the conference, an important United Nations commission – Commission for Sustainable Development (CSD) – was founded; its goal was to sum up the results of the conference and monitor how the Agenda 21 was implemented on a national, regional and international scale in order to ensure worldwide sustainable development.

Agenda 21 called upon the governments to develop a strategy that would further and ensure sustainable development by attracting non-governmental organisations and the general public. Agenda 21 particularly emphasised the necessity of having multilateral partnership with international organisations, state governments and municipalities, business organisations, non-governmental organisations and different resident groups. The document daringly suggested to develop an environmental development plan for the 21st century. It required that a general inventory in all spheres be performed to assess their sustainability, connecting the spheres and developing action plans for the future. Thus, the guidelines for and structure of implementation of future action were set. The 40 chapters of Agenda 21 (over 500 pages) are classified into four main parts:

- social and economic issues;
- resource conservation and management for development;
- establishing the role of the main action groups;
- determining and solving the most important issues.

Figure 9.16. **United Nations Conference on Environment and Development in Rio de Janeiro, 1992 – the meeting of 103 state leaders**

The conference was opened by the United Nations Secretary-General Boutros-Boutros Ghali on June 3, 1992, and Fernando Collor de Mello, President of Brazil, was elected President of the Conference. The Conference adopted the Rio de Janeiro Declaration on Environment and Development, Agenda 21, the Statement of Principles on the Management, Conservation and Sustainable Development of All Types of Forests, the United Nations Framework Convention on Climate Change and the United Nations Framework Convention on Biological Diversity.

However, the main problem of Agenda 21 is the lack of actual financing. Approximate expenses estimated by the secretariat of the Conference amounted to EUR 430 billion a year, 100 billions of which should be covered by international financial aid. These sums seemed unrealistic, taking into account the opportunities of attracting and exploiting financial resources.

A report on implementation of Agenda 21 was submitted at the meeting of the United Nations World Commission of Environment and Development in the summer of 1997. Global Environmental Facility (GEF), established due to the report of the United Nations World Commission of Environment and Development in 1987, planned on spending only EUR 0.93 billion in the period of 1991 to 1994 and EUR 1.33 billion in 1995 to 1998, most of which would be spent on global climate change, international water pollution and protection of biological diversity and the ozone layer. On the whole, international financial aid (including multinational and bilateral financial cooperation) to developing countries has decreased because of political and economic factors. At the end of the Cold War, some of the financial resources due for developing countries were shifted to the former Soviet Block countries. In addition, the former market relations between eastern Europe and the developed countries weakened, leaving some of the former Soviet Bloc countries in a political deadlock and forcing them to search for new partners. The cut in international aid was also related to a financial crisis affecting the developed countries. In order to diminish the consequences of the crisis and stabilise the local situation, the countries drastically cut the resources for international financial aid.

In addition, the environment in the countries of the former Eastern Bloc was a concern, as well as the competition between these countries and the developing countries for the economic aid from the West. The former Eastern Bloc countries had to overcome many problems to be able to embrace sustainable development. In May 3–4, 1996, Prime Ministers of the Council of the Baltic Sea States and EU top officials, including President of the European Commission, met in Visby, Sweden. The setting was one of the most remarkable scenes of regional policy making since the end of the Cold War. In the final declaration of the meeting, the issue of environmental protection was high on agenda, including Agenda 21 for the Baltic Sea Region, as well as co-operation and knowledge transfer. Sweden, as the host of the meeting, set aside a sum of one billion Swedish crowns (about 110 000 EUR) to fund the proposed activities with the help of the newly created Advisory Council for co-operation on the Baltic Sea Region issues. During economic difficulties, it is of utmost importance to ensure that environmental protection is a political priority. That can be achieved only if environmental organisations keep pressing the issues and have the support and involvement of the society. In all eastern Europe countries in which Green Parties were a significant force in the struggle for independence, the priorities have gradually changed. Many representatives of Green Parties elected in the first free elections lost their mandates in the next. At the moment, there is a tendency in society for economic problems to come first regarding political action. Despite that, there is some progress regarding advancement towards the drafting and adoption of national sustainable development strategies. Similarly to developed countries of the West, the advance towards sustainable development takes place on several levels of the society: between politicians and the civil service, between regional and local authorities, between different business organisations and residents.

9.6 RECENT TENDENCIES IN INTERNATIONAL COOPERATION ON ENVIRONMENTAL PROTECTION AND SUSTAINABLE DEVELOPMENT

Multilateral international environmental agreements (conventions) are one of the oldest forms of cooperation in solving problems of the environment and nature. After the United Nations Conference on the Human Environment in 1972, international environmental agreements have become the main instrument of global environmental administration; however, the emphasis is on international diplomacy, not technical understanding. Approximately 140 international agreements have been signed, ratified and come into force since 1920; the number of the documents accompanying them (protocols and amendments) is much greater. Some of the conventions and protocols are of greater significance – on degradation of the ozone layer, biological diversity and climate change.

Although the conventions and protocols differ in both their subjects and goals, there are similarities as well. The conventions are international laws that independent countries or institutions have agreed upon. Since the conventions set down the obligations and rights of the countries in a particular sphere, the representatives of the states spend quite a lot of time on harmonising the documents before adoption of the conventions. After that, technical experts develop the project of the convention and submit it to the member states for evaluation. The highest ranking officials of the states sign the convention during an international conference dedicated to the debate on the questions related to the convention. The procedure of ratification takes place after signing; it involves an official decision by the parliament confirming that the convention complies with the national legislation and that the state is willing to observe the rules of the convention and undertake international liabilities. If an established number of states (the minimum number of states needed for the convention to function efficiently is decided by the member states themselves) have ratified the convention, they convene the first conference of the parties of the convention to agree upon the actions

Figure 9.17. **First Conference of the Parties of Aarhus Convention**
Conference took place in October 2002 after about four years of preparation since its adoption and signing in Aarhus, Denmark, in June 1998. To commemorate the decade of Aarhus Convention, the Third Conference of the Parties was held in Rīga in June 2008

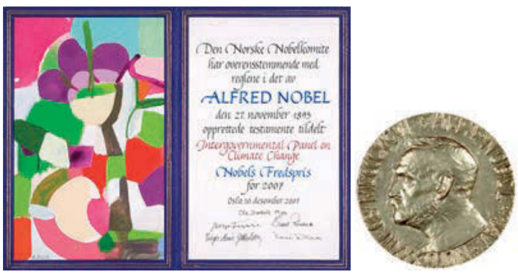


Figure 9.18. **Nobel Peace Prize 2007 was awarded to the Intergovernmental Panel on Climate Change**

Figure 9.19. **The Club of Rome General Assembly**
From the right: Queen Beatrix of the Netherlands, J. Cohen, Mayor of Amsterdam, R. Lagos, former President of Chile, R. Lubbers, former Prime Minister of the Netherlands, M. Gorbachev, former President of the USSR, who all took part in the work of the Club of Rome General Assembly in October of 2009

Figure 9.20. **Chair of Intergovernmental Panel on Climate Change R. Pachauri addresses the delegates of COP15 in the official opening of Copenhagen Conference on December 7, 2009**

Table 9.2. **International conventions on nature and environmental protection**

Conventions and agreements	Place of adoption	Year of adoption
International Convention for the Regulation of Whaling		1946
Radiation Protection Convention		1960
Vienna Convention on Civil Liability for Nuclear Damage	Vienna	1963
Nuclear Non-Proliferation Treaty		1968
Convention on Wetlands of International Importance, Especially as Waterfowl Habitat	Ramsar	1971
UNESCO World Heritage Convention		1972
CITES Convention on International Trade in Wild Species of Fauna and Flora	Washington	1973
International Convention for the Prevention of Pollution from Ships	London	1973
Convention on the Conservation of European Wildlife and Natural Habitats	Bern	1979
Convention on the Conservation of Migratory Species of Wild Animals	Bonn	1979
Convention on Long-range Transboundary Air Pollution	Geneva	1979
United Nations Convention on the Law on Seas		1982
Convention for the Protection of the Ozone Layer	Vienna	1985
Montreal Protocol	Montreal	1987
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	Vienna	1986
Convention on Early Notification of a Nuclear Accident	Vienna	1986
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal	Basel	1989
Convention on Environmental Impact Assessment in a Transboundary Context	Espoo	1991
Agreement on the Conservation of Bats in Europe	London	1991
United Nations Framework Convention on Biological Diversity	Rio de Janeiro	1992
Cartagena Protocol on Biosafety	Cartagena	2002
United Nations Framework Convention on Climate Change	Rio de Janeiro	1992
Kyoto Protocol	Kyoto	1997
Convention on the Protection of the Marine Environment of the Baltic Sea Area	Helsinki	1992
Convention on the Protection and Use of Trans-Boundary Watercourses and International Lakes	Helsinki	1992
Convention on the Transboundary Effects of Industrial Accidents	Helsinki	1992
Convention to combat desertification in countries seriously affected by drought and/or desertification, particularly in Africa	Paris	1994
Convention on Nuclear Safety	Vienna	1994
The Agreement on the Conservation of African-Eurasian Migratory Waterbirds		1995
Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management	Vienna	1997
Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Rotterdam	1998
Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters	Aarhus	1998
Stockholm Convention on Persistent Organic Pollutants	Stockholm	2001

needed to implement the convention, including the establishment of the secretariat of the convention, financing, usage of financial means, the procedure of reporting the progress and, if necessary, the criteria for evaluating the conformity of member states. In some cases, expert committees and work groups are formed in order to solve current issues.

Regarding the making of global environmental policy and development of conventions and their protocols, the role of scientists and experts is invaluable. A good example is the Intergovernmental Panel on Climate Change (IPPC), which consists of approximately three thousand scientists. The results of their research and a mutual exchange and collective interpretation of the results have raised global awareness of the current environmental problems and helped in developing a unified policy for subduing the negative consequences of climate change. The contribution of IPPC has been awarded with the Nobel Peace Prize in 2007.

Since as early as the 1960s, scientists have been attempting to link global climate change with anthropogenic action. At the beginning the initiative came from the scientists working on research on the atmosphere, who were trying to make the connection between the impact of the collective action of humankind on the whole atmosphere and its possible changes. This kind of interdisciplinary approach was used in a scientific programme 'Human and Biosphere' carried out by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) from 1971 to 1984. In a way, it set the foundation for interaction between environmental science and environmental politics and enabled solving current global problems more efficiently.

In September 2000, the General Assembly of the United Nations, which 191 member states took part in, signed the United Nations Millennium Declaration and set eight Millennium Development Goals to be fulfilled until 2015.

UNITED NATIONS MILLENNIUM DEVELOPMENT GOALS

Goal 1: Eradicate extreme poverty and hunger.
Goal 2: Achieve universal primary education.
Goal 3: Promote gender equality and empower women.
Goal 4: Reduce child mortality.
Goal 5: Improve maternal health.
Goal 6: Combat HIV/AIDS, malaria and other diseases.
Goal 7: Ensure environmental sustainability.
Goal 8: Develop a global partnership for development.

Figure 9.21. **Emblem of the United Nations and the stand at the UN Headquarters in New York with the Millennium Development Goals**

Figure 9.22. **Environmental protection activists protest against the world leaders' inability to make decisions on definite and immediate actions to diminish the negative consequences of climate change. Copenhagen, COP15 Conference, December 2009**

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CASE STUDY: NORWAY

NORWAY'S ROLE IN INTERNATIONAL COOPERATION ON THE ENVIRONMENT: THE UN REDD CLIMATE-FOREST INITIATIVE

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University of Oslo

The World Commission on the Environment and Development was chaired by the then Norwegian Prime Minister Gro Harlem Brundtland in 1983. The widely read book based on the Commission's report, *Our Common Future* (1987), was published in an era when Norwegians set agendas on a number of international environmental issues. Norway was active in the preparation of the First United Nations Conference on the Environment and Development in Rio de Janeiro in 1992, in the climate negotiations initiated in Kyoto in 1995, and in a number of subsequent international environmental initiatives on climate change, biodiversity and deforestation. Over 25 years, the Norwegian government, NGOs and research institutions have built up considerable expertise on key challenges regarding the environment and development.[1]

Norway's heretofore most ambitious international environmental effort is entitled 'Reducing Emissions from Deforestation and Forest Degradation in Developing Countries' (REDD). The ideas behind this initiative were first laid out at UN climate change negotiations in Bali in 2007; a year later, the UN and Norway jointly launched the programme. The UN REDD concept involves the transfer of funds from developed countries with high greenhouse gas emissions to developing countries with tropical forests. The objective of the program is to achieve cost-effective and verifiable reductions of greenhouse gas emissions in the forestry sector in these countries. The rationale behind the program is that deforestation and forest degradation releases the climate gas CO_2 and at the same time diminishes the future global carbon storage capacity. The IPCC estimates that greenhouse gas emissions due to deforestation constitute 20% of global emissions today – the second largest source of emissions after the energy sector; yet, deforestation continues at an alarming rate. Between 1990 and 2005, the rate of global deforestation was on average 13 million hectares, mostly in the tropical zone. It is estimated that by 2100, clearing of tropical forests could release 87 to 130 gigatons of carbon into the atmosphere. The Norwegian government dedicated USD 35 million to the initial phase of the UN REDD. Norway has been one of the most ambitious drivers in the international policy process of UN REDD and is one of the most important sponsors of climate projects in tropical forest areas.

The UN REDD process provides a good example of how a Nordic country, working with and through multilateral organisations, has facilitated a major international environmental effort. The programme involves a wide range of international partners, including the Food and Agricultural Organization (FAO), the UN Development Programme (UNDP), and the UN Environmental Programme (UNEP). In Norway, the Ministry of the Environment and its Climate and Forests Secretariat (KOS) have lead the work of REDD planning and negotiating, but the process has benefited from the knowledge of a diverse set of actors, including researchers from a number of countries, consulting companies, NGOs, large financial companies and forestry organisations. Important scientific contributions such as Stern (2006) and IPCC (2007), as well as the scientific links between Norwegian NGOs and their counterparts in developing countries have also facilitated a process that cuts through the usual north-south and science-policy divides.

The UN REDD effort tackles many of the same issues of earlier international development projects: transfer of know-how, establishment of institutions in order to insure sustainability, engaging local people in the planning process and insuring that the initiatives provide incentives and benefits for people living in and around the affected areas. It is expected that the partner country REDD strategies are developed in a broad, transparent and inclusive process, and that all stakeholders who may have an influence and interest in REDD are involved in strategy development. These may include indigenous peoples, multilateral organisations, NGOs, civil society organisations and the entire forestry sector, including forest plantations.

Millions of people live in tropical forests and depend on them for food, animal fodder, wood for fuel and building materials. According to the World Commission on Forests and Sustainable Development, the survival and subsistence of 350 million of the world's poorest people, among them 60 million indigenous people, depend almost entirely on forests, while another billion of people depend on forests as an important part of their livelihoods and as a safeguard against poverty. It is a major challenge to find ways of ensuring that local communities can continue to harvest sustainably from forests, or that alternative livelihoods or paths of economic development are open to them. The micro-

[1] Notably the Ministry of Environment and Development, Norwegian Development Authority (Norad), the Rainforest Foundation Norway, Friends of the Earth Norway and research institutions such as the Centre for International Climate and Science Research (Cicero), the Norwegian University of Life Sciences (UMB) and the University of Oslo's Centre for Development and the Environment (SUM).

Figure. **Rainforest logging**

economies of peoples depending on forests can be called 'biomass economies'. In countries with extensive forests, the national economies are fuelled by biomass. For example, Klunde and Mugisha (1999) have assessed that 87% of the Ugandan economy depend on biomass. It is essential that REDD programs safeguard the interests and rights of indigenous peoples and other communities. The intention is that forest dwellers participate in forest management. They are offered economic incentives to protect forests, and a system of monitoring and control to insure funds are being used as planned.

In many of the forested areas which REDD focuses on, activities of people are not the only cause or even the main cause of deforestation and ecosystem deterioration. Research extends back to the 1970s on the effects of industries such as mining, logging (both legal and illegal), energy (hydro-power plants and coal), agriculture, commercial livestock grazing. In the Amazonian Rainforests of Brazil and in Africa, an estimated 35 to 45% of annual deforestation is estimated to be due to logging, cattle ranching, cash crop plantations and the construction of dams, roads and mines (Borner and Wunder, 2008; Porter and Brown, 1991). These activities create extensive ecosystem problems and might actually force local people to increase the use of forest biomass as their access to land diminishes. Local people do get some benefits from commercial extraction activities, such as paid work; nevertheless, the main benefits go to investors, stock holders and consumers in developed countries, including Norway.

Another contentious issue concerning REDD is the setting of forest baseline against which success of reforestation will be measured: what counts as forest in the estimation of the baseline? The definition of forest will affect the ways agriculture in forested areas will be treated in REDD. Will, for example, REDD schemes count agriculture development in forested areas as forestry gain? This could encourage the conversion of forest lands into lands for agriculture and increase the pressures on indigenous peoples, as well as deplete biodiversity.

Early recipients of REDD funding have included Tanzania, Indonesia, Bolivia, Brazil, Mexico, Vietnam, Zambia and Guyana. These countries have developed national REDD strategies and have established systems for monitoring, assessment, reporting and verification of forest cover and carbon stocks. Brazil has an operational framework for licensing and forest management systems. Both Brazil and Indonesia have previous experience and expertise with certification systems. However, uncertainties about land ownership and tenure rights remain a problem in these and many other of the REDD partner countries. In Brazil (Amazonia), for example, 25% of the land is private, 35% is dedicated to indigenous communal territory, and the remaining land is considered public with weakly enforced tenure laws. If the REDD model is organised so that payments for reforestation are only linked to private property, as it has been suggested, indigenous peoples and landless peasants will not have any chance of benefiting from REDD schemes. If these tenure issues are not taken into account in Brazil, it is estimated that large land owners, who account for about 80% of all deforestation, would reap the highest benefits (Borner *et al*, 2010).

While a system of legal safeguards to protect the interests of indigenous peoples is emerging in Brazil, the status of indigenous communities is much weaker in Indonesia. The implementation of rules and regulations also differs tremendously. Brazil faces an enforcement problem. In Indonesia, however, awareness and observance of the law is weak both among the general public and government officials. The lack of governmental capacity, accountability and effective judicial systems is a further impediment to the international system that aims to attract investors and channel the flow of funds (Bond *et al*, 2009).

Norway states that a 25% reduction in global deforestation can be achieved by 2015 – reducing seven billion tons of CO_2, the equivalent of China's annual emissions – if EUR 15–25 billion were provided for REDD in the period between 2010 and 2015. Thus, the environmental amelioration potential of this international environmental programme is enormous, not only regarding climate change, but also forest resources and biodiversity. However, the program faces many challenges, including systems of project licensing, monitoring results, measuring outputs (emission reductions), crediting investors and positively influencing micro-economies and the lives of people in the affected areas. REDD projects will most likely lead to a system of payments to avoid deforestation and to reduce greenhouse gas emissions. An important issue regarding REDD is how to balance environmental amelioration with development, a classic dilemma in virtually every international effort to promote sustainable development.

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10 ENVIRONMENTAL TECHNOLOGIES

$$I(\lambda_i)=\frac{1}{2\pi n}\left[\sum_{n-1}^{n} x_\tau e^{-i\tau\lambda}\right]^2 = \frac{1}{2\pi n}\left\{\left(\sum_{n-1}^{n} x_\tau \sin\tau\lambda_j\right)^2+\left(\sum_{n-1}^{n} x_\tau \cos\tau\lambda_j\right)^2\right\}$$

10.1 ENVIRONMENTAL TECHNOLOGY DEVELOPMENT PRINCIPLES

10.1.1 CLASSIFICATION OF ENVIRONMENTAL TECHNOLOGIES

The impact of production on the environment is determined by the fact that, during the process of production, raw materials are used, making products and waste (Figure 10.1). The process of production includes physical, chemical and biological processes actualised through technological equipment.

Environmental technologies are technological solutions of environmental problems, and they mitigate the impact of production on the environment. Environmental technologies are used in such sectors as industry, agriculture, services and transport, as well as in everyday housework. We would not have all the goods without which our daily life today seems almost inconceivable if they were not produced by means of certain technological processes. Production of any product is related to the use of natural resources, energy, materials and water, and it creates environmental pollution. Hence, the effectiveness of production and product use is essential.

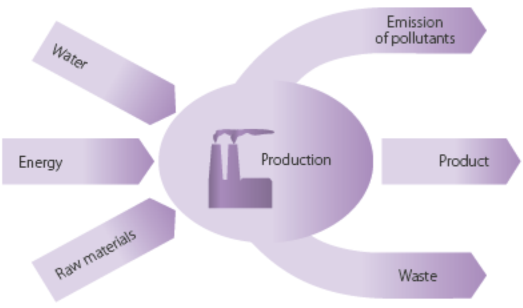

Figure 10.1. **Impact of production on the environment**

The term 'technology' designates more or less complicated technical systems. For example, textile manufacturing technology comprises not only looms but also bleaching, dyeing and washing reservoirs, as well as drying and ironing machines. They all consume water, dyes, bleach, detergents, thermal energy and electricity. Technology also includes the skills and techniques of using and operating the system, and they require constant improvement. The Industrial Revolution three centuries ago began with a number of discoveries, technological achievements and various technical improvements. However, contemporary innovative technologies should provide for the advancement of the technological process in the whole industry sector in order to minimise the impact on the environment and climate change.

Technological processes affect the environment. Production generates waste and has such side-effects as heat and noise. The more fully the raw materials and inputs are used, including materials, water and energy, the more products can be produced and the less there is waste and side-effects. The purpose of environmental technologies is to improve the technological process in such a way that it would affect the environment and aid the climate change as minimally as possible. Environmental technologies are assessed with respect to their effectiveness in reducing the impact on the environment, and they can be put into effect differently: either to eliminate the causes of environmental pollution, or to reduce its consequences. Environmental technologies can be classified into three large groups (Figure 10.2):

1) *clean production technologies*, which eliminate the root causes of environmental pollution or reduce their impact. Production can be made 'clean' if the emissions and waste are used as resources for another plant. It is possible to make production more efficient with lesser input (materials, energy and water), producing the same output of the same or higher quality. In order to implement clean production, technological processes in enterprises are changed or enhanced by other processes;
2) *end-of-pipe environmental pollution reduction technologies* eliminate environmental pollutants from the production process. Environmental pollution reduction facilities are installed in order to purify exhaust gases and wastewater and to ensure waste management. By means of these environmental technologies, pollutants are separated as soon as they have been formed, then they are treated before they are released into the environment. Hence, the environmental technologies of this group are purification technologies;
3) *climate technologies* reduce greenhouse gas emissions or separate these gases before release into the environment. Climate technologies include both above-mentioned environmental technology groups when they reduce the impact on climate change, as well as those technological processes that reduce greenhouse gas emissions into the atmosphere.

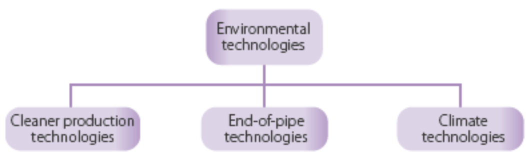

Figure 10.2. **Classification of environmental technologies**

Eco-efficiency is a parameter of the operational efficiency of technologies, and it shows the consumption of raw materials, water and energy per unit of goods produced or services rendered. Eco-efficiency is used to describe the progress of production and the national economy towards sustainable development. Eco-efficiency enhances the market economy conditions with environmental protection requirements. This means that eco-efficiency improvement requirements pertain to the production of goods and rendering of services that are both cost-efficient and environment-friendly. Characteristic features of eco-efficiency are:

- reduced consumption of materials, energy and water;
- reduced toxic discharges;
- increased recycling of materials;
- sustainable use of renewable sources;
- increased durability of materials and products.

10.1.2 ENVIRONMENTAL POLLUTION REDUCTION POSSIBILITIES IN PRODUCTION

Reduction of environmental pollution is essential for the improvement of conditions of human life and ecosystems as well as for the enhancement of existing and development of new competitive products or services, at the same time minimising the impact on the environment and climate. Environmental pollution can be reduced by choosing environment-friendly technologies. Environmental pollution reduction measures can be ranked according to their priority. The first stage includes the identification and classification of environmental pollution types and their impact. Environmental technology experts carry out environmental audit, evaluating processes taking place in an enterprise, identify the environmental pollution sources, their causes and impact, then prepare the concept and proposals for pollution reduction. Figure 10.3 shows the relationship between environmental technologies and the order of their application.

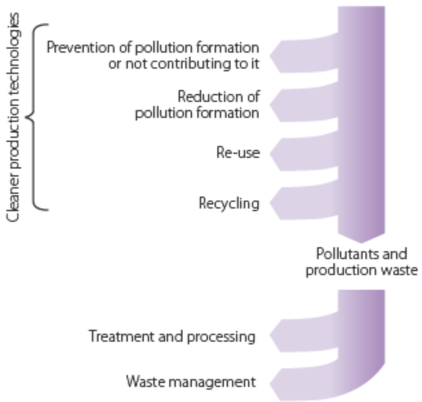

Figure 10.3. **Conceptual scheme for pollution reduction**

The technological solutions effective in eliminating environmental pollution causes or reducing their impact always have priority. Eliminating the consequences of pollution makes sense only after having exhausted all the possibilities of preventing pollution.

The concept of environmental pollution reduction requires a step-by-step approach in analysing all possibilities in order of priority:

1) prevention and elimination of pollution formation,
2) reduction of pollution,
3) reuse,
4) internal recycling,
5) external recycling,
6) purification and processing,
7) waste management.

10.2 HOW TO MAKE PRODUCTION ENVIRONMENT-FRIENDLY

10.2.1 CLEAN PRODUCTION

Clean production is a production process in which hardly any waste is produced; instead, in the technological process, all the raw materials are used up for the end product.

Clean production can be achieved by implementing the following conditions:

- minimal use of water, and no wastewater;
- minimal use of energy, or the use of energy generated during the production process for the production needs;
- economical use of raw materials, and no waste.

Currently, the technological solutions that provide for maximum use of resources without waste are closest to the concept of clean production. Any solution that prevents waste generation should be taken as a measure for environmental and human protection. Admittedly, clean production is more of a theoretical concept hardly attainable in practice because nearly any production process generates emissions, noise and waste.

The clean production concept is also known as zero-emission production, because it is aimed at zero pollution levels in air, water and soil.

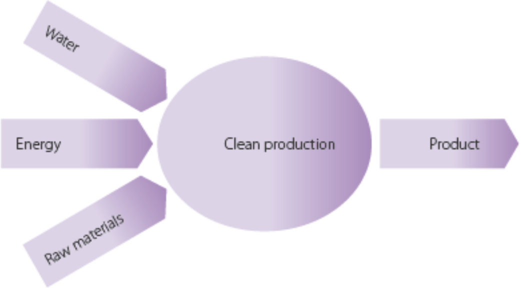

Figure 10.4. **Clean production scheme**

A zero-emission production unit is a technological process or a set of technological processes which uses up 100% of the raw materials, transforming them into end products.

The zero-emission concept is implemented gradually, moving step by step from the simplest to the most complex solutions.

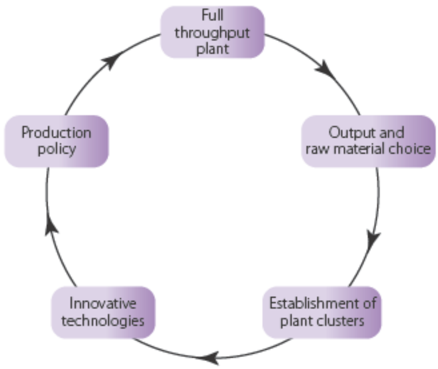

Figure 10.5. **Implementation scheme for the zero-emission**

10.2.2 CLEANER PRODUCTION

Cleaner production is a gradual approximation of the actual production to clean production. Cleaner production is characterised by high eco-efficiency.

The idea of cleaner production has emerged relatively recently – at the end of the 80s of the 20th century.

The simplest way to implement cleaner production in an enterprise is to use *the best available technology* – the most efficient and advanced way to implement the production process, which at the same time prevents or reduces emissions into the environment. The best technologies for almost all industry sectors are available to producers in the EU.

The concept of cleaner production provides for measures related to the implementation of environment-friendly production processes, products and services to increase eco-efficiency and reduce the impact on human health, the environment and

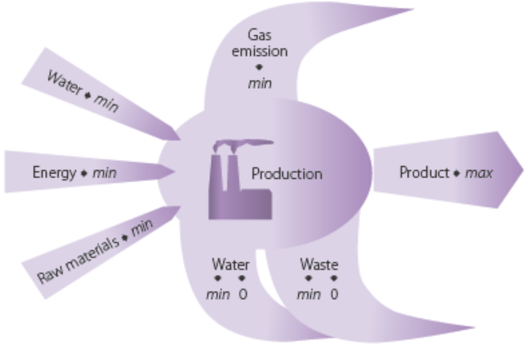

Figure 10.6. **Cleaner production scheme**

climate. The concept of cleaner production also includes issues of eco-efficiency improvement and risk (for humankind and the environment) reduction. These issues pertain to:

- production processes: economy of raw materials and energy, reduction of emissions and waste, improvement of the quality of water, air and soil;
- environment-friendly products: implementation of the eco-design concept that allows to reduce negative impact on the environment and climate during the life cycle of the product – from raw material extraction until the product becomes waste;
- services: integration of environmental protection issues into the services of designing and delivery.

Products are called environment-friendly if the impact on the environment and natural resource consumption is minimal during the process of their production, use and discharge into the waste flow.

10.2.3 PRODUCT ECO-DESIGN

The impact on the environment occurs not only from discharging wastewater, burning fossil fuels or removing waste. Environmental conservation and protection issues should be tackled already when developing a product, evaluating its potential impact on the environment throughout its life cycle. To accomplish the goals of clean production, it is important not only to improve the technological processes but also to ensure that environment-friendly products are produced. Eco-design is an important sphere for implementing the idea of clean production. Production of environment-friendly products (throughout their life cycle) without compromising their quality or raising their cost is called eco-design. The product life cycle means closely related, successive stages of the system of production or rendering services – beginning with natural resource and raw material

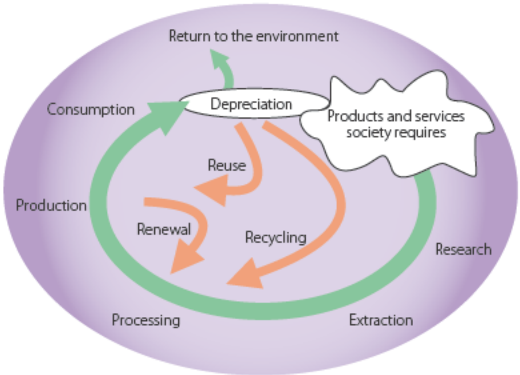

Figure 10.7. **Life cycle of a product**

extraction and ending with recycling when the product has fallen into disuse.

Up to the beginning of this century, the most important condition to produce any product was the economic benefit. Now the issue of the product's environmental impact is becoming increasingly important. The following equation most accurately defines the criterion for creating an environment-friendly product: enhancement of the technological solutions for product design with the environmental and economic factors.

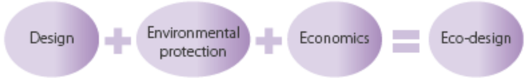

Figure 10.8. **Eco-design**

The aims of eco-design are to reduce the consumption of resources, to use environment-friendly materials, to optimise the production, distribution and use of the product as well as to ensure proper management at the end of its life cycle, i.e. renewal, recycling or disposal.

10.3 ENVIRONMENTAL POLLUTION REDUCTION TECHNOLOGIES

It is not easy to decide what is better – either to prevent, eliminate or at least minimise the causes of pollution, or to fight the effects of pollution by purifying the flows of contaminated gas, water and solids already after they have passed the technological process.

10.3.1 GAS PURIFICATION TECHNOLOGIES

Depending on the aggregative state of pollutants, gas purification technologies fall into three broad categories:

- purification of polluted gas and air from dust and aerosols,
- separation of gaseous substances from technical gas, flue gas and air flows,
- separation of liquid droplets from air.

The choice of the polluted gas purification technology depends on production requirements, which determines the selection of engineering solutions based on the principle of cost optimisation. First priority is always given to technological solutions that reduce gas emissions with minimal capital investments and minimal costs of equipment operation and maintenance.

The choice of the gas purification technology also depends on whether water and soil pollution does or does not occur while using a particular technological solution. For example, flue gas purification from sulphur oxides in absorption facilities increases the wastewater amounts and energy consumption, thus affecting the operational efficiency of the respective technologies.

Various mechanisms and forces are used to remove solid particles from the gas flow: gravity, centrifugal force, inertia and electrostatic interaction. The most appropriate technological solutions for gas purification can be chosen from a wide range of devices for dust and aerosol removal. There are technologies available that remove relatively large particles at low cost. They are generally used in the first stage of solid particle removal. The finer the dust particles, the more sophisticated technologies are required.

The particle removal devices can be divided into four large groups:

- dry dust-catching devices,
- wet dust-catching devices,
- electrofilters,
- bag filters.

Dry dust-catching is the simplest and cheapest, and it provides effective bonding of large particles. The most commonly used dust removal device is a cyclone, in which centrifugal force is used for the separation of particles.

In wet dust-catching technologies, solid particles are trapped in a liquid drop or layer, or precipitated in a volume of liquid. Although this equipment has high gas purification efficiency for fine particles (98–99%), it has some problems as well. First, the wet technology of environmental pollutant removal generates wastewater. Second, tiny droplets can form mist, leading to additional air pollution. In electrofilters, positively and

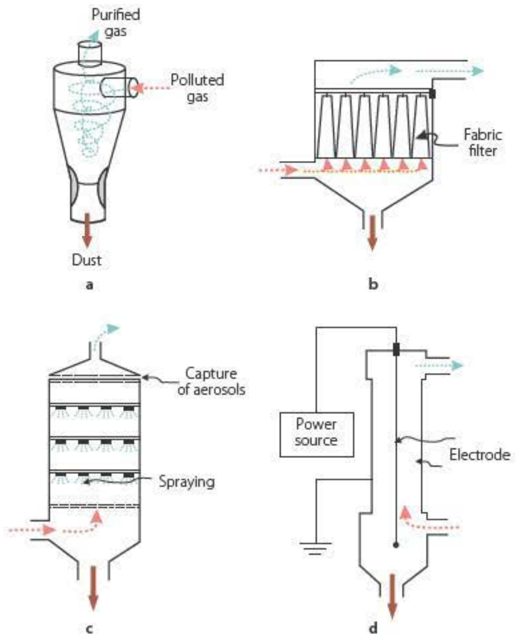

Figure 10.9. **Purification of polluted air from dust and aerosols**
a – cyclone; b – bag filter; c – wet scrubber; d – electrostatistic precipitator

negatively charged electrodes create an electric field through which the contaminated gas flows. Charged solid particles are attracted by the counter-charged electrodes and accumulate on their surfaces. In this case, gas purification efficiency is high for fine particles (99%); however, energy consumption also is high. Bag filters are made of materials that retain solid particles on their surface. Sackcloth filters are the most common. This method has high gas purification efficiency for fine particles (99.9%); however, much electricity is consumed to move gas through the filter.

In almost every production unit, there are technological and combustion processes which generate gaseous emissions that need to be reduced. Gaseous substances in technical gases, flue gases and the air of exhaust ventilation systems differ in the chemical composition, concentration and impact on the environment and climate. To purify combustion products from hazardous gases, a specific solution based on gas absorption, adsorption and catalytic treatment principles should be tailored to each production unit. Purification of gas from gaseous components is almost always associated with high costs, usually 25–50% of the total production costs. When the 'end-of-pipe' technologies are chosen for gas purification, usually various options are considered in order to arrive at the most efficient solution for the respective production unit.

10.3.2 WATER TREATMENT

Water is one of the most essential substances in human life, production and technological processes. In production, just as in nature, water circulation can be described as a cycle consisting of several stages. The water cycle comprises the source of water, its purification to make it potable or usable in production processes and consumption, which, in turn, results in contamination and subsequent need for wastewater treatment.

There are two types of technological processes for maintaining water for human consumption – preparation of drinking water and wastewater treatment.

Water is purified for two reasons: to ensure the water quality the consumers require or to prevent the formation of water pollution. Consumers need water with quite different quality parameters; therefore, water treatment generally falls into three broad categories:

- preparation of drinking water,
- preparation of technological water for production processes,
- wastewater treatment for reuse or to the quality of environment-friendly water before discharge into open bodies of water.

PROCESSING OF DRINKING WATER

One of the greatest achievements of modern technologies is the successful elimination of such diseases related to contaminated water as cholera and typhoid fever. The success was based on the finding that the pollution of public water sources with household waste is the main cause of these infectious diseases and that they can be eliminated by more effective water treatment or better waste disposal management.

Municipal drinking water was filtered for the first time in Paisley, Scotland, in 1802. In London water vendors started water filtration in 1828. In the USA water filtration began in the state of New York in

Figure 10.10. **Clean water is not available for domestic use in many countries of the world**

1872. At the beginning of the 20th century, various technologies that made water safer for use began spreading rapidly in Europe and North America; yet, a large part of the population not always had access to clean drinking water.

Nowadays water treatment plants are being built in order to supply every consumer with water that meets the quality standards. Such a system is based on four elements: water source selection, water quality protection, water treatment methods and protection against re-contamination.

The aims of water treatment are to guarantee the required water quality or to prevent water pollution. Without doubt, purification methods, technologies used, and the water purification level clearly depend on the purposes for which the purified water is going to be used. It is especially important to destroy micro-organisms in drinking water. It is important to soften (reduce hardness of) the water used in heating systems. These differences determine the use of different methods for water purification.

Methods for drinking water preparation can differ quite substantially depending on the contamination level and the composition of the water used. Water taken from surface sources (rivers, lakes) usually needs filtering. First, water is let through metal screens or sieves to separate large floating objects (leaves, twigs, fish, plastics).

The particulate matter settling process in water is slow, and fine colloidal particles (particles of the size of about one micro-metre that form an intermediate state between dissolved and suspended substances in water) remain in water. It is purified from these particles by means of coagulation, which significantly reduces the concentration of particles, bacteria, yeast, fungi and other colloidal particles suspended in water. The most often used coagulants for drinking water treatment are iron or aluminium salts (chlorides, sulphates). Of these, aluminium sulphate $Al_2(SO_4)_3 \times 18\ H_2O$ is most widely used. The presence of this substance in water initiates the process of aluminium ion hydrolysis, which results in the formation of aluminium hydroxides and polymers.

Formed aluminium hydroxide is poorly soluble, and, in the process of hydrolysis, they form loose sediments also known as flock. Since the complex aluminium compounds are positively charged, they can attract negatively charged colloidal particles, bacteria and acidic organic substances dissolved in water (humic and fulvic acids), thus becoming the flock formation or coagulation centres. By means of the coagulation process, the colloidal particles present in water (up to 99%), as well as bacteria, viruses (99%) and organic macro-molecular substances (60–90%), are separated from water. The resulting metal hydroxide precipitate is then removed in secondary settling reservoirs and by filtration.

Drinking water can be purified from the organic substances dissolved in it using activated carbon, purified anthracite coal and synthetic sorbents. Activated carbon is usually used in a granular form. Activated carbon or anthracite is used in water treatment as a filling material in sorption columns. Although water purification with activated carbon is an effective method which significantly improves the quality of drinking water, it is expensive and therefore still quite rarely used in industry.

After coagulation, water is settled in secondary settling basins and filtered.

The purified water from the settling or flocculation reservoirs is drawn into the filter tank, where it moves by gravitational force through the sand filter layer down to the drainage system installed at the bottom part of the filter, from where it is then drained to the water storage tank.

Since the presence of bacteria in drinking water is not permissible, the water is disinfected after the treatment stages described above.

Traditionally, the most commonly used water disinfection method is chlorination. Chlorine is easily transportable, simply dispensable and cheap. The main negative aspect of chlorination is the formation of chloro-organic substances, some of which are mutagenic and carcinogenic. For this reason, alternative methods of water disinfection are sought.

Ozone is considered a more effective disinfectant than chlorine. Ozone for disinfection of water is generated by feeding purified and cooled air in an electric discharge zone. The ozone-enriched air is then injected into the processed water. Nevertheless, the ozone solubility in water is much lower than that of chlorine, and the use of relatively sophisticated aerators is therefore required. Ozone in water decomposes quite soon. For that reason, in order to prevent microbial growth in the water distribution system, light chlorination of water is still advisable

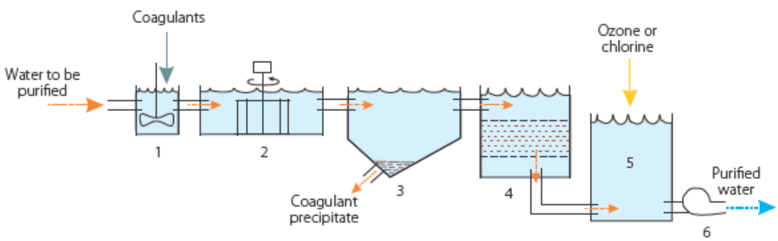

Figure 10.11. **Preparation of drinking water**

1 – adding coagulant; 2 – coagulation; 3 – settling tank; 4 – filter; 5 – disinfection reservoir; 6 – water pumps and supply to a water distribution network

after ozoning. The main shortcoming of ozoning is that this technology is considerably more expensive than chlorination.

Water can also be disinfected by UV radiation.

All the main water treatment stages can also be accomplished by using individual water filtering devices. Such devices come in many different models, capacities and sizes. For example, some of them can be compact enough to take with when going on a trip (the water is filtered and disinfected; capacity – a few glasses); some can be connected to the faucet; some can purify water for a house or a block of houses. Typical basic modules of such devices are:

- sediment filter. It is usually made of porous material, and filters water from sediment and rust particles;
- water-softening filter. Such filters work on the basis of ion exchange, and they can be easily regenerated at home. Quite often these filters are the main component of local water treatment facilities;
- device for reducing the iron content in water. Usually based on ion exchange technology;
- selective ionites for water purification from nitrates and metal ions;
- water disinfection devices. Several methodologies for water disinfection are used in local (personal) water treatment devices. One is water disinfection with silver, filtering the treatable water through a porous surface (usually ceramic) coated with finely-dispersed silver. In this process, trace amounts of silver dissolve, and, owing to its bactericidal effect, microorganisms are eliminated. Another approach is based on the use of halogen (iodine) bound to polymers. Water can also be disinfected by UV radiation;
- water treatment with activated carbon purifies it from organic substances and disinfection by-products, and improves the taste and odour of water.

The efficiency of local (personal) water treatment devices depends on what kind of structural elements they have and what kind of water treatment processes they perform.

Although there are many achievements in water supply technologies that facilitate public health and welfare, three issues difficult to tackle still remain. They are related to the need for a balance between the demand for clean water and a normal functioning of ecosystems.

First, at least half of the world's population does not have sufficient quantities and proper quality of water. In developed countries, financial growth was accompanied by the advancement of technical infrastructure, including water supply. Developing countries have not had such an opportunity because the growth of population had been exceeding the growth in revenue, and, as a result, the improvement of welfare lags behind. The United Nations have deemed the demand for clean water supply to both urban and rural population in developing countries a priority already since 1980, with the launching of the International Drinking Water Supply and Sanitation Decade.

Second, the biosphere becomes more and more saturated with different chemical compounds used in industry and household, and this fact raises concerns whether the existing water treatment methods will be effective enough to reduce the ever-increasing concentrations of hazardous substances in water.

Third, the quality of freshwater sources generally is growing worse, mainly due to the heavy use of these sources by the industrialised society.

Modern water supply systems in developed countries were built over long periods of time and in an environment where capital investments in the construction and maintenance of these systems were not the key concerns. Such an approach is not feasible in developing countries where water supply systems have to be built fast because the demand for water is growing exponentially with the population growth.

Figure 10.12. **Personal water filter after use (left) compared to a new one (right)**

Figure 10.13. **Personal water treatment device that can be connected to the tap**

It is not the engineering and scientific substantiation that determines the choice of technology; it is the resources available, which is the critical factor for the construction or improvement of water supply systems. Fortunately, simple solutions that can significantly improve the water supply systems in developing countries are used ever more widely.

WASTEWATER TREATMENT

Wastewaters are all polluted waters resulting from human activity.

Wastewater treatment depends on the composition and source of pollutants. Wastewater types are as follows:

- residential wastewater, containing mostly organic substances (dissolved and undissolved) and micro-organisms. A substantial part of municipal sewage consists of wastewater from residential areas, including sewage from toilets, kitchen, bathing, laundry and floor washing wastewater. These wastewaters together with the effluent from commercial and industrial structures are called municipal wastewater;
- polluted water resulting from the production or service rendering processes;
- precipitation runoff;
- agricultural wastewater.

Municipal wastewater is a complex, highly diluted water solution that contains over 99% of water, while the remaining part is organic and inorganic substances in a suspended or dissolved state. Typical municipal wastewater contains substances that use oxygen in their degradation process, as well as particles suspended in water, petroleum products, surfactants, bacteria, viruses, nitrogen and phosphorus compounds, stable organic substances, metal ions and all kinds of coarse impurities (pieces of wood, plastic packaging).

After treatment, wastewater from houses can be discharged into filtration fields where it is dispersed over a wide area through culverts and subsequently decomposes in various biological processes. Wastewaters can also be collected in closed tanks and transported to the municipal wastewater treatment plants. Today a variety of accelerated decomposition methods (biotoilets, sand filters) are used for the treatment of wastewater from houses.

Municipal wastewater volumes per capita per day range from 280 litres in small settlements to 900 litres in big industrial cities. In densely populated areas and cities, wastewater is collected and drained through sewage pipes to centralised treatment plants.

Wastewater treatment process at treatment plants has three stages:

1) primary treatment,
2) secondary treatment,
3) special treatment.

In the primary treatment of wastewater, both solid and liquid water-insoluble substances are separated from water. Usually the first step in wastewater treatment process is straining, which is done by passing the treatable water through metal screens and sieves that can be positioned at different angles against the water flow. Large-size trash accumulated on the sieves is cleaned off mechanically at regular intervals and is further processed as solid waste or activated sludge residues.

In the secondary treatment of wastewater, the remaining organic substances suspended in water are subject to biological degradation by means of micro-organisms. In order for this purification process to be effective, it is important to use special micro-organism cultures that can effectively degrade organic substances. These cultures have to be provided with optimal growth conditions, first of all by supplying oxygen and, if necessary, also ensuring the optimum temperature (heating in winter), pH, content of nutrients.

Activated sludge process is one of the most effective and universal wastewater treatment methods. It works on the basis of the ability of micro-organisms dispersed in the treatable water to degrade organic substances in the presence of sufficient amount of oxygen in water. Activated sludge is a cluster of micro-organisms that form dispersion in an aquatic environment, sticking around the particles of organic substances – mud (mostly the remains of micro-organisms). In the activated sludge process taking place in the aeration basin, the organic substances are consumed for the growth of micro-organisms and converted into CO_2, the organic nitrogen compounds – to ammonium or nitrate ions, and phosphorus compounds – to phosphate ions. Activated sludge is an artificial biological community, which is composed of bacteria (the main mass of the biological community), fungi, yeasts, protozoa, rotatoria and other groups of organisms. One gram of activated sludge contains 10^8–10^{12} bacteria. Each group of organisms forming activated sludge has a role in the mineralization process of energy-rich compounds, thus – in the treatment of wastewater. Bacteria, yeasts and fungi decompose organic substances. The filtering organisms bind the substances suspended in water, whereas, for example, infusorians consume micro-organisms. The in water is treated in the aeration basin; after that, activated sludge mass is settled. Since the mass of micro-organisms is growing rapidly (in proportion to the content of organic substances in water), settles at the bottom of the settling basin has to be removed continuously. The activated sludge process definitely is a significantly accelerated and optimised model for natural processing of particles.

The activated sludge process generates considerable amounts of substances that need to be recycled. Sludge can be further processed or used as an agricultural or forest fertiliser. In anaerobic (anoxic) environment, in the presence of methane-forming anaerobic bacteria, it is possible to obtain biogas.

$$2\{CH_2O\}_n \rightarrow CH_4 + CO_2$$

In this process, the content of organic substances and sludge volume are reduced, the organic substances of sludge turn into humic substances and pathogenic micro-organisms are eliminated. The anaerobic process generates methane to cover the energy needs of the wastewater treatment facility and surplus for consumers.

After the anaerobic treatment, sludge can be filtered and alkalinised by treating with lime. Yet sludge too often contains quite a significant amount of various toxic substances. If the content of stable environmental pollutants in the treated sludge exceeds the permissible concentration limits, then, considering the likelihood of accumulation of these substances, sludge cannot be used in agriculture. In this case, it has to be disposed of (as hazardous waste) or incinerated after dehydrating and drying.

To pass an overall judgment regarding the present-day wastewater treatment processes – despite the shortcomings, they still make it possible to purify contaminated, low-quality water to the required purity grade.

10.3.3 WASTE MANAGEMENT

Waste is solid substances generated as a result of human activities, and, being no longer of value for the respective economic, physiological or technological process, are removed from it.

Solid waste in a broader sense is understood as any household, industrial and agricultural materials that have been used up. Since such waste accumulates in the territories managed by municipalities responsible for its removal and storage, it is termed 'municipal solid waste'. The term also denotes such types of waste as ash generated in thermal or electric power plants, sludge from wastewater treatment plants, animal farm waste, gangue rocks from mineral extraction. Sometimes these types of waste require separate sectors in landfills.

Municipal solid waste is a mixture of substances difficult to identify and describe exactly due to their changing composition, and its reuse is not economically feasible.

Waste accumulation is considered one of the main impacts of human activities on the environment, especially industrial waste.

Waste formation occurs virtually in every economic sector and in every situation of life. Therefore, it is important to reduce the amount of waste and, if it is not possible to prevent waste formation, to find ways to store it in such a way as not to endanger the environment. Waste management means its analysis, collection, transportation, sorting, processing, recycling and storage. To address waste management challenges, it is important to understand its origination, sources and effects on humans. Waste is classified taking into account these factors.

Waste is formed in the processing of natural resources; it can be classified according to its origination:

- industrial waste, for example, from food, different sectors of industry;
- specific waste, such as tires, sewage sludge, street rubbish;
- municipal waste, for example, household, commercial waste;
- mining waste.

Waste is also classified according to its properties and effects on humans and the environment:

- hazardous waste – waste which has properties that make it dangerous to human life, health, the environment, property or material assets, and which conforms to the hazardous waste classification categories (explosive, flammable, toxic, corrosive, infectious and carcinogenic

Figure 10.14. **Anaerobic methane production tanks at a wastewater treatment plant (Rīga, Latvia)**

Figure 10.15. **Use of biogas as a fuel for buses (Uppsala, Sweden)**

substances); this waste differs by the degree of hazard:
- toxic waste, such as waste containing radioactive and toxic substances,
- dangerous waste, such as garden waste or kitchen scraps;

- inert waste – waste with a low pollutant content and insignificant toxicity; it does not have a negative impact on the environment or human life and health, and it does not affect other substances or materials with which it comes into contact. It does not undergo significant physical, biological or chemical changes at disposal; the examples of inert waste are rocks, ferroconcrete.

According to its sources, waste is classified into industrial, agricultural, energy, domestic, service and public sector waste.

The aim of sustainable waste management is to reduce waste formation and to use resources more efficiently and rationally, ensuring that the waste of one sector is used as a raw material in another sector.

It is estimated that the amount of solid waste per capita is around 500 kilograms per year. However, this figure may vary greatly in different cities and seasons.

Disposal of solid waste or waste incineration ash in sanitary polygons can endanger groundwater or surface water sources. Therefore, the construction of sanitary polygons has to be planned very carefully, and their operation has to be strictly monitored in order to prevent groundwater pollution.

Recycling of materials and substances contained in solid waste is very simple in theory but extremely hard in practice. People have always collected utilisable and valuable materials (e.g. metals) from waste and used them in industry because it is cheaper than extracting them from raw materials. Moreover, it is also useful to separate cheap materials from waste because they still have some value (old newspapers to produce pulp and new paper) or it is inconvenient to throw them away (bottles). Economic reasons are decisive for the reuse of materials. For the time being, to produce glass from natural raw materials is cheaper than from discarded, used glass, and using glass chippings to replace stones in the road or street construction consumes much more energy. In many countries regulations require sorting waste at the source. Residents need to sort waste into such types as food scraps, paper, ash and glass.

Solid waste sorting at the source in cooperation with residents is prospective in the future. Difficulties associated with the limited capacities of landfills, increasingly stringent environmental restrictions, stabilisation of the recycled material market, economic incentives and political support in the future will open even wider opportunities for progressive solid waste management.

Centralised sorting of municipal solid waste is another method to use raw materials at least partially. It seems to be the most prospective method for densely populated, industrialised urban areas where waste sorting at source is difficult. Unfortunately, sorting requires manual work even if technological equipment is used.

Solid waste can be incinerated in special furnaces where all the waste mass is burnt up. It is also possible to obtain hot water or steam for heating purposes, as well as superheated steam for the generation of electricity. Solid waste can also be converted into efficient waste granule or briquette fuels.

Waste fuel is made of the paper, cardboard and plastic separated from waste.

Waste collection in waste dumps or sanitary landfills is the most commonly used least expensive method in many European and North American countries. For instance, in Germany and Switzerland – the countries that have been investing huge amounts into the construction of solid waste incineration or composting companies – more than half of municipal solid waste is stored in landfills.

The area needed for a landfill is approximately 1 ha per year per 25 000 residents. Waste mass compaction and covering with a layer of mineral substances are the basic operations of a modern landfill. These operations, together with the

Figure 10.16. **Waste dumpsite in India (A) and the Getliņi sanitary landfill in Latvia (B)**

Figure 10.17. **Sorted plastic waste prepared for further processing**

Figure 10.18. **Hazardous waste sorting unit in Toronto, Canada**

collection of leachate and monitoring of the local environment, represent a principally new method for storage of municipal solid waste.

Sanitary landfill operators are subject to a number of requirements: to reduce the impact on the environment, to create a buffer zone, fencing and drainage ditches, to choose the proper slope, to collect and treat leachate, to equip the landfill with proper technology, including the biogas collection system.

Landfills in Europe often have depositories for storing all types of unsorted waste. In landfills, biodegradable substances produce biogas, which is then collected and brought to biogas users. Landfill biogas is mostly used for generation of energy. Purified biogas can be fed into a natural gas main or used in motor vehicles.

In recent years, the concept of waste management has been changing rapidly. A reduction in the amounts of disposed waste is projected. The future belongs to the waste sorting solutions: all waste that can be used as fuel or to produce biogas is separated before delivery to the landfills. After sorting, the volume of disposable waste decreases on average from 20 to 30% of the total volume.

Figure 10.19. **Compaction of solid waste at the Getliņi sanitary landfill in Latvia**

Waste that contains a sufficiently large amount of organic matter can be incinerated. The latest advanced waste incineration plants are equipped with systems that continuously feed fuel into the furnaces. Initially, only municipal solid waste was used as fuel in waste incineration furnaces. In these old furnaces, combustion temperature reached ~760 °C, which was not high enough for complete combustion and glass melting. Waste incineration in such conditions generates unpleasantly smelling gases and highly toxic substances – dioxins. To prevent that, the combustion gases need to be captured in secondary combustion chambers, where the temperature reaches 800 to 1 000 °C. In state-of-the-art solid waste incineration facilities the temperatures reach up to 1 650 °C, allowing to reduce the volume of solid waste by 97% as well

Figure 10.20. **A solid waste incineration plant in Vienna (design by the Austrian architect Friedrich Hundertwasser)**

as to convert metal and glass into ash or slag. Such a high combustion temperature can be attained only by using additional fuel, usually natural gas. The most difficult challenge was the prevention of air pollution, especially the capture of fine solid particles and toxic substances (dioxins). Now these problems have been solved, and solid waste incineration plants can be built even in the central parts of large cities without causing any adverse effects to people.

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CASE STUDY: LITHUANIA

COMPARATIVE ANALYSIS OF BUS- AND TROLLEYBUS-RELATED GREENHOUSE GAS EMISSIONS AND COSTS

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The main environmental issues in towns and cities are related to the predominance of oil and its products as a transport fuel, which generates greenhouse gases (GHGs) and air pollutant emissions. Usually, the contribution of the transport sector is estimated from the statistical data on fuel consumption or mobility of citizens living within the municipality area.

Most of the National Strategic Reference Frameworks submitted by the Member States include sustainable urban transport as an area for action. The EU should continue to promote and support the extension of and upgrades to clean urban public transport such as trolley buses, trams, metros and suburban railway as well as other sustainable urban transport projects (Green Paper, 2007).

Responding to the target of the European Council to reduce the greenhouse gas emissions by 20% until 2020, the case study illustrates the development of urban public transport system in Lithuania.

The functional unit used in the comparative analysis of bus- and trolleybus-related GHG emissions is *CO_2 equivalent per one km of travel*. To estimate GHG emissions, the author used the COPERT 4 software (Copert 4, 2008).

This type of bus falls into the midi-urban bus category. The bus operates only in urban conditions and does not perform a commuter service. The emission factors (g/km) of GHGs emitted by the bus are provided in Table.

Like other electric vehicles, the trolleybus does not release pollutants directly. However, pollutants are released during generation of electricity at centralized power plants. Emissions from generation of electricity depend on the method of generation, the plant (its type, capacity, efficiency, technologies of emission control and lifetime) and the source of primary energy. Emissions like SO_2 vary due to the varying content of sulphur in fossil fuels. The largest amounts are emitted from fossil fuel-based power plants. Nuclear power and renewable sources, however, do not generate emissions directly. There are no emissions at the point of generation of electricity from nuclear power and almost all renewable sources, but there are releases during the mining and processing of the fuel, construction of the plant, disposal of spent fuel and its by-products, and waste management and decommissioning. Figure 1 shows GHG emissions in g/kWh from electricity production systems, using the life cycle analysis (World Energy Council, 2004).

The average electricity (fuel) consumption of *Solaris Trollino 12AC* is 0.9 kWh per kilometre.

The EU has taken an initiative to develop harmonised guidelines for transport costs. The evaluation was based on the principles of welfare economics, contributing in the long run to a sustainable transport system. The HEATCO project provides cost factors in euros per ton of pollutants emitted for the majority of EU countries. Evaluation of air pollution effects is based on the damages caused by air pollutants, including costs for human health hazards, agricultural and forestry production loss and damage and corrosion of building materials.

The method for calculating costs of greenhouse gas emissions basically consists of multiplying the amount of CO_2 equivalents by a cost factor. The CO_2 equivalent of a greenhouse gas is derived by multiplying the amount of the gas by the associated Global Warming Potential (GWP). The GWP for methane is 25, for nitrogen (I) oxide – 298, and for CO_2 – 1. Carbon dioxide, methane and nitrous oxide are also called direct GHG's. Some of the local pollutants – CO, NMVOC's, NO_x and SO_2 – contribute to global warming by forming ozone and sulphate aerosol particles; therefore, they are also called

Table. **Emission factors (g/km) of GHG's from the bus *Solaris Urbino 12***

Emission factors, g/km	Road slope, %			
	0	2	4	6
CO_2	723.05	1074.45	1459.69	1857.98
CH_4	0.0977	0.0977	0.0977	0.0977
N_2O	0.0057	0.0057	0.0057	0.0057
CO_2 equivalent*	727.19	1078.59	1463.83	1862.12

* Assessment is based on the Global Warming Potential (GWP).

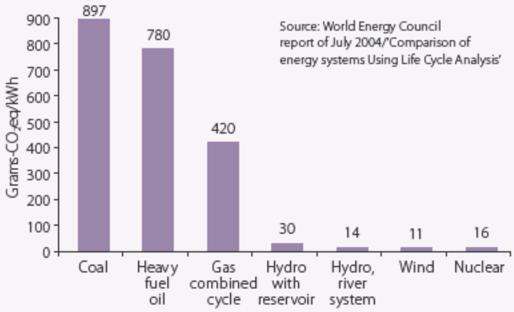

Figure 1. **GHG's emissions in grams-$CO_{2equiv.}$/kWh from electricity production systems, using the life cycle analysis.** The estimated result of $CO_{2equiv.}$ emission factors for a trolleybus in 2010 is 440.1 g/km

Figure 2. **Bus *Solaris Urbino 12***

Figure 3. **Trolleybus *Solaris Trollino 12AC***

indirect GHG's. The study did not estimate the monetary values of indirect GHG's.

Due to the global scale of the damage, there is no difference between the European Union countries. The value of EUR 26 per ton of CO_2 equivalent emitted between 2010 and 2019 is recommended for all EU countries.

Values of emissions are calculated using HEATCO factor prices (Bickel and Droste-Franke, 2006). The monetary value of emissions from a bus and trolleybus is 0.011 EUR/km in 2010.

The results of the study demonstrate that environmental costs are much higher for buses than for trolleybuses. Replacement of buses by trolleybuses will decrease GHG emissions by 287.09 g of CO_2/km. Expressed in terms of money, this replacement will save 0.039 EUR/km.

Analysis shows that the bus transport in cities with hilly relief contributes more to the climate change compared to flat relief urban areas. Bus-related $CO_{2equiv.}$ emissions on 0% of road slope make up 727.19 g of CO_2/km, whereas on 4% of road slope – 1 463.83 g of CO_2/km.

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11 ENVIRONMENTAL MANAGEMENT: LEGISLATION, POLICIES, INSTITUTIONS

11.1 LEGISLATION OF ENVIRONMENTAL PROTECTION

The terms 'environmental law' and 'environmental legislation' are used for denoting the measures of environmental legal protection.

Environmental law means a body of legislative provisions, regulating the public rules of conduct in the area of environmental protection. Environmental law is a relatively new and complex area of public law, which includes such legal provisions of constitutional law, administrative law, criminal law and administrative procedure law that aim to ensure and promote environmental protection. Environmental law belongs to public law, which means that, to protect the environment, the state prescribes for the public certain requirements that must be followed. If a person fails to comply with these requirements, the state may use coercive measures against such a person, imposing a corresponding penalty or ordering to eliminate the adverse effects on the environment resulting from the violation.

What are the rules of conduct contained in legal provisions can be ascertained through studying the sources of law. Environmental law consists of several types of legal sources, representing the written law (legislation) and the unwritten law (general legal principles and customary law). In addition, the sources of environmental law can be divided into the basic sources (laws) and ancillary sources (case law or the rights of judges and jurisprudence – legal science or jurists' law).

The main source of environmental law is the law (external legal provisions), *viz.* the written sources of law, which include generally binding rules of conduct. The generally binding legal provisions comprise laws adopted by parliament, regulations issued by government and binding rules issued by local authorities. Furthermore, EU legislation – including regulations, directives and decisions – is binding to the European Union Member States. EU environmental legislation is developed mainly in the form of directives that the Member States must then integrate into their national law.

National environmental legal protection is also based on international legislation. For the most part, they are international agreements (conventions, protocols) to which the Member State is a party.

The term 'environmental legislation' is associated with national environmental law, and it mostly refers to legal acts (laws of parliament, regulations of government and local authorities) that pertain to the environment or help to achieve the national aims of environmental policy – to preserve, protect and improve environmental quality, provide for sustainable use of natural resources and ensure a high-quality living environment. Therefore, environmental legal protection is associated with both environmental and natural resource protection and sustainable use, and the protection of human health from harmful environmental factors in the following environment-related areas:

- water protection,
- soil protection,
- protection against noise in the environment,
- ambient air protection,
- nature and biodiversity conservation,
- waste management,
- turnover of chemical substances and products, including biocides and pesticides,
- turnover of genetically modified organisms,
- various emissions and releases into the environment,
- environmental impact assessment,
- access to environmental information and public participation in environmental decision-making at the state level,
- urban and rural spatial planning.

For the purpose of the law, 'the environment' is taken to mean an aggregate of natural, anthropogenic and societal factors. Obviously, 'the environment' includes not only natural factors (the natural environment) but also human beings and their impact on the natural environment.

11.1.1 LAW AS AN ENVIRONMENTAL PROTECTION INSTRUMENT

Various cultures of the world have different understandings of law. The conception of law largely depends on what is recognised as the sources of law. The world's developed countries, including European countries, have quite similar conceptions of law. The laws of these countries belong to the so-called Western law, where 'law' usually means a body of legislative sources regulating community life. The laws of the Baltic Sea region countries belong to the continental European law family or civil law system. Although this system may also include unwritten law, the main recognised sources of law are written – above all, the laws adopted by national parliaments. Generally binding rules of conduct or regulations, to a limited extent, may also be issued by executive powers – the government and local authorities. The legal provisions of the highest legal force – the State Basic Law (Constitution) – are at the top of this hierarchy.

In many countries, environmental protection is a constitutional norm. For example, Article 115 of the Constitution of the Republic of Latvia stipulates: 'The State shall protect the right of everyone to live in a benevolent environment by providing information on environmental conditions and by promoting the preservation and improvement of the environment.' Several state obligations can be derived from this constitutional provision – to

Figure 11.1. **German Parliament (Reichstag) building in Berlin**
The dedication *Dem Deutschen Volke*, meaning 'For the German people', can be seen on the architrave.

protect the right of everyone to live in a benevolent environment, to provide for the preservation of such environment and to promote the improvement of the environment as well as to ensure public access to environmental information.

The countries that belong to the continental European civil law system have codified laws, which are often referred to as codes. In several countries, there are civil and criminal as well as environmental law codifications. For example, Germany, France and Sweden have environmental codes. Latvian environmental regulatory standards are included not just in one but in several laws: the Environmental Protection Law, the Law on Pollution, the Law on the Conservation of Species and Biotopes, the Law on Specially Protected Nature Territories, the Protection Zone Law, the Waste Management Law.

The laws of such countries as the United Kingdom and United States, in turn, belong to another group of Western law – the English-Saxon common law system. In this group of laws, the basic recognised sources of law are both the laws adopted by the parliament (legislative statutes) and judicial precedents. Therefore, in these countries, the so-called rights of judges have significantly greater weight than in continental Europe.

Human behaviour is governed by different types of rules – from etiquette and morality to legal provisions. However, only the latter are contained in the sources of law and are binding.

Environmental laws are primarily focused on solving environmental problems and include measures that should be taken in order to prevent known environmental problems. Compliance with the requirements of legal provisions makes possible to eliminate environmental damage or to reduce its impact.

To prevent human-created environmental problems successfully, we need to develop a strategy to change human behaviour, making it more environment-friendly. Since law is the most effective regulator of social behaviour, it is widely applied in order to change social behaviour patterns in the use of the environment. In general, environmental law is primarily incentive and disincentive rules of conduct contained in environmental legislation. They underpin different areas of life. Hence, the law may set a binding framework, within which economic, technical, informative, educational and other measures are often implemented on their merits.

The desired behaviour can be achieved with two kinds of methods, working as a 'pie' or a 'whip'. The 'pie' strategy means that the law stimulates the implementation of environment-friendly behaviour in a way that compliance with environmental protection requirements is beneficial. The 'whip' strategy, in contrast, provides for measures impeding specific actions. These measures have to be such that the disadvantageous consequences of environmentally unfriendly actions would inhibit people from these actions. The 'whip' strategy is most commonly used in the provisions that impose penalties or other coercive measures for non-compliance with environmental protection requirements.

Usually, environmental law drafts are developed by executive powers or politicians, adopted by the legislator and implemented by specialised state or municipal environmental protection authorities, whereas courts exercise control over the compliance with these laws. Unlike it is with other social norms, the compliance with legal provisions can be enforced by compulsion. Therefore, only the law has a specific implementation process – the legal provision.

Legal provision is a mechanism for ensuring the compliance with legal provisions or their fulfilment. In order to make this process work, the state has created relevant institutions (authorities) – courts, police, prosecutor's office, specialised state environmental departments – which have been granted a monopoly of coercion. The coercion mechanism grants the state (the law enforcement bodies) the lawful right to apply coercive measures against the violators or non-observers of the law. The coercive measures themselves are established by the law, and they are quite different.

The state has the right to monitor the compliance with environmental legislation. Such control can be exercised by state environmental inspectors. If non-conformities with the requirements of environmental legislation are found during inspections, state environmental inspectors may, for example, issue binding injunctions (administrative acts) for temporary suspension of the company's operations, draw up statements of the cases for less grievous (administrative) violations and impose statutory administrative penalties for these violations. Although the law also provides for criminal liability for environmental legislation offences, in practice the environmental regulatory violations are classified primarily as less serious violations. The most common punishment for environmental violation is an administrative fine, whose amount is usually fixed by the law.

If it is economically more profitable for a company to pay fines and compensate for environmental damage instead of continual conformity with environmental protections requirements, such a situation is indicative of the inefficiency of the legislator's chosen 'whip' strategy, as it does not promote the compliance with these requirements.

11.1.2 LAW AND ENVIRONMENTAL SCIENCE

Environmental science and environmental law each has its own specific tasks. Environmental science explains and forms understanding about the processes taking place in the natural environment, interaction going on among the elements of nature and between humans and the natural environment. By contrast, the task of the law is to regulate social relations for the purpose of protecting and improving the environment and to solve the related disputes. Although the environmental science and law are quite different areas, they are at the same time closely related. Regulation of social relations in such a way that human activity would not have any destructive environmental impact is possible only if both the legislature and general public have an understanding of the processes in the environment and their causes, as well as of the impact of various human activities on the environment. If the knowledge of environmental science was not taken into account in drafting environmental legal provisions, it would be impossible to achieve the goals of environmental law. Consequently, such a normative regulation would have to be regarded as an ineffective means of environmental protection. Environmental science, in turn, without binding environmental protection regulations, would not have the tool for transforming the behaviour of society and directing it into a more environment-friendly direction.

11.1.3 LAW AND ENVIRONMENTAL ETHICS

Regulating social relations, the law as such is silent on ethical issues. Is it acceptable to degrade the natural environment and to consume a large part of the planet's natural resources during one generation? What kinds of actions in relation to nature should be regarded as good or bad? What is the moral value of nature? Answers to these questions should be sought in environmental ethics. Environmental law is based on two main conceptions of environmental ethics – anthropocentrism and ecocentrism. According to the anthropocentric approach, the environment should be protected in the interests of human welfare – today's environmental protection conserves environmental resources for future consumption. The ecocentric approach, in turn, implies that the environment (nature) has an intrinsic value in itself; therefore, the human responsibility is to protect it without regard to the benefits humans could obtain from it, and to provide for the possibility to exist not only for humans but also for other living beings. Contemporary environmental law is primarily anthropocentric.

In the legal system, animals or nature in general are usually regarded as legal objects, which can be equated to things. Usually, neither nature nor animals are recognised as legal entities which may have rights. Only humans possess rights. Hence, the law, being for the most part anthropocentric, guarantees the priority and protection of rights and interests just to one species – humans.

11.2 LEGAL PRINCIPLES OF ENVIRONMENTAL PROTECTION

Environmental protection principles are guiding ideas, on the basis of which the state develops its environmental policy. Compared with legal provisions as sufficiently clear rules of conduct, the environmental protection principles are more abstract. Therefore, they are often considered as an intermediate stage between environmental policy and environmental law. These principles are established by law and serve primarily as guidelines for the development of environmental laws and regulations.

There are several environmental protection principles effective in the European legal space – the principle of high level of environmental protection, the precautionary principle, the principle of preventive action, the assessment principle and the 'polluter pays' principle.

When new environmental laws and regulations are adopted, **the principle of high level of environmental protection** prohibits deteriorating the existing level of environmental protection.

The precautionary principle does not allow to start on an environment-affecting action until the information has been obtained as to how high a risk exists and what measures have to be taken to reduce it. If the research process reveals a threat, the precautionary principle calls for precautionary measures, despite the fact that there is some uncertainty as to whether the risk is indeed real. The aim of the precautionary principle is not to permit certain actions only when the risk to the environment or human health is equated to zero, but to assess the magnitude of the risk and, in case of need, take the necessary measures.

Although all kinds of chemical substances we use on a daily basis help to simplify our life, they can imperceptibly harm us in the future. Humans have created thousands of new chemicals, and only part of them have been proven dangerous and, therefore, are prohibited to use (for example, the use of some plastic softeners in children's toys). At the same time, there is a great deal of chemicals still in use whose hazards have not yet been properly researched. These substances are contained in various goods and products that are widely used on a daily basis, and we can take them in with food, breathe in with air or absorb through the skin. Until now, before a country could be prohibited to produce some chemical substance, its hazardousness had to be conclusively proved. Now the European Union law has brought new binding requirements based on the precautionary principle – over 30 thousand existing and new chemical substances will have to be tested with regard to their effect on human health. It is no longer the country but manufacturers and importers of chemical substances who must obtain certain information on the properties of these substances and test them to determine their impact on the environment and humans, as well as guarantee their safe use, that is, prove that the substance is not hazardous.

The principle of preventive action requires to prevent pollution or other harmful impacts on the environment or human health as much as possible, or, if it is unfeasible, then at least to prevent further spreading of these harmful effects and their negative consequences. The principle of prevention combines two EU environmental protection principles – the principle of preventive action and the principle of causation.

The principle of preventive action is implemented through such regulatory enactments which require, for example, compliance with the environmental pollutant emission standards or waste management regulations. Waste should be processed and disposed of as close to its place of origination as possible (the proximity principle), and each state or local government should, as far as practicable, by itself treat and manage in an environmentally sound manner the waste generated at its territory (the self-sufficiency principle).

The assessment principle prescribes: if the consequences of an action or project can significantly affect the environment or human health, they must be assessed before such an action or project is permitted (commenced). If it becomes evident after the assessment that the action or project in question will adversely affect the environment or human health, the government may allow it on condition that the expected positive result for society as a whole will exceed the harm that the respective action or project will have caused to the environment and society.

The assessment principle clearly attests to the aforementioned anthropocentrism of environmental law. Moreover, 'the expected positive result for society as a whole' may be related to the implementation of economic interests, such as the construction of roads, dams, pipelines, nuclear power plants. Therefore, the environmental legislative regulation is aimed not so much at prohibiting any negative impact on the environment than at controlling and minimising this impact as far as reasonably practicable.

'The polluter pays' principle requires that the costs of assessment, prevention and mitigation of pollution as well as the costs of elimination of its effects are borne by the person whose activity has caused the pollution in question.

There are over 3 000 sites (including land areas and waters) identified in Latvia that are actually or potentially contaminated with hazardous substances. On the European Union scale, there are over 300 000 such sites. But this should not happen at all.

The earlier environmental regulatory framework has not prevented the possibility of origination for such sites, because the environmental polluters could have easy ways to avoid responsibility. Now, there are new legislative acts passed on the basis of 'the polluter pays' principle in order to make the polluters accountable for restoring the contaminated sites to their previous environmental condition.

Persons – individuals or companies – whose actions have caused harm to the environment, i.e., such detectable changes in the environment that are likely to have significant negative impacts on both human health and also the environment (e.g., waters, specially protected areas, species, habitats) are required to restore the previous state of the environment, covering the pollution removal and environment restoration costs.

'The polluter pays' principle will fully come into effect when each contaminated site is decontaminated and the decontamination costs are covered by the persons who have caused the respective pollution.

To put 'the polluter pays' principle into effect, it is important to determine who is the polluter and for what the polluter must pay.

Companies engaged in such economic activities that have a high environmental risk – for example, carrying dangerous cargos, transporting chemical (oil) products via pipelines, operating fuel filling stations or producing cement, glass fibre or chemical products – have to prevent the damage caused to the environment due to their activities and to restore the environment to its previous state even if these companies have not violated environmental regulations. In legal context, this is called strict liability.

Latvia and other former Eastern Bloc countries have established the register of historically contaminated (and potentially contaminated) sites. The new legal acts on environmental liability are not applicable to the restoration of these sites, as their requirements are not effective with regard to past events. Therefore, specific requirements have been set for the restoration of such sites. First of all, the responsibility lies with the person whose activity has caused the pollution. If that person cannot be held liable due to objective reasons, then the current landowner will have this responsibility. The contaminated site has to be restored to such an extent as to prevent the contamination from spreading or entering the groundwater, so that it would no longer be hazardous for human health or the environment.

'The polluter pays' principle is not applicable in cases when it is impossible to determine who has caused the environmental pollution, or the company at fault for the pollution is known but no longer exists, while the contaminated site has not been transferred to another owner. In the Baltic states, for example, these sites are mainly the territories formerly occupied by the Soviet army as well as the sites contaminated by the former Soviet plants.

If the actual polluter does not exist anymore, and the contaminated site does not have another owner, the clean-up of the contaminated site has to be covered from the state budget. Besides, legislation usually establishes less stringent requirements for the state – the polluted site restoration works are to be carried out only if the state has sufficient funds for this purpose. This is one of the reasons why past pollution continues to be a major environmental problem in the Baltic states.

Finally, in the cases provided by the law, 'the polluter pays' principle is also extended to the manufacturers of specific products.

Figure 11.2. **Deepwater Horizon offshore drilling rig on fire, Gulf of Mexico, 2010** Vessels combat the fire on Deepwater Horizon while the United States Coast Guard searches for missing crew.

The Deepwater Horizon oil spill (also referred to as the British Petroleum (BP) oil spill) was a massive oil spill in the Gulf of Mexico that was the largest offshore spill in the history of the United States and among the largest oil spills in history. The spill stemmed from a sea-floor oil gusher that resulted from the 20 April 2010 Deepwater Horizon drilling rig explosion. The explosion killed 11 platform workers and injured 17 others. On 15 July, the leak was largely stopped by capping the gushing oil wellhead.

The quasi-official Flow Rate Technical Group estimated the oil well was leaking 5 600 to 9 500 cubic metres of crude oil per day. This volume is approximately equal to the 1989 Exxon Valdez oil spill every four to seven days. The resulting oil slick covered at least 6 500 km^2, fluctuating daily depending on weather conditions. Scientists have also reported immense underwater plumes of dissolved oil not visible at the surface.

The spill caused extensive damage to marine and wildlife habitats as well as the Gulf's fishing and tourism industries. Crews worked to protect hundreds of miles of beaches, wetlands and estuaries along the northern Gulf coast, using skimmer ships, floating containment booms, anchored barriers and sand-filled barricades along shorelines. The USA Government has named BP as the responsible party, and officials have committed to holding the company accountable for all cleanup costs and other damage.

11.3 PROCESS OF ENFORCEMENT OF ENVIRONMENTAL LEGISLATION

11.3.1 APPROACHES TO ELABORATION OF LEGAL DOCUMENTS

Environmental quality is affected by different factors – pollution, excessive deforestation, land cultivation and unreasonable fertilisation, the use of substances or organisms foreign to the natural environment. To encompass all these and other factors, several approaches and measures are used in the legal regulation of environmental protection.

First, environmental law contains regulations that focus on quantifiable and stationary sources of pollution. These are mainly standards for the companies that operate different stationary industrial (technological) equipment. Since the operation of such equipment leaves a more or less extensive environmental impact, they are called polluting activities. State exercises control over the polluting activities: they are permitted only if the company previously obtained a relevant permit from a competent national environmental authority. Moreover, the law requires the competent national environmental authority to issue such a permit on condition that the emissions of pollutants into the environment would be maximally reduced.

Second, environmental law includes mandatory regulations, which require the state to take complex steps to achieve certain objectives defined by law. For example, EU legislation requires from the new Member States that water in their natural and artificial water bodies must be in *good condition* by 2015. The water condition is defined as good if it does not endanger the survival of diverse aquatic ecosystems even if the effects of human activities can be detected. This kind of regulation is also referred to as the ecosystem approach. The objectives in other environmental areas are set forth in a similar way: to mitigate climate change and reduce greenhouse gas emissions as well as to facilitate the removal and recycling of waste (for example, packaging waste recovery standards).

Third, there are also regulations for various state and local government decision-making processes. For example, to decide on where to locate a waste disposal landfill, a special procedure has to be carried out – *the environmental impact assessment* for this landfill. During this process, the potential impact is assessed and actions for the reduction of this impact are planned, and alternative landfill sites are ascertained. A decision on locating the landfill at a particular site can be taken only after the environmental impact assessment. Such regulation is necessary in order to ensure that every decision, whose implementation may affect the environment, would be taken on the basis of sufficient information regarding its possible impact on the environment, to take into account environmental considerations in addition to the economic and social ones, to make such decision-making transparent and to facilitate the interested public to become involved in the decision-making process and influence it, in particular the residents in the vicinity of the planned object who may be directly affected by the project in question.

All three approaches are used in the normative regulation of environmental protection. However, going back to the beginnings of environmental laws, it is possible to trace their changes and developments over time. Initially, environmental legislation was focused on controlling the pollution from industrial enterprises. Then it became clear that other economic activities also degrade the environment – agricultural and forestry practices, uncontrolled use of chemical substances and products, construction works at environmentally sensitive areas, such as the sea coast and river banks and lake shores. Therefore, the legislature began to set forth the objectives to be attained within specified periods of time and to require complex measures – gathering and analysis of information on the actual situation of the environment, planning and execution of measures required for the attainment of objectives set. Moreover, such a planning process should be transparent, involving the community as well.

11.3.2 ENVIRONMENTAL LEGISLATION INSTRUMENTS

Binding regulatory requirements are also called standards. Often they are regarded as the core of environmental law, because they, as the means of 'command and control', directly set forth certain requirements (standards) for environment-polluting activities, substances and products, as well as for the implementation and application of environmental regulations. There are several categories of standards: emission standards for the permissible pollution that can be released from the end-of-pipe of industrial facilities into the environment; the environmental quality standards for such environmental components as air, surface and ground water and soil; standards for different processes, requiring the use or abandonment of specific technologies, materials or practices. For example, there are requirements to use the 'best available technologies' in cellulose production, or specific fishing gear and dragnets with specific mesh sizes in fishery. Likewise, specific environmental standards are established for the production, use and disposal of various products; for example, the environmental requirements for fuel, laundry detergents and electronic appliances.

Voluntarily made commitments (self-regulation). Self-regulation is rooted in the idea that enterprises voluntarily assume additional commitment for environmental protection.

Another form of self-regulation is *environmental audit*, which is carried out within the framework of the *environmental management and audit system* established by law. When a company becomes involved in this system on a voluntary basis, it commits itself to develop and implement its own environmental policy and regularly conduct environmental audits, that is, to check whether the company's environmental policy is being implemented, whether the environmental protection investments are not spent in vain and whether the company's business activity meets the environmental protection requirements. The purpose of such a system is to encourage the involved companies to be more environment-friendly, at the same time gaining some benefits from the involvement in the system – to raise their competitiveness in the market.

Another self-regulation measure is *eco-labelling*. Eco-labels provide consumers with information on the environmental impact of products.

In Europe, a transition to a new public management model took place in the 90s of the 20th century. In accordance with this model, public management takes over the management style typical to the private sector, i.e. it is aimed at economy and efficiency. As a consequence, environmental regulation has been increasingly using economic means with the objective to promote economy that would be economically viable and environmental friendly at the same time. Examples of such means include environmental taxes (in Latvia – the natural resource tax) and the EU's newly implemented pollution rights trading system. This system provides that a company which, as a result of technical improvements, has not used all the allocated CO_2 and other greenhouse gas emission allowances, can sell the unused allowances to another company.

To make the right decisions, accurate information is needed first of all. The information at the basis of making political decisions and dealing with environmental issues has to be public and transparent. Today, obtaining environmental information has become one of the state functions. Environmental laws require the state to establish and maintain registers and databases, providing access, for example, to the data on environmental situation, pollution and its sources, state-issued permits for polluting activities, environmental monitoring, environmental impact studies, as well as environmental legislation and policy documents.

At the same time, public access to the environmental information at the disposal of the state has been significantly liberalised – in the EU Member States, the right of public access to this information is stipulated by law. The state has to create publicly available and free online databases, the publicly available environmental information has to be presented in an easily perceivable and comprehensible manner, the requesters of the environmental information do not need to provide reasons why they need this information. The receipt of environmental information can be restricted only in the cases specified by law. However, it should be noted that these requirements for public access to environmental information does not apply to private companies.

Finally, the right of society – any of its member – to apply to court, so that it would verify whether the decisions or actions of the state itself (its authorities) comply with the requirements of environmental legislation can also be considered a means of environmental legal regulation.

11.3.3 DIALOGUE WITH SOCIETY AND THE ROLE OF SOCIETY IN ENVIRONMENTAL PROTECTION

The authority of public opinion is crucial in environmental protection. Environmental laws can have the necessary support and effect only if the majority of society understands the importance of favourable environment for human life and the need to preserve the environment. Public pressure often expedites the drafting and adoption of laws.

Besides, there are such legal provisions today, whose implementation is not even possible without public activities. A vivid example is the Aarhus Convention on public rights in environmental matters. This Convention deals with environmental protection in close relation with human rights. The Convention is particularly significant, as it not so much prescribes mutual obligations for the participating countries than determines the basic principles how to form relations between the state and the public in the area of environmental protection, establishing an internationally recognised standard.

The Aarhus Convention envisages environmental protection as a precondition for ensuring the public welfare and right to live in an environment that is not hazardous to health.

To facilitate this objective, the Aarhus Convention guarantees the public (any of its member) the following individual rights:

- the right to access environmental information at the disposal of the state;
- the right to participate in environmental decision-making;
- the right to apply to court in environmental matters.

The Aarhus Convention is based on the idea that if the public is active and well-informed, it can be a powerful force in sustainable and environment-

Figure 11.3. **In need of strong environmental legislation**
Turkish environmentalists in anti-nuclear/anti-dam protest in Istanbul, on the 24th anniversary of the Chernobyl disaster.

friendly development. Therefore, the members of society are not required to provide reasons as to why they need any specific environmental information.

The public has a right to participate in adopting environment-related decisions. These can be decisions on issuing permits for polluting activities or construction of major infrastructure objects. The public has a right to participate in the environmental impact assessment process of proposed projects and in the preparation of various environment-related planning documents – including spatial planning – establishing restrictions for the use of land and buildings (constructions).

Exercising their rights to participation, members of the public may express their opinions and concerns with regard to the proposed plans, projects or activities. The institution that takes the decision, in turn, has an obligation to take into account and evaluate these opinions and concerns. Furthermore, if the institution rejected the people's protest against the proposed project, it is obliged to give reasons for such rejection. If these public rights are violated, everyone, including non-governmental organisations (environmental associations), is entitled to apply to court to protect the infringed public rights.

Nowadays, the role of the public in state governance has increased significantly in both environmental policy drafting and implementation. For all that, it is up to the members of the public themselves whether they exercise these extensive rights.

11.4 ENVIRONMENTAL POLICY

The aim of environmental policy is to identify and resolve environmental problems, establish a system of environmental legislation and set tasks to ensure environmental quality. Environmental policy should promote the participation of the public in solving environmental issues and ensure the integration of environmental protection and nature conservation issues in all economic sectors.

Environmental policy provides a framework for the environment and natural resource use, so that an adequate economic structure and social security could be established for the needs of society. Environmental policy has more general and broader functions than environmental management. The latter provides for the practical implementation of the former. The purpose of environmental management, in turn, is to ensure that national economy utilises the natural resources efficiently, that the necessary goods are manufactured and the necessary services – received, and that pollution is reduced to the level which is not harmful to human health and ecosystems. In a word, environmental policy can be considered as environmental protection and conservation strategies.

Environmental policy provides a framework for setting objectives and tasks for environmental protection and for ensuring the improvement of environmental quality. Environmental policy consists of several interrelated stages that form a cycle.

At an early stage of policy-making, usually an understanding emerges that there is an environmental problem. Then the problem to be solved

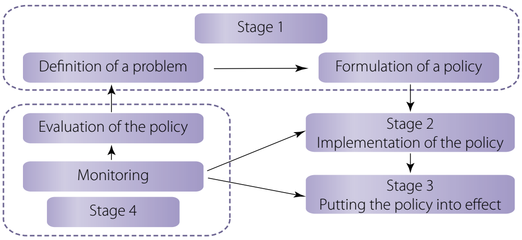

Figure 11.4. **Stages of environmental policy-making**

is defined more exactly through collecting and analysing the known facts, data and information. After that, the environmental policy planning documents are being developed – concepts, guidelines, strategies, programmes and plans, subsequently to be approved by the parliament or government.

Medium-term policy planning documents usually reflect the current situation, formulate environmental policy objectives, challenges and directions for action to attain these objectives. In many cases, the overarching objective of environmental policy is to build a framework for the preservation and restoration of environmental quality as well as for sustainable use of natural resources, at the same time limiting the impact of adverse environmental factors on human health.

Some of the key problems to be solved are:

- air quality standards in major cities are frequently exceeded, and transport emissions make the largest proportion of air pollution;
- eutrophication of inland waters is increasing, and it is largely caused by agricultural activity; this factor, in turn, adversely affects water quality in the Baltic Sea;
- in the situation of economic crisis, the use of recycled materials cause a problem; considering the substantial drop in prices and demand, the attainment of waste recycling targets are also becoming problematic;
- planning documents for economic sectors do not sufficiently reflect various environmental factors – air quality and noise in traffic planning documents, geological and flood risks, industrial accident prevention measures;
- society's lack of understanding about the dependence of long-term availability of natural resources on the forms and methods of current economic activities;
- lack of long-term, systematic scientific studies on the potential impacts of climate change on the environment in many of the EU Member States, climate change risks, effects of climate impact mitigation measures on economy, as well as lack of economic and social adaptation measures and programmes prepared for their implementation;
- lack of funding to control the compliance with the statutory requirements.

Solving of environmental problems directly depends on the level of society's knowledge on environmental protection. Environmental education and communication are the main tools of raising public awareness. Communication is an ongoing two-way exchange of information between decision-makers and the general public. It is an important policy tool, having a major role throughout the implementation process of the policy and environmental management. Although communication has a different function at each policy and management development and implementation stage, these stages are interrelated.

The most important communication functions are:

- to make information available to the public;
- to draw public attention to specific issues or problems;
- to involve the public in discussing and solving specific problems;
- to provide information on new developments in various fields, promote the exchange of ideas and knowledge;
- to facilitate changes in public behaviour and attitudes.

Environmental education is one of the most important means of raising public environmental awareness in the progress towards a sustainable society. The role of environmental education is:

- to promote community development in a way that would harmonise the spiritual and material needs and interests;
- to increase substantially the public sense of responsibility, involving citizens and society in environmental conservation and rehabilitation;
- to educate the public about the environment and nature, raising the level of knowledge and self-education opportunities;
- to involve the responsible organisations, educational institutions, experts and enthusiasts in the process of environmental education, thus supporting the national and local initiatives.

Environmental education helps build environmental awareness – to study the environment, identify its problems and obtain a careful and conscientious attitude towards it. Environmental education of staff involved in environmental management and protection should be considered a prerequisite for the environmental protection system to exist. Environmental education justifies the need for mobilising financial resources for environmental policy challenges. Environmental education, decision-making and practical activities are based on research and knowledge of environmental science. Environmental education and environmental science are a foundation for setting environmental policy and social sustainability goals and dealing with problems.

Environmental education is needed in order to make possible drafting and implementation of laws and regulations – not only those on environmental protection but also on economic sectors, addressing internationally significant environmental protection problems at the local level, studying the environmental quality and developing new environmental technologies, and ensuring protection of the environment in general.

At schools, environmental education and education for sustainable development are generally integrated into various subjects according to their specific content, ensuring the continuity and coordination in various stages of education.

Research development and the use of knowledge and environmentally sound technologies is the principal economic development path that can ensure sustained prosperity. Consequently, it is essential to develop exact principles for the content and objectives of environmental education and science. Environmental studies should focus not only on knowledge acquisition and research proficiency but also on the skills to identify and address environmental protection problems significant for society.

11.5 ENVIRONMENTAL MANAGEMENT SYSTEM – FROM VISION TO IMPLEMENTATION

Environmental protection is a set of measures of environmental quality preservation and sustainable use of natural resources, whereas its purpose is to eliminate, mitigate or prevent environmental damage. Environmental management system is a continuously repeated cycle of planning, implementation, outcome evaluation and more precise definition and improvement of further action. It is used in state and local government as well as in commerce – in order to identify and implement environmental quality improvement goals.

This approach helps to ensure continuous improvements and achievements. The set of measures includes:

- planning of the overall process, starting with the environmental situation assessment for the purpose of setting goals;
- actions required for pilot projects ran for the purpose of gaining experience and knowledge and becoming prepared for the main tasks;
- control of the process and situation changes, including monitoring to make adjustments if necessary;
- implementation of the process to achieve the set objectives, evaluating performance at regular intervals to determine whether the achievements match the plans.

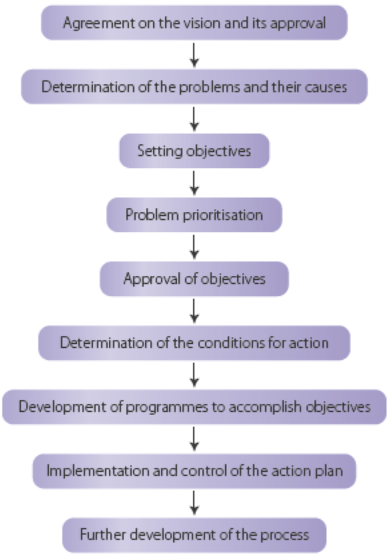

Figure 11.5. **Scheme of the development of a general environmental protection system**

11.5.1 DISCUSSION AND APPROVAL OF THE ENVIRONMENTAL POLICY VISION

To initiate an integrated environmental assessment and the necessary management process, first of all there must be such a desire. It can be expressed by state and local government leaders, deputies, non-governmental organisations, citizens groups, environmental protection enthusiasts or business representatives. Regardless of what caused the initial impetus, leaders must be ready to listen and to prepare adequate documentation for starting the process to resolve issues relating to financial resources and administrative involvement. Since most government institutions, municipalities and other organisations have already been integrated into the processes associated with the use of the environment for rendering services or the environmental impact assessment, the deputies must be ready to listen to their voters' wishes and put them into practice.

After the initial steps of the process, an increased interest should be awaked on national or community levels. Also, the necessity of various activities or campaigns should be carefully studied by interviewing people. However, it is quite difficult to evaluate the need for comprehensive long-term planning. Various communication methods can be used, giving priority to those which have already been successful in cooperation with public groups. Interest groups may already exist, but in many cases they come into being when there is an increase in public interest about environmental issues.

The next task is to prepare a statement of reasons for the entire action. It should include public participation principles and vision of the future that could be acceptable to a wide range of representatives of public groups and even those who have different opinions.

To initiate such a process, it is useful to review society's environmental values and to draw the participants' attention to the environmental preservation and protection needs. Objects of value can be visited, such as individual natural features, wildlife systems, historical buildings. Besides, the spirit of unity and patriotism within the community, territory-specific crafts and decorative art activities and the ability of mutual understanding should also not be neglected. Ideas can be generated at meetings of various groups, using the brainstorming method. The ideas put forward should be kept for the vision development stage.

Vision could include population health, keeping in mind that the associated problem area is usually much broader, involving, for example, such factors as deterioration of the demographic situation or a higher mortality rate of lung disease in a district and on average in the country. One of the causes of problems in the human environment is deterioration of the living standards; consequently, the task of normalising the situation can be related to the improvement of economic situation.

It should be taken into account that the vision cannot be borrowed from the neighbours or someone else – it can only be single and specific to a particular country or community. The vision should express the society's future expectations and aspirations that can be articulated through such important factors as health, living standard, lifestyle, environmental quality and future directions of economic development. The vision should be brief, composed in an easily comprehensible language, and it should reflect the main directions toward which the society will have to work hard.

11.5.2 DETERMINATION OF ENVIRONMENTAL PROBLEMS AND THEIR CAUSES

Environmental information has a major role in environmental policy development and environmental management system operation. This information comprises knowledge and data obtained through environmental studies, statistical information, long-term and systematic observations of the environment, society and its activities. Environmental information consists of the observational data, whose gathering, processing, analysis and interpretation make the facts describing the processes in the environment and society. Environmental information should enlighten the scientists, politicians and persons working in environmental management, so that they would be able to make the correct policy decisions – i.e. matching the actual situation and the environmental challenges in the region – and to make well-founded and rational environmental protection and management measures. An important task of environmental information is to identify environmental problems before starting the processes that may threaten the environment quality. The efficiency of environmental policy and management is dependent on the completeness and quality of environmental information.

In the context of good management provision, it is important that citizens have access to the Internet, enabling them to follow the activities of the state government, local government and non-governmental organisations and business processes as well as to engage in discussions and decision-making process by sending their opinions and recommendations to relevant authorities in an electronic form.

Environmental information cannot be restricted access information – it should be public. The public is entitled to have environmental information on

- environmental situation, including information on water, air, soil and subsoil, flora, fauna, natural areas and landscapes, biodiversity, species and habitats and their interactions, as well as information on genetically modified organisms;
- anthropogenic pressures and activities that affect or may affect the environment;
- environmental protection measures affecting the environment;
- reviews and reports on environmental protection, policy planning documents in the field of the environment, laws and activities affecting the environment, cost-benefit analysis, economic analysis reports in relation to the implementation of environmental policy.

If a decision on a vision is taken, it is necessary to clarify the specific environmental problems. There are several methods that can be used for collecting and processing information in order to ascertain the real problem and its scope. The collection of data on certain parameters to assess the root of an environmental problem is of particular importance. The process should move on in such a way that the degree of its complexity would be acceptable to the public – from a highly sophisticated computer programme to a brainstorming session on local environmental issues that people know well enough.

Even a small summary of data may give a hint regarding the current situation in a district, across the country, the EU Member States or the world at large. Such information can also be obtained from the European Environment Agency, the statistical bureaus and municipal authorities of the EU Member States.

The data shown in Figure 11.6 predict a reduction in this metric of approximately 2 $\mu g/m^3$ or more per year in central and north-western Europe. Smaller reductions are predicted outside this region (Spain, Balkan countries, the Baltic and the Nordic countries).

It is very difficult to carry out in practice a complete, objective analysis, covering all environ-

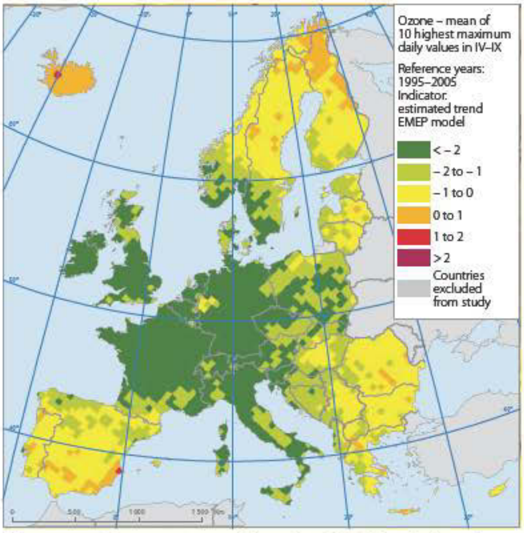

Figure 11.6. **Ozone estimated trend in MTDM calculated using the EMEP model**

Note: MTDM – the mean of the ten highest daily maximum ozone concentrations (based on hourly mean data) during April-September, corresponding approximately to the mean of the data ≥ 95 percentile.

EMEP (European Monitoring and Evaluation Programme) is a scientifically-based policy-driven programme under the Convention on Long-range Transboundary Air Pollution for international co-operation to solve transboundary air pollution problems.

mental problems, without delimiting the research scope. Any observer is more or less subjective, and any perception is influenced by the manner in which an observation or measurement is made. Nevertheless, a relative objectivity can be achieved.

Some method of objective analysis could apply to a particular component of the environment, such as water, or to a specific pollutant. In the case of subjective analysis, the opinions of the society and citizens as to what they perceive as environmental problems are ascertained. Although this type of information does not give a complete picture, because the respondents usually do not mention problems that cannot be seen or felt, it may give some direction where to look for the environmental damage. One example is the noise. The perception of noise as a problem can be very different. The noise that is loud according to physical measurements, might not be a problem if people need it. Even so, if the noise is strong and damages hearing, it is a problem.

People should be interrogated as to what kinds of environmental problems they see and how, in their opinion, these problems should be ordered by importance. Such information can be obtained from population surveys, by listening to the views of elected deputies and by other methods.

Estimations regarding future problems should also be made. Some of these problems can affect the entire country, such as a sharp increase in packaging material waste due to increased import of goods, or growing road traffic intensity due to increasing number of cars.

When problems have been identified, an accurate and possibly complete database should be created. It should be based on a suitable choice of parameters, which can vary in each specific case of local environmental problems. These parameters can be both subjective and objective, but, in any case, they must be measurable. Otherwise, it will be impossible to determine whether any changes have occurred in the environment – environmental quality improvement or degradation.

Sometimes the choice of standards can lead to sharp political debates. Even if the administration prepares research reports and, based on these results, proposes parameters or standards for selection, ultimately it is government or municipal council that has to take the final decision.

The EU has established a common framework of reference for standards. Still, in some cases, standards are also set at a national level, and local governments retain the right to use more stringent requirements, but not vice versa, i.e. they are not entitled to lower the national standard requirements.

Furthermore, when the indicators or parameters have been chosen and the corresponding measurements have been performed, they need to be assessed in order to understand the environmental situation. If the parameters have corresponding standards, it is possible to make comparisons and assess whether a given parameter exceeds or does not exceed the standard.

If a problem is detected, it is necessary to study its causes and consequences. In many cases, it is obvious that there are a number of phenomena which point to existing problems, while in other cases it is not so clearly perceivable.

Figure 11.7. **Music shop window in Stockholm (Sweden)**
Environmental and social problems (e.g., noise pollution) can be used to advertise the business.

Each problem can have a hierarchical chain of causes, and, in case of its successful detection, there is a possibility to detect the root causes and deal with them first. If changes are found in the natural environment of a rural area, for example, some populations of species become larger, while some – disappear, the cause could be changes in agricultural activity, which could have been focused on more intensive production. This effect, in turn, could have been caused by some farm's decline in income, forcing them to decide on a sharp increase in production to at least avoid impairing their quality of life. However, the deeper the root cause could be sought in the national food price policy and regulations on food product import.

If the root causes are discovered, some problems can be easily resolved. The situation may be improved – even if slightly – in any case. If enough data have been gathered and assessed, a public information material should be prepared – a report on environmental situation or a similar document.

At any rate, the process should be pushed on, so that, by combining the administrative management of the environmental impact assessment with the initiation of practical measures, it would be possible to improve environmental quality. It may later become the basis for creating an environmental monitoring system.

11.5.3 SETTING ENVIRONMENTAL POLICY OBJECTIVES

Environmental policy objectives reflect society's expectations about the future. They may be scientific, social, cultural, long-term or short-term. They do not always need to be measured or evaluated quantitatively or against some previously accepted standards or criteria. Even more important, the objective should include environmental philosophy, which should underpin the vision even if its development has been entrusted to the experts of specific fields. Environmental philosophy should also appear in environmental action plans – as a mediating ground between the vision and specific objectives.

Once the objectives have been formulated, one can see that immediate completion of all the objectives is not possible due to budgetary and other constraints. However, it is very important to identify all the necessary works and to have a general view on the entire course of action, before taking a step back and starting to set priorities. Setting priorities is likely to be the most difficult of all parts of the process, so it should be done with full awareness of the potential benefits.

The analysis of the collected information should reveal the areas which have the greatest weight, which significantly influence the process in general, or which require immediate action to prevent irreparable harm. There are many known methods to set priorities, and it is better to choose several of these methods because they give an opportunity to consider the process from different perspectives.

Problems can be sorted in order of importance by several criteria:

- how much the pollution levels exceed the standards;
- how big the costs of environmental damage elimination will be;
- what the expected expenses for health care or other important areas are.

One of the most widespread methods is comparative risk analysis of population health, environmental protection and quality of living conditions. Problems are ranked taking into account the selected criteria and mutual agreement on the acceptable level of risk.

Environmental impact assessment is carried out in order to decide on what the consequences will be if nothing is done to change the existing situation and on what will be achieved through specific measures. Both of these borderline cases are very important – if they show that an action of a relatively small impact can be carried out relatively easily with few resources, it could be taken on to achieve rapid success, which would also earn public recognition and decrease the likelihood of unforeseen side results. Conversely, if a serious problem cannot be solved or the situation cannot even be improved by using all the available and potential resources, then it is better to divert resources to other targets.

All possible choices need to be analysed for their impact on the environment, costs and social implications. Impact on the environment involves two groups of issues: assessment of the effectiveness of a choice if the objective is achieved and the potential unforeseen impact on the environment. Even if it is not possible to predict the consequences of each action, it is desirable to determine many of them. Although each situation is unique in a sense, much can be learned from others, using their experience.

11.5.4 TYPES OF ACTION TO ACCOMPLISH ENVIRONMENTAL POLICY OBJECTIVES

If priorities are clear, types of action should be determined with the purpose of accomplishing the objectives stated. The types of action can be carried out as special projects, which also stipulate some policy compliance and maintenance. Economic methods and the use of the mass media can also be suitable and may have a positive effect on the behaviour and attitudes of officials and citizens. For the purpose of implementing a common strategy,

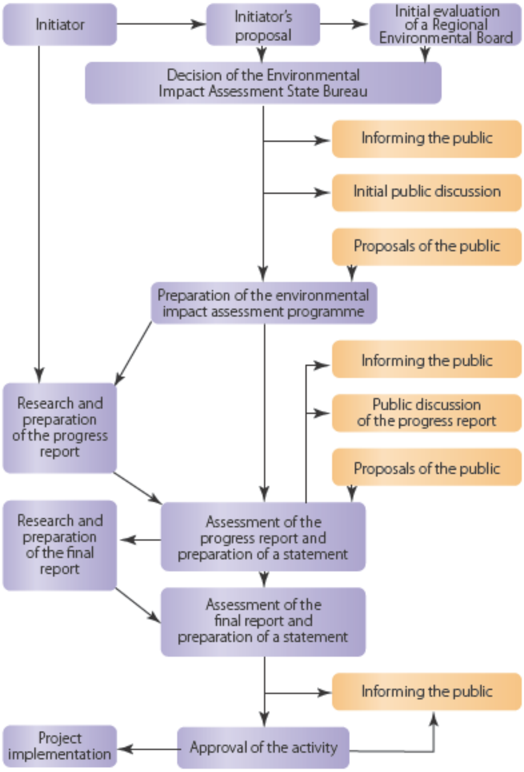

Figure 11.8. **Procedure for environmental impact assessment**

influence on the behaviour of certain social groups should sometimes be exerted. For example, it is necessary to guarantee that the land use would not be detrimental to nature protection objectives. The land owner, obtaining a permit from the environmental authority for performing a desirable activity, at the same time commits himself or herself to participate in an environmental protection measure. In this way, private land owners or users can also contribute towards the accomplishment of the objectives set.

Administration staff do not necessarily have to be green-minded, but their attitude may have serious effects on solving the environmental problems. For example, the municipal employee who is in charge of procurement for local needs can greatly affect the state of the environment if he or she truly understands the situation.

This applies to both state administration or local government leaders and the officials lower in the hierarchy, who may come up with good ideas – for example, to hold regular discussions with local residents and hear their views. So, this is an opportunity to engage in the environmental protection process and timely prevent problems that might arise, for instance, due to a mistake in the environmental action plan or because of dissatisfaction of the population.

Social implications of all the proposals should always be taken into consideration. Shut-down of a company caused by its failure to comply with environmental requirements would have significant consequences, such as job loss. In such a case, it would be difficult to take a political decision on the suspension of operations of the company, and, most likely, such a decision would not be taken after all. A better solution would be to start cooperation with the company's management in order to make improvements and move towards the compliance with environmental requirements gradually.

Moreover, jobs are not the only social problem. Requiring people to change their daily patterns, habits or traditions is always quite difficult. Besides, such factors as the cultural level and religious beliefs need to be taken into account. At the global level, the extent of these kinds of difficulties can be seen, for example, in the debates associated with birth control.

Changes that may be disadvantageous to population's standards of living or family budget will always be perceived as unacceptable – as long as people's thinking is changed by way of education or information.

11.5.5 DEVELOPMENT OF THE PROGRAMMES TO ACCOMPLISH ENVIRONMENTAL POLICY OBJECTIVES

The development of an environmental programme is initiated on the basis of the analysis performed and objectives set. The programme may contain separate plans or projects and a variety of methods to ensure information exchange, legislative compliance and economic conformity. Projects can be carried out by the institutions or organisations that have won the state or local government tenders.

Accomplishing a certain objective, the agricultural pollution discharge into streams, rivers and lakes can be reduced in rural areas. Another objective could be related to the diversification of regional economic by attracting tourists. A clean river with nature trails and opportunities to observe wildlife could draw the attention of tourists; at the same time, a certain balance should be kept in order to avoid the rise of new conflicts between tourists and nature. For example, if the river is used for water sports development, it can adversely affect the fauna of the river. Additional difficulties and new challenges may arise, and they have to be dealt with to avoid contradictions in the overall execution of the environmental programme.

As of 1 May 2004, when several Baltic Sea region countries became Member States of the EU, the environmental impact assessment of planning documents was begun, which is actually a strategic environmental impact assessment under the EU Directive 'Assessment of the effects of plans and programmes on the environment'. The objective is to assess the possible environmental impacts of the implementation of planning documents and to involve the public in discussions and decision-making regarding these documents, as well as to develop proposals to eliminate or minimise the negative impacts. The strategic assessment is carried out during the planning document preparation, before it is submitted for approval.

The strategic impact assessment should be performed for those planning documents, whose implementation can significantly affect human health and the environment, including the planning documents in the areas of agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism and mining, as well as the planning documents related to regional development, land use, spatial planning and the use of EU co-financing.

The strategic environmental impact assessment procedure ensures that the developers of various planning documents (development plans and strategies for national economy and its various sectors as well as spatial development plans) are responsible for assessing how the implementation of these documents would affect the environment and for introducing the draft documents and environmental reports contained there to the public, so that the latter could express opinions.

11.5.6 IMPLEMENTATION AND CONTROL OF THE ENVIRONMENTAL ACTION PROGRAMME OR PLAN

The implementation of an environmental action plan begins with the determination of institutions and persons who will be responsible for the execution of the programme or its parts. For some programmes, there is no need to appoint the responsible leader. In this case, collective decisions are taken by people who are directly involved in the process.

To ensure a successful implementation of programmes, different organisational models can be used. These models can have a more or less complex or simple hierarchical structure. However, in all cases it is necessary that the persons in charge have sufficient environmental knowledge and understanding of the nature of the process as a whole. In some cases, short-term training or seminars on individual substantive issues relating to the programme implementation may be held.

The implementation of a programme requires resources. If funding for the attainment of the programme objectives has been approved and allocated and the responsible persons – designated, the implementation of the programme or plan can be started. Careful planning of the implementation process is crucial for a successful completion of the programme.

Process control is a very important element in implementing programmes because it ensures two important things, namely, it guarantees that the expected environmental improvement effect will be achieved and dangerous side effects will not arise.

The opportunities of using environmental indicators towards the attainment of specific objectives should be evaluated in order to ascertain the progress made. If a programme is implemented for reducing nitrogen dioxide concentrations in urban air for a specific amount (the yearly threshold for human health safety set by the law is 40 $\mu g/m^3$), the assessment of the environmental status change can be made by determining the NO_2 concentration and comparing it with the concentration at the time of beginning the programme.

It is difficult to carry out systematic and regular measurements of a parameter that is difficult to control. Yet, such controls are required. If environmental monitoring data show that the programme does not bring the desired results, it should be reassessed to determine the changes needed.

If the programme implementation process has been appropriate, but the desired result has still not been achieved, the reasons of failure have to be looked for. They could be, for example, incorrect assessment of the cause of the problem; however, in most cases, the reason is inaccuracies in the calculation.

Then there are three options:

- to stop this activity completely and look for an activity of different type;
- re-assess the same process and then go on with it;
- persistently continue the process already begun, at the same time looking for some alternative action.

Table 11.1. **NO_x emissions and projections: current and projected progress towards the ceiling**

	Denmark	Latvia
2010 emission ceiling	127 Gg	61 Gg
2010 WM projections (existing measures in place)	126.0 Gg	45.1 Gg
Distance to NO_x emission ceiling in 2007	39.7 Gg	–18.2 Gg
Comparison of 2010 emission ceiling with WM projections 2010	–1.0 Gg	–15.9 Gg

Depending on the scale of the required changes, additions can be included in an already existing programme, or the programme can be modified. Even if it is possible to fit the changes in the existing programme, this fact should be made known to the public.

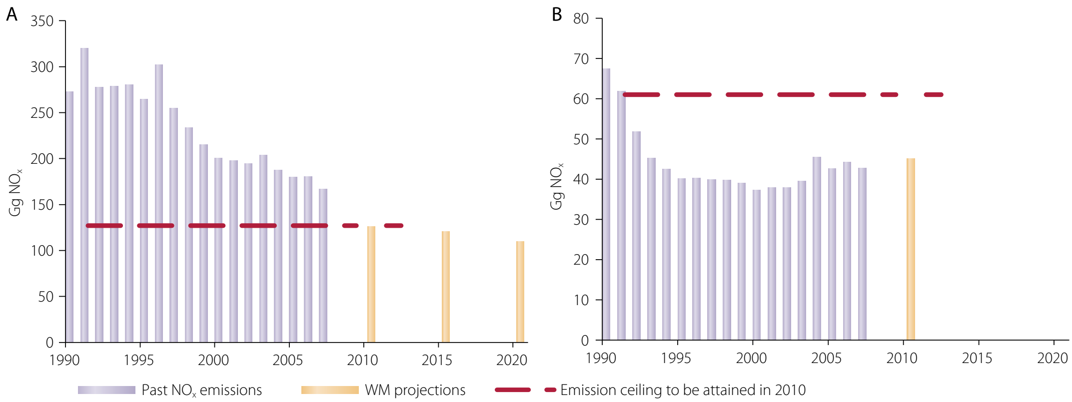

Figure 11.9. **NO_x emissions and projections in Denmark (A) and Latvia (B)**
Reporting by the Member States under Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.

ENVIRONMENTAL MONITORING

Environmental monitoring comprises systematic observations, measurements and calculations of environmental situation, pollution, emissions, population and species needed for the environmental assessment and planning of nature conservation and measures for controlling the effectiveness of environmental protection. In environmental information system development and implementation, resource accounting data are of great importance – cadastral data, information on the country's socio-economic situation and development tendencies provided by the national statistical data analysis and public opinion polling. Effective decision-making in environmental protection is possible only if all the available information is analysed.

Sometimes the environmental monitoring information – which is an essential part of the environmental information system – is stored in various institutions, in the databases of different size and accessibility or only on paper. This factor makes it difficult for the interested persons – the public, decision-makers, experts – to obtain and use this information for environmental problem-solving or decision-making. Unfortunately, it is often impossible to know whether the monitoring data are being aggregated and made available.

Environmental monitoring is divided into the environmental situation, environmental policy implementation and early warning monitoring.

The environmental situation monitoring consists of systematic observations carried out in different natural environments in order to detect and assess changes caused by natural processes or anthropogenic impacts. This includes the monitoring of emission, spreading and concentration of pollutants and assessment of the status of ecosystems, including the development of proposals for ecosystem quality improvement. The monitoring of environmental situation is carried out regularly in order to obtain information on environmental conditions and changes, and also, in specific cases, to assess the environmental condition changes after an accident or after the implementation of an environmental protection programme or to obtain information on the environmental impact of a particular object.

The policy implementation monitoring is a systematic assessment of environmental changes effected through the implementation of environmental policy measures. This is one of the key elements in the development of environmental policy and assessment of its effectiveness as it helps to ascertain the causes which impede the attainment of environmental quality targets in conformity with the environmental quality regulations and standards.

The main functions of the early warning monitoring is early detection of dangerous changes in environmental quality, fast-track provision of information and making of short-term forecasts.

The execution of an environmental monitoring programme is coordinated by the state institution of appropriate level. This institution is also responsible for public access to the information on pollutants and monitoring results on the Internet. In addition, it prepares and provides the required information

Figure 11.10. **Environmental sampling to monitor tasks**

for the European Environment Agency and the European Commission.

The implementation of the programme helps to avoid duplication in the environmental monitoring work, when several institutions perform similar functions for limited state budget funds. The environmental monitoring programme also ensures monitoring in the areas which are important at both national and EU levels. These programmes primarily consist of the following components:

- air monitoring,
- water monitoring,
- soil and land surface overgrow monitoring,
- biodiversity monitoring,
- radioactive contamination monitoring,
- climate change monitoring.

Each part of the programme provides information on such aspects as monitoring objectives, legislation stipulating the need for monitoring, criteria for environmental quality assessment, indicators, priorities and funding necessary for the execution of the programme.

Furthermore, each part of the programme consists of monitoring subprogrammes. Each subprogramme contains such data as the monitoring network description, inspection schedule, parameters to be determined, actual and potential methods to be used, development tasks, necessary maintenance costs and investments. The executor of the specific monitoring programme part creates and maintains one's own monitoring data processing system in accordance with the legislative requirements for national information systems.

Environmental monitoring information is structured according to the principle of causality, grouping the data in a logical five-phase model: driving force – load – condition – impact – action.

ENVIRONMENTAL POLICY AND ENVIRONMENTAL QUALITY INDICATORS

In the 1970s, reports in different fields were started to be prepared according to the principle of causality, logically grouping the characteristic variables into the causal model, later on extended into the five-phase model by the Organisation for Economic Co-operation and Development (OECD). The characteristic variables contained in the analytical model are called indicators.

The indicators are integrated into a single causal chain, showing:

- what causes the problem;
- why it occurs;
- what are its effects;
- how and by what means the problem can be solved.

Certain methodological requirements are set for the indicators, so that countries and specialists could come to an understanding when they are published and interpreted in various reports. The

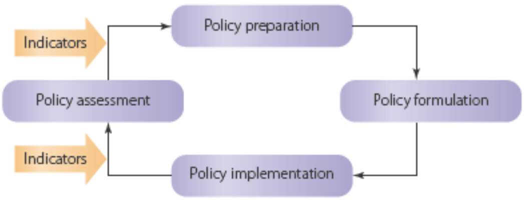

Figure 11.11. **Policy cycle and indicators**

indicators must be credible, represent certain time periods and regions, scientifically accurate, obtained through standardised methodologies, expressed in standardised units, verifiable, easily perceptible and comprehensible, comparable, non-duplicating, necessary to users, sensitively reacting to changes, predictive of processes and ensuring acquisition of information at a reasonable cost.

The main function of indicators is to provide information during the decision-making process and to adjust different levels of policy according to the policy cycle scheme.

The use of sustainable development indicators in such a scheme is focused on the interaction links between the traditional indicators, but the synergistic effects in such a complex system are stronger as the direct cause-effect interactions.

Integrating economic, environmental and social issues, the following factors are taken into account:

- sectoral and sectoral strategic plans and programmes, indicating how environmental issues are integrated into these plans and programmes;
- whether appropriate action plans with specific time and resource planning have been developed;
- what environmental policy measures and methods are used in the particular sector;
- what general-purpose policy measures function particularly widely and effectively;
- what the major projects of environmental protection or conducive to environmental protection are.

Granting environmental issues a dominant or equal status compared to economic and social issues, the system is supplemented by sectoral indicators, creating mutual integration (at the policy level – the integration of environmental issues in sectoral policies; at the indicator level – eco-efficiency and energy intensity estimates, analysis of environmental profiles).

Under the EU Sustainable Development Strategy, EUROSTAT uses approximately 100 indicators, while the headline indicators characterise the key directions of sustainable development (socioeconomic development, sustainable consumption and production, social inclusion, demographic changes, public health, climate change and energy, sustainable transport, natural resources, global partnership, good governance).

Table 11.2. **EU Sustainable Development Strategy implementation progress for the period between 2000 and 2009**

SDI theme	Headline indicator	EU-27 evaluation of change
Socio-economic development	Growth of GDP per capita	☀
Climate change and energy	Greenhouse gas emissions*	☁
	Consumption of renewables	☁
Sustainable transport	Energy consumption of transport relative to GDP	⛅
Sustainable consumption and production	Resource productivity	☀
Natural resources	Abundance of common birds**	⛅
	Conservation of fish stocks***	⛈
Public health	Healthy life years****	⛅
Social inclusion	Risk of poverty****	⛅
Demographic changes	Employment rate of older workers	⛅
Global partnership	Official development assistance*****	⛈
Good governance	[No headline indicator]	:

* EU-15 ** Based on 19 Member States *** In North East Atlantic
**** EU-25, from 2005 ***** From 2005

☀	Clearly favourable change/on target path	☁	Moderately unfavourable change/far from target path
⛅	No or moderately favourable change/ close to target path	⛈	Clearly unfavourable change/moving away from target path
:	Contextual indicator or insufficient data		

11.5.7 FURTHER DEVELOPMENT OF THE PROCESS

For a better assessment of the progress made, and to ensure the communication of the results to the public, a few questions have to be answered in the first place: have all plans been fully implemented? Have the planned results been achieved?

General environmental quality indicators should be used in order to ascertain whether the measures taken have led to the expected environmental situation improvement. For example, if the city's thermal power plant is modified to replace peat fuel with natural gas, the expected result in reducing nitrogen dioxide emissions from the power plant to the planned level can be fully achieved. Nevertheless, the overall air quality improvement effect can be relatively low as the atmospheric concentration of NO_2 remains about the same as in previous years. Apparently, not enough attention has been paid to another source of NO_2 – transport, which in many cases is the main source of NO_2 pollution in cities.

The reasons for not fully achieving the planned results have to be analysed. Environmental monitoring data will also show which objectives of the programme have been achieved and in which cases adjustments are necessary in order to make progress towards what has not been achieved yet. Admittedly, it could be quite an unpleasant situation, because nobody wants to assume responsibility for mistakes. However, it is essential to know the real reasons, not just carry out formal investigation. Emphasis should be put on shared learning from mistakes, so that the implementation of measures would get better in the next stage, given the actual capabilities of employees and budget allocation.

The programme implementation results should be communicated to the public through the mass media, creating conditions for the public to express comments and discussions. Only in this way people can get the true information on the process that has taken place and its outcomes. It could also be the basis for future discussions on the adjustments necessary to the environmental measures.

In essence, the whole process can be likened to a continuous spiral, not to a closed circle, for each successive loop is a little more advanced than the previous one and strives toward the ultimate goal – a sustainable society. Even if the ultimate goal is not reached in the near future, society will still seek to mitigate the impact on the environment both locally and globally.

11.6 VOLUNTARY MEASURES OF ENVIRONMENTAL POLICY

Any form of business or production as well as any individual action can have an impact on the environment, causing environmental degradation. At the same time, the public interest in environmental issues and the impact of specific manufacturing processes or companies on the environment is increasing. In addition, the lawmakers are also interested to make the operations of companies, plants, industrial units comply with the requirements of the law, whereas consumers want them to operate or provide services in an environment-friendly way. Finally, employees also want to work in a safe and healthy work environment.

An environmental management system helps satisfy the interests of everyone by establishing certain requirements or principles related to processes and products, by preparation of information, as well as by granting companies and plants certification of an independent authority (certification organisation) that they meet certain requirements.

In this way, not only those concerned can feel safe and have assurance but also every company is enabled to make its business comply with the environmental requirements, as it has an opportunity:

- to identify and assess the company's impact on the environment,
- to formulate the company's intentions in the area of environmental protection (the company's environmental policy and environmental protection objectives),
- taking into account the financial and technical capabilities, to develop the company's environmental programme aimed at systematic and targeted reduction of the negative impacts,
- to know the legal requirements regulating the company's business activity,
- to perform accountancy of the company's resources and analysis of the environmental pollution caused.

The International Organisation for Standardisation (ISO) is a worldwide federation of national standardisation organisations, which brings together approximately 100 countries. ISO is a public organisation established in 1947.

Figure 11.12. **Emblem of the International Organisation for Standardisation**

The ISO 14001 standard developed by the International Organisation for Standardisation is a global-scale environmental standard.

The EU Eco-Management and Audit Scheme (EMAS) was developed and implemented as a management tool to promote environmental protection, wise use of resources and improvement of public information activities at the companies and organisations that voluntarily participate in the system.

In the EU Member States, this system works since 1995, initially involving industrial enterprises. As of 2001 – after the adoption of the European Commission Regulation (EC) 761/2001 allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS) – the system is open to all organisations. Upon completing the necessary preparation, any enterprise, company, institution and municipality can participate in this system. The companies and organisations which are included in the EMAS register obtain the right to use the EMAS logo.

In 2009, the Commission decided to extend this environmental management system to all its activities and buildings in Brussels and Luxembourg as described in Decision C (2009) 6873. The European Commission recognises the positive contribution it can make to sustainable development as a long-term goal through its policy and legislative processes as well as in its day-to-day operations and decisions.

To be more specific, the Commission commits to minimise the environmental impact of its everyday work and continuously improve its environmental performance by:

- taking measures to prevent pollution and to achieve more efficient use of natural resources (mainly energy, water and paper);
- taking measures to reduce overall CO_2 emissions (mainly from buildings and transport);
- encouraging waste prevention, maximising waste recycling and reusing and optimising waste disposal;
- integrating environmental criteria into public procurement procedures and into the rules regarding the organisation of events;
- complying with relevant environmental legislation and regulations;
- stimulating the sustainable behaviour of all staff and subcontractors through training, information and awareness raising actions;
- progressively extending all the above to all its activities and buildings;
- systematically assessing the potential economic, social and environmental impacts of major new policy and legislative initiatives and promoting the systematic integration of environmental objectives into Community policies;
- ensuring the effectiveness of environmental legislation and funding in creating environmental benefits;
- promoting transparent internal and external communication and dialogue with all interested parties.

Organisations are registered with the competent national authority that assesses the applicant's compliance with the requirements of the Regulation, registers organisations and decides on their removal from the register temporarily or permanently.

Pursuant to the requirements of the Regulation, a participating organisation should, involving and educating all its employees, identify environmental problems, develop an environmental policy, establish and implement an environmental management system and internal auditing system and draw up an environmental statement, which includes information on what has been accomplished and what is planned for the future. The environmental management and audit system of the organisation is inspected by an independent, accredited environmental assessor (verifier), who also approves the environmental statement.

The information included in the environmental statement is updated on a regular basis and is freely available to the public and all interested persons.

With the emergence of 'green' marketing, 'green' consumer organisations began to develop as well. Consumer protection authorities have been active already since the 1960s. Marking of goods to indicate that they are environment-friendly has been promoted in many countries, including USA, Canada, Germany and Sweden. In most cases, independent agencies measure certain products against similar products to determine which of the compared products cause less environmental impact. Germany was among the first countries introducing the 'green' labelling of goods (1978).

Figure 11.13. **EU EMAS and Eco-labelling emblems**

In the EU eco-label system, ecological criteria are developed for each group of goods or services. These criteria are aimed at reducing the product environmental impacts throughout their life cycle – from manufacture to disposal. The criteria are developed by expert working groups under the guidance of the presiding Member State, in consultation with the representatives of all interested parties (manufacturing and retail businesses, state and public consumer protection and environmental protection organisations).

This was one of the ways to influence consumer behaviour, helping them to identify the environmental impact of products. Eco-label also requires manufacturers to address environmental protection issues and reduce environmental impact.

The eco-labelling process helps to determine the impact on the environment and build an informative link between producers, traders and consumers. However, in eco-labelling the attention is paid to the product and almost none to the production and distribution processes. Consequently, an environment-friendly product can be manufactured in a company causing extensive pollution, or this product can cause damage to the environment or human health after its use.

11.7 EU ENVIRONMENTAL MANAGEMENT INSTITUTIONS[1]

11.7.1 EU DIRECTORATE-GENERAL FOR THE ENVIRONMENT

Many EU countries have long environmental protection traditions, which are also reflected in their environmental law. In some countries – for example, in the Mediterranean – environmental protection issues have received less attention. Increasing integration of the EU requires supporting the implementation of the most effective environmental policies at a much larger scale. It is also necessary to ensure a common framework of environmental law, uniform monitoring methodology and standards. These issues are the competence of the European Commission's Directorate-General for the Environment.

The Directorate-General (DG) for the Environment is one of the more than 40 Directorates-General and services that make up the European Commission. Commonly referred to as DG Environment, the objective of the Directorate-General is to protect, preserve and improve the environment for present and future generations. To achieve this it proposes policies that ensure a high level of environmental protection in the

Figure 11.14. **European Union flags outside the Commission building**

[1] This chapter is prepared based on the materials of the home page of the EU Directorate-General for the Environment – *http://ec.europa.eu/environment/index_en.htm*

European Union and that preserve the quality of life of EU citizens.

The DG makes sure that Member States correctly apply EU environmental law. In doing so it investigates complaints made by citizens and non-governmental organisations and can take legal action if it deems that EU law has been infringed. In certain cases DG Environment represents the European Union in environmental matters at international meetings.

GENERAL OBJECTIVES OF DG ENVIRONMENT

> In the current crisis, part of our economic activity is coming from the stimulus to demand. But we cannot rely forever on a short-term stimulus. New sources of growth will have to take up the baton – sources of growth that are sustainable. Sustainability means keeping up the pace of reform, targeting our skills and technology on tomorrow's competitiveness and tomorrow's markets; modernising to keep up with social change; and ensuring that our economy can respect the need to protect the European environment, its countryside, its maritime zones, and its biodiversity.
>
> José Manuel Barroso, September 2009
> Political guidelines for the next Commission

Environment policy is a fundamental pillar in ensuring green growth in the EU and the shift to a low carbon and resource efficient economy. To serve this purpose these are the general objectives of DG Environment:

- to contribute to a high level of quality of life and well-being for citizens, by aiming to secure an environment where the level of pollution does not give rise to harmful effects either on human health or on the environment and by supporting the development of a greener and more resource efficient economy;
- to ensure a high level of environmental protection by promoting measures at international level to deal with regional or worldwide environmental problems;
- to preserve, protect and improve the quality of the environment by promoting and supporting the implementation of environmental legislation and the integration of environmental protection requirements into the definition and implementation of other EU policies and activities, with a view to promoting sustainable development.

The Sixth Environment Action Programme of the European Community (2002–2012) takes a broad look at the environmental challenges and provides a strategic framework for the Commission's environmental policy up to 2012. Every year the Directorate General makes public its priorities for the upcoming year and also publishes a yearly report on the preceding year's policy initiatives.

DG ENVIRONMENT MANAGEMENT PLAN FOR 2010: MISSION STATEMENT AND CHALLENGES

(by Karl Falkenberg,
Director General of DG Environment)

The main role of DG Environment is to initiate and define new environment policy and legislation, to promote integration of environmental concerns into other policy areas, and to ensure that agreed policy measures are implemented effectively in the EU Member States. Its mission statement is 'protecting, preserving and improving the environment for present and future generations, and promoting sustainable development'.

The political guidelines highlight that the exit from the crisis should be the point of entry into a new sustainable social market economy, a smarter, greener economy, where our prosperity will come from innovation and from using resources better, and where the key input will be knowledge. Conserving energy, natural resources and raw materials, using them more efficiently and increasing productivity will be the key drivers of the future competitiveness of our industry and our economies. Consequently, developing a resource efficient low-carbon economy and stimulating green innovation, growth and jobs are among the main priorities of the EU-2020 Strategy.

Harnessing the environment policy contribution to this goal will mean putting in place the right mix of smart regulation, incentives and market-based mechanisms to foster eco-innovation, sustainable consumption and production and these considerations will underpin all our work. Exploiting the resource potential of waste streams, an action plan for eco-innovation and reviewing the Environment Technology Action Plan, the Thematic Strategy on Natural Resources and the Waste Thematic Strategy will be part of the contribution from environment policy to improve resource efficiency.

The threats from biodiversity loss are becoming clearer and the failure to meet interim goals on biodiversity loss cannot continue. The real value of ecosystems must be recognised and the link between biodiversity conservation and greenhouse gas mitigation should be fully explored. New EU and global targets will have to be agreed in 2010 and a new realistic – but ambitious – action plan for biodiversity will have to be designed and negotiated. Further initiatives are required to protect endangered species of fauna and flora and to address illegal logging and deforestation worldwide. Achieving and maintaining good soil quality is essential in a world where resources are becoming increasingly scarce and there is increased competition for land use from transport, energy, food production and nature preservation and adoption of the Commission proposal by the Council will support this goal. A coherent forest information system for the EU will also be an important element.

With the adoption of REACH, the new law entered into force on 1 June 2007. (REACH is a European Community Regulation on chemicals and their safe use (EC 1907/2006). It deals with the Registration, Evaluation, Authorisation and Restriction of Chemical substances.) The EU has set the benchmark for chemicals policy. But it is the implementation of REACH which will determine its effectiveness and will be a key area of cooperation with DG ENTR (Directorate-General for Enterprise and Industry) and ECHA (European Chemicals Agency). Registration of chemicals by industry, appropriate evaluation by authorities and substitution of substances of very high concern are key to ensure the safety of chemicals and will also stimulate innovation in the chemical industry. Ensuring a successful co-decision outcome on biocides constitute further important elements to increase the chemical industry's sustainability. Nanotechnology is also rapidly developing and can bring benefits to the environment and contribute to economic growth, but can only flourish if its safety is ensured by a clear regulatory framework. It is more important than ever to focus on using water resources more efficiently, exploiting the potential for water savings and on keeping water clean. Implementing the Water Framework Directive and the Marine Strategy Framework Directive effectively will be essential and will depend on implementation of the urban wastewater and nitrate directives in particular. But it will also require a cross-cutting approach involving support from other sectoral policies.

Air quality legislation brings substantial health and environmental benefits. We need to investigate in more detail the underlying causes of implementation problems in some Member States so that the environmental and health benefits from better air quality are secured. In this context the adoption of the revised proposal on industrial emissions by Council and Parliament is important. In addition, the pending Commission proposal for a revision of the directive on national emission ceilings of certain air pollutants will be re-examined.

Implementation of our legislation maintains environmental progress and ensures that the health and environmental benefits intended from proposals at the time of their adoption actually materialise. Implementation gaps notably in the areas of waste and nature legislation have to be addressed.

Increasingly, progress in environment policy depends on measures taken in other policy areas – such as transport, energy or agriculture – to address the drivers of environmental degradation. We must therefore ensure that environmental objectives are mainstreamed into other Community policies and reflected in the preparation of the future multiannual Financial Perspectives for the 2014–2020 period.

Improving and refining our knowledge base through better information, better management of information systems and the development of appropriate indicators will help target environment policy as efficiently and as effectively as possible. Following up on our communication on *GDP and Beyond*, we will work to develop complementary indicators to GDP to measure societal welfare and progress more appropriately. We will work with the EEA (European Economic Area) and the Member States on an implementation plan to see how a shared environmental information system could be put in place. 2010 is the international year of biodiversity, and among other communication activities, a special focus on this theme is planned.

Environmental challenges are increasingly global and moving towards a green economy and sustainable production and consumption patterns requires action well beyond EU borders.

The EU is a global leader in developing environment policy and has an important role to play in improving international environmental governance, in particular through multilateral environmental agreements, and ensuring positive synergies with other polices, in particular trade and development, and the growing significance of the environmental impact of emerging economies. We also need to build alliances and promote global solutions in several areas e.g. in chemicals, in order to capitalise on our experience with REACH.

The 6th Environment Action Programme will be assessed to help assess how policies on air, water, waste, biodiversity and chemicals can be further improved. Environment and health threats from issues such as endocrine disruptors and chemical mixtures will also be addressed.

EC DG Environment

Commissioner for the Environment DG
Janez Potočnik

Office of the Director-General

Directorate A: Legal Affairs and Cohesion
Directorate B: Nature
Directorate C: Industry
Directorate D: Water, Chemicals and Biotechnology
Directorate E: International Affairs
Directorate F: Strategy
Shared Resources Directorate

Figure 11.15. **Structure of the Directorate-General for the Environment of the European Commission**

EUROPEAN ENVIRONMENT AGENCY[2]

The task of the European Environment Agency (EEA) is to provide sound, independent information on the environment. EEA is a major information source for those involved in developing, adopting, implementing and evaluating environmental policy, and also the general public. Currently, the EEA has 32 member countries.

The regulation establishing the EEA was adopted by the European Union in 1990. It came into force in late 1993 immediately after the decision was taken to locate the EEA in Copenhagen. Work started in

[2] This section is prepared based on the materials of the home page of the European Environment Agency – *http://www.eea.europa.eu/*

Figure 11.16. **EEA member countries and cooperating countries**

earnest in 1994. The regulation also established the European environment information and observation network (Eionet).

EEA's mandate is:

- to help the Community and member states make informed decisions about improving the environment, integrating environmental considerations into economic policies and moving towards sustainability;
- to coordinate the European environment information and observation network (Eionet).

The main clients are the European Union institutions – the European Commission, the European Parliament, the Council – and member countries. In addition to this central group of European policy actors, EEA also serve other EU institutions such as the Economic and Social Committee and the Committee of the Regions.

The business community, academia, non-governmental organizations and other parts of civil society are also important users of our information. EEA try to achieve two-way communication with clients in order to correctly identify their information needs, and make sure that the information provided is understood and taken up by them.

The EEA Information Centre gives individual responses to external requests for information and is open to the general public every working day. The EEA provides assessments and information in the form of reports, short briefings and articles, press material and online products and services. The material covers the state of the environment, current trends and pressures, economic and social driving forces, policy effectiveness, and identification of future trends, outlooks and problems, using scenarios and other techniques.

Summaries of major reports and various articles and press releases are often translated into the official languages of EEA member countries.

In February 2008, the European Commission proposed to establish a European Shared Environmental Information System (SEIS) – a web-based system where public information providers share environmental data and information. SEIS will bring together existing data flows and information related to EU environmental policies and legislation and make it easily accessible to both policy-makers and citizens. A major challenge will be to develop SEIS as a platform for two-way communication, enabling users to upload and share information.

Over the coming years, EEA and Eionet will work together with the European Commission and other stakeholders to implement SEIS. It will be done by building on existing reporting systems and tools (Reportnet), initiatives related to e-Government, the Infrastructure for Spatial Information in Europe (INSPIRE), Global Monitoring for Environment and Security (GMES) and the Global Earth Observation System of Systems (GEOSS).

The EEA Management Board consists of one representative of each of the member countries, two representatives from DG Environment and DG Research of the European Commission and two scientific experts designated by the European

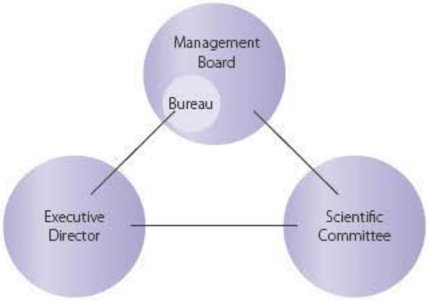

Figure 11.17. **EEA governance**

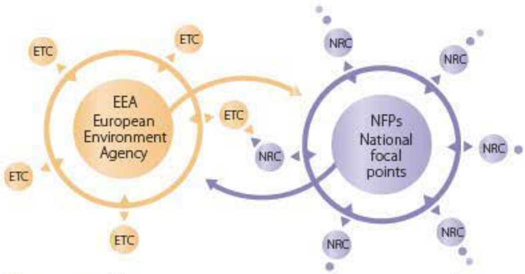

Figure 11.18. **European environment information and observation network**

Parliament. Among its tasks, the Management Board adopts the EEA's work programmes, appoints the Executive Director and designates the members of the Scientific Committee. The Committee is the advisory body on scientific matters to the Management Board and the Executive Director.

The Executive Director is responsible to the Management Board for implementing the work programmes and for the day-to-day running of the EEA.

The EEA organises its activities in yearly work programmes, overarched by a five-year strategy and multiannual work programme. The current strategy covers the period 2009–2013.

The information provided by the EEA comes from a wide range of sources. A network of national environmental bodies was set up to work with the EEA – the European environmental information and observation network (Eionet) – which involves over 300 institutions across Europe. The EEA is responsible for developing the network and coordinating its activities. To do this, EEA work closely with national focal points (NFPs) – typically national environment agencies or environment ministries in member countries. They are responsible for coordinating the activities of Eionet at national level. The main tasks for the national focal points are to develop and maintain the national network, identify national information sources, capture and channel data and information from monitoring and other activities, help the EEA analyse the information collected and assist in communicating EEA information to end-users in member countries.

Other important partners and sources of information for the EEA are European and international organisations, such as the Statistical Office (Eurostat) and the Joint Research Centre (JRC) of the European Commission, the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme (UNEP), the Food and Agriculture Organization (FAO), and the World Health Organization (WHO). The EEA cooperates closely with these organisations in producing information and assessments for its clients and target groups.

11.8 EU NATURE AND ENVIRONMENTAL PROGRAMMES[3]

Figure 11.19. **Some of the programmes of the European Commission's Directorate-General for the Environment**

Sectoral environmental management comprises separate environmental sectors and deals with general environmental issues in all sectors of national economy in relation to:

- natural resources (soil quality, air and water protection, subsoil use and protection);
- nature protection (protection of species and habitats, management of specially protected areas);
- waste management (municipal waste, packaging, environmentally harmful trade waste, discarded electronic equipment and vehicles);

[3] The following chapter is prepared based on the materials of the home page of the EU Directorate-General for the Environment – *http://ec.europa.eu/environment/index_en.htm*

- production processes (industrial pollution, hazardous waste, use of chemical substances and products, nuclear safety and radiation protection);
- general environmental problems (climate change, emission trading, protection belts, protection against noise, natural resources tax);
- water use (surface water quality, drinking water, wastewater treatment).

11.8.1 BIODIVERSITY CONSERVATION PROGRAMMES

Wilderness and large natural areas are areas which are and have been for a long time relatively little influenced by man and in which natural processes are going on relatively undisturbed. They are very rare in Europe. Some larger ones are found especially on the mountains and northern and eastern geographical limits of Europe. Smaller wild areas are found scattered all around Europe. Despite the relatively small overall area these areas form an important part of Europe's natural heritage. They host natural processes which are vitally important to a number of species and hence are of significant importance in order to obtain the EU's objective of halting the loss of biodiversity. They are healthy and resilient ecosystems which offer also many important possibilities in Climate change mitigation and adaptation. Carbon sequestration, flood mitigation, erosion control, water purification and pollution alleviation are examples of the valuable ecosystem services they offer.

The conservation status of these wild areas varies drastically between countries according to their biogeographical location, fauna, flora, cultural meaning and history. Often these areas are subject to conservation measures and some countries have given special legislative status and definition of their own for wilderness areas.

Figure 11.20. **Northern European natural environment is characterised by high biodiversity and incidence of species rare in other European Union countries**

The overall strategic objectives of the national programmes for biodiversity conservation are as follows:

- to preserve and restore ecosystem and the diversity of its natural structure,
- to maintain and enhance local wild species diversity,
- to preserve the genetic diversity of wild species as well as cultivated plants and domestic animals,
- to enhance the traditional landscape structure preservation,
- to ensure a balanced and sustainable use of biological resources.

The national programmes of biodiversity conservation of the Baltic Sea Region countries mostly pertain to:

- the Baltic Sea and bays,
- beaches and dunes,
- rivers and lakes,
- forests,
- swamps,
- fields,
- meadows and pastures,
- rock outcrops and caves,
- karst sink-holes,
- ecosystems of populated places,
- species protection,
- protection of varieties of cultivated plants and domestic animals.

Sustainable use of natural resources should be provided in the following economic sectors: forestry, agriculture, fisheries, game management, tourism and leisure, construction, power industry, transport, public utilities, urban environment, mineral mining, peat and sapropel extraction as well as national defence.

According to a preliminary survey, 99% of protected areas in the EU are covered by the *Natura 2000* network, i.e. Member states have the legal obligation under the Birds and Habitats Directives (the EU nature legislation) to ensure inter alia the maintenance of the integrity of the sites and a favourable conservation status of the habitats and species of European importance included in those areas.

A European Parliament Resolution on Wilderness in Europe emphasized the importance of wilderness areas and called on action to protect these areas. The Commission hosted together with the Czech Presidency a Conference on Wilderness and Large Natural Habitat Areas in Europe on 28–29 May 2009 in Prague. As a follow-up to this conference, the Commission is developing specific guidance on the protection and management of wilderness areas in the context of the EU nature legislation.

Natura 2000 is the centrepiece of EU nature and biodiversity policy. It is an EU-wide network of nature protection areas established under the 1992

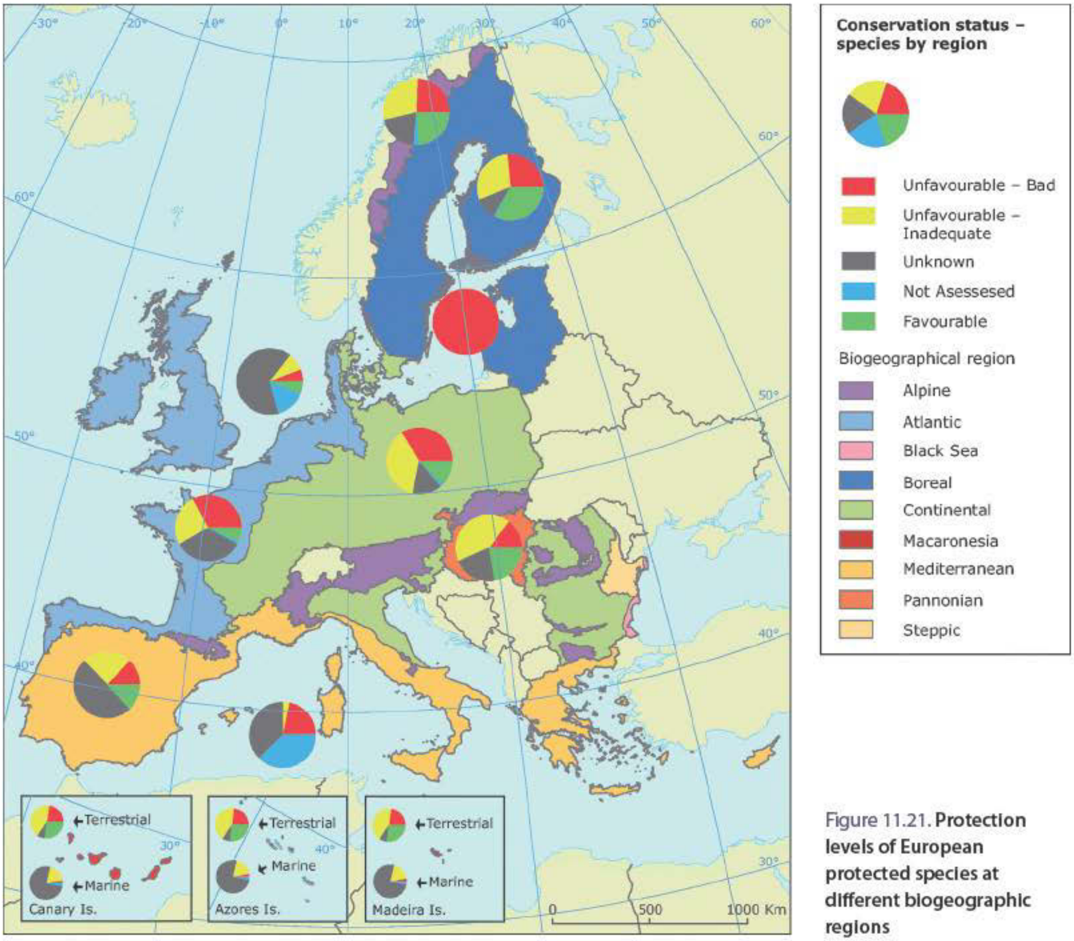

Figure 11.21. **Protection levels of European protected species at different biogeographic regions**

Habitats Directive. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. It is comprised of Special Areas of Conservation designated by Member States under the Habitats Directive, and also incorporates Special Protection Areas which they designate under the 1979 Birds Directive. *Natura 2000* is not a system of strict nature reserves where all human activities are excluded. Whereas the network will certainly include nature reserves most of the land is likely to continue to be privately owned and the emphasis will be on ensuring that future management is sustainable, both ecologically and economically. The establishment of this network of protected areas also fulfils a Community obligation under the UN Convention on Biological Diversity.

Figure 11.22. ***Natura 2000*** **logo. Motto –'*Natura 2000* – Europe's nature for you'**

Natura 2000 applies to Birds Sites and to Habitats Sites, which are divided into biogeographical regions. It also applies to the marine environment.

The *Natura 2000* Barometer gives updated statistical information on the progress in establishing the *Natura 2000* network, both under the Birds and the Habitats Directives. The *Natura 2000* Barometer gives an evaluation on the progress made in establishing the *Natura 2000* network, both under the Birds and the Habitats Directives. It is based on information on number of sites and areas covered, as indicated by Member States and is published in the *Natura 2000* Newsletter.

The statistics are provided twice a year by the European Topic Centre on Biological Diversity in Paris.

11.8.2 CLEAN AIR FOR EUROPE PROGRAMME

Air pollution seriously damages human health and the environment: respiratory problems, premature deaths and damage to ecosystems as a result of the deposition of nitrogen and acidic substances are some of the consequences of this problem which is both local and transfrontier in nature. The pollutants causing the greatest concern where public health is concerned are tropospheric ozone and especially particulate matter (in particular fine particles or $PM_{2.5}$).

The aim of the Clean Air for Europe (CAFE) Programme is to establish a long-term, integrated strategy to tackle air pollution and to protect against its effects on human health and the environment. The Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management, and a number of daughter Directives had already been adopted to improve air quality. Strategies have also been formulated to combat acidification, ozone and eutrophication, notably via the Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.

Figure 11.23. **Nelson's Column in London during the Great Smog of 1952**

Early in December 1952, a cold fog descended upon London. Because of the cold, Londoners began to burn more coal than usual. The resulting air pollution was trapped by the inversion layer formed by the dense mass of cold air. Concentrations of pollutants, coal smoke in particular, built up dramatically. The problem was made worse by use of low-quality, high-sulphur coal for home heating in London. During the four day period of fog, at least 4 000 people died as a direct result of the weather.

Existing Community measures and proposals to improve air quality had established:

- target values for air quality;
- national emission ceilings to tackle transboundary pollution;
- integrated pollution-reduction programmes in targeted areas;
- specific measures to limit emissions or raise product standards.

CAFE lays the basis for the first of the thematic strategies announced in the Sixth Environmental Action Programme.

CAFE's objectives are:

- to develop, collect and validate scientific information on the effects of air pollution (including validation of emission inventories, air quality assessment, projections, cost-effectiveness studies and integrated assessment modelling);
- to support the correct implementation and review the effectiveness of existing legislation and to develop new proposals as and when necessary;
- to ensure that the requisite measures are taken at the relevant level, and to develop structural links with the relevant policy areas;
- to develop an integrated strategy (by 2004 at the latest) to include appropriate objectives and cost-effective measures. The objectives of the first programme phase are: particulate matter, tropospheric ozone, acidification, eutrophication and damage to cultural heritage;
- to disseminate the information gathered during the programme among the general public.

The strategy chosen sets health and environmental objectives and emission reduction targets for the main pollutants. These objectives will be delivered in stages, and will make it possible to protect EU citizens from exposure to particulate matter and ozone in air,

Table 11.3. **Direct and indirect impacts addressed in the CAFE**

	$PM_{2.5}$	SO_2	NO_x	VOC_s	NH_3
Direct impacts					
Tropospheric ozone formation, leading to effects on health, crops, materials and ecosystems			✓	✓	
Health impacts from primary pollutants and secondary pollutants (ozone and aerosols)	✓	✓	✓	✓	✓
Ecosystem acidification		✓	✓		✓
Ecosystem eutrophication			✓		✓
Damage to building and other materials		✓	✓		
Indirect impacts					
Changes in greenhouse gas emissions as a result of measures employed to control CAFE pollutants	✓	✓	✓	✓	✓
Wider social and economic effects from impacts and the measures recommended for their control	✓	✓	✓	✓	✓

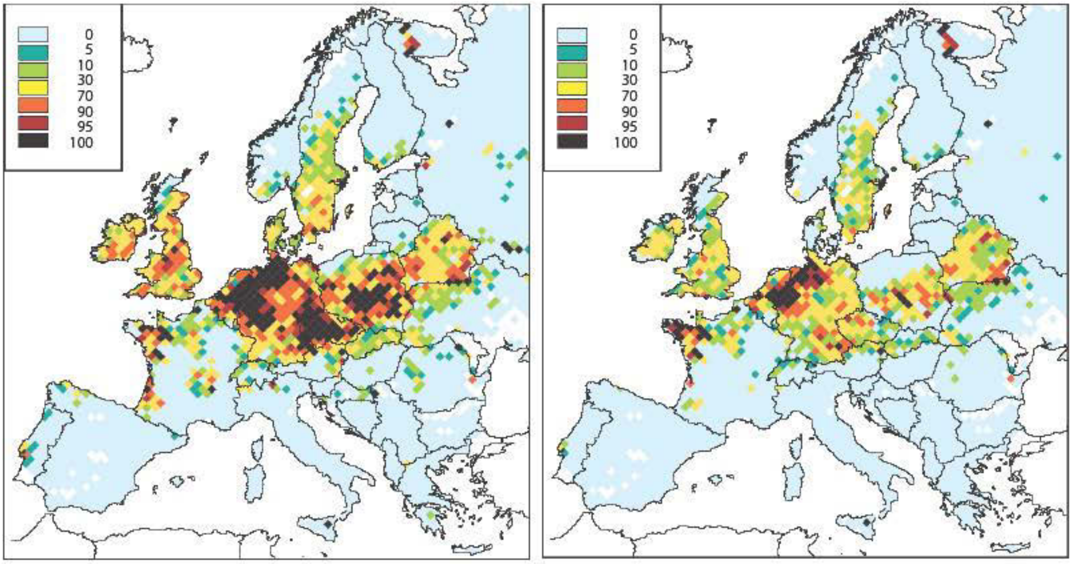

Figure 11.24. **Percentage of total ecosystem area receiving nitrogen deposition above the critical loads for eutrophication for the baseline emissions for 2000 (the left panel), the current legislation case of the 'Climate policy' scenario in 2020 (the right panel)**

and protect European ecosystems more effectively from acid rain, excess nutrient nitrogen, and ozone. A significant reduction in these substances will have beneficial effects in terms of public health, and will also generate benefits for ecosystems.

The strategy sets specific long-term objectives for 2020:

- 47% reduction in loss of life expectancy as a result of exposure to particulate matter;
- 10% reduction in acute mortalities from exposure to ozone;
- reduction in excess acid deposition of 74% and 39% in forest areas and surface freshwater areas respectively;
- 43% reduction in areas or ecosystems exposed to eutrophication.

To achieve these objectives, SO_2 emissions will need to decrease by 82%, NO_x emissions by 60%, volatile organic compounds (VOC_S) by 51%, ammonia by 27%, and primary $PM_{2.5}$ (particles emitted directly into the air) by 59% compared with 2000.

Implementing the strategy will entail an incremental additional cost compared with spending on existing measures. This additional cost is likely to amount to EUR 7.1 billion per annum from 2020.

In terms of health, the savings that will be made as a result of the Strategy are estimated at EUR 42 billion per annum. The number of premature deaths should fall from 370 000 in 2000 to 230 000 in 2020 (compared with 293 000 in 2020 without the Strategy).

Where the environment is concerned, there is no agreed way to assign a monetary value to ecosystem

Table 11.4. **Implementing current EU legislation: core estimates of annual health damage due to air pollution in 2000 and projected in 2020 in EU-25, plus the difference between 2000 and 2020**

	2000 (EUR bn)		2020 (EUR bn)		Difference (EUR bn)	
	Low estimate	High estimate	Low estimate	High estimate	Low estimate	High estimate
O_3 mortality	1.12	2.51	1.09	2.43	0.03	0.08
O_3 morbidity	6.3	6.3	4.2	4.2	2.1	2.1
PM mortality	190.2	702.8	129.5	548.2	60.7	154.6
PM morbidity	78.3	78.3	54.1	54.1	24.2	24.2
Total	275.8	789.9	188.8	608.9	87.0	181.0

Table 11.5. **Implementing current EU legislation: annual non-health damages due to air pollution in 2000 and projected in 2020 in EU-25, plus the difference between 2000 and 2020**

	2000 (EUR bn)	2020 (EUR bn)	Difference (EUR bn)
Crops (ozone)	2.8	1.5	1.3
Materials	1.1	0.7	0.4
Total	3.9	2.2	1.7

damage or the likely benefits resulting from the strategy. However, there should a be a favourable impact as a result of reducing acid rain and nutrient nitrogen inputs, resulting among other things in better protection for biodiversity.

11.8.3 EU CLIMATE AND ENERGY PACKAGE

Climate change is already happening and represents one of the greatest environmental, social and economic threats facing the planet. The European Union is working actively for a global agreement to control climate change and is taking domestic action to achieve substantial reductions in its own contribution. It is also developing a European strategy for adapting to climate change.

The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) shows that the Earth's average surface temperature has risen by 0.76 °C since 1850. Most of the warming over the past 50 years is very likely to have been caused by emissions of carbon dioxide and other greenhouse gases from human activities.

AR4 describes warming and cooling effects on the planet in terms of radiative forcing – the rate of change of energy in the system, measured as power per unit area (W/m²). The report shows in detail the individual warming contributions (positive forcing) of carbon dioxide, methane, nitrous oxide, halocarbons, other human warming factors, and the warming effects of changes in solar activity. Also shown are the cooling effects (negative forcing) of aerosols, land-use changes, and other human activities. All values are shown as a change from pre-industrial conditions:

- total radiative forcing from the sum of all human activities is about +1.6 W/m²
- radiative forcing from an increase in solar intensity since 1750 is about +0.12 W/m²
- radiative forcing from carbon dioxide, methane, and nitrous oxide combined is very likely (> 90%) increasing more quickly during the current era (1750 – present) than at any other time in the last 10 000 years.

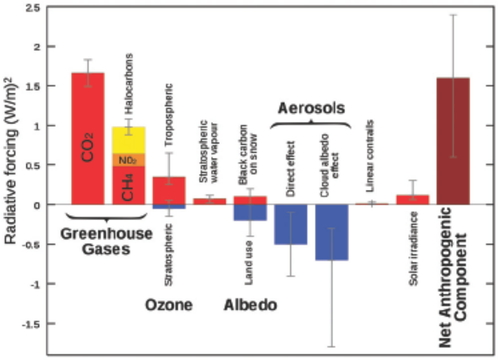

Figure 11.25. **Changes in radiative forcings between 1750 and 2005 as estimated by the IPCC**

Without action to reduce these emissions, the global average temperature is likely to rise by a further 1.8–4.0 °C in this century, and by up to 6.4 °C in the worst case scenario. Even the lower end of this range would take the temperature increase since pre-industrial times above 2 °C – the threshold beyond which many scientists believe irreversible and possibly catastrophic changes would become more likely.

The European Union has long been at the forefront of international efforts to combat climate change and was instrumental in the development of the two United Nations climate treaties, the 1992 UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, agreed in 1997. The EU has also been taking steps to limit its greenhouse gas emissions since the early 1990s.

In 2000, the European Commission launched the European Climate Change Programme (ECCP) which has led to the adoption of a wide range of new policies and measures, including the pioneering EU Emission Trading System.

In 2007, EU leaders endorsed an integrated approach to climate and energy policy and committed to transforming Europe into a highly energy-efficient, low carbon economy. They made a unilateral commitment that Europe would cut its emissions by at least 20% of 1990 levels by 2020. This commitment is being implemented through a package of binding legislation. EU Heads of State and Government set a series of demanding climate and energy targets (collectively they are known as the 20-20-20 targets) to be met by 2020. These are:

- reduction in EU greenhouse gas emissions of at least 20% below 1990 levels,
- 20% of EU energy consumption to come from renewable resources,
- 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

The EU leaders also offered to increase the EU's emission reduction to 30%, on condition that other major emitting countries in the developed and developing worlds commit to do their fair share

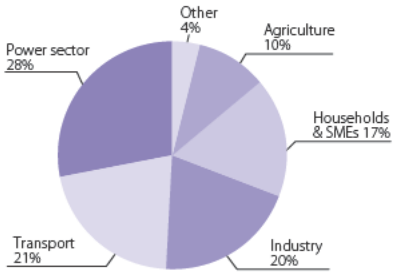

Figure 11.26. **Sources of EU greenhouse gas emissions**

Figure 11.27. **Shrinking of Fedchenko Glacier in the Pamirs of Tajigistan**

Figure 11.28. **Growing evidence of the cost of climate change points to one simple conclusion: we cannot afford to do nothing**

under a global climate agreement. United Nations negotiations on such an agreement are ongoing.

In January 2008, the European Commission proposed binding legislation to implement the 20-20-20 targets. This 'climate and energy package' was agreed by the European Parliament and Council in December 2008 and became law in June 2009.

The core of the package comprises four pieces of complementary legislation.

1) Revision and strengthening of the Emission Trading System (EU ETS), the EU's key tool for cutting emissions cost-effectively. A single EU-wide cap on emission allowances will apply from 2013 and will be cut annually, reducing the number of allowances available to businesses to 21% below the 2005 level in 2020. The free allocation of allowances will be progressively replaced by auctioning, and the sectors and gases covered by the system will be somewhat expanded.
2) Effort Sharing Decision governing emissions from sectors not covered by the EU ETS, such as transport, housing, agriculture and waste. Under the Decision each Member State has agreed to a binding national emission limitation target for 2020 which reflects its relative wealth. The targets range from an emission reduction of 20% by the richest Member States to an increase in emissions of 20% by the poorest. These national targets will cut the EU's overall emissions from the non-ETS sectors by 10% by 2020 compared with 2005 levels.
3) Binding national targets for renewable energy which collectively will lift the average renewable share across the EU to 20% by 2020 (more than double the 2006 level of 9.2%). The national targets range from a renewables share of 10% in Malta to 49% in Sweden. The targets will contribute to decreasing the EU's dependence on imported energy and to reducing greenhouse gas emissions.
4) Legal framework to promote the development and safe use of carbon capture and storage (CCS). CCS is a promising family of technologies that capture the carbon dioxide emitted by industrial processes and store it in underground geological formations where it cannot contribute to global warming. Although the different components of CCS are already deployed at commercial scale, the technical and economic viability of its use as an integrated system has yet to be shown. The EU therefore plans to set up a network of CCS demonstration plants by 2015 to test its viability, with the aim of commercial update of CCS by around 2020. Revised EU guidelines on state aid for environmental protection, issued at the same time as the legislative package was proposed, enable governments to provide financial support for CCS pilot plants.

Such agreement should take effect at the start of 2013 when the Kyoto Protocol's first commitment period will have expired. The Copenhagen Accord reached in December 2009 represents a step towards such an agreement. The EU is pressing for a global deal that is ambitious, comprehensive and legally binding.

International negotiations are under way to draw up a United Nations agreement to govern global action on climate change after 2012, when the first commitment period of the Kyoto Protocol expires. The European Union has taken a leading role in these negotiations and wants them to result as soon as possible in a comprehensive, ambitious, fair and science-based global agreement that is legally binding.

The EU sees the Accord as a basis for further progress and is working to make it operational at the earliest opportunity.

Like the Copenhagen Accord, the post-2012 agreement should aim to keep global warming below 2 °C above the pre-industrial temperature, equivalent to below 1.2 °C above today's level. It should cover all elements of the 2007 Bali Action Plan, which sets the agenda and scope of the international negotiations.

Scientific evidence shows that for the world to have a 50% chance of keeping within the 2 °C ceiling, global emissions of greenhouse gases need to peak by 2020 at the latest, be cut by at least 50% of their 1990 levels by 2050, and continue to decline thereafter.

These reductions can be achieved only through a worldwide effort involving developed and developing countries alike. However, the emission targets by developed countries and the emission actions by developing countries pledged under the Copenhagen Accord so far appear insufficient to keep warming below 2 °C.

Industrialised nations must take the lead by making deep emission cuts of 25–40% below 1990 levels by 2020 and of 80–95% by 2050. In this context the EU has made a unilateral commitment to cut its emissions in 2020 to at least 20% below 1990 levels, and is offering to scale up this reduction to 30% provided other major emitters in the developed and developing worlds take on their fair share of the mitigation effort under a global agreement.

Action by developing nations (except the least developed countries) is also needed to limit the rapid growth in their emissions. Overall, developing country pledges need to amount to a substantial deviation – in the order of 15–30% – below the currently predicted growth rate in their collective emissions by 2020.

The EU fully recognises that developing countries need financial assistance from industrialised nations and international institutions to help them mitigate emissions and adapt to climate change. The Copenhagen Accord foresees 'fast start' financing for the 2010–2020 period approaching a total of USD 30 billion (EUR 7.2 billion of which will come from the EU alone) and medium-term financing of USD 100 billion a year by 2020.

The EU's position on post-2012 global action is set out in two parts of conclusions representing the views of the Council of EU Environment Ministers and of the European Council.

The EU's position has been shaped by a series of policy papers from the European Commission. These papers have also served to stimulate international debate about more important issues.

Climate change: Commission invites to an informed debate on the impacts of the move to 30% cut of EU greenhouse gas emissions if and when the conditions are met. The European Commission today presented an analysis of the costs, benefits and options for moving beyond the EU's greenhouse gas reduction target for 2020 from 20% below 1990 levels to 30% once the conditions are met. At present these conditions have not been met. The measures taken to support energy-intensive industries against the risk of carbon leakage are also examined as required under the ETS (Emission Trading System) Directive. Reduction in EU emissions as a consequence of the economic crisis, together with a drop in carbon prices, has changed the estimations two years ago when the revised ETS was presented. Therefore, in light of the new data, an analysis of the implications of the different levels of ambition as a motor for modernising the EU economy and creating new jobs by promoting innovation in low-carbon technologies is provided. This analysis encompasses the efforts required in the main different sectors to reduce greenhouse gas emissions beyond 20%, up to 30%, looking also at the impacts of these efforts and the potential policy options to achieve them. The current context of constrained public finances and economic contraction is also fully taken into account when assessing possible alternatives.

Cost of meeting targets: Since 2008, the absolute costs of meeting the 20% target have decreased from EUR 70 billion to EUR 48 billion (0.32% of GDP) per year by 2020. This is due to several factors: lower economic growth has reduced emissions; higher energy prices have spurred energy efficiency and reduced energy demand; and the carbon price has fell below the level projected in 2008 as EU ETS allowances not used in the recession are carried forward. However, at the same time, this reduction in absolute costs comes in the context of a crisis which has left businesses with much less capacity to find the investment needed to modernise in the short run.

As of 2007, the EU is committed to move to a 30% emission cut by 2020 if other major economies take on their fair share of the effort under a global climate change agreement. The cost of reaching the 30% target is now estimated at EUR 81 billion per year by 2020, EUR 11 billion higher that the price tag for the 20% target two years ago. The 30% target would cost EUR 33 billion (0.2% of GDP) more than the 20% target is estimated to cost today.

Low-carbon growth: Countries worldwide are recognising the potential of green, low-carbon growth to create new sustainable jobs and strengthen energy security. Europe's lead in this revolution cannot be taken for granted as global competition becomes fiercer. The 20% target was seen as a critical driver for modernising the EU economy, but now, with carbon prices lower than expected, its potential as an incentive for change and innovation has decreased. Moreover, Europe has also to prepare its long term objectives, as part of the developed countries group, of achieving 80–95% reduction by 2050 at an optimal cost

Options for moving to 30%: There are options for meeting the 30% target within the EU ETS and in the other sectors. These include: reducing the number of auctioned allowances under the EU ETS; regulation to promote greater energy efficiency; smart use of fiscal instruments; directing EU cohesion policy

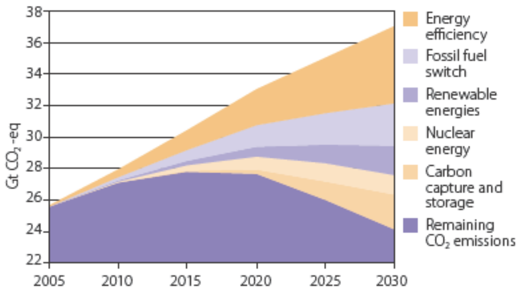

Figure 11.29. **Technologies that could reduce global CO_2 emissions from energy combustion**

funding towards green investments; and improving the environmental integrity of the international carbon credits recognised in the EU ETS.

A measure that is attractive even ahead of a possible move to 30% would be to use some unallocated free EU ETS industry allowances to accelerate innovation in low-carbon technologies, in a similar way to the existing demonstration programme for innovative renewable energy and carbon capture and storage technologies funded with 300 million allowances.

Carbon leakage: The Commission has examined the situation of energy-intensive industries with regard to the risk of carbon leakage (relocation of production from the EU to countries with laxer carbon constraints). The key conclusion is that the existing measures to prevent carbon leakage from these industries – free allowances and access to international credits – remain justified. The analysis also shows that raising the target to 30% while other countries implement their reduction pledges under the Copenhagen Accord would have a limited impact in terms of carbon leakage, provided the existing measures stay in place.

The Commission will continue closely to monitor the risk of carbon leakage, particularly in relation to third countries which have not yet taken action to limit emissions. Among the potential measures that merit continued examination is the inclusion of imports in the EU ETS.

Next steps: The documents described above are addressed to the EU institutions and Member States for implementation.

Figure 11.30. **EU brochure for young people about climate change**

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CASE STUDY: GERMANY

ENVIRONMENTAL MANAGEMENT AND SUSTAINABLE DEVELOPMENT – APPROACHES TO IMPROVE THE PROFILE OF UNIVERSITY



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Universities play a leading role in teaching and promoting environmental management systems and advancing the principles of sustainable development, thereby trying to integrate three principles –economic, environmental and social ethics. Due to environmental awareness, a growing number of universities are undertaking audits to assess their sustainability and environmental performance by controlling the impact of their activities and services on the social and natural environment. However, universities and equivalent institutions of higher education are currently confronted with several problems such as budget constraints and the consequences of the demographic change. The eminent risks posed by reduced student numbers and increasing competition call for strategies to develop curricula to make them more attractive.

The notion of sustainable development has been heavily discussed for many years. A variety of definitions exists. A widely cited definition of the United Nations defines sustainable development as development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs[1]. This includes a process of change in which the use of resources, the direction of investments, the orientation of technological development. Transformation of technology, societal structures and economic methods is required. However, there seems to be an obvious lack of interest into sustainability and environmental issues on the part of the general public due to the complexity of sustainability issues. Opposing this pessimistic assessment, however, major industry sectors in Europe and elsewhere have changed their agenda, setting a priority orientation towards sustainable future. 'Human capital', 'ethical investment' and 'industrial ecology' are recognised as useful notions for implementing sustainability into business life, mainly driven by depletion of available resources and more restrictive legal standards. Institutions of higher education can play an important role in transition to sustainability by changing educational approaches and redesigning structures and goals of systems or their organisation. However, universities are not only acting as mediators of change anymore; they have to face competition and economic restrictions due to negative demographic developments in many industrialised countries. Universities are also invited to consider the principles of sustainability in respect to their own activites. The consideration of sustainable approach in this context may help overcome difficult and somewhat painful transformation processes at university level.

The University of Applied Sciences Zittau/Görlitz was founded in 1992. It has long-standing academic traditions as a college teaching about energy, electronics and information processing. The University is located in the eastern part of Germany in the Federal State of Saxony, right at the Polish and Czech border.

The key competence of the University in education and research lies in applied life sciences, energy systems, business administration, management and social sciences. In 1998 the University of Applied Sciences Zittau/Görlitz launched its environmental management system (EMS). In March 1999 the University was successfully validated and registered as one of the world´s first institutions of higher education with EMS. One of the key determinants for successful implementation of the EMS was the active involvement of students in all phases and elements of implementation of the EMS from the very beginning. The University has been improving its EMS ever since: the system was validated by an external audit several times. The EMS of the University is both a way to take ethical responsibility for sustainability and a way to fight against negative trends like limited budgets or consequences of demographic decline. The EMS of the University focuses on the following aspects:

- cost and resource efficiency: This combines high environmental relevance with large capacity for economising, e.g. by reduced consumption of water and energy and reduced greenhouse gas emissions[2]. Indirect environmental impacts, e.g. public procurement, administration and decision-making as well as research on environmental management and technologies are also considered important;
- improved image: internal (meetings, assemblies and colloquia) and external (events, the annual Environmental Protection Day, conferences and workshops) information and communication;
- improved understanding of internal processes;
- social and economic responsibility.

In order to limit negative socio-economic impacts and to foster the transition to sustainable society, the

[1] **United Nations General Assembly.** (1987) Report of the World Commission on the Environment and Development: Our Common Future. Transmitted to the General Assembly as an Annex to Document A/42/427 – Development and International Co-operation: Environment.

[2] Data on the EMS can be found at *http://www.hs-zigr.de/agumwelt/index.php* (in German).

Figure. **Environmental management system was validated several times by an external audit**

importance of education must not be underestimated. According to the UNESCO definition, education for sustainable development (ESD) seeks to develop attitudes, skills and knowledge and to support more sustainable decision-making[3]. Change towards sustainability requires inter- and transdisciplinary knowledge forms. Systemic and holistic knowledge is desired related to the economic and social aspects of a globalised and dynamic planet as well as to ecological aspects of societal change at a global and local level. This also means respecting the complexity, uncertainty and incompleteness of knowledge and integrating potential risks.

According to the decision of the Senate of the University of Applied Sciences Zittau/Görlitz, all students are obliged to participate in a one-semester course as an integral part of their curricula. This course, which is quite unique among German universities, addresses biological, ecological, technical, social and economic concerns. The lecturers have different backgrounds, and the topics include a range of subjects from climate change and energy, introduction to ecology, nuclear waste disposal to technology assessment and geothermal energy systems. Each year around 800 students from various faculties take the course intended to motivate them and enhance their environmental awareness. Therefore, the lectures are presented in a popular science way not to be too complicated for students with non-technical background as well. The course is highly demanded and valued.

As of 1994, the University of Applied Sciences Zittau/Görlitz offers a study programme 'Ecology and Environmental Protection'. The programme is offered as an eight-semester diploma programme and recently as a seven-semester Bachelor's programme in line with the Bologna requirements. The philosophy of the programme is to provide both theory and its application opportunities, not reduced to classical biotic ecology and natural conservation but holistic, integrating a variety of technical and economic environmental protection issues. Opportunities for specialization are offered after completing three semesters (courses in natural sciences, mathematics, physics, information, economics and law): nature conservation/spatial planning and environmental management/leadership technology. The latter focuses on business options for environmental protection and offers lectures on climate change and climate protection issues, environmental and sustainability management, energy efficiency, emission trading systems, energy and material management systems, life cycle assessment and integrated management systems.

The University of Applied Sciences Zittau/Görlitz has been working on education for sustainable development for a long time. A process of continuing improvement takes place, i.e. by reducing the environmental impacts of the University itself as its EMS requires. The official organisational philosophy and culture of the University focuses on sustainability and interdisciplinarity. A sustainability report was elaborated in order to start a discussion. Starting with the report scheme of the Global Resource Institute (GRI), a preliminary assessment was carried out as a starting point for indicator development and sustainability management. The university takes its social responsibility and enhances its performance, credibility and image. Although this means certain expenditure and effort, the University expects to generate a lot of positive developments, the more so because the University is recently in a heavy competition with other institutions of higher education for numbers of enrollment and budget. The key points of our sustainability approach are:

- social responsibility and sound environmental performance;
- gender equality;
- interdisciplinary and international cooperation.

However, the issue of sustainability remains a challenge for the future. It is an ongoing process that will hardly reach an end, but the university is committed to the issue and we are optimistic about building a sustainable future.

[3] *http://www.unesco.org/en/esd/* (18.08.2010).

12 CULTURAL ENVIRONMENT

12.1 AESTHETIC POTENTIAL OF THE ENVIRONMENT

The majority of people have an emotional approach to landscape, guided by the desire to highlight nature's aesthetic as well as human-created qualities that manifest themselves visually, materially and ecologically. Among a number of definitions of the term 'cultural landscape', the formulation provided by Meyers Universallexicon appears to be particularly apt and describes it as 'human-created landscape under the impact of biotic and abiotic factors that reflects the level of material development along with the social and cultural evolutionary changes'.[1] The notion of cultural landscape is closely related to the notion of cultural environment; however, the latter covers a wider meaning and includes phenomena of both material and non-material culture, focusing on their social aspects. The concept 'cultural environment', its comprehensive implications and visions of its development were widely discussed in the columns of the Latvian journal 'Karogs' in 1989.[2] Latvia's leading philosophers, sociologists, literati, folklore researchers, linguists and experts of other fields mostly treated of the sphere of non-material culture, thus covering the social context. The concept of cultural environment comprises numerous aspects, including political, denominational, professional, artistic and other kinds of environment. Although the modern international practice is to recognize and use the notions 'cultural landscape' and 'cultural environment' alternatively or even interchangeably, it is logical to use the term 'environment', that is, 'cultural environment' as philosophically more embracing and comprehensive when speaking of spiritual structures as well as social and cultural phenomena. Besides, it is expedient to form such conceptual framework of cultural environment that recognizes elements of landscape as the basis for the expression of material and non-material culture.

The important factors in the cultural landscape are its components: the geological and geographical environment, the flora and fauna, which have an inherent value without direct human influence. People appreciate such virgin landscape, typical of a certain region and evolving naturally, from the aesthetic perspective; it creatively affects an individual's criteria of values and is mirrored in thinking and artistic reflection. This is testified by the proportion of the landscape genre in art, with an individual's emotional experience endowing the depiction of various elements of nature with particular value. Observation of a virgin environment or part of it through fine arts or music transforms it into an emotional and intellectual spiritual experience, motivating the individual to regard nature with consideration and responsibility.

Figure 12.1. **'Floodwaters in March' by Vilhelms Purvītis, 1910**
The value of the landscape in this work of art is in the richness of feelings and intimacy that is so characteristic of the miniature scale of Latvia's natural landscape environment with its reflection of the Earth's global processes.

The estimation of the aesthetic qualities of a landscape in material terms can be illustrated by the taxation of real estate, when the price of land is converted into a monetary equivalent according to a scale of certain criteria. A monotonous landscape devoid of artistic or aesthetic natural elements will be awarded the smallest number of points: an endless grassy open space, a wild plain, steppe, a salt lake or a similar homogeneous biotope. A landscape whose monotony is interrupted by at least a single natural element – a stone, a tree, a hill or a lake – will be awarded a higher taxation value. A landscape with terrain and plant diversity will be much more valuable than a landscape without emotionally arousing components. It is according to

Figure 12.2. **Kaive oak – an ancient cult place of the Balts**

[1] **Meyers Universallexicon.** (1979) VEB Bibliographisches Institut Leipzig, Bd. 2, S. 641.
[2] **Kultūras tradīcija – kultūrvide** [Cultural Tradition – Cultural Environment]. Series of articles in journal 'Karogs', 1989, No. 4, 5.

these principles that the value of land is calculated in the real estate market, and the price grows considerably for the environment that abounds in diversity of natural elements – rivers or lakes, hilly areas and landscapes with various biotopes. However, from a philosophical perspective, such utilitarian approach to the evaluation of natural environment in the modern world deprives nature of its inherent value and presents danger for it leads to senseless waste of natural resources by overexploiting them.

When the primitive tribes of hunters and fishermen used natural resources, they singled out objects with atypical features and attributed special value to them. An individual or a community selected remarkable objects – huge boulders, secular trees, caves, rocks and landscapes with distinctive forest stands or groves, springs, waterfalls – and venerated the unusual object endowed with supernatural powers, thus cultivating careful attitude to it. Moreover, people included these objects of nature in their systems of aesthetic, ethical and religious values, which reflected in both their domestic culture and the highest level of their spiritual culture – folklore, the poetic and mythological thought.

12.2 ENVIRONMENTAL AWARENESS IN THE CONTEXT OF CULTURAL LANDSCAPE

Until the 21st century, Central European cultural environment developed under the influence of agrarian and industrial economy. Only the territories of marshlands and wetlands, unsuitable for farming, were devoid of economic activities. These territories have now rapidly decreased or even disappeared due to intensive industrialisation, road building and urbanisation. Since each geographical territory is used differently (acculturation), the Central European landscape, rich in forests and areas of wetland flora, has still preserved considerable biological diversity. The German scientist Gottfried Briemle characterises cultural landscape as 'an intensively populated and small-scale agrarian landscape whose structure, regardless of a large proportion of landscape elements, remains ecologically relatively stable, its face preserving the typical natural variety.'[3] Briemle draws attention to social factors as transformers of landscape and the environment. The Dictionary of General Geography, published in Braunschweig, provides a definition of a cultural landscape creation process which highlights the interaction between nature and people: 'Cultural landscape is formed in an initial natural landscape under the impact of the life and economic activity of groups and communities of people as they cater for their needs. Cultural landscape acquires its regional features owing to the population (determined by the type and size of settlements), economic activity (agriculture, mining, industry and crafts) and road construction.'[4]

The aforementioned definitions correspond to the widespread 20th century philosophical view that culture is the universal integrator of human existence and activity, which effectuates public relations in the nature-created environment and necessarily transforms the landscape. The notion of 'cultural landscape' denotes a human-transformed natural environment which includes diverse footprints of human activity. This paradigm brings out distinct polarities: on the one hand there is the virgin natural environment with its aesthetic potential and inherent value, both *a priori* and human-endowed; on the other hand, there is the cultural environment as a result of the interaction between man and nature, which undergoes certain acculturation that can at times be viewed as a negative impact. The price of civilisation and progress of culture is the loss of the original quality and harmony of the environment with eventual degradation and change. The latter is typical of the cultural environment even when humans create a biotope that differs from the natural environment, consciously bred and unable to exist independently without care, for example, a park comprising a large number of introduced plants. The principal typical quality of the cultural environment is its evolution wherein the variable components create an infinitely large typological diversity, depending on the aims, character, scale and intensity of man's impact on the environment. Consequently, cultural environment awareness requires an experienced and informed individual who would convert the gains of the progress of civilisation into cultural values.

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3 **Briemle G.** (1978) Flurbereinigung – Bereicheerung oder Verarmung der Kulturlandschaft? In: Schwäbische Heimat, 29. Jg. Stuttgart, Heft 4, S. 226–233

4 **Dierke – Wörterbuch der Allgemeinen Geographie.** (1984) Braunschweig.

12.3 RURAL CULTURAL ENVIRONMENT

On the threshold of the second millennium *anno Domini,* European economy had created preconditions for decoupling crafts from agriculture. This was followed by the division of living space into towns and the countryside, with the eventual social stratification according to the place of residence and occupation. This division has survived to our time. The rapid development of towns promoted the development of architecture and the urban environment. Concentration of urban population facilitated the formation of complex, socially stratified administrative, religious and craft structures, The social roles of the stratified society were reflected in construction, fashion, behaviour and the culture of human interaction. The rural lifestyle, however, retained individual farmsteads or poorly developed rural community centres with a persistently dominating model of patriarchal economy and archaic traditions of domestic life. The merchant class maintained the link between the countryside and the towns by buying agricultural products, shipping them to towns and ports. Merchants grew into an indispensable intermediary that ensured the exchange of goods and expansion of trade. This, in turn, promoted a faster turnover of cultural achievements both in towns and rural areas.

12.3.1 DISTINCTIVE FEATURES OF THE CULTURAL ENVIRONMENT

In eastern European and Scandinavian regions, countryside still is the territorially largest agglomeration; at the same time, it is a complex phenomenon of the cultural environment. Just like any peoples' folklore and mythology is a syncretic (combined) expression of practical life observations, origins of mythological and philosophical thought, ethical and aesthetic concepts, so is the rural cultural environment the cradle of a system of social and labour culture, based on the lifestyle adjusted to the agrarian cycles. The individual farmstead, having broken away from the tribal community, turned into the living space for the household and the family amidst a landscape that was adapted for tilling and cattle-breeding and capable of providing for the material and spiritual needs of all the individuals who lived in the farmstead.

Figure 12.3. **Farmstead in Vidzeme**

The surviving witnesses of the heathen period in the Baltic cultural landscape are the castle mounds of the ancient tribes of the Balts. The mounds give evidence of the transformed terrain, the banked or levelled-off terraces, the steep slopes, water barriers adjusted for defence purposes. The castle mounds at Tērvete, Mežotne, Buse, Talsi are the best-known in Latvia, also the legendary Embūte hill and Tanīsa hill at Rauna and Mākoņkalns that rises high above the bank of Lake Rāzna. Popular in Sweden is the remarkable ancient burial mound at the Gamla Uppsala (Old Uppsala) Church. From the 11th to 12th century onwards, the cultural environment of the patriarchal tribes of Scandinavia and the Baltic area, their economic and spiritual life as well as the landscape fell under the influence of the economic, religious and administrative culture of Danish and German missionaries. That created a different spiritual and material environment. The eastern European and Scandinavian landscape, transformed by the immigrant culture, with the foreign building styles and objects of economic and domestic culture, has survived to our time. It constitutes a cultural environment and landscape representative of eastern Europe's geographical and social setting, whose economic development continues in the 21st century.

What is the nature of a farmstead as a constituent part of the cultural environment, what are its traditional elements and what constitutes the economic, aesthetic and landscape value of a farmstead? It is an autonomous economic unit, maintained by a single family, with a complex of masonry or wooden buildings, characteristic of the particular region and incorporated in the rural environment. Today, only 1–2% of population are employed in the traditional type of economy in the country and maintain their domestic and agricultural buildings. However, near big cities, for example, near Bremen, there still are transformed rural farmsteads used as places of residence by the city's civil servants, artists and people of other walks of life. In the case of such farmsteads, fields are alternatively used, while household buildings are either taken down as unwanted or adjusted to functions not characteristic of the rural environment. Considering the rapid transformation of the rural environment in the developed European countries, the historical rural farmstead with its complex of buildings, tools and household objects is preserved and displayed in open-air museums, like Skansen in Stockholm, Schleswig-Holstein Open-air Museum in Molfsee, ethnographic open-air museums in Lithuania, Latvia and Estonia. In a concentrated way, they illustrate the close link between the rural population and nature as the source of resources for construction, furniture, crockery, clothing, tools and other essential domestic objects. The world of occupational and household objects, typical of the people involved in exploiting environmental resources (field, forests and waters), enhance the landscape with elements that have functions, forms, colours and place of their own. Everybody is familiar with the sentimental feelings when observing a rural landscape with a Dutch-type windmill in Germany or Latvia, fish ponds, beehives or haystacks. The various occupations of the rural population are still dictated by the specifics of the seasons, the agrarian rhythm of work in the fields and the tools, eventually transformed by the technological progress. Farming determines specific jobs, tools and their impact on the environment, e.g., leaving visible seasonal footprints. Similarly, building a house, hay-making, fishing, hunting, beekeeping, gardening and other rural occupations transform the surrounding environment.

An essential quality of the rural environment is the aesthetically attractive placement of dispersed farmsteads in the landscape: at a river or a lake, on an elevation, nested at a forest, surrounded by fields and meadows. The rural folk's excellent sense of nature and the environment when organizing their living space goes hand in hand with a responsible attitude towards the economically available territory and the immediate areas, very carefully selecting the place for residential and ancillary buildings. Trees and alleys have been planted thinking of a harmonious environment; individual landscape elements have been adjusted: bushes have been cut, springs and huge boulders have been cleared, free space given to peculiar trees and attractive panoramic views. The domestic culture and environmental aesthetics of farmstead families of any nation have ancient traditions which have, over nearly a millennium, coalesced with the typical Central European norms of economic and spiritual life. It is characteristic of farming peoples that in every country the rural landscape is cultivated with particular reverence and responsibility. This is a typical feature of the nations who have nurtured a deeply emotional and almost religious link with nature and the environment. The accumulated folk wisdom of Russians, Poles, Finns, Swedes and Balts, their annual seasonal traditions, folklore and poetry of the 19th and 20th century reflect a pantheistic worship of nature as a value *per se*, which organically includes the perception of farmsteads and the living space of their inhabitants – the cultural environment – as part of the universe.

However, the rural cultural environment is not only nature, farmsteads and agricultural land. The rural environment, in contrast to the urban environment, is characterised by elements of high cultural, historical, architectonic and landscape potential. Important components are big complexes, for example, manors and their parks, public institutions: churches and churchyards, parsonages, schools, shops, pharmacies, municipality buildings, wind- and water-mills, factories and plants, ancient inns and post offices, bridges, roads, railways and railway stations. Their concentration on arterial roads creates a transitional cultural environment – villages and small towns – that already have several features of the urban environment, while still retaining the link with the virgin nature, cultivated land, gardens, fields, forests, waters, all of which was in the rural community's collective use. Single-family houses became a characteristic element of the cultural environment in villages; adapted for residence, production or public functions and adjoined by a small territory for recreation. The economic activities of the individuals in such a limited living space were not based on agricultural production as the only means for sustenance; they were supplemented with small-scale manufacturing, crafts, trading and sole proprietorship. Being of a dual nature, this environment, on the one hand, had not alienated itself from the typically rural mode of production and intensive exploitation of land; on the other hand, agriculture in the lives of these people had ceased to play the main role in profit-making.

Today historically significant and valuable elements of human-created environment are awarded the status of cultural monuments. Manors, parks, churches, medieval castles and their ruins have a high cultural, historical, artistic and emotional potential as well as a considerable impact on the surrounding environment since all of them are, for military, logistical or even symbolic reasons,

Figure 12.4. **Responsibly tended rural landscape near Aglona**

masterfully located in the landscape. Feudal lords, bishops and their vassals built their castles on hills or steep banks of rivers or lakes to serve as military support bases, to protect their property and territory and to maintain control over the local population.

The settlements in the vicinity of the medieval feudal castles developed into villages and towns whose residents could engage in crafts and trade, thus becoming mediators between the country folk and the buyers of their production. The most impressive fortresses in Latvia are the former castles of the Teutonic Order in Rīga, Ventspils, Cēsis, Sigulda, Dobele, Bauska and Krustpils, while the fortresses in Turaida, Rauna, Straupe and Koknese used to belong to Livonian bishops or their vassals. A similar picture can be seen in the other Baltic states – Estonia and Lithuania. Due to the late process of Christianisation in the 13–15th century, the landscape in the Baltic countries has integrated imposing medieval masonry fortresses which constitute a unique stratum of the cultural environment. Unfortunately, most of this evidence of the past has survived to our day only in the form of ruins. However, their majestic and austere architecture illustrates significant historical periods and creates a romantic ambience that facilitates tourism, whose management is unimaginable without exploiting the educational and recreational advantages of the cultural landscape elements.

Along with fortresses as military factors for conquering, defending and administrating the Baltic territories, a network of castles and inheritable estates belonging to the Livonian Order and bishops' vassals developed in the 14–16th century, partly for the defence of important Hansa trade routes and the borders of the Livonian state, although mostly to supply markets and kitchens of the feudal lords with agricultural production. The inheritable estates can also be described as complex elements of the rural environment, the dwellings of the nobility, with a higher level of comfort than that of the indigenous population who had been reduced to the state of peasants. The economic life on the castle-owners' estates thrived as arable land for large-scale production, forests and ponds constituted most of the territory, with the farmsteads of serfs in bondage. The castles and manors were surrounded by parks and gardens; large-scale industrial buildings – stables, granaries, factories, pubs, mills, greenhouses – were concentrated in vicinity. It is by their architectonic image alone that such ancient castles and manor houses like in Dundaga, Ēdole, Šlokenberga, Jaunpils, Nurmuiža in western Latvia manifest the political and economic might of feudal lords. The economic potential concentrated in castles and manors served to facilitate progress. Being productive enterprises, they fostered the economic development of the area, attracted and educated labour force and stimulated the formation of villages or even small towns with a stratum of craftsmen and merchants.

As Europe's civilisation developed, manor economy and manor complexes in the 18th and 19th century experienced the last period of growth, characterised by a high level of aesthetic organisation of the rural environment. However, the greatest cataclysms of the 20th century – World War I and II with the ensuing social, political and economic changes – undermined and destroyed this unique heritage of cultural environment in all eastern European countries, especially in Czechoslovakia, Poland, western and eastern Prussia, part of economically degraded territory of which today belongs to the Kaliningrad Region.

The architecture of the 17–19th century manor houses and their ensembles is the treasure of the cultural heritage of Scandinavian and eastern European countries, including the Baltic states, and has a large potential for the development of tourism. The palaces built by Dukes of Courland in Rundāle and Jelgava and several tens of former medieval fortresses in Latvia have been recognized as valuable cultural monuments and taken under the protection of the Latvian state, along with Renaissance, Baroque and Classicism palace ensembles in Mežotne, Kazdanga, Durbe, Stukmaņi, Varakļāni, Preiļi, Krāslava, Cesvaine, Bīriņi, Dikļi, Ungurmuiža.

Figure 12.5. **Turaida Castle on the bank of the Ancient Gauja Primeval Valley**

Figure 12.6. **Example of a restored cultural environment: the Bauska residence of von Kettlers, Dukes of Courland**

12.3.2 DEVELOPMENT OF THE CULTURAL ENVIRONMENT

By improving the virgin geo-botanical environment, humans gradually developed special territories separated from the surrounding landscape – gardens, decorative green areas and parks. In each climate and geographic zone they reflect the concepts of beauty and value of nature of a particular nation. The landscape cultivated according to definite aesthetic and landscaping principles is the cultural environment in the true sense of the word. By irrigating and fertilising to improve the conditions of growth as well as by picking and selecting plants, gardens gave been created in Europe for growing flowers, vegetables and fruit, collecting medicinal herbs and decorative plants. It was in such gardens that ideas of plant classification originated and observations were made on how the curative qualities of plants, their taste and smell could be best used. According to the principle of usefulness, gardens were divided into kitchen gardens and ornamental gardens. The same principle was observed arranging rural farmstead gardens, although the functional zones there may merge to combine the practical and the ornamental functions.

Ancient records, literature, artworks and surviving cultural landscape artefacts bear testimony to the multitude of variations of the cultural environment. The Old Testament depicts paradise or the Garden of Eden where flora and fauna created by God's wisdom existed in ideal harmony. People in different centuries and different countries have wished to implement this idea of a paradise garden in the place where they lived or depict it in artworks, thus coming closer to the dream of the ideal landscape, whose selectively created environment would provide treat to all five senses. The history of culture mentions the Hanging Gardens of Semiramide, one of the Seven Wonders of the World, planted on watered terraces by the gardeners of Babylonian rulers. Egyptian frescoes have preserved images of pharaohs' gardens with fruit trees and flowers growing around ponds. Medieval cloister gardens, the symbolic analogues of the Garden of Eden, were divided into several sectors, each allotted to either burying the deceased or growing medicinal herbs, vegetables and spices and flowers for decorating the altar. In this way cloister gardens became the predecessors of botanical gardens.

The Alhambra Palace gardens in the Spanish city of Granada and decorative greens in Topkapi Palace in Istanbul convey the idea of the garden culture of Arabs, Turks and other eastern peoples. We come into contact with the traditional Japanese and Chinese garden culture when we grow *bonsai* – miniature trees in small containers. Gardeners all over the world are also familiar with *ikebana* – the art of arranging flowers and plants according to special rules of composition. Natural scientists of the Renaissance period laid out botanical gardens at their universities as special territories for scientific observation of plants and selection work. The first botanical garden in the modern meaning of the word was created in 1543 in Pisa. Its creator was Luca Ghini, a physician and natural scientist at the University of Bologna. Similar gardens were also established at the universities of Florence and Padua in 1545. Carl von Linné, the outstanding Swedish 18th century naturalist and founder of the plant taxonomy, created a botanical collection at Uppsala which was planted in the centre of the city in compliance with the regular planning of the Baroque style surrounded with a fence. Linné's garden showed the baroque fashion in gardens and originated the principle of creating collections of groups of plants of related species. Compared to the world's botanical gardens, the Botanical Garden of the University of Latvia is new. It was established in 1922 by merging the lands of three rural estates which covered a territory of 15 hectares and included the buildings and the 18–19th century cultivated cultural landscape – terrain, network of footpaths, alleys and plantations of dendrologically rare trees.

During the Baroque and Classicism period, the culture of the nobility pursued the creation of impressive architectonic and landscape ensembles where a prominent place was allotted to French-style regular gardens and tree plantations. In the second half of the 18th century, they were transformed into romantic parks with an irregular network of paths and plantings of trees that reminded of a natural landscape. The Rundāle Palace park was reconstructed in 1980–2007 in Baroque traditions, and the landscape diversity of the territory was achieved by alternating regular paths, ponds and plantations, trimmed hedges and alleys, seasonal plants, as well as the architecture of small forms: arbours, pergolas and pavilions.

Figure 12.7. **Reconstruction of a Baroque garden in the Rundāle Palace ensemble**

In European countries, Baroque gardens of a smaller scale have been created since the third quarter of the 17th century. However, as the age of planted trees is between 150 and 250 years, the park landscapes of today comprise predominantly old or over-aged trees or their seedlings which deform the gardeners' original design. Nevertheless, even among such aged parks there are many parks valuable for their dendrological composition, English landscaping principles in planning, relief, network of paths, alternation of plantings and open spaces, and recreational architecture (the famous Łazienki Park in Warsaw, the park in Palanga in Lithuania,– Palmse manor park in Estonia, and the parks in Eleja, Alūksne, Varakļāni, Mežotne, Gaujiena in Latvia).

The landscaping of the territory of manors was entrusted to professional architects and gardeners, which is why the environment around manors is emotionally potent. Sometimes use has been made of elements of natural biotopes, although customarily specially created features have been introduced. For example, the landscape of the manor parks in Ungurmuiža and Dunte in Latvia is exceptionally decorative because of the old and huge oaks. The courtyard of the Vandzene Manor, also in Latvia, can be accessed along a straight alley of lime-trees a kilometre long; the traveller can reach the centre of the Kocēni manor along one of the several larch-tree alleys that branch off the Valmiera motorway. The nearly two-kilometre long early 19th century alley of chestnut-trees in four lines in the Eleja manor park link the courtyard to the obelisk to Duchess Dorothy. In the small town of Priekule in western Latvia, a ceremonious and beautiful promenade alley from the manor house to the church has been created by planting two lines of chestnut-trees on either side of the road. The owners of Nurmuiža in northern Latvia, the family of von Firks, attempted to create elements of the environment characteristic of the landscape in Germany: roads lined with larches and forest edge decorated with rows of beeches, the bushes of the Common Broom *(Cytisus scoparius)* with beautiful yellow flowers in spring planted as food for game animals.

12.3.3 OTHER SOCIALLY IMPORTANT COMPONENTS OF THE RURAL ENVIRONMENT

Ecclesiastic architecture also plays an essential role in the rural environment. In Christian lands, churches eloquently dominate the landscape with their impressive size and the outline typical of the architecture of the particular denomination. In the territory of the present-day Latvia, Christian missionaries started building churches in the late 12th – early 13th century, choosing the construction sites at the main trade routes, lakes and rivers, also in more densely populated areas. This was how churches arose in Ikšķile, Krimulda, Salaspils, Aizkraukle, Āraiši and elsewhere. To eradicate the heathen traditions of the Baltic tribes and make use of the habits of the locals to worship at ancient sacred sites, Christian missionaries used to build churches close by springs, boulders and ancient trees, thus replacing the ancient sacred site with a Christian site. At the churches, they erected belfries and established churchyards for Christian parishioners. Marking off the church and churchyard territory, layered stone walls were built to surround chapels, crosses of ancient burials, monuments and plantations of trees. The location of churches in rural areas was chosen to make the church visible from afar – in this way sacred architecture attracted flows of people. Gradually, other socially requisite buildings appeared near the churches: vicarages, pubs, shops, schools, pharmacies. All these objects were instrumental in the formation of the Baltic cultural environment up to the mid-20th century, when their initial importance waned. However, in the context of the traditional cultural environment, they have great historical, social and symbolic importance.

An integral element of the cultural environment of a scenic, botanical and historical significance is rural churchyards, steeped in typical Scandinavian and Baltic traditions. In the minds of the indigenous peoples, their image carries the meaning of an ancient archetype for in bygone times burying the deceased and offering treats to the spirits took place in specially selected sites – sacred forests or groves, or at big trees. Such sites were revered and people refrained from using them for any economic purpose but frequented them as cult places. In medieval times, Catholic missionaries attempted to adapt heathen burial sites to Christian traditions by erecting crucifixes and introducing Christian burial rituals. To confine the spread of epidemics and follow the European examples of sanitation norms, on 1 May 1773, the Russian empress Catherine II issued a decree that prohibited burials

Figure 12.8. **Church in a rural landscape: Elkšņi (Elerņa) Catholic church in Tabore**

under church floors and in medieval churchyards at town churches. Steps taken to implement the decree included establishing new cemeteries, which in the Baltic Region promoted the formation of a burial culture that corresponded to the rational spirit of the Enlightenment. The majority of rural cemeteries in Latvia and Estonia, now turned into shady parks, had a rectangular plan in the late 18th and early 19th century. The main alley crossed the cemetery longitudinally, traversed by one or several alleys and minor paths so that the whole territory had a cruciform division in regular quarters. Regulations stipulated that cemeteries should be surrounded with a stone wall and the inner paths should be lined with trees to form alleys. In Scandinavian countries and the Baltic states cemeteries are regularly visited and carefully tended; they constitute an inseparable element of the rural social and cultural environment. All cemeteries in the eastern European cultural environment have been arranged according to the Christian tradition, burying the dead with the head towards the west. The burials of Soviet soldiers may present an exception to the general rule, and their charge is regulated by international agreements.

In the rural environment, everything is biologically, socially and economically integrated in a structural entirety, and human-created structural elements in the rural environment serve the community and ensure its vital functions. It is in the interests of single farmsteads, villages or small towns that all human-created elements of the cultural environment should function and be accessible to all members of the community. Every person needs a dwelling, a yard, some land and outbuildings; similarly, everybody needs a school, a pharmacy, a railway or bus station, a shop and a church. Every member of the community also consumes the common resources – roads, forests, waters, marshes and meadows. The inhabitants of a farm, a village or a small town are directly responsible for the maintenance and regeneration of biotopes and the cultural environment. The awareness of the interconnection between the individual and nature facilitates a respectful attitude to the community resources; the established social standard also urges care of one's cultural environment – the cultural heritage handed down by the former generations.

12.4 STRUCTURE AND COMPONENTS OF THE URBAN ENVIRONMENT

A city is a highly developed form of a human settlement where the individual and social needs are met in the most rational way. The people who settle for city life create a system of collective behavioural norms to ensure their social needs. Geographically, a city can be defined as a living space that is densely populated by a relatively closed community of a vital economic importance to the surrounding territory. A city is a continuation of the countryside, the prerequisite for its very existence and its antithesis. The city population does not participate in agricultural production although, as a result of labour division, they have created part of society that performs the functions of an intermediary and supply the countryside with artisan and industrial goods. Therefore, cities grow at port sites (Stralsund, Tallinn), navigable rivers (Hamburg, Lübeck, Toruń, Rīga), their fords or crossings (Frankfurt-am-Main, Würzburg, Wrocław, Kuldīga), important roads (Augsburg, Nürnberg, Narva) or road junctions (Hannover, Leipzig, Tartu).

Cities can be classified according to their size, that is, their population; however, such statistics are relative. For example, the population of the town of Ape, one of the smallest towns in Latvia, amounted to 1941 in 2004 (Durbe had 648 inhabitants, data of 2009). The population of Tokyo is 12 790 000 – Latvia's capital city Rīga (713 000) looks like a small village in comparison.

Nevertheless, all cities have certain common features: a concentrated multi-storey development, a branched structure of streets and roads, developed traffic and other systems of communication, a complicated administrative mechanism with numerous institutions that regulate the individual's actions and life. Because of the high population density, urban communities create a special network of institutions that cater for leisure time activities and social needs which serves a particular function, creates the cultural environment and diversifies the visual image of the city.

Figure 12.9. **Skyline of Rīga: a feature of the urban landscape highly appreciated by UNESCO experts**

Cities of ancient civilisations mostly developed without any preconceived plan although attending to the rights of the rulers and other privileged members of society and the clergy to occupy a more desirable living space than the financially disadvantaged citizens. Planning cities, architects of the Ancient Roman Empire were guided by the planning principles of a legionary camp, and the spatial structures of such modern cities as Timgad, Florence, Pompeii and others are based on an adapted plan of a legionary camp. Architects of the Renaissance and Baroque period used similar techniques, laying out projects of ideal cities and trying to build them in real life. Typical features include a polygonal or stellar outline and a regular street network, for example, the city of Palma Nova in northern Italy. In rich countries such ideal urban designs enabled the implementation of utopian ideas of an absolutely beautiful and architectonically sumptuous urban environment that was favourable for an individual's spiritual interests. Protected by the safety of fortified ramparts, the city would lead a prosperous life, dedicated to art and welfare. Guided by such theoretical formulations, in the late 16th century and throughout the 17th century, land surveyors and military engineers in Latvia created city centres with regular planning in Rīga, Jelgava, Bauska, Jaunjelgava and Valmiera.

From the perspective of the organisation of the environment, any urban structure is divided into several functional levels which coincide with definite administrative zones of the city and occupy a definite territory. Not every city plan has a central composition and a radial street network, but every city has its symbolic centre, with the main streets converging at it. As a rule, it is the centre of the administrative power – the castle of the feudal lord or the bishop, the Town Hall or, in modern times, the municipality building. A spatial satellite of these symbols of power and architectonically expressive buildings is an ample presentational space – a central square or a market place, a garden and a park, fountains adorned with sculptures and ponds as a venue for festivities, parades and ceremonies. In Venice, it is St Mark's Square *(Piazza San Marco)* with the cathedral, the Doge's Palace, the impressive bell tower of St Mark's Basilica, St Mark's Library, the Procuratie Vecchie and numerous cafés. Until the 1940s, the centre point of the historical part of Rīga was the Roland's sculpture and the Town Square, flanked on both sides by the Town Hall and the Blackheads House. In the 1920s–1930s, the independent Latvia's government attempted to create the symbolical centre around the Monument to Freedom. Under the pressure of the Soviet occupation regime, architects transferred the centre of the capital city outside its historical part and used political means to establish a new administrative and symbolic centre.

A typical feature of Rīga's urban environment is its park belt – a chain of parks created in the second half of the 19th century to skirt the historical part, and the Canal Gardens with an interesting man-made relief and a diverse dendrological and botanical composition, a complex network of paths and many objects of decorative sculptures and monuments. The dismantling of the city's defence bastions and ramparts took place in Vienna and Rīga around the same time – in the mid-19th century; therefore, both cities have many common features. In Vienna, it is the *Wiener Ring* with museums, theatres and administrative buildings in this exclusive park zone. In Rīga, it is the Canal Gardens within which the city built the Opera House, the house if the Rīga Water Supply Company and new schools, and erected numerous monuments. Beyond this park belt, there was the new part of the city with the main streets, boulevards and side-streets. In the late 19th and early 20th century, the regular and irregular rectangular street blocks were lined with apartment buildings, buildings of educational and administrative institutions and public buildings among which churches of various denominations stand out. This architecture

Figure 12.10. **Rīga's dense development borders with the Daugava River and the green zone**

Figure 12.11. **Rīga's Town Square and its reconstructed development**

Figure 12.12. **Jūrmala. A wooden Orthodox church integrated in the complex of the Ķemeri sanatorium**

Figure 12.13. **Jūrmala. Monument to the physicians of the Ķemeri sanatorium**

is characterised by polyphony of different styles; however, Rīga's cultural landscape is unquestionably dominated by Art Nouveau forms. This quality in 1997 earned a high international evaluation for Rīga – the inclusion of the city in the UNESCO World Heritage List. The memorial plaque on the pavement of the Dom Square bears the following inscription: 'Historic centre of Rīga has been inscribed upon the World Heritage List. Inscription on this List confirms the exceptional universal value of this cultural site which deserves protection for the benefit of all humanity.'

12.5 INDUSTRIAL ENVIRONMENT AND ITS PRESERVATION

Just like the circular waves caused by a stone dropped into water travel towards the outside, so does the functional zoning change towards the periphery in cities, and beyond the impressive blocks of administrative and apartment buildings begins a belt of industrial architecture that embraces the centre. For example, in the suburban area of Rīga, surrounded by convenient access roads and warehouses, yellow brick blocks of 19th century factory buildings rise. The development of the port, domestic and foreign trade, banking business, growth of industrial production contributed to an economic boom in Rīga in the late 19th and early 20th century. Breweries and metal foundries, shipyards and engineering plants, textile factories and bicycle plants, water supply stations, railway stations, paper mills, cement plants, glassworks, wood-working factories, soapworks and ceramics factories make up a small part of the multitude of Rīga's enterprises. Their full list would take several pages while their production units with their boiler houses and chimneys constitute a large part of the city's industrial cultural environment.

In the modern world, industrial architecture is regarded as an important part of historical

Figure 12.14. **Āraiši windmill – an example of industrial architecture in the rural cultural environment**

heritage and a unique component of the cultural environment, and the buildings that had once been built for industrial or other technical aims are creatively adapted to new functions. Examples of this can be found in every country. In the suburbs of the German city Kiel, an old factory has been turned into a students' club. In the suburbs of Zürich, the former shipbuilding factory 'Schiffbau' has been turned into a theatre. With the population and territory of Rīga growing, the former suburban industrial districts have become parts of the city centre and are easily accessible by transport. This situation has raised the issue of the reconstruction of the architectonically valuable factories in Rīga. The reconstruction of a gypsum factory in Ķīpsala, an island on the Daugava River in the middle of the city, is an example of transforming a former industrial building into an exclusive complex of apartments, artists' studios and restaurants. Latvian architects have successfully adapted other factories for recreation by converting factory buildings into multi-functional entertainment centres ('Sapņu fabrika'), the warehouses of the Rīga Central Market have been adapted to accommodate concert halls, art galleries, offices and shops. A gas plant and gas towers built in the second half of the 19^{th} century are used as office buildings now; a fire station in Art Nouveau forms is now a fire-fighting museum which displays historical fire-engines in the halls and workshops of industrial architecture. A reconstructed building of an engine-shed houses relics of Latvian railway history; is the water supply equipment that dates back to the 19^{th} century is on show in the building of the pumping station 'Baltezers'.

An inseparable part of suburbia and industrial environment is the infrastructure built for the workers' needs: brick and wooden apartment buildings, kindergartens, schools, buildings of various societies, hospitals. Their architecture is an illustration of $19–20^{th}$ century architects' mastery of creating a pleasant living environment which had no modern conveniences and comfort but whose qualities of town planning, landscaping and artistic features urge us to gather the motivation to preserve wooden architecture. In several cities of Finland with a developing paper industry, since the early 20^{th} century, the residential buildings for the administration and workers of the paper-mill have been carefully preserved as part of the heritage of industrial urban environment. Over the last decades in Latvia, too, the awareness of this cultural heritage has been growing. Considerately restored wooden houses can provide modern living conditions. Kalnciema and Mūrnieku Streets, whole blocks of houses in the Latgale suburb and private housing areas in the suburbs of the capital city of Latvia testify to the popularity of the so-called 'wooden Rīga' and outline a perspective of the preservation of an authentic cultural environment.

Figure 12.15. **Development in part of Rīga – Mežaparks – with a variety of architectonic forms**

To tackle the problems of the preservation and development of the cultural environment, there should be a conception based on the assessment of economic, engineering, geographical, cultural, historical, ecological, social and other aspects. For Rīga it is Rīga Development Plan 1995–2005 which was prepared by the City Development Department of the Rīga City Council and the Urban Planning Board, involving joint efforts of many experts.[5] This plan stipulated the scale of Rīga's territorial growth, defined the city's development goals and main principles to be observed in the preservation of the city's historical centre, improvement of each territory and implementation of new projects. Being aware of the risks to Rīga's unique cultural heritage in the rapid urban development, the State Inspection for Heritage Protection, the chief institution in charge of the state policy concerning the protection of the cultural environment and its control, devised the Concept of the Preservation and Development of Rīga's Historical Centre in 2002: Vision 2002–2020.[6] If consequently observed, its stipulations and conditions will help ensure a harmonious evolution of the capital city's diverse cultural environment and considerate integration of its most valuable elements into the urban structure.

[5] Rīgas attīstības plāns 1995–2005. (1995) Rīga.
[6] Rīgas vēsturiskā centra saglabāšanas un attīstības koncepcija. Vīzija 2002–2020. (2002) Rīga: VKPAI.

12.6 PRESERVATION OF A UNIQUE CULTURAL ENVIRONMENT

Latvia can pride itself on wide territories that are significant environmental examples and, from the cultural environment perspective, display characteristic natural diversity and a rich geo-botanical environment. They may include virgin natural sites as well as artificially created objects which testify to the eventual alienation from the natural environment. An example of the first type of cultural environment is Ķemeri National Park, which covers a territory of 38 165 hectares and was awarded the status of a protected area that includes 57% of forests, 24% of marshland and 10% of open water. Its main asset is protection of ecosystems, virgin flora and fauna in a natural environment, which provides possibilities of unlimited ecological education for people of the 21st century individuals. However, even the ecosystems of Ķemeri National Park are exposed to interference in natural processes, thus this formation is given a unique cultural component related to the development of resorts and the exploitation of the medical properties of sulphurous water, mud and the environment.

In Latvia, with its small territory, dense population and inescapable presence of industrial infrastructure, there are few ecosystems devoid of economic activity. An excellent example of virgin environment is the Teiči Bog in the district of Varakļāni. In 1982 it was awarded the status of a nature reserve. It has a virgin marshland environment and is an important habitat of birds. It is protected from economic activity. Most environmental sites in Latvia and other eastern European countries are of a complex, mixed structure of natural and economic components, e.g., Gauja National Park created in 1973 to preserve an area of 91 745 hectares of biological and geological treasures of the Ancient Gauja River Valley, outcrops, magnificent picturesque landscapes and over 500 cultural monuments. The Park is divided into functional zones with definite types, scale and intensity of economic activities, and each zone has an individual nature protection regime.

As an environmental structure, every city is an autonomous value with an individual face and concentrated architectonic and other unique cultural and historical elements. Since 1983, several tens of Latvian cities and their urban development have been declared protected territories. Many Latvia's cities can pride themselves on an exceptionally rich cultural environment: Kuldīga, Talsi, Liepāja, Kandava, Tukums, Rēzekne, Daugavpils, Cēsis, Sigulda. As the biggest city in the eastern part of Latvia, Daugavpils has gained international attention for its early 19th century military defence complex – a fortress whose unusual architectonic features harmoniously blend into the material and spiritual background of this multicultural city. Ventspils, a port city, is attractive for its neatness and tidiness and for the 13th century castle of the Teutonic Order surrounded by 17–19th century urban development. The charm of Kuldīga is enhanced by the 200 m wide waterfall on the Venta River, a peculiar natural monument. Liepāja also has a port city charm and a well-preserved 17–18th century wooden development. An exceptionally high visual aesthetic potential due to a diverse relief and a variety of landscape elements is characteristic of such towns as Talsi, Kandava and Sabile. The urban environment of Latvia's small port towns with the features of industrial culture – wharfs and fish processing enterprises – is inseparable from the attractive small-town environment with private houses and gardens. As small agglomerations, Pāvilosta, Mērsrags, Roja, Salacgrīva subtly combine the components of both urban and rural environments in their landscapes.

Nearly all of these romantic towns can be compared to other European cities that have earned the UNESCO experts' attention for their rich cultural environment, for example, Krumlov in the Czech Republic, Bergen in Norway, Rauma in Finland; yet, each of them has its own individual charm and identity. Global tourism and the activities of international institutions for protection and popularisation of cultural heritage, such as UNESCO and ICOMOS, assist in defining the identity of a site rich in cultural, historical or natural components, and urge every citizen to appreciate the inimitable essence of their living space.

The notion 'cultural environment' has become firmly rooted in people's minds and its use in advertising materials and in tourist guides helps create an attractive image for every populated place and region to make it interesting for visitors. Pride in one's cultural heritage can be interpreted as an expression of local patriotism, typical of any country. It becomes obvious as we open almost any rural municipality's home page. For example, the home page of Sēme rural municipality begins with the section 'Cultural Environment' which lists

Figure 12.16. **Picturesque landscape of Talsi reveals the high aesthetic potential of a rich cultural environment**

the local natural, art and architectural monuments and prominent people. Similarly, the Internet information on the administrative and economic activities of the Usma rural municipality leads to the section 'Cultural Environment and Tourism', which advertises the local cultural heritage, diversity of nature and recreation facilities at Lake Usma.

There are many sites on our planet that humans have recognised as possessing curative properties and researched them for health improvement and recreation. Owing to their geological, hydrological, botanical and climatic features, such sites have been adjusted to therapy and recreation by creating a suitable environment. Ancient Chinese rulers and ancient European society knew how to use the curative and relaxing properties of thermal waters by building pools and baths. In the Middle Ages, representatives of the upper classes used to recover health with the help of springs of mineralised water, well-known for their magic power of 'springs of eternal youth'. Such places grew into health resorts, forming an urban structure accommodated to receive guests, provide treatment and recreation. Such are the German towns of Bad Nauheim, Bad Homburg and the spa town of Karlovy Vary (Karlsbad) in the Czech Republic; the resort town of Wieliczka in Poland grew at a salt mine and, like Chelmno, gained popularity as place beneficial for the treatment of respiratory diseases, where the curative effect was achieved by breathing the air ionised with crystalline salt. With the development of the public bathing culture in the mid-19th century, such cities as Warnemünde and Travemünde in northern Germany, Sopot in Poland, Haapsalu and Pärnu in Estonia, Palanga in Lithuania and many others rapidly flourished and became known as resorts.

Latvia's urban environment is diversified by such resort towns as Sigulda, Ogre, Baldone, Saulkrasti, Liepāja and Jūrmala with their peculiar cottage architecture, the exterior design for recreation purposes, also the curative resources for the benefit of seasonal guests. The development of Liepāja into a resort on the threshold of the 20th century was facilitated by activity of the trade and military ports, which attracted both funds and the middle class who cared for recreation and health improvement. The fact that Jūrmala was within an easy reach to Rīga's inhabitants was a major development factor for the city. It provided access to pine woods, sun and a convenient beach, the attraction of fishing villages that supplied fish, berries and cheap recreation facilities. The history of Baldone and Ķemeri as resorts is related to the development of balneology (use of medicinal mud) and climatotherapy. Their scientific research dates back to the late 18th century when court physicians of the Russian Empress Catherine II visited these places. Gauja Ancient River Valley, also called the Switzerland of Vidzeme, began to be involved in tourism already in the 19th century. Tourism brought about a boom of Sigulda and Krimulda as resorts in the early 20th century. Later the category of climatotherapeutical resorts was awarded to Ogre, Pabaži, Saulkrasti and several other towns. The varied links between the spa resorts of Jūrmala and the medical and political history are memorised in the unusual monument to the outstanding doctors who have contributed to the therapeutical practice of the Ķemeri Sanatorium and in the memorials to the victims of World War I and II in Sloka, Ķemeri and Kauguri.

The spa environment often is multi-ethnic, multi-cultural and multi-denominational. Several Lutheran churches in Jūrmala, Latvia's oldest resort city, testify to the affiliation to a certain denominational tradition. The most distinctive is the Lutheran Church of Sloka, built in the 17th century and rebuilt in the late 19th century. Another noteworthy monument of resort architecture is the Church of Dubulti, designed in Art Nouveau forms by the outstanding Baltic German architect Wilhelm Bockslaff. The Orthodox churches in Ķemeri and Dubulti, Catholic churches in Majori, Sloka and Ķemeri, the former German Lutheran Parish Church in Bulduri and the synagogues that have changed their appearance and function in Sloka, Dubulti, Dzintari and Bulduri are witnesses of Jūrmala's rich denominational past. Every resort town is proud of its architectural heritage, designed to accommodate healing, recreation and entertainment. On the scale of the European culture, Latvia's spa environment is particularly attractive because of the rich variety of forms and styles of its wooden architecture. The façades of hotels, health institutions, restaurants and concert halls with their light decorations, balconies, terraces, turrets and verandas are a significant factor contributing to the charm of resort towns.

The creative atmosphere of resort towns has facilitated the creation of many works of art, literature and music, and each resort town has its individual historical memory of prominent guests of the resort, writers, artists and musicians who have created works of national importance and whose presence has enriched the resort town environment. Many masterpieces of Latvian culture have originated in the emotionally potent atmosphere of resort life. Vilis Pūdonis wrote his poem 'Two Worlds' *('Divi pasaules')* on a summer holiday in Bigauņciems where he witnessed the fishermen's hard life and struggle for existence. In the early 20th century prominent musicians and writers published their witty reviews of the summer concerts in Horn's Garden in Dzintari (then called Edinburgh) in Jūrmala's newspapers. Among them were Emilis Melngailis, Emīls Dārziņš, Jānis Sudrabkalns, the concerts were attended by nearly all of the emerging Latvian art elite who had chosen Jūrmala for their creative work and recreation. Today the evidence is preserved in a number of museums, memorial places and monuments to Rainis, Aspazija, Ludis Bērziņš.

12.7 QUALITY OF THE CULTURAL ENVIRONMENT

Citizens of the Baltic states and Scandinavian countries deeply love their native lands; therefore, they feel highly responsible for their cultural environment. A proof of this is careful tending of individual farmsteads, private houses, restored manors, their territories and gardens, decorating them with original design objects. An example of a responsible development of the cultural environment is the work of people whose names were made known to the general public in Latvia in the late 1990s and early 2000 on the initiative of the popular writers Imants Ziedonis, Aivars Berķis and Ēriks Hānbergs to evaluate and praise Latvia's best farmsteads, their architecture and well-tended cultural landscape. This initiative triggered a popular movement aimed at tending and reconstructing symbols of traditional rural environment, economic life and domestic culture – roads, yards, granaries, bath-houses, gardens, residential buildings, wells and many other components; it also urged the owners to preserve artefacts in a modern form. The public acknowledgement of the most beautiful farmsteads and words of praise for their owners strengthen the citizens' commitment to their land and motivate them to follow the example.

Continuous changes of the traditional environment improve the quality of life and promote the development of the cultural environment. Theatre, circus, travelling menageries and cabinets of curiosities attempted to bring the urbanized society closer to nature and the animal world already in the ancient times. From this perspective, the Rīga Zoo, the oldest animal park in the Baltics, founded in 1912, serves as a reminder of the desire of the modern era to complement the afforested dunes in Rīga's suburbs with a human-created environment, integrating animal shelters and attractive buildings, open-air cages and pools into the natural landscape. The Rīga Zoo is a recreational garden in the environment typical of the maritime climate zone and, like in other zoos, purposefully created design objects simulate the natural environment for animals in captivity to provide educational information and entertainment for the visitors. One of such popular zoos in Europe is the Berlin Zoo whose architects and designers have striven to achieve maximum perfection in constructing near-natural living conditions and environment for the animals. Founded the early 20th century, Skansen (ethnographic museum) in Stockholm is part of a complex that also includes a zoo with open-air cages of the animals characteristic of Scandinavia. In an attractive way the zoo provides its visitors with an illustration of the unity of the rural living environment, animals and nature.

A different environment has been constructed in Rīga's urban space to create the image of the catering and entertainment complex 'Lido', heavily using clichés of ethnographic architecture and national culture. Using traditional techniques of peasant wooden architecture, several large-size buildings of horizontal logs have been built to accommodate restaurants that cater for several hundred customers. The complex even includes a Dutch-type windmill. Over a territory of several hectares, there are original objects of environmental art – water cascades, fountains and luxuriant plantations, also an amusement park for children and teenagers, a skating rink, swings, merry-go-rounds, examples of park architecture and grottos complemented with artworks. The designers constantly strive to re-decorate the attractive environment, replete with kitschy elements, according to Latvian national seasonal festivities, introducing new elements of commercial culture: Christmas trees, moving dolls and Santa Claus symbols on Christmas, traditional decorations of rabbits and eggs on Easter, birch and oak twigs, oak wreaths and flowers on summer solstice festivities typical of Scandinavian and Baltic countries.

Since Latvia regained independence, out of a Soviet hyper-industrialised environment doomed to degradation of nature and culture, by laudable management, the port city of Ventspils has created a physically and ecologically restored, human-friendly and diverse urban environment. Over a rather short time, artists, architects and gardeners with international experience have transformed the urban environment of the town of Ventspils according to the best Western examples, introducing fanciful flower plantings and floral sculptures in pedestrian areas, gardens and parks. The reconstructed market square and the promenade are replete with new elements of environmental design; the city's streets and parks are decorated with original sculptural works, such as Sun Boats, Ship-Watcher and Floral Clock. In the

Figure 12.17. **Town Hall in Ventspils – an example of a well-tended cultural environment**

town's historical centre, the medieval castle of the Livonian Order, Town Hall, St Nicholas Church, historical streets and 17th–20th century architecture are fully restored and reborn. In the seaside park the visitors can stroll ecologically educational paths, and its collection of anchors is the only open-air exhibition of this type in the world. The park includes the Seaside Ethnographic Open-Air Museum with a rich collection of fishermen's houses and domestic objects. A restored steam engine and a couple of ancient railway carriages carry the visitors. The barren spaces of Ventspils have been transformed into parks and playgrounds. There is no city in Latvia that could sport an Adventure Park for those who love extreme sensations, Phantasy Park and Children's Town in the city centre. For active recreation, Ventspils has a word-class BMX track, the Olympic Centre, Aquapark and a skiing slope.

Latvia's diverse cultural environment is rich in objects created by talented people, combining elements of landscape, architecture, art and design. In 1982, several sculptures by the sculptor Indulis Ranka were erected in the picturesque area at the Turaida medieval castle. On the occasion of the 150th anniversary of the folklore researcher Krišjānis Barons, the park established in 1985 was called *Dainu kalns*. *Dainas,* four-line folk songs that contain Latvian wisdom of life, philosophy and mythology, have been included in the UNESCO World Heritage List. The twenty-six large granite sculptures at the site reflect the topics that are essential for Latvian mentality and philosophy of life in a philosophically generalised form. It is the largest one-man sculpture park in Latvia, comparable to such acknowledged counterparts as Viegeland Sculpture Park in Oslo or Millesgården in Stockholm.

The Pedvāle Open-air Art Museum, established in 1991 by the sculptor Ojārs Feldbergs in an area of 100 hectares near Sabile, has now been recognised as an item of cultural environment in art books. The permanent collection of the museum numbers nearly 150 sculptures and environmental installations created during annual symposiums by both Latvian and foreign artists. The museum concept stipulates a synthesis of the natural landscape, agricultural land, cultural heritage and works of art in a united space of the cultural environment to integrate the new artworks as harmonious components. At symposiums of sculpture and creative workshops of environmental art, attention is paid to philosophical and symbolic values, prime elements, cultural archetypes and artistic aspirations to overcome the borders of matter, time and space with sculptural means.

Figure 12.18. **Landscape of the Abava Ancient River Valley in the Pedvāle Open-air Art Museum complemented with professional artworks**

Mmany landscape parks are of educational nature, and creative persons constantly strive to improve them. Cognitive trails urge people to get to know nature and the cultural environment in an interactive way. The collaborative effort of the Skrīveri Secondary School and the staff of the Memorial Museum of the writer Andrejs Upīts has resulted in one of the first cultural environment trails (1982), the Dīvaja trail. Accompanied by well-informed students, already 40 years ago visitors could enjoy the landscapes, nature, trees and plants that were described in the writer's prose, and learn many details about the local history of culture. Today, there are already 13 tourist trails of varied length and content, providing information about the rich history of culture of this place. The names of trails suggest a literary and poetic offer to appreciate the cultural environment.

Latvia's national parks and reserves have invited the public to get to know endangered and unique species of plants, rare animals, geological features and landscapes unaffected by economic activity. It is instrumental in informing and educating the population on issues of environmental culture. A variety of trails at Slītere National Park acquaint the visitors with unusual geological formations, the Ice Age shoreline landscape and the biotope under protection at a European level. A lot of effort has been put into the creation of several informational trails in the territory of Ķemeri National Park, which acquaint visitors with the marsh landscape, flora and fauna, as well as teach to understand the peculiar features of nature and observe the unique life of the marshland biotope.

Municipality and private parks emphasise the entertainment and recreational functions. Such parks have been often created in the territories of former manors, rich in ancient trees, dendrological rarities, alleys, pools and other park elements. In one of the most beautiful Latvia's landscapes, among the lakes of the Talsi District lies the vicarage of Talsi, the residence and burial place of Ludwig van Beethoven's friend Karl Ferdinand Amenda. The scenic landscape displays objects of environmental art. However, since the aesthetics of manor parks is rooted in the paradigms of historical styles, the educational objective of their cultural environment is to reveal the achievements of landscaping art in the previous centuries. Valuable in terms of dendrology and landscape, the Rūmene Manor Park near Kandava was ameliorated in 2008–2009 and can serve as an example of considerate preservation of a gardener-created landscape. In contrast, in the Kukši Manor, where only several big trees have survived at the 18th century manor house, the owner takes care of the territory in his own way – it has components of modern international 21st century culture of gardening and landscaping characteristic of Italian landscape – a pergola, marble fountains, an arbour of untrimmed fir logs, several sculptures and terracotta figures of Chinese soldiers.

A different approach to the creation of the cultural landscape has been practised in Mazsalaca where environmentalists, secondary school students and the municipality tend the three-kilometre-long Salaca River Valley, rich in sandstone outcrops, grottos and springs. The access to Skaņaiskalns Nature Park in Mazsalaca, with its 14-m-deep Devil's Cave, rocks and other interesting objects is comfortable because of the introduced amenities – stairs, railings and bridges. Due to the unusual acoustic properties of Skaņaiskalns and the scenic landscapes, the Nature Ark is popular among both tourists and newly-weds. To excite children's imagination, the Gnomes' trail and the trail of the Latvian fairy-tale hero Kurbads are established. Both trails are decorated with 50 wooden sculptures featuring Latvian fairy-tale motifs, work of the sculptors of the applied arts studios 'Dzīne' and 'Cēre'.

Another example of interactive recreation in the cultural environment of Latvia is the territory of the 'Laumas' farmstead in the rural district of Īve, near Talsi. Wide areas of fields and forests have been adapted for sport and tourism. The nature park is especially popular with tourist families. It offers informational trails of Bees, Birds, Plants and Forest. Such park popularises organised cultural environment and makes people become more considerate of nature.

12.8 DEGRADATION OR IMPROVEMENT OF THE CULTURAL ENVIRONMENT

Global processes testify to an irreversible depletion of the Earth's resources and degradation of the natural environment. These regularities refer to the cultural environment, too. In spite of human efforts to protect it, the possibility of holding back the loss of authentic cultural evidence is limited. With the growing population and intensification of production, the areas of natural biotopes decrease, animal and plant species become extinct, the composition of the atmosphere and the climate change, and human living conditions deteriorate. However, the progress of civilisation, which eventually facilitates erosion of the global environment and degradation of the cultural environment, cannot be stopped although the mass media are trying to sway the public opinion towards a hopeful solution.

Various measures have been taken at the regional, national and global level to restore and preserve individual components of the cultural environment; the strategy of salvaging the most valuable objects of the world cultural heritage is being coordinated. In spite of that, restoration cannot bring back the original authentic quality of the environment or human-made objects. Marketing of cultural symbols in the 19th and 20th century has given rise to the understanding of restoration as a complex of salvaging measures. This interpretation is based on the fallacy that it is possible to make time stop and on a romantic desire to travel in time and space. An artificial conservation of the cultural environment will produce something similar to the permafrost zone where natural evolution is deterred, and it will be inevitably accompanied by regressive changes in the cultural environment.

Since 1992, the UNESCO World Heritage Committee has been working on the World Heritage List of cities, architectural complexes and individual great monuments, for which an essential criterion for selection is the quality of the cultural landscape, thus exaggerating the role of architectural heritage while narrowing the meaning of the concept of cultural environment by paying insufficient attention to the components of nature.[7]

Figure 12.19. **Desolate farmstead in Vidzeme – degraded cultural landscape caused by discontinued agricultural activity and changes in population density**

Internationally acclaimed monuments of material culture with a rich variety of cultural landscape elements are Dessau-Wörlitzer Gartenreich, the Elbe Valley near Dresden, Fürst-Pückler-Park in Bad Muskau in Germany, historical sites in Austria, for example, the complex of salt caves in Hallstatt-Dachstein, vine terraces in Lavaux, Switzerland.

In 1997, Latvia's capital city Rīga was recognized as the only such highly valued object of cultural landscape for its typologically and stylistically diverse architecture in a concentrated urban environment. The Turaida Museum Reserve within Gauja National Park might meet the criteria of the international expert commission and is a serious candidate for the UNESCO World Heritage List. To offer efficient return to the society, it is in the Turaida Museum Reserve that the components of cultural landscape – the museum collections, medieval architecture, the glacier-transformed picturesque landscape and diverse nature – are actively protected.

The cooperation between the Ministry of Culture and the Ministry of Regional Development and Local Government has resulted in a national operational programme 'Infrastructures and Services' which includes an essential analytical chapter 'Socio-economic Impact of the Cultural Environment'. In its preamble the creation of an attractive cultural environment and a developed cultural infrastructure have been pointed out as preconditions for the improvement of the quality of life. The document guidelines are oriented towards implementation of economic and social projects to improve the quality of the cultural environment.

In real life, however, both global and national achievements in the preservation of the cultural environment consist of initiatives, programmes and concrete steps to ensure sustainability of the cultural environment taken by the governments of individual countries, municipalities and local administrations.

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CASE STUDY: UKRAINE

PRESERVATION OF AN AUTHENTIC CULTURE AND FOLK ART THROUGH GREEN RURAL TOURISM IN THE MOUNTAIN AREAS OF WESTERN UKRAINE

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Culture and traditions are among the resources of social and economic development of states in the 21st century. In the local traditions one can find answers to a number of contemporary problems; similarly, through ethnic relations a human being can find his or her ties with nature.

Among European countries, Ukraine is distinguished by a great diversity of landscape complexes, considerable historical and cultural, ethnic and genetic heritage. Largely due to this diversity, a rational use of the tourism and recreational potential of Ukraine is considered to be one of effective ways of solving the problems of Ukraine's economic development as well as preservation and revival of its authentic culture. Tourism industry should actively participate in the preservation of natural and cultural heritage – material heritage and the language, traditions, folk songs, dances and other components of non-material cultural legacy. When tourism is based on the uniqueness of the object and its authenticity, and the income from tourism stays with the local community, tourism helps support the cultural heritage. Tourism is also a cultural exchange with the help of which tourists and local people perceive and learn cultural diversity and interact with each other. According to this understanding of tourism, the focus is on the local people – how they benefit in different aspects, including the cultural aspect. The principle of sustainability should lie at the basis of such kind of tourism. The sustainability principle envisages support of the local culture through preservation of cultural and natural objects and improvement of the quality of life of the local population.

The Ukrainian countryside boasts extremely rich historical and architectural heritage, an authentic way of life, picturesque landscapes and medicinal and recreational resources. Ukraine has all the prerequisites to develop recreation in the countryside – natural and cultural potential which enables to use the historical and cultural heritage to the full and contribute to preservation of the national identity of the country. The idea of rural recreation in Ukraine along with preservation of ethnographic uniqueness is gaining national importance nowadays. First, rural recreation gives impulse to the revival and development of the traditional culture, national architecture, art, handicrafts – all that, alongside with natural and recreational factors, is attractive for tourists.

Second, through rural recreation, the urban population can get acquainted with authentic Ukrainian customs and traditions.

Third, the ethnic rural culture represents Ukraine in the world and attracts foreign tourists.

According to research, the beginnings of organised recreation in the rural areas in western Ukraine date back to the beginning of the 19th century when the distinguished historians and ethnographers Markiyan Shashkevych, Ivan Vagylevych and Yakiv Holovatskyy organised trips to rural areas in the Carpathian mountains and studied the traditions and folklore of the region. Recreation in rural areas in the period between the end of the 19th century and the middle of the 20th century was called *'litnysko'* (summer stay) because it meant a long-term stay of townspeople in the rural areas mostly in summer months. This form of recreation combined several components of tourism, such as relaxation, the cognitive component (studying the local history, culture and natural values) and the active component – hiking, horse-back riding and skiing.

Diversity and beauty of the landscapes, the distinctive folklore and art, tasty home-made food, physical and spiritual recreation attract thousands of tourists to the hospitable homesteads of the Carpathian mountains in the western part of Ukraine.

From the point of view of the consumer, recreation in the countryside is a possibility to change the environment from polluted areas and dynamic and stressful life style in the city to calmness and silence, giving a chance to return to the origins of his nation, to its natural and cultural heritage and, this way, to satisfy a number of spiritual needs. In the context of Ukraine the main aim of rural tourism is to create a tourism product that offers more than the traditional tourist offer and takes into account the natural, historical and cultural specifics of the region. The world experience testifies to the extremely important role of tourism based on incorporating national values in the economy of countries and viability of their historical and cultural environment.

The Carpathian Mountain Region is the most charming place in western Ukraine enveloped in ancient myths and legends – the treasury of old traditions, many-century cultural achievements of its people. Most of them are the fruits of Christianity beared by the tree of local pagan beliefs. The latter still live in the genetic memory of ethnic groups and are reflected in the architecture and handicrafts. They are echoed in the beautiful customs of church and village celebrations. As in the ancient times, the mountain people sing and dance to traditional music, wake the mountains with the sounds of folk instruments – *trembitas*, *sopilkas* and *drymbas*.

The Carpathian Ethno-geographical Region is divided into three main parts: the Pre-carpathian Region, the Carpathians Proper and the Transcarpathian Region. For a considerable amount of time, they were parts of different states. Nevertheless, the people have preserved ancient features of their culture quite different from their neighbours.

There are three ethnographic groups living in the Carpathian region at present: Lemkos, Boykos, and Hutsuls. The Lemkos live on the slopes of the Beskidy, between the San River and Poprad River, and in the Transcarpathian Region. The first historical records about this ethnic group date back to the 6th century. The Boykos reside in the Ivano-Frankivsk and Lviv regions and in the Transcarpathian Region. Many historians consider them descendants of the Celts. Their territory is marked with Celtic monuments. The Hutsuls live in the areas of Ivano-Frankivsk and Chernivtsi regions and the Transcarpathian Region. The Hutsuls markedly differ from all other inhabitants of the Carpathian Mountains in their life style, customs and traditions. The specifics of the Hutsul culture have given birth to the hypotheses that they are of Caucasian origin mixed with Ukrainians. Researchers find a number of features common with the legacy of ancient Etruscans in the Hutsul architecture.

The sub-regions of Ukraine are characterised by abundance of natural, historical and cultural resources and a developed network of green tourism. The main tourism products are: cultural tours to the workshops of skilled folk craftsmen, ethno-cultural tours, attending *festyny* (national festivals connected with agricultural traditions). The local authorities, experts and businesspeople defined the following representative objects of rural tourism:

- open-air museum 'Hutsul Village' in an urban village Kosiv (Ivano-Frankivsk region), representing traditional rural architecture;
- open-air museum 'Boyko Village' in Drohobych district (Lviv region), representing traditional life style;
- 'Hutsul Homestead' in the village of Tatariv (Ivano-Frankivsk region) with traditional Hutsul cuisine;
- cottage site in the Hutsul and Boyko style in the Skole and Yaremche district (Lviv region);
- museums and schools of traditional crafts (Kosiv and Rakhiv regions).

The centre of ethnographic and festival tourism – the ancient town of Kolomyya in the Carpathian Region (the first record in 1240) is even more popular. Among the attractions of the town there are J. Kobrynskyy's Museum of Folk Art of Hutsul and Pokuttya Districts, the Museum of Pysanka (painted Easter egg) with an exposition of 10 thousand painted eggs with different ornaments and painting techniques. Every year in August, Kolomyya organises the international Slavic Folk Festival 'Kolomyjka' with Ukrainian dances and songs.

Figure. **Painting of Easter eggs in traditional techniques**

Another example is the Hutsul village Kosmach. It is the largest village in Europe (area 84 km²), with 6 000 inhabitants, 8 schools and a hospital. The name is translated as the 'sun cell', and from above the village looks like a sunflower with a centre and 32 petals. Rich yellow colour is characteristic of the local fabrics, embroidery and crafts. The village is said to have never been incorporated into any kind of collective economy even in the years of the Soviet rule. Nowadays it is the only place where people can watch and take part in authentic Hutsul wedding ceremonies.

Ethnographic and festival tourism is gaining ever more popularity in the Transcarpathian Region. Among the destinations of recreation are the Highlands of Rakhiv. Objects of interest are, e.g., 'Hutsul Bryndzya' (Hutsul sheep cottage cheese). The ethnographic entourage aimed first of all at tourists is of great practical importance to the locals, as it revives sheep breeding because the traditional technology of making cheese is upgraded and the market is expanded.

The World Boyko Celebration is an international ethnic festival of the Boykos held once every five years in the Turka district (Lviv distric). Amateur folklore ensembles from western Ukraine and all over the world take part. The festival is a symbol of the nation's origins and its present as an indivisible unity, stability and succession.

Ever more people are excited by the possibility to be introduced to the lifestyle of the highlanders, a presence of a unique ethnos in the urbanised and globalised contemporary world.

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13 SUSTAINABLE DEVELOPMENT

13.1 LIMITS TO GROWTH

13.1.1 NATURE OF GROWTH AND SOCIAL DEVELOPMENT

The development of humanity in the 20th century is characterised by an exponential growth of human population, production and consumption as well as globalisation of numerous processes. Certainly, not everything grows at the same rate; for example, the world oil consumption rate has been slightly decreasing, while that of natural gas – increasing. The nature of selected characteristic changes in the development of humanity is presented in Figure 13.1, which clearly shows that the rates of change are different but the common trend – growth – persists.

The world human population exponential growth started with the Industrial Revolution. The amount of the world industrial production (as an aggregate of the gross national product) demonstrates the trends of exponential growth, even if we disregard the changes created by the fluctuations in the world oil price and the economic crisis. The amounts of pollutant emissions are also growing, and global climate change is the consequence of rising concentration of CO_2 in the atmosphere.

Social development has often been viewed as an achievement. Many communities and peoples, rich and poor, are seeking opportunities for the expansion of their activities to solve vital problems. In the developed part of the world, the necessity of economic growth is justified by the need to create new jobs and provide social security and technical achievements. In developing countries, economic growth appears to be the only way out of poverty.

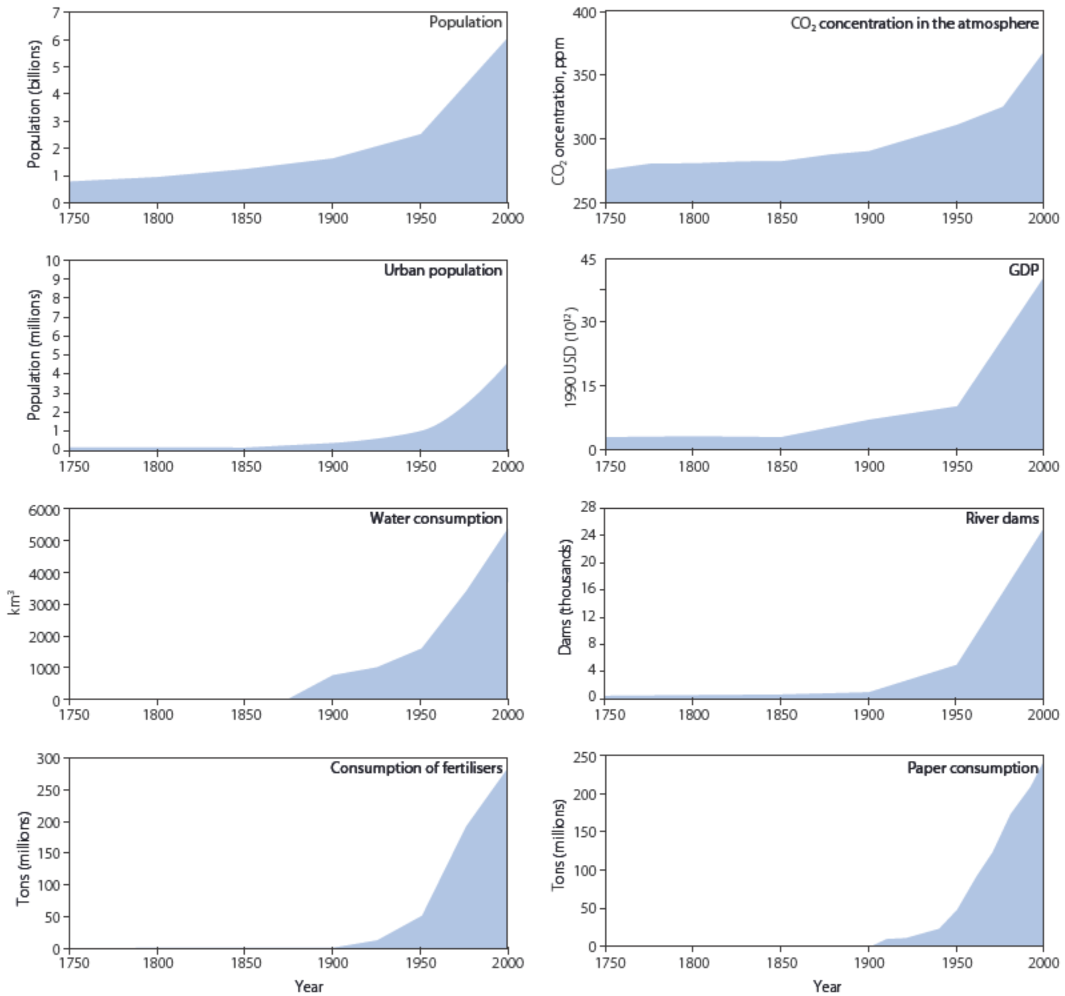

Figure 13.1. **Variability of characteristic human development indicators over the last centuries**

Unless a different solution for world's problems is found, people will look upon development as the main road to a happy future and will do everything to promote growth. Such is the psychological and material motivation for growth.

Obviously, growth can solve some problems; unfortunately, it also causes new ones. This is due to the growth and development limitations. The Earth has its limits. Any physical growth, also population growth, rising numbers of automobiles and buildings, increase in pollution still continues. However, human birth rate, number of cars or buildings and pollution levels are far from the most important limits to growth. The truly vital limits are related to the flows of energy and materials required to sustain people, make cars and construct buildings.

Society and economy depend on constant flows of air, water, food, raw materials and organic fuel, which come from the Earth. However, these flows create the flows of pollution and waste. Limits to growth in fact are limits of global resources and our planet's limited capacity to absorb waste and pollution.

A range of human activities, from the use of mineral fertilisers to urban development, are growing exponentially and can be represented graphically (Figure 13.1).

Exponential growth is the driving force that is responsible for our economy approaching the physical limits of our planet. Rooted in human culture, exponential growth has become an inseparable part of the global system.

The concept of exponential growth, simple on the face of it, can produce surprising results if we look into what it means in our everyday life. It can be illustrated by a Persian legend about the wise courtier who gave his ruler a gift of wonderful chessboard. When asked about a reward, he asked for grains of rice the number of which would be doubled on every next square of the board. One grain on the first square, two grains on the second, and on the tenth square there should be already 512 grains, on the fifteenth – 16 384, while the twenty-first square required over a million grains of rice. Naturally, the ruler's resources of rice were insufficient.

The number of human population and capital are the driving forces that ensure the growth of the industrialised world. Other parameters – food production, use of resources and pollution – also show a trend of exponential growth, although not because they themselves multiply but because of the impact of the human population and capital. Thus, food production and the use of resources and energy have been increasing not because of their structural capacity but because the exponential growth of human population demands ever more food, materials and energy. It is the growing number of population and capital that determine exponential growth. As they increase, they call forth demands for materials and energy which, in their turn, increase pollution emission. This is no arbitrary assumption; it is a fact. Exponentially growing systems have a structural nature, and the mechanism that determines growth is known and comprehended. We have to bear in mind that human population and capital as well as the supporting flows of energy and materials have been increasing for centuries, with a few short-term lapses. Production capital includes equipment, hardware, machines and plants that are necessary to produce goods with the help of labour force, energy, raw materials, land, water, technologies, management and our planet's natural ecosystems. Production capital creates an incessant flow of production.

Changes in the nature of capital can be characterised by exponential growth, exponential decrease or dynamic balance. Just like the number of population depends on demographic changes in the process of industrialisation, so is economy dependant on the process of long-term changes. Production capital grows exponentially and faster than the number of population. Between 1970 and 2008, the world production volume has grown by almost 100%. Such a growth should have produced twice as many industrial goods per person if the number of population had remained constant. However, with the growing human population, the average amount of industrial goods per person has grown only by a third.

If the rate of capital growth exceeds that of population growth, according to the demographic transition theory, an increase in the material standard of living should slow down the rate of population growth. To a certain extent and in some places this is true. However, neither economic growth nor its demographic counteraction is sufficiently fast. In individual cases these factors even facilitate each other. That is why economic welfare dwindles while the number of population remains constant or is on the increase. In a way, this trend is determined by the type of distribution of goods.

While all sectors of world human activity have witnessed huge development, social problems in the world become more vexing year after year:

- every year over two million children below the age of 5 die of easily preventable diseases;
- every day 6 000 children die of diseases that are related to the shortage of clean drinking water or poor living conditions;
- about two billion people have no electricity, another two billion suffer from its shortage;
- since 1985, over seven million people in 25 countries have died of AIDS;
- out of 1.2 billion people who live in extreme poverty, around 900 million reside in rural regions; their survival directly depends on biodiversity, level of water pollution and soil degradation.

Economic stratification of the world society is particularly evident. The type of distribution of natural resources as well as human-produced material and non-material wealth has created both very well-to-do people and an extremely destitute part of society. According to the World Bank estimates, an average income of one-fifth of the world's population is less than 0.7 euros per day. 70% of these people are women.

The world's twenty most developed countries, comprising approximately one-fifth of the world's population, mostly are in North America and Western Europe, and Japan, Singapore, Australia, New Zealand, the United Arab Emirates and Israel also belong to this group. Over three billion live in the poorest countries in Africa and Asia. The gap between these two worlds is growing. The annual income level of an average person in a world's affluent country is over 100 times higher than that of an average resident of a low-level income country. The inequality gap is even more striking at the level of individuals. The total wealth of the world's 200 richest people amounts to 0.7 trillion euros, which is more than possessed by the three billion of world's poorest people together.

The lifestyle of the well-off people has an essential impact on the consumption of the world's resources. For example, the USA with its 5% of the world's population consumes about one-fourth of the world's industrial goods and produces nearly half of industrial waste. An American citizen's average daily consumption comprises 450 kilograms of raw materials, including 18 kilograms of fossil fuels, 12 kilograms of agricultural produce, 10 kilograms of timber and paper, and 450 litres of water. Annually, Americans dispose of 50 million tons of paper, 67 billion bottles, 18 billion pampers, 2 billion razor blades and other resources.

The economist Jeffrey Sachs, Director of the United Nations Millennium Project, points out that eradication of extreme poverty by 2025 is feasible if the developed countries donated just 0.7% of their GNP towards aid to developing countries. These funds should be used on vaccinating children against infectious diseases, ensuring general accessibility to primary education, family planning services for those who need them, provision of drinking water and sanitation, food for the famine-stricken, and for strategic micro-loans to self-employed people. This sum – 10 billion euros a year – is much bigger than the current donations; however, the question is about the priorities. At present, military expenditure exceeds 0.7 trillion euros per year, which amounts to the annual income of half of the world's population. The price of an aircraft-carrier is tantamount to the sum that all the industrially developed countries donate to aid developing countries in ten years.

In industrialised countries, economy develops more rapidly, and economic growth is systematically in progress. Economic stagnation in developing countries is determined by a number of causes, including systematic injustice and oppression, especially concerning the poorest layers of society. It is much easier for a developed country to economise, invest and accumulate capital not only because developed nations have a better control of markets, develop and purchase new technologies and manage resources. During the previous centuries of growth, the developed countries have accumulated more capital which can now be multiplied even more efficiently. However, providing for basic needs in the future is feasible without the depletion of the existing reserves by economising resources and preserving the volume of investments. A smaller population growth in more developed countries enables them to allocate most of production capital to industrial investments and diminish investments in the service sphere, particularly in health care and education. Rapidly developing countries and economies cannot afford it.

In developing countries, there are considerable restrictions to capital growth due to growing population and other reasons. The surplus value that could be used for investments is allocated, luxury of the power elite, payment of external debt or excessive militarisation. Conducive to poverty is corruption, low level of education, and mismanagement, while population is placed under the growth model that increases the number of population and prevents the growth of welfare. The structure that relates the number of population to capital ensures the principle of the global economy model which can be illustrated by an ancient

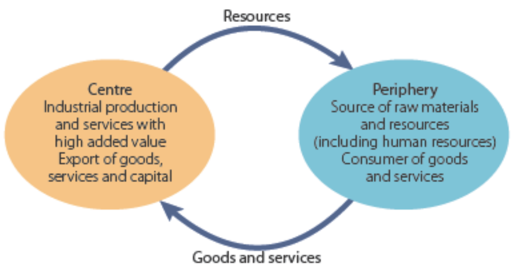

Figure 13.2. **Simplified scheme of division of labour in globalised economy: structures of centre and periphery**

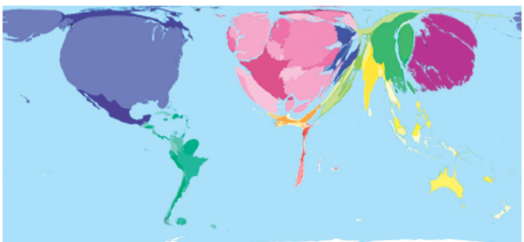

Figure 13.3. **Distribution of welfare: countries of the world**
The size of the countries on the map is in proportional to their per capita GNP.

proverb: the rich become richer, the poor beget children. Notably, these features of the system are by no means accidental. The system has been created to produce precisely such results, and the process will continue if the structure is not subjected to well-considered changes. Population growth impedes the growth of production capital, calling forth ever-increasing demands of schools, hospitals, resources and basic goods, in this way diminishing the part of industrial produce that could be invested in production. Poverty makes the growth of human population endless, forcing people to live without quality education, health care and access to family planning. The only choice or way to live on is a big family and a hope that children will help to raise the family income or serve their family as labour force.

Poor people need food, shelter and material values. The well-off people use material growth in order to satisfy other needs, real but non-material: boosting their own recognition, self-confidence, unity, personality. While we are rapidly approaching the limits of our planet, unfortunately, discussions about the limits to growth in many cases does not have any influence on these people.

13.1.2 LIMITS TO DEVELOPMENT

Considering the self-regeneration potential of population and industrial capital, they can be viewed as the driving forces of the world system's exponential growth. Society promotes their growth in every way for the purpose of ensuring production.

The number of population and capital have a potential that ensures their production and reproduction. This potential cannot be realised without a continuous supply of energy and materials or without a continuous removal of pollution.

People need food, water and air for their growth, sustenance of their bodies and procreation. Production, in its turn, needs energy, water and air as well as huge amounts of minerals, chemicals and biological material to produce goods, to facilitate human life, to maintain the system of production and ensure its increase. In accordance with fundamental laws, people- and plant-consumed materials and energy do not vanish. Materials can be recycled, or they turn into waste and pollution, whereas energy is dispersed as heat.

Materials and energy consumed by population and capital are extracted from the Earth, returning waste and heat to the Earth instead. There is a constant flow from the global sources of energy and materials via economy to the environment, where waste and pollution are accumulated. However, there are definite limits to the increase rate of the use of materials and energy and the resultant production of waste, so that it would not harm people, economy or the Earth's absorption processes, regeneration and self-regulation.

All resources that people use – food, water, iron, phosphorus, oil and thousands of others – are limited in terms of both their sources and resulting emissions. These limits are complex, since both the sources and emissions constitute part of a dynamic, interrelated and single system – the Earth. There are short-term limits, for example, the amount of oil in a reservoir stored for a specific purpose; there are also long-term limits, for example, the amount of oil in the Earth. Sources and discharges can interact, while the planet can, through natural processes, influence both the sources and pollutant emissions. Thus, soil can be both a source for food production and a recipient of acidic precipitations resulting from air pollution. The capability of soil to perform a particular function largely depends on the performance of other functions.

To introduce some clarity in this complexity and to define long-term or equilibrium limits to development, the World Bank economist Herman Daly has offered three simple regularities:

1) for renewable resources – soil, water, forests, fish – the rate of long-term use must not exceed that of their regeneration. For example, catch of fish is viable if the fishing rate is in balance with the reproduction of the remaining fish population;
2) for non-renewable resources – fossil fuels, high-concentration mineral ores, natural underground water – the rate of their balanced use must not exceed that of the use of renewable resources to replace the non-renewable resources. For example, the use of oil fields would be balanced if part of profits were systematically invested in the production of solar panels or planting trees. This means that when oil reserves are exhausted, the flow of renewable energy will be sustained;
3) the rate of pollutant emissions must not exceed the rate of absorption of pollution or the rate of rendering it harmless to the environment. For example, a discharge of wastewater into a lake or a river is admissible only if the rate of discharge corresponds to the ecosystem's natural capability of self-purification.

There is plenty of evidence to support the idea that development and growth take place at the expense of irreversible depletion or degradation of the existing resources.

The nature of human development demonstrates that people do not use the Earth's resources and possibilities of development in a balanced way. Soil, surface waters and groundwater, wetlands, nature and the environment are degrading. Even in the places where renewable resources seem to be plenty (for example, North American forests or European soils), the quality and diversity of these resources and their potential of survival can be questioned. Mineral and fossil fuel resources are running out. Moreover, there is no plan and

Figure 13.4. **Forest gutted by fire (summer of 2009, Greece)**

no satisfactory capital investment programme to sustain industry when fossil fuel will have run out. Pollution is accumulating – pollution emission has started to overtake the flow of substances in their biogeochemical cycles, and the chemical composition of the atmosphere is changing.

If only a single resource or several resources run out while there is sufficient amount of others, we might presume that growth will continue by replacing one resource with another (although there are limits even to such replacement). However, if many sources are depleted and pollution flows are overloaded, there is no doubt that human consumption of materials and energy has gone too far. Humanity will have overstepped the limits of sustainable development.

These limits apply to the amount of raw materials that has been used up over a given period of time. Humanity has accelerated the consumption of resources not only in terms of space, rate of flows or limits; this is also true concerning human population growth.

13.1.3 BEYOND THE LIMITS

In 1972, an interpretation of the nature of as well as limits to human development and, what is more important, modelling the consequences of exceeding these limits and guidelines for action were offered by Dennis Meadows, Donnella H. Meadows and Jørgen Randers, authors of the book *Limits to Growth*. The character of human economic development and the approach to the solutions of environmental and social problems confirm that the offered prognoses and models are correct and that it is necessary to change the character of development.

The modelling of humanity's development is based on the assessment of the volume of the existing and available resources, correlating their changes with the number of population and capital. To achieve this aim, it is necessary to turn from the static analysis of a single factor in time to a dynamic analysis of the whole system.

In the majority of the world countries, capital grows faster than the population, although in some other countries a reverse process can be observed. In some countries the growing economy allows to slow down the birth rate, while in other countries poverty and social inequality increases mortality. People who have become richer demand more goods, more energy and cleaner air. Poor people fight for clean water, agricultural land and firewood. Some technologies increase pollution flow, others decrease it. The reserves of non-renewable and some renewable resources are running short, while the remaining reserves are used more intensively and more efficiently.

The modelling of the nature of human development (Figure 13.5) demonstrates that, with the existing trends of development, even with sustained technological progress and expanded accessibility of raw materials and resources, an overshoot of limits to growth and catastrophic drop in welfare can occur already in this century. A possible consequence of

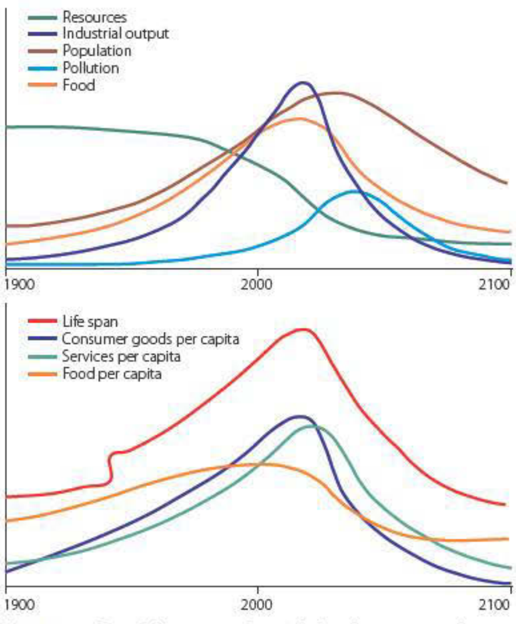

Figure 13.5. **Possible nature of social development at the existing consumption rate**

The number of human population, the volume of the use of resources and the volume of consumption in developed countries continue to grow like it was in the 20th century, until the growth rate is decreased by the availability of non-renewable resources and their rising price. Eventually, this leads to the decrease in production volumes and allocation of investments to support resource flows, whereas the decreased availability of investments in other sectors of economy leads to the decrease in industrial production and services. As the volume of industrial and food production diminishes, the availability of health services shrinks, and, as the environmental pollution increases, the life span falls into decline.

this is decreased industrial production and food availability, as well as a decrease in the number of population.

Over the last century, modern society has witnessed a rapid human population growth and has made remarkable achievements in the technological and social spheres: from the steam engine to democracy, to the computer and corporations. The achievements have enabled economy to overstep the visible physical and material limits and sustain continuous growth. This is especially true about the last decades, when the full-scale industrial culture was associated with the development of consumer society and implanted in human minds as an idea of unceasing growth. To most people this makes the idea of limits to growth inconceivable and unacceptable. Politically, limits should not be mentioned; economically, they are inconceivable. Society tends to dismiss the possibility of limits and tries to replace it with a possible fight for the improvement of technologies and the development of free market. Meanwhile, the results of social growth modelling show that the existing way of human development has exhausted itself.

- If the tendency of growth for the world population, industry, pollution, food production and consumption of resources continues, the limits of our planet will be reached approximately within this century. Use of more common resources and numerous types of pollution have already exceeded the rates that can be physically balanced. Unless a considerable decrease in the flows of materials and energy is achieved, the coming decades will see an uncontrolled decrease in per capita amount of food, energy and industrial produce. As a foreseeable result, there may be a sudden and uncontrolled decrease in population and volumes of production.
- However, this decrease is not unavoidable. It is feasible to diminish the tendencies of growth and create conditions for environmental and economic stability that can be well balanced even in a long-term future. The global equilibrium should be created with a view to satisfy every person's basic material needs and provide equal possibilities of self-development for all.
- The existence of a balanced and sustainable society is technically and economically viable, and it is more desirable than a society that seeks to solve its problems through continuous expansion. Transition to a balanced and sustainable society requires carefully balanced long-term and short-term goals, preferring sufficient provision for life, equality and quality instead of the volume of the aggregate product. It takes more than just labour productivity, more than just technology; it also takes maturity, empathy and wisdom. Should people opt for the second option, the sooner they start acting, the better are the prospects for the success.

13.2 CONCEPT OF SUSTAINABLE DEVELOPMENT

Today the concept of sustainable development is not just an opinion on how humanity as such and also each community and society should develop; it is principally a set of opinions about the model of a society that can ensure its own existence. The concept of sustainable development includes physical conditions, political conceptions, the notions of the quality of life or welfare and an optimised influence on the environment to ensure that the resources are equally accessible to all generations. The concept of sustainable development is based on the understanding of three notions: development, needs of society and needs of the future generations. Within the concept of sustainable development, the notion 'development' includes not only growth (of production, gross national product, welfare) but also the development of social and economic spheres that guarantees the preservation of natural ecosystems and the human living environment. Thus, the concept of sustainable development not only looks at short-term processes (to satisfy the current needs) but also aims at ensuring equal possibilities for the next generation.

A society that would exist eternally could be deemed sustainable. With this perspective, the concept of sustainable development is a frame of reference that aims at influencing the future of humanity and the existence of society. So far, social development models have been unsuccessful and have proved either their obvious inability to ensure social development, or they have not managed to take into account essential differences between various regions of the world. Re-evaluation of social development conceptions largely depends on understanding the impact of social development on the environment and the urgency of environmental protection. Many arguments support the necessity to re-evaluate the models that have been practiced up to now.

- Development, especially in Western societies, is understood as human domination over nature (illustrated by the phrase 'man – the crown of creation') and the use of its resources for the development of production. This attitude ignores the role of nature and ecosystems in providing for the development of humanity; it also ignores the value of nature *per se* and that other forms of life and living organisms may have needs and, most importantly, a right to exist.

- The main priorities in the development model that dominates in Western societies is economic growth and consumption, the latter being the principal parameter of an individual person's and humanity's welfare. In conformity with this concept, social welfare is the standard of life – the part of income that is used to purchase goods and services. This model of development, based on individual consumption, eventually leads to huge inequality in terms of income and welfare even within a single country (especially because of the cyclic nature of free market economy), to say nothing of the arising differences between different regions of the world. The inevitable differences of such welfare model result in social tension, military conflicts and social instability.
- The consumer society's development based on the increase in resources unavoidably leads to the increase in consumption and industrial waste (pollution) and depletion of resources. Due to the growth of production and increase in consumption, the nature of environmental problems over the last decades has changed.
  - *Environmental pollution sources – point or non-point.* In the past, point sources of pollution were common, for example, pollutant discharge into the air or water from a plant, leakage of hazardous substances as a result of an accident or from a landfill. Gradually, the harmful influence on the environment became less concentrated, and non-point sources of pollution started dominating, such as agricultural runoff of nutrients, domestic use of chemicals, pollution arising from automobile exhausts. The consequences of point source pollution can be tackled by restrictive measures; dealing with the problems created by non-point sources is much more complicated and takes more time to achieve positive result.
  - *Scale of environmental problems – local, regional or global*. Until quite recently, pollution was of a local nature, usually around the point source of pollution. Later on, it transpired that pollution can impact regions, crossing the borders of countries, for example, acid rains and eutrophication. At present the most topical environmental problems are of a global scale. The larger the scale of the problem, the more difficult it is to tackle it, as it requires international cooperation.
  - *Duration of environmental problems – short-term or long-term*. In many cases the harmful impact on the environment is short-term if the activity of the source is limited in time. Such were the cases of air pollution from district heating plants or water pollution from small inhabited places. Currently, most of the environmental problems are long-term; they do not disappear immediately even after the source is liquidated. Persistent organic compounds, compounds of heavy metals or radioactive contamination can affect the environment long after the pollution has stopped. An example of this is the eutrophication of the Baltic Sea, the reduction of which is going to take several decades, even if the nutrient release were totally stopped.
  - *Complexity level of environmental problems – simple or complex*. Many environmental problems are becoming more and more complex. A single enterprise may use hundreds of various chemical substances and many of them can be environmentally persistent. Also, consumer goods can affect the environment in more ways than one. Not just various substances, even different sectors of industry, have a synergistic influence on the environment. The more complex the environmental problem is, the more complicated it is to understand and tackle it.
- The consumer society's model of development ignores the fact that it is unviable to globally sustain the type of production which consumes resources and degrades the environment and which ensures the lifestyle of the world's most developed countries. Already now, when the desirable consumption level has been attained in a relatively small number of the world countries, all the ecosystems of the planet cannot absorb the human-created pollution, like in the case of greenhouse gas emissions causing climate change. It is obvious that the Earth's resources are insufficient to ensure the existing consumption level in West European and North American countries over a long period of time, not to speak of ensuring such a volume of consumption for all people in the world. Similarly, the consumption rate increase is unviable in the future, even if we do not take the technological progress into account.
- The understanding of the character of the development of the so-far existing Western societies was based on the idea of limitless development and growth. Now we have to admit that there are limits to economic growth. They are determined by the planet's carrying capacity, accessibility of resources whose amount is limited, and the capacity of the planet's ecosystems to absorb pollution. Although technological progress can, undoubtedly, increase the efficiency of how resources are used, it is impossible to overcome these development limits. Hence, the development of humanity must guarantee a balance between the planet's ability to sustain human existence and the desired lifestyle.

13.3 FORMATION OF THE CONCEPT OF SUSTAINABLE DEVELOPMENT

The necessity of sustainable development was first declared in Stockholm in 1972, at the UN Conference on the Human Environment. The contemporary understanding of sustainable development is based on the idea that was voiced in the 1987 Report by the UN World Commission on Environment and Development: Our Common Future: 'Sustainable development is development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs.'[1] The concept of sustainable development, its agenda and solutions for its implementation today are important tasks of the UN. The UN Conference on Environment and Development in Rio de Janeiro, 1992, was dedicated to the above issues. Two important documents were adopted at the conference: 'Declaration on Environment and Development' and action programme for the 21st century 'Agenda 21'.

The strategy 'Think globally, act locally' highlights the idea that no global action is feasible without purposeful local steps. Many countries of the world have recognised the necessity to design their development strategies in such a way that not only the rates and prospects of economic development as well as quality of life are sustained but also environmental degradation and over-consumption of resources are eliminated. Thus, the concept of sustainable development became a frame of reference that could influence the activities of the contemporary society and the development of the future society. The sustainability of the development of the world countries was evaluated in 2002 at the UN World Summit on Sustainable Development in Johannesburg, the Republic of South Africa.

An updated and more elaborated definition of sustainable development is provided in the European Union Sustainable Development Strategy:

Sustainable development means that the needs of the present generation should be met without compromising the ability of future generations to meet their own needs. It is an overarching objective of the European Union set out in the Treaty, governing all the Union's policies and activities. It is about safeguarding the earth's capacity to support life in all its diversity and is based on the principles of democracy, gender equality, solidarity, the rule of law and respect for fundamental rights, including freedom and equal opportunities for all. It aims at the continuous improvement of the quality of life and well-being on Earth for present and future generations. To that end it promotes a dynamic economy with full employment and a high level of education, health protection, social and territorial cohesion and environmental protection in a peaceful and secure world, respecting cultural diversity.[2]

The concept of sustainable development is based on the necessity to optimise economic development and social system, as well as the impact on the environment and the use of resources. This model of development has to ensure the sustainability of economy, environment and the social sphere in time and space (Figure 13.7). The three basic spheres requisite for the humanity's existence today are the following: viable economy, harmonious society and healthy environment. These are also the desirable external prerequisites for the development of an individual. Sustainable development implies that each economic, social or environmental issue must be solved in such a way that the adopted decision is favourable, or as little unfavourable as possible, for the development of other spheres.

Figure 13.6. **Boutros Boutros-Ghali, Secretary General of the UN, opens the Conference on Environment and Development in Rio de Janeiro, 1992**

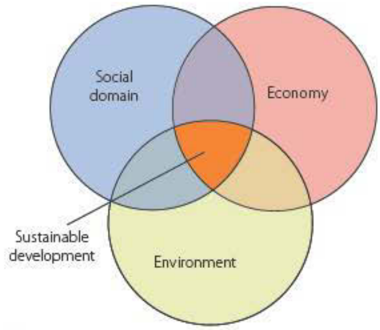

Figure 13.7. **Sustainable development of the environment, economy and the social domain**

[1] Our Common Future (1987) Oxford: Oxford University Press.
[2] EU sustainable development strategy. Accessible: *http://ec.europa.eu/environment/eussd/*

Sustainable development goals and principles have become guidelines for the adoption of corresponding decisions concerning economy, policy and environment protection with the aim to:

- restrict human impact on the surrounding natural environment and prevent further overstepping the self-regeneration capacity of the environment;
- maximally decrease the consumption of non-renewable resources and ensure a more extensive use of renewable resources;
- safeguard and protect nature to ensure the preservation of biodiversity;
- promote economic development to satisfy human needs, improve the quality of life and ensure fair distribution of the world wealth;
- create a decision-making and management system that is conducive to citizens' participation in the decision-making process.

The main tasks of sustainable development are the following.

- Preservation of resources, i.e. ensuring the availability of resources for humanity's development not only to the present but also to the future generations. This involves the necessity to implement an agenda and policies that aim at raising the efficiency of the use of non-renewable resources, their replacement with renewable resources, at the same time preserving biodiversity and protecting the genetic potential of species. The ways of carrying out this task are well known, for example, the development of alternative energy sources, recycling of industrial and other waste, development of new, environment-friendly technologies.
- Balanced development of the human-created (anthropogenic) environment and the natural environment, related to, for example, the necessity to preserve the productivity of agricultural lands or optimise the use of urban territories and traffic flows.
- Ensuring the quality of the environment that allows social development by discontinuing or restricting the processes that degrade the environment and exert an adverse impact on the self-regeneration of ecosystems, and by eliminating processes that may be hazardous for human health and lower the quality of life. Besides, it is necessary to restore the degraded environment at the same time.
- Ensuring social equality. Sustainable development cannot be achieved without ensuring social equality in individual countries as well as among countries by preventing the growth of income inequality and ensuring the kind of development that reduces social inequality.
- Social participation in the management of the state and the environment clearly shows that sustainable development must enjoy an overall people's support. Sustainable development is unattainable without a change in the citizens' attitude to consumption and use of resources. Social transition to sustainable development can be ensured only if there is a political commitment and transition from a socio-economic society based on the overuse of the existing resources and unequal distribution of benefits to a society based on social equality, considerate use of resources and efficient management. It is also clear that such social changes cannot be achieved by administrative reforms; instead, they must be introduced and supported by the grass roots. The objective of sustainable development is to bring about changes in the people's attitude to values by ensuring greater participation of citizens in political decision-making and social management.

Sustainable development can be attained by solving the above five tasks – implementing social planning within the framework of market economy without stipulating the instrumental political system.

Sustainable development is functioning when the aggregate stocks of the Earth's capital remain undiminished or continue growing. The aggregate stocks of the Earth's capital can be classified into three principal forms:

- economic (human-made) capital, which conventionally comprises equipment, technology, buildings and infrastructure, and which is used for producing goods and providing services;
- social capital, which is related to human welfare both socially and individually. It consists of social norms and formal and informal structures that ensure access to resources, helps to solve common problems and enhances social unity. It is based on human spiritual and physical health, education, motivation, talent, skills and abilities;
- natural capital, which includes all ecosystems and natural resources (renewable and non-renewable). Besides the conventional natural resources (timber, water, energy, minerals), the natural capital comprises also such values of nature that are difficult to express in monetary terms – biological diversity, species and ecosystems that ensure ecosystems services (for example, purification of air and water).

Sustainable development involves continuous development and preservation of all forms of capital, as humanity's existence and welfare depend on them now as well as in the future. Since the Earth's aggregate capital consists of the totality of these capitals, there is a possibility that the aggregate capital stocks can increase even if one form of capital diminishes. For example, the natural capital can decrease, while the economic growth may be sufficient to ensure the growth of the aggregate capital.

This is why the mutual substitution of capital forms can be described as two approaches to sustainable development:

- strong sustainability is achieved if none of the sustainable development capital forms is depleted. This approach is not based on the substitution principle and does not admit of the substitution of the natural capital with the human-made capital. As a result, the approach creates problems when the critical limits of the natural capital are determined. The denial of substitution of capitals, in turn, creates a situation when certain forms of capital are endowed with an absolute value which is higher than that of others;
- weak sustainability is based on the assumption that welfare and sustainability do not depend on a certain form of capital; instead, it is ensured if the Earth's aggregate capital stocks grow. This approach permits the mutual substitution of different forms of capital. Consequently, it would admit of logging Brazilian virgin forests to develop green farming in the vacated territory, or to invest the procured funds in the development of human capital. In this case, the problem arises as two incomparable categories – forests and people – are compared, determining their value and level of substitution. Weak sustainability is also based on the analysis of gains and losses, which admits of mutual substitution.

13.4 GUIDING PRINCIPLES OF SUSTAINABLE DEVELOPMENT

In the process of planning, implementing and evaluating the sustainability of development, a number of basic principles have been worked out. Some of these are socio-ecological principles, which clearly outline regularities of development and enable precise identification of development goals. There are different transition routes to sustainable development, and mistakes are possible; however, having a precisely defined goal is prerequisite. The advantages of socio-ecological principles lie in their assessment of sustainable development from a systemic perspective and consideration of activities in succession from the very beginning.

Among the basic principles of sustainable development, the most important are four ways of sustainability that give answers to the question 'how to act?' to ensure social development.

- **Diversity** should be viewed as a prerequisite for the development of any system (including society). Biological diversity, economic diversity and cultural diversity underpin the capacity of the biosphere and society to sustain their dynamic stability. Innovation and adaptation to new conditions are feasible if there are different approaches and alternatives to development, which can serve to form new, stable social systems. To enhance long-term stability, as often as not the most suitable strategy is the diversification of development.
- **Subsidiarity or self-government** implies all possible functions at the lowest possible level of management. External assistance or directives are acceptable only if they help to perform the delegated functions without endangering the autonomy of the subsystem. Self-government is closely connected with social responsibility and social security, and it can be applied to all spheres – politics, administration, entrepreneurship, technical systems, management of material flows in economy. This principle does not provide clear instructions; instead, it urges to seek the optimum solution between autonomy and integration in more comprehensive systems. The implementation of the principle of self-government stimulates individual participation and the proactive attitude of local governments with the aim to improve and manage their life, thus promoting democracy.
- **The principle of cooperation** emphasises the significance of horizontal, non-hierarchical interactions. This model of cooperation is based on common objectives and rules and, as a rule, is open: participants can join in or opt out. Cooperation networks ensure the exchange of experience and information, promote mutual support, stabilise systems as well as facilitate competition – participants can choose another, more attractive cooperation network. This is why a vitally important feature of cooperation networks is their ability to adapt to novelty and focus on the participants' needs.
- **The principle of participation** or involvement corresponds with the basic ideas of democracy and forms the grounds for diversity of approaches. It can play an essential role in avoiding conflicts. It is of utmost importance that all the parties involved in the solution of a problem should participate at the initial stage of defining the problem and identifying the possible alternatives. Participation facilitates responsibility and motivates people to make their contribution towards the implementation of the adopted decision. Besides, participation claims the participants' time and interest, openness of the institution involved and, as a rule, more time and funds than the accurate hierarchic decision-making. The chosen

procedure may pose a risk that the decision may not comply with the experts' opinion, while the principle of participation commands respect for diverse interests and opinions.

Although there are various basic principles of sustainable development, their application adds a practical dimension to adopting responsible decisions concerning economy, policy and environmental protection.

Assessing the implementation of sustainable development, the issue of using the concept of sustainable development in countries with different economic and social regimes is particularly important. Up to now, the most extensive research pertains to the perspectives of sustainable development in industrially developed countries. Although the number of such countries is relatively small, their complying with the basic principles of sustainable development is particularly topical due to the high level of consumption which, in interaction with the free market economy and globalisation processes, is, in fact, one of the principal causes of global environmental and development problems. At the same time, precisely the industrially developed countries display the understanding of the necessity of sustainable development. A strategically important trend of sustainable development in industrially developed countries is the concept of dematerialisation – decoupling economic development from material consumption or ensuring the growth of well-being against the background of diminished needs of material consumption and use of resources. The situation in industrially developed countries is considerably different from the situation, for example, in Africa, most of Asia, in South America as well as in many European countries. The people's desire to reach the level of welfare of industrially developed countries as fast as possible makes the necessity to decouple economic development and material consumption even more topical. Even so, sustainable development issues in the developing countries are related to the solution of the problems caused by the backlash of free market economy and globalisation, which cannot be solved locally.

13.5 ECOLOGICAL FOOTPRINT

To satisfy human needs for goods and services, the use of natural resources creates environmental pollution and waste. Ecological footprint is an indicator of sustainable lifestyle which shows how much land is required to satisfy people's needs.

Mathis Wackernagel, one of the author's of the ecological footprint concept, defines it as the area of land and water, converted into hectares, necessary to produce the products that an individual or a population, or an activity has consumed and to absorb the pollution formed in the life cycle of the products, using the existing technologies and experience of resource management. For example, the ecological footprint of a given country is the total land area in hectares that is necessary to produce food, goods and services consumed by its population and to absorb waste and pollution that have arisen in the full life cycle of these goods. The ecological footprint allows to measure and analyse the consumption of natural resources, volume of created waste and regenerative capacity of nature. Unlike other indicators (of impact on the environment), the ecological footprint also shows the pressure on the environment that our consumption causes in other countries, because the pressure on the environment from producing imported goods is in the country of origin.

The ecological footprint as an efficient indicator of the environment and development is rapidly gaining attention. It was the ecological footprint that the European Environment Agency in its reports of 2005 and 2007 on the environmental situation in Europe used as one of the indicators. This graphical representation of human impact on the environment

Figure 13.8. **Ecological footprint**

Ecological footprint is a means for measuring the flows of energy and materials in a given economic system (country, city, household), and the values are converted into the land area necessary for nature to maintain these flows.

Figure 13.9. **Ecological footprint in world's countries**
People consume resources and ecosystem services from different countries of the world, and their ecological footprint is the totality of these territories irrespective of their whereabouts. The map shows territories of countries by their ecological footprints in proportion to the total world ecological footprint. The largest ecological footprints are those of the USA, China and India. However, the largest ecological footprint per capita is in the USA, while in China and India it is three times smaller than the world average.

allows to compare different countries and also the dynamics of indicators within a particular country.

At present the ecological footprint is widely used in the world to characterise environmental sustainability and form public awareness of environmental issues. Several countries (Switzerland, United Arab Emirates, Japan, Belgium, Ecuador and France) have included the ecological footprint in their national statistics and carry out these calculations regularly. In the United Kingdom, the ecological footprint is extensively used in the environmental impact assessment, including that of the local development scenarios.

13.5.1 ECOLOGICAL FOOTPRINT CALCULATION METHODOLOGY

Bioproductivity is an essential parameter to assess the ecological footprint as an indicator of the consumption of natural resources in global hectares. It shows the planet's ecological capacity or biological productivity. In this way, the balance reflects the demand (ecological footprint) on the one hand and the supply – bioproductivity that consists of various bioproductive territories – on the other hand. These territories are:

- cropland,
- pasture,
- forest,
- sea,
- territory allotted to the preservation of biodiversity.

National bioproductivity is the whole of all the territories (including those not used because of economic, nature protection or other reasons). Each bioproductive territory is converted into global hectares, multiplying this territory by the equivalence factor of the given territory and the corresponding productivity factor. This calculation can be expressed with the following formula:

$$B = T \times EF \times PF\ ,$$

where
B – bioproductivity, ha_g,
T – territory, ha_g,
EF – equivalence factor, ha_g,
PF – productivity factor, t/ha.

As to the ecological footprint, its calculation begins with creating a matrix of the type of land use which includes, apart from bioproductive territories, the infrastructure and territories that are necessary for the absorption of carbon dioxide. Consumption categories within this matrix are food, dwelling, transport, consumer goods and services. The matrix of the land use type shows the kind of land use necessary to ensure the production of goods and consumption for a given number of people and consumption patterns. The number of population and information about various consumption categories are used to calculate the average annual consumption per person. The consumption is calculated by adding up the data on import and national production and subtracting export. The term 'seeming consumption' has also been introduced, which is different from the real household consumption since it includes the resources that are used in export and excludes the resources that have been invested in the imported goods (for example, energy that has been consumed to produce tomatoes in Spain and transport them to Latvia).

The territory of land necessary to produce the annual consumption of goods is attributed to a category of bioproductive territory (cropland, pasture, forests, fishing and built-up territories) which is multiplied by the equivalence factor to calculate the ecological footprint in global hectares:

$$EFp = \frac{C}{PF \times EF}\ ,$$

where
EFp – ecological footprint, ha_g,
C – consumption, t/g,
PF – productivity factor, t/ha,
EF – equivalence factor, ha_g/ha.

The methodology for ecological footprint calculation stipulates the parameters of the data used, re-calculation factors, boundaries of research and dissemination of results.

The methodology for ecological footprint calculation is based on the assessment of the area of bioproductive territory. Global hectares (ha_g) is the bioproductive territory (total area of the Earth is 11.2 billion hectares) with the world's average productivity. Instead of the volume of the produced biomass, productivity in this case is the maximum potential of agricultural production. This makes a hectare of fertile soil equal to several global hectares. Global hectares have been normalised so that the total number of hectares of productive territory would be the same as the quantity of global hectares. Global hectare is a means to compare the ecological footprints and bioproductivity of different countries.

Equivalence factor helps to convert the given bioproductive territory (cropland, pasture, forests, developed and marine territory) into global hectares. For example, cropland is more productive than pasture and its equivalence factor is correspondingly higher.

Table 13.1. **Land use equivalence factors (ha_g/ha)**

Land use	Equivalence factors (ha_g/ha)
Cropland	0.50
Forest	1.33
Built-up territory	2.64
CO_2 absorption	1.34

Productivity factors show the fertility of a particular type of bioproductive land in different countries. For example, owing to its high fertility of grass, one hectare of pasture in New Zealand can yield more meat than in Latvia. Such differences may be related to the local peculiarities, such as precipitation, quality of soil or particular management.

The ecological footprint is not a comprehensive indicator that would reflect all of the environmental pressure. It does not directly reveal chemical pollution, soil erosion, consumption of water resources, nutrient runoffs and sensitivity of forests to pests or storms, or other factors that can have a considerable impact on bioproductivity. However, the majority of possible impacts will affect productivity and are reflected in the ecological footprint and bioproductivity. The ecological footprint does not reveal the depletion of non-renewable resources (oil, coal, mineral resources) because the regenerative capacity of resources in the calculation functions as the delimiting factor. The impact of fossil and mineral resources on the environment in the ecological footprint calculation appears only in relation to the energy invested in the full life cycle of these resources. Therefore, the ecological footprint calculation is often complemented with the analysis of resource flows, which also includes information about the consumption and flows of mineral resources.

13.5.2 CONTEMPORARY SOCIETY'S ECOLOGICAL FOOTPRINT

The area of productive land available to the human population of our planet is only 2.1 hectares per person. However, the annual average ecological footprint per person worldwide is 2.7 hectares, and this means that our planet's ecoproductivity is being consumed faster than it can regenerate. We live in nature's debt.

Industrially developed countries with a comparatively smaller number of population are responsible for most of these pressures because the average ecological footprint in the high income countries is 6.4 ha_g/per capita, while in the developing countries it amounts on average to 2.2 ha_g/per capita, which is just slightly more than the globally available amount (2.1 ha_g/per capita). In the developing countries (approximately 2.4 billion inhabitants) the ecological footprint is even smaller – only 1.0 ha_g/per capita. Such differences in the ecological footprint distribution can also be observed at the regional level.

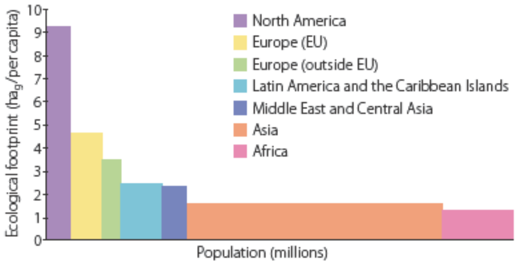

Figure 13.10. **Ecological footprint in the world regions**

The largest ecological footprint (9.5 ha_g/per capita) is in the United Arab Emirates and the USA (9.4 ha_g/per capita), where the consumption of non-renewable resources is the biggest. The smallest ecological footprint belongs to Afghanistan (0.48 ha_g/per capita) and Malawi (0.47 ha_g/per capita). None of the extremes is sustainable as, in the first case, more resources are consumed than available, while the second extreme is related to poverty and inability to satisfy basic human needs for food, safety and dwelling.

To satisfy all the needs of a citizen of the USA, 9.4 ha_g are required. Strikingly, if all the people of the world consumed such an amount of natural resources, we would need 5 planets. Although the average ecological footprint of the EU population is much smaller – 4.7 ha_g/per capita, it exceeds the global bioproductivity twice (2.1 ha_g/per capita) and the bioproductivity of the European Union (2.3 ha_g/per capita) itself. This means that the territory necessary for ensuring the needs of the EU population should be twice than that available.

13.5.3 HOW TO REDUCE THE ECOLOGICAL FOOTPRINT

An individual's ecological footprint can be calculated using the electronic calculator created by the World Wide Fund for Nature. By calculating one's own ecological footprint and understanding the most instrumental factors of one's impact, it is possible to trace one's habits and try changing those that most affect the environment. The three essential spheres for a decrease in the ecological footprint are food, transport and dwelling. Therefore, by choosing the local biological and seasonal food, by going on foot or using public transport or bicycle instead of a private car wherever possible, by taking care of the heat insulation of one's home as well as by using only energy efficient electric appliances, every person can decrease his or her ecological footprint in a comparatively simple way. However, all responsibility cannot be laid at the citizens' door only. Governments should also take action:

- by taking stock of nature's capital and regulating its use. A good example is the establishing of fishing quotas to ensure the regenerating capacity of fish populations;
- by including the full life cycle of goods and services associated with nature degradation and environmental pollution in the costs. One way to achieve this could be a tax reform, imposing a higher tax on the use of natural resources, at the same time alleviating the citizens' income tax. In this way, consumption would be shifted towards more environment-friendly groups of goods while preserving equilibrium in the state budget. Another option could be the eradication of subsidies that facilitate the overuse of natural resources and pollution;
- by promoting the development of environmental technologies that facilitate a more efficient use of natural resources – alleviating taxes for the enterprises that introduce environment-friendly technologies;
- by working out state procurement mechanisms that would require state institutions to choose more environment-friendly goods, thus setting an example to the private sector and creating a new type of market relations;
- by heightening public awareness of environmental issues, improving environmental education and providing citizens with the information that would enhance public understanding of environmental processes.

Since environmental problems are of global nature, they cannot be solved at the level of individual countries. This is why it is necessary to improve international environmental legislation and work out such international trade agreements that would facilitate full payment of ecological and social costs. All the above measures would ensure long-term economic stability, preservation of natural capital, higher employment level and welfare.

13.6 SUSTAINABLE CONSUMPTION AND PRODUCTION

13.6.1 AVAILABILITY OF RESOURCES AND DEVELOPMENT OF HUMANITY

People have always managed to solve the problem of limited resources by developing new territories and increasing the extraction of resources. However, there have been civilisations that had destroyed themselves by depleting their vitally important resources. Thus, for example, the downfall of the Mayan and Anasazi Native American civilisations is explained by climate change and unsustainable management of resources. The latter has also been at the basis of the end of the Easter Island civilisation, which is known for its impressive stone sculptures.

However, humanity has also positive examples of sustainable management of the available resources. In New Guinea and South America there are local sustainable communities which go in for gardening. The Polynesians, for example, have been living on small islands with limited resources for many thousands of years. The existence of these communities has been possible due to the local regulations – prohibitions and custody, which ensures sustainable management of resources.

In all the above cases, the communities have been comparatively small and have not been

Figure 13.11. **Easter Island sculptures**

The overall situation of the Easter Island is an extreme example of deforestation in Oceania: all forests have vanished and all species of trees are extinct. Once the island had been rich in palm-tree forests, and it is believed that the inhabitants of the island were responsible for the destruction of the forests, as they had used huge amounts of timber to make and erect the statues. Because of the lack of timber, the islanders could not build boats, and birds had lost their nesting ground. This marked the beginning of the decline of the civilisation of the Easter Island.

able to achieve the balance between demand and the volume of the available resources and their regenerative capacity. Today the world faces a similar problem – depletion of resources, and degradation of ecosystems and pollution.

Over the last 300 years the world human population has increased tenfold and now approaches seven billion. The main cause of such rapid population growth is Industrial and Agricultural Revolution – which ensured the availability of food and improvement of the quality of life – as well as progress in health care, which allowed to increase human longevity substantially. After the World War II came a rapid growth of birth rate, which continued to trigger off population growth. The number of the world population is expected to grow, and it may reach 9 billion already in 2050. Of all the continents in the world, population has been decreasing only in Europe, including the Baltic Sea Region.

Rapid population growth and patterns of unsustainable consumption in developed countries are the key problems of sustainable development. During the last hundred years it has been the reason of rapidly increasing consumption of natural resources and pressure on the environment. Impact on the environment manifests itself not only in terms of depletion of natural resources but also as degradation of ecosystems and changes in the global biogeochemical cycles, especially those of water, oxygen, carbon, nitrogen and phosphorus.

Depletion of natural resources is mostly related to agriculture, fishing industry, extraction of minerals and production of energy. Traditionally, the depletion of resources is understood as unsustainable use of renewable resources, which means that their use is more intensive than their regenerative capacity. The most convincing example is fishing industry – most of the commercially used ocean fish are overfished, and their populations cannot replenish themselves and thus face eventual extinction.

Issues concerning resource management and consumption pattern change is nothing new in the world. Already in the 18th century, economists launched a discussion about efficient use of resources and overconsumption, as well as about the lack of balance in the volume of consumption between the rich and the poor. At present, international debate is going on about the necessity to change the patterns of consumption and production in order to ensure sustainable development. However, the term 'patterns of sustainable consumption' itself was first used in the Agenda 21, its fourth chapter 'Changing Consumption Patterns' stating that 'the major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production, particularly in industrialised countries.' Hence, the Agenda 21 calls on countries to

- promote patterns of consumption and production that reduce environmental stress and meet the basic needs of humanity;

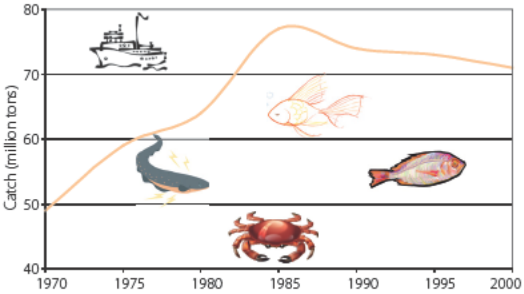

Figure 13.12. **Changes in the global catch of the ocean and sea fish (1970–2000)**

- develop a better understanding of the role of consumption and how to bring about more sustainable consumption patterns.

In compliance with the Agenda 21, many international and local initiatives have been launched with the aim to facilitate sustainable consumption patterns. In 1995, The UN Commission on Sustainable Development introduced a plan to propose changes in the consumption and production patterns, since the unsustainable consumption and production patterns are considered to be among the basic barriers to sustainable development. On the UN initiative and according to the Johannesburg Action Programme, the Marrakech process on sustainable consumption and production has been launched with the aims to assist countries in their efforts to 'green' their economies and to encourage consumers to adopt more sustainable lifestyles.

The European Commission has also prepared an action plan for sustainable consumption and production and sustainable industry policy.

13.6.2 CONCEPT OF SUSTAINABLE CONSUMPTION

Originally, the discussion on consumption patterns basically focused on the negative aspects of consumption. The Agenda 21 underlines the necessity to restrict the use of unsustainable consumption patterns. This raises an obvious question: What is the alternative? How to define sustainable patterns of consumption?

There are two approaches to the definitions of sustainable patterns of consumption and production. The first concentrates on the sphere of consumption and pays main attention to needs, lifestyle and ecological limits, assessing the ways of more efficient, responsible or restricted consumption.

The second approach pays more attention to production – its eco-efficiency and ecodesign. Thus, sustainable production mostly regards supply, concentrating on the most important sector of economy (for example, agriculture, energy sector, industry, tourism, transport) to diminish the

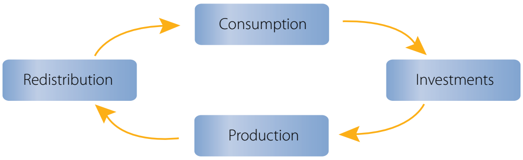

Figure 13.13. **Production and consumption cycle**

A sustainable production and consumption cycle can be illustrated with a chart consisting of 4 elements: consumption, investments, production and redistribution. Each stage creates environmental pressure which must be reduced to make the system work.

negative impact on the environment. Sustainable consumption refers to demand, assessing the ways how goods and services that are necessary to satisfy basic needs and improve the quality of life (food, health, clothing, leisure, mobility) can be provided at a reduced pressure on ecosystems. To implement sustainable patterns of consumption and production, changes are necessary in the sphere of consumption and production and in redistribution of resources and investments.

13.6.3 CONSUMPTION EFFICIENCY – DEMATERIALISATION

In their policies of sustainable consumption, most governments, also the EU with its Action Plan on Sustainable Consumption and Production, lean towards the approach of efficient consumption rather than lifestyle changes, as the latter is commonly viewed as too subjective and value-oriented field of life for the state to regulate it. The policy in support of the decrease in consumption means questioning the system of the world economy, since the economy of growth is largely dependent on growing consumption. Besides, decrease in consumption mostly concerns developed countries, because in many developing countries people are still struggling to satisfy their basic needs. Therefore, consumption in developing countries should be increased.

Efficient consumption is connected with dematerialisation, which means less pressure on the environment at all cycles of the product turnover: more efficient use of raw materials and energy in the process of production, using less energy and materials at the use stage and less waste and pollution at the use stage. The main aim of dematerialisation is to reduce the consumption of resources and impact on the environment, and this aim can be attributed to the whole turnover cycle of goods, since it is related to the development of new products, production and the distribution of goods.

Implementation of the concept of dematerialisation in an economy or a sector may result in the decoupling effect. This means that economic growth in the particular sector is faster than the growth of the consumption of resources and the ensuing pollution. As for the dematerialisation potential, it is determined by the availability of resources and technologies, the management systems of enterprises, the development level of ecodesign and the overall conditions of entrepreneurship in a given country.

The level of dematerialisation is measured by eco-efficiency which shows the amount of resources necessary to produce one unit of gross domestic product:

$$\text{Eco-efficiency} = \frac{\text{Consumption of natural resources}}{\text{Gross domestic product}}$$

Eco-efficiency is usually identified for the principal sectors of national economy: energy sector, industry, transport, construction, fisheries and agriculture.

In additon to eco-efficiency, another essential indicator is the productivity of using the natural resources. It is the amount of the gross domestic product that has been created using the whole input volume of natural resources:

$$\text{Productivity of resource use} = \frac{\text{Gross domestic product}}{\text{Consumption of natural resources}}$$

The general developmental trends of the EU national economies show that, in absolute figures, the extraction of resources per capita is growing and the productivity of the use of resources is improving. The productivity of natural resource use grows if the national economy, having used one unit of particular natural resources, has created a bigger added value.

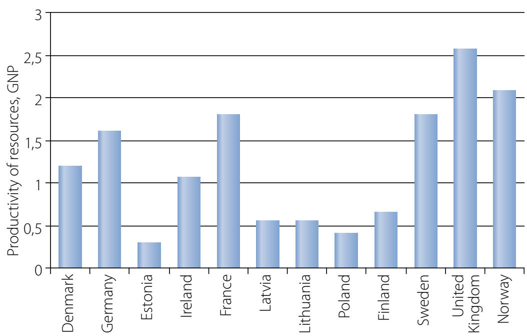

Figure 13.14. **Productivity of the use of natural resources in the EU**

The productivity of the use of natural resources in east European countries is gradually improving, and the proportion of renewable resources in the overall consumption of resources is much higher than in west European countries. However, the new Member States should increase the efficiency of resource use at least fivefold to reach the figures of the old Member States of the EU.

Unfortunately, by concentrating only on dematerialisation, the issue of scale is sidestepped because, according to this approach, the production and consumption of environment-friendly goods should be increased as much as possible. However, to prevent the rebound effect, note should also be taken of the cumulative nature of the impact that national economy makes on the environment. The rebound effect is the absolute growth of consumption that comes from efficiency growth and decrease in consumption costs. In addition, the rebound effects can be direct and indirect. The direct rebound effect can be illustrated in the following way: although an energy efficiency measure in an enterprise may decrease the energy loss by 50%, the actual energy consumption does not decrease at the same rate, because the enterprise starts expanding production, using saved energy. The difference between the 50% potential energy economy and the actual decrease in energy consumption is the direct rebound effect. The indirect rebound effect, in turn, occurs in the cases when an enterprise channels the funds saved as a result of the resource efficiency measures to other but no less harmful activities.

The rebound effect is closely related to the demand and supply law which stipulates that, as prices fall, demand and production volumes grow. This leads to the paradox that the government programmes or technologies that have been aimed at the decrease in costs and pressure on the environment tend to increase consumption and, eventually, also demand. Furthermore, the rebound effect can be affected not only by financial expenditures but also by the decrease in time expenditure, mitigation of risk or increase in comfort. For example, the measures that increase the efficiency of fuel consumption or reduce traffic jams – thus decreasing the costs per kilometre – usually increase the total run. On balance, the overall impact on the environment is not necessarily diminished in proportion to the savings; moreover, in some cases it can even grow.

13.6.4 INFLUENCE OF LIFESTYLE CHANGES ON THE ENVIRONMENTAL PRESSURE

Human lifestyle can be described using two models of human behaviour as proposed by behaviourism and cognitivism respectively. Behaviourism applies to the situation when behaviour is changed by imposing certain conditions that cannot be avoided and that are connected with physical or social stimuli. In the case of cognitivism, an individual evaluates his or her choice and learns through reflection. The latter approach emphasises individual behaviour as opposed to social behaviour (Table 13.2).

Table 13.2. **Classification of behavioural awareness processes**

	Individual processes (conviction, personal needs, individualism)	**Social processes** (uncertainty, social needs, egalitarian values)
Cognitivism (high level of motivation, low behavioural control)	**Deliberation** Reflection on possible behavioural choices, 'pro' and 'contra', evaluating alternatives	**Social comparing** Being influenced by others
Behaviourism (low level of motivation, high behavioural control)	**Repetition** Regular positive repetition of one's experience, habit	**Imitation** People automatically copy the others' behaviour to follow their norms or example

Although focused on efficient consumption, political discussion has also turned to the change of patterns of human behaviour and formation of their environmental awareness. Governments have been increasingly interfering in the patterns of human behaviour, mostly by means falling under the behaviourism approach – taxes, regulations and infrastructure. Such an interference can also be called the editing of choices, for example, a tax on plastic bags to eliminate them from the market and the EU decision gradually to give up using incandescent bulbs and banning the sale of 100 W bulbs as of 2010, thus urging consumers to choose energy efficient bulbs. Not only the state administration but also enterprises can implement change. For example, supermarkets have volunteered to give up providing customers with free plastic bags, many shops have refused to sell genetically modified products or goods that have been tested only on animals.

Attention is also paid to the formation of people's environmental awareness through informative campaigns and environmental education. These methods are mostly used by public organisations, although enterprises are also getting more and more involved.

Speaking of environment-friendly choice, it is important to review several theories that

Figure 13.15. **Supermarket – symbol of consumer society**

analyse people's choice and motivation. Initially, it was believed that human behaviour is basically determined by attitudes and intents (attitude-behaviour model). However, human behaviour is determined not only by rational considerations, and the link between the environment, person's environmental awareness and behaviour can be more psychological than logical. Still, the above model does not take the social context of behaviour into account – people belong to communities with their values and norms, and their behaviour is affected by these norms and values within the given political and economic context. As values and convictions change, so does human behaviour, and, conversely, if behaviour changes, it is followed by changes in conviction and values.

Consumption is not merely an individual choice either – it is largely determined by the social and cultural context. Thus, sustainable consumption and behavioural patterns depend not only on the environmental awareness of individuals but also on social norms, habits, as well as political and economic environment and infrastructure. At the same time, individuals have both long-term and short-term interests, and they are not only consumers. To a great extent, sustainable consumption is limited by people's short-term thinking and poor understanding of future consequences. The better people understand the consequences of their actions in a distant future, the more they are characterised by environment-friendly actions.

An essential issue is human needs and desires. Psychological theories dealing with individual's behaviour recognise that the primary source of behaviour is need. According to the pyramid of needs proposed by the American psychologist Abraham Maslow, people's needs are arranged hierarchically and activated gradually, one after another. People would seek to satisfy the lowest level needs first (physiological needs, safety) and only then motivation increases to satisfy the needs of a higher level (social needs, esteem, self-actualisation).

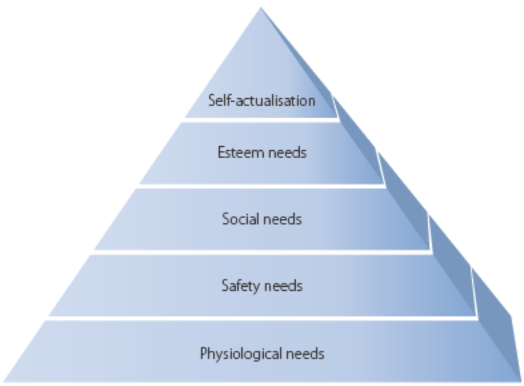

Figure 13.16. **Abraham Maslow's Pyramid of Needs**

It is believed that consumption is related to the modern persons' identity rather than to their needs and the use-value of goods. However, it is impossible to replace needs with desires, since in that case it is impossible to provide an answer to the question: How much is enough? It appears that individual desires have no limits, while the available resources and the world's ecological potentialities are limited. This is why it is not possible to satisfy all desires, and it is the main reason for restricting desires and the necessity to concentrate on the satisfaction of basic needs.

Motivation is an essential factor in the analysis of behavioural patterns. Motivation comprises needs, ideals, goals, value orientation and other behaviour-facilitating and guiding elements that characterise a personality. In terms of modelling sustainable behaviour, it is important to consider the following factors:

- information on an environment-friendly lifestyle is an essential although not sufficient reason for changing the patterns of behaviour;
- as the behavioural patterns of individuals depend both on the individual and collective experience, changes must take place at both levels: the individual and that of the community or society;
- since consumption and behavioural patterns are largely determined by habits, lifestyle changes are more likely at crucial moments of one's life, for example, when retiring or starting a family;
- the attempts to introduce behavioural changes should not be concentrated on a person's psychological and functional needs only; attention should also be paid to the social and symbolic value of the modern patterns of consumption and behaviour.

13.6.5 CONSUMPTION-CREATED ENVIRONMENTAL PRESSURE

The majority of important environmental problems (climate change, eutrophication, loss of biodiversity, depletion of resources, acidification of the environment) are affected by three groups of domestic consumption: food and drinks, dwelling (heating, electricity) and transport. The role of other consumption groups should not be undervalued either – especially clothing, recreation, hotels and restaurants – as these categories of consumption leave an essential impact on the environment.

Life cycle analysis is the most widely used means for assessing the impact of consumption on the environment. This method is applied to analyse the environmental impact of products at all stages of their life cycle: extraction and processing of resources, production, redistribution, use and

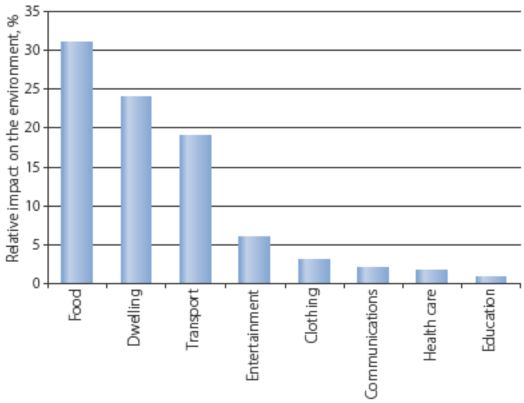

Figure 13.17. **Categories of consumption with the strongest impact on the environment (EU-25)**

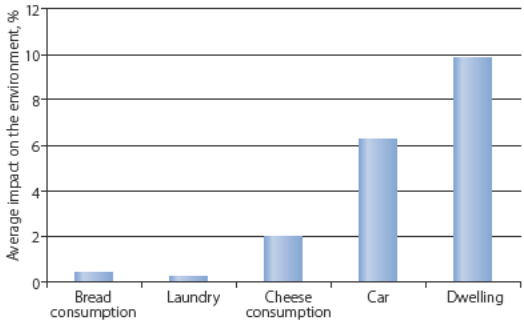

Figure 13.18. **Average daily environmental impact of a citizen of Finland**

On average, a citizen of Finland has 41 m² of dwelling space, the maintenance and heating of which comprises nearly 10% of the overall impact on the environment. A citizen of Finland covers 20 km per day by car (6.5% of the impact on the environment), consumes 30 g of cheese and 83 g of bread (2.4%), and does laundry every other day (0.3%).

disposal – 'from cradle to grave' (now the aim is 'from cradle to cradle'). The life cycle analysis allows to assess all kinds of impact on the environment and human health. This method is being increasingly employed both in entrepreneurship and political decision-making.

With the help of the life cycle analysis, it is possible to confirm that food, tourism (basically, air transport), energy, water and waste constitute the principal loads that households exercise on the environment. Research shows that dwelling, transport and food consumption in the EU are responsible for 60–70% of domestic impact on the environment, making 60% of domestic expenditures.

13.6.6 POLICY METHODS TO PROMOTE SUSTAINABLE CONSUMPTION

Different methods are used in modelling sustainable consumption and production, and they can be classified according to a number of features. Depending on whether the methods are aimed at changes in demand or supply, whether they are voluntary or compulsory, whether they are of local, state or international importance, they can be divided into four groups:

- Normative methods that stipulate rights, obligations and prohibitions as well as standards via normative acts (emission restrictions, pollution and recycling quotas, 'green' procurement policy and guidelines).
- Financial methods that include subsidies, taxes and tariffs, trade relief, financial support mechanisms (funds, credits, guarantees) and emission trading systems.
- Informative methods that comprise informative events, training, publications as well as compulsory and voluntary certification systems (eco-labelling, consumer education campaigns).
- Horizontal methods that aim at improving management processes and comprise gathering information and environment-related statistics (necessity of standards, criteria and methodology), promoting research and development of technologies, perfecting sectoral and spatial planning as well as public participation and professional training.

The inclusion of the concept of sustainable development in the political discussion in the Baltic states has been motivated mainly by an external factor – the high priority of this issue at the level of the European Union and the United Nations. There is every reason to maintain that the initiatives coming from the administrative institutions, political forces or the public would be inconsequential.

The goals of sustainable development in the Baltic states stem from the principles of Rio de Janeiro Declaration, their geopolitical place in the world, natural features, experience of social and economic development and the present situation. They are as follows:

- to create a welfare society that would highly regard and develop democracy, equality, fairness and cultural heritage;
- to form a stable national economy that would provide for the public needs and would ensure such rates of economic growth that would not exceed the rates of pollution and consumption of resources.

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CASE STUDY: FINLAND

FURTHERING EDUCATION FOR SUSTAINABLE DEVELOPMENT

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The final declaration of the UNESCO World Conference on Education for Sustainable Development in Bonn in 2009 states that the challenges of the present societies arise from values that have created unsustainable societies. Solving these complex and interlinked problems requires strong political commitment and decisive action: we have the knowledge, technology and skills available to turn the situation around. We now need to mobilise our potential to make use of all opportunities for improving action and change.

Over the years, there have been many university declarations on sustainable development all over the world. Already in the 1990s, in Europe many universities signed the University Charter for Sustainable Development (the Copernicus Charter), which presently has more than 300 signatories. The Copernicus Guidelines for Sustainable Development in the European Higher Education Area (2007) have been prepared as a contribution to the Decade of Education for Sustainable Development (DESD, 2005–2014). It is an instrument to be used by universities to integrate the principles of sustainable development in all activities.

What does it mean to address sustainability in higher education? A general answer is that it means incorporating more knowledge, skills, issues, values and perspectives related to sustainability into existing courses and programmes.

Another effort to define what students should know when they graduate is to identify learning outcomes. In 2009 Portland State University introduced campus-wide learning outcomes: creative and critical thinking, communication, diversity, ethics and social responsibility, internationalisation, engagement and sustainability. All of them contribute to Education for Sustainable Development (ESD).

Universities also have a special responsibility for extending opportunities for learning about sustainable development to many already active groups in society. Continued education and professional competence development are essential for introducing the sustainability agenda, with each and every new skill required to change society towards sustainability.

Persons with a university degree have the basic know-how and skills needed in the professional world. They are capable of acting as active citizens and of influencing decision-making. They are also able to keep themselves up-to-date with the innovations and research conducted in their own field according to the principle of sustainable development.

The future labour market will need professional individuals, with good professional, social and learning skills. The responsibility for obtaining these skills lies with an individual, and society should provide the possibilities to enhance these skills through life-long learning.

The background of Finnish policies has been previously described by Lindroos and Melén-Paaso (2009). Respecting the autonomy of the institutions of higher education also in the field of sustainable development, the institutions have mainly been supported by providing literature and financial support for networking. One example is the book *Towards Sustainable Development in Higher Education – Reflections* (2007), which was a contribution to the DESD. The Finnish Ministry of Education has also financed a special resource centre for ESD in higher education on the basis of projects since 2004 (*www.bup.fi*). This centre serves as a national centre for the Baltic University Programme (*www.balticuniv.uu.se*).

As of 2007, many universities worldwide have intensified their cooperation on ESD. A common forum on ESD has been created, with members appointed by university rectors. In addition, cooperation between university networks on development policy, education and research is ongoing.

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14 A STUDENTS' PERSPECTIVE ON SUSTAINABLE DEVELOPMENT: IT IS OUR TASK TO CREATE AN ATTRACTIVE, SUSTAINABLE FUTURE!

We are writing to you as students. We wrote this chapter because we are deeply concerned. The very conditions for human life on this planet are being destroyed as we write. Sustainable development is no longer only about the environment; actually it never was. It is not about pretty birds, frogs, pandas or polar bears. Sustainable development is about us, about how we relate to each other and to the planet. It is about how we can envision a society that does not destroy its resource base and where a good life is available for everyone.

As we have learnt in previous chapters, our society is in overshoot and has only two alternatives: a planned retreat to sustainability or collapse. In our lifetime we will have to make that choice. Our generation will have to drive the transformation of our societies towards sustainability, and everyone has something to contribute, regardless of the field of study.

During our time as students, we have seen people mature and build their capacity to take on a leadership role when our region meets the complex and difficult challenges of our times. We have seen the energy, compassion, knowledge and commitment of people around us, and that makes us confident that there is still hope indeed.

This chapter is based on the obtained experiences. We will outline important challenges we face as students today and discuss how we as students can work together to make the world a better place: both through increasing our own knowledge and capacities and through ensuring the best possible conditions around us. We will focus on practical examples of how students can organize themselves to participate in the work towards sustainable development in their research field, society, student organisations and through exchange and networking.

We hope that these examples will inspire you as they inspire us.

14.1 SUSTAINABLE DEVELOPMENT IS A GENERATIONAL ISSUE

Sustainable development concerns our generation more than any else. Whatever we choose to study or do with our lives – now and in the future – we will most certainly find ourselves preoccupied with a host of issues related to human well-being, resource use and survival on this planet. We live in a time of converging crises, an interconnected set of challenges that need to be approached in an integrated way. Climate change, strained ecosystems, security and global poverty are just some of the more prominent challenges. How we respond will shape the future. We still have time to turn these trends, control our future and create a planet that is

- *attractive*, where we are better off than we are now;
- *fair*, where everyone has the resources to live a decent life;
- *sustainable*, where we as a species live within our limits.

Basically, we need to make it possible for an estimated nine billion people by 2050 to lead good lives that do not depend on fossil fuels or depletion of renewable resources. The scenario of business as usual will drive our planetary systems to collapse. What is called for is a huge restructuring of our social, economic, technological and cultural systems: a transformation of our societies on a scale compared to the Agricultural and Industrial Revolution. A little polishing on the edges just will not do. Whatever we do, we need to understand how our actions relate to the scale of the transition of the coming decades.

It is during our lives – as students and professionals – that much of this profound transformation of our societies will have to take place. We will have to come up with the social and technical innovations that can make it possible. Companies and organisations around the world are realizing this. They want to hire people that understand sustainable development, and they will expect us to have the competence, knowledge and skills needed to work in a society that is rapidly retreating from overshoot.

Our window of opportunity is closing fast. During our time as students, we have to make sure we get the knowledge, skills and contacts we need to shape our future. We will have to fight for that because much of what we need is just not available through conventional academic channels.

14.2 EDUCATION FOR SUSTAINABLE DEVELOPMENT

The important role that education plays in preparing us to work towards sustainable development is acknowledged in the growing commitment by universities, schools and governments to Education for Sustainable Development (ESD). As students, we need to demand from our teachers and universities to live up to these commitments. Systemic thinking, interdisciplinarity, ethics, critical analysis and the ability to apply theoretical knowledge to practical problems are all central to ESD. Learning for sustainable development also means that we need to change from being passive recipients into active co-producers of knowledge by taking a more active role in our education.

When we think about our education, we inevitably have to ask ourselves what we *really* want to achieve by studying, and what kind of world our universities are shaping and maintaining through research and education. Right now we have inherited a set of problems that our current educational system has created.

'We have arrived at a point in our human evolution,' notes the Chilean economist Manfred Max-Neef (2009), 'where we *know* a lot, but we *understand* very little.' Present university structures – divided into disciplines and departments – have been very effective for accumulating detailed knowledge on physical processes and for driving the development of new technologies. They have brought a man on the moon, created computers and helped us understand the climate system. It is, however, inadequate for dealing with many of the pressing issues of our time. Rigid disciplinary boundaries hide the bigger picture. Important questions are disregarded by disciplinary sciences.

The Icelandic author Andri Snaer Magnason (2008) notes:

> People make a thick layer of facts but cannot apply the facts to the real world. [..] They forget that science is about huge, burning questions crying out to be answered, not answers that need to be learned. Science, philosophy and the arts were once branches of the same tree, not starkly demarcated opposites.

We can do a great deal to influence our education and to connect it with the challenges of our time. Through active participation in seminars and lectures, we can raise important questions. Through our choice of subjects for essays, we can dig deeper into a specific issue. Through cooperation with organisations or industries during work on our Master's thesis, we get a chance to use our knowledge and understanding of sustainable development in solving concrete problems.

14.3 TOOLS FOR THE TRANSITION TO SUSTAINABILITY

Being a student today is a challenge but also a tremendous opportunity. The transition to sustainability – reaching a growth of the population and the economy that can be supported by the natural systems in the long run – will largely happen during our lives. All skills are needed in what will be a celebration of creativity and ingenuity. The 30-year-update of the classic *Limits to Growth* (Meadows *et al*, 2004) points out that

> [t]he generations that live around the turn of the twenty-first century are called upon not only to bring their ecological footprint below the Earth's limits, but to do so while restructuring their inner and outer worlds. That process will touch every arena of life, require every kind of human talent. It will need technical and entrepreneurial innovation, as well as communal, social, political, artistic, and spiritual invention.

What tools do we have at our disposal to drive the transition of our societies to sustainability? The system modeller authors of *Limits to Growth* propose seemingly soft tools based on their understanding on how systems work. When these five tools are used effectively, they can be profoundly powerful in transforming the structure of our societies.

- **Visioning** is about imagining and specifying what we really want. Visioning is essential to guide and motivate our efforts. To be successful, we need to take off the usual constraints of feasibility, disbelief and past disappointments in order to imagine a sustainable society that we would really like to live in.
- **Networking** is essential to get our jobs done, whatever we do. Networks are connections among equals, held together by shared values and the understanding that some tasks are better accomplished together. They help us find new information, learn and pass on our knowledge to others. The Internet makes it easier than ever to network at all levels, from the local to the global.
- **Truth-telling** is about affirming truths and countering lies. Lies distort the information flow and prevent a system from functioning well. Many lies and untruths are deliberate and understood to be so by everyone. The discussion on sustainable development is full of untruths and distortions that need to be challenged if we are ever to manage our society within ecological limits.
- **Learning** includes acknowledgement that no one knows everything and that whatever we do, we should do it humbly. One cannot learn without making mistakes. Learning therefore implies a willingness to try things out, accept that an action is not effective and try another one.
- **Loving** is about patience and trust in ourselves and others and viewing ourselves as part of an integrated global society. Our current societies promote individualism, competitiveness and a short-term focus that hides the bigger picture. Love is a powerful tool that helps us act together, find common solutions and create a society that permits the best of human nature to be expressed and nurtured.

In the following chapters, we describe student initiatives which have built on these approaches. Through them, large numbers of students have already gained valuable contacts, skills and work experience. We hope that they will give you ideas and inspiration on how you can work towards sustainable development both in your education and on a practical level at your university and in your community.

14.3.1 COLLABORATION AND NETWORKING

In most difficult situations, we search for a hero to take the situation under control and save the world. We probably feel apathy and think that a little man like ourselves cannot solve problems on a planetary scale – it is not even worth trying. It might be true that we cannot change the old stagnant system alone. But the symbol of a hero – a strong man or woman who will go through all difficulties alone and sacrifice himself or herself for the good of others – is a misrepresented projection of our dream that someone powerful will come and solve all our problems. It is the symbol of human laziness and lack of responsibility.

The real power able to change the chain of events lies in collaboration, in team-work. In most cases, it is our initiative, our eagerness to collaborate with other people that brings us closer to success. Some actions may seem to be very small steps, but they could be part of a much bigger scheme.

Negotiations went off-track at the UN Climate Change Conference in Copenhagen in 2009, when representatives from 193 countries were trying to negotiate the question of binding numbers in the Kyoto Protocol. The organisation '350.org' organised a protest to push some sluggish countries to speed up the process. As a consequence, non-governmental organisations were no longer allowed to enter the main hall of the negotiations. The response was a surprise for everyone. As they were not allowed to raise their voice, suddenly, in the middle of the most crowded part of the conference venue 'Bella Center', young people from all over the world froze in a standstill for 350 seconds. The message was clear: 'If you force us to be silent, we will be, but we will protest in other ways.'. The politicians could not pass the place without paying attention. Believe it or not, such actions do put certain pressure on the decision-makers.

It is not always easy to start thinking together. The life in the modern industrialised society makes people more and more individualistic. We get the illusory feeling that the time when we had to work in a family or other group in order to survive is far away in the past, in our history. We forget how to work in a team and how to strive for success in common issues.

Conferences, workshops, field trips and other networking activities are ways we can collaborate and improve our team-work skills. The student activities of the Baltic University Programme are just one example. All the activities are based on the principle of team-work, whether navigating a tall ship in the Baltic Sea or getting together to take on the defining issues of education and sustainable development. Students come from all over the Baltic Sea Region – with diverse educational and cultural backgrounds. Throughout the years, Baltic University students have created amazing projects together and made lots of close friends in the process. It is a strong foundation for a growing network of interested students and soon-to-be professionals in the region.

One example is the annual students' conference in Rogów, Poland, which gathers students from all countries in the region. In April 2009, students used their time together to write two declarations, where they expressed what they demand from their education and the global climate policy process in order to reach sustainable development. Each and every member of the conference participated in this work. There were heated discussions when the main statements of the declarations were drafted in workshops and later adopted in consensus at the end of the conference. The drafting committee consisting of students from four different countries coordinated the process. The declarations were presented later that year to 60 university rectors at the Baltic University Rectors' Conference and at a side event during the United Nations Climate Change Conference in Copenhagen.

The Baltic University Programme has a tradition to send their students on sailing voyages. Life onboard is not always easy when one has to make at least two navigational watches and one watch in the kitchen each day. Even during storms, everyone is expected to perform their duties. It makes people close and teaches them to work as a team, like a real crew. Often the students try to contribute to the communities they visit by raising awareness on issues of sustainable development in the region. Visitors, attracted by the beauty of the sailing ship, learn about the Baltic Sea Region and its challenges from the students.

Since its establishment right after the fall of the Berlin Wall in 1991, the Baltic University Programme has grown to become the largest university network in the world, encompassing more than 200 universities in 14 countries in the Baltic Sea Region. The Programme offers a series of bachelor's and master's courses on issues related to sustainable development at member universities. The aim is to support the contribution of universities to promoting a peaceful, sustainable and democratic development. Moreover, the Baltic University Programme provides cooperation in research and applied projects.

Figure 14.1. **Collaboration and networking – students participate in a voyage on a sailing ship in the Baltic Sea**

Joint activities alone do not guarantee that the group will manage to cooperate: it is important that a group has a common goal. Shared values and goals help people work together as a team and can support a group in difficult times. There are different types of leadership. Group members may choose to elect leaders for a fixed time, or leaders change naturally according to the tasks ahead. Defining shared goals and objectives helps a team find the best strategies to fulfil its aims. One has to try to look at things from other people's perspective in order to understand each other, avoid unnecessary conflicts and work efficiently together.

Your initiative and belief can change the world – just remember that it all depends on you.

14.3.2 WORK WITH SOCIETY FOR SUSTAINABLE DEVELOPMENT

In Latvia, there are several good examples of how student initiatives towards sustainable development have been introduced into different spheres. In this part we will focus on two organisations involving students who promote sustainability in Latvia: *Ideju Māja* (Latvian – 'The House of Ideas') and S-putns (Latvian – 'S-bird').

The non-governmental organisation The House of Ideas was originally established in Riga by a small group of students of various backgrounds. They promoted cooperation among students from different disciplines, the faculty, civil society, the government and the business. The benefit of this activity was more the experience of the process itself than the result. The students also actively participated in such projects as 'A day without a car' and 'Mobility day' in Rīga, when citizens were invited to leave their cars at home and try an alternative means of transport for a day.

Many people have great ideas, but they do not feel capable to start something on their own. In 2009, The House of Ideas organised regular events to encourage and help people cooperate towards creating a happier society. They were called *Ideju talkas* ('Idea Workshops'). These gatherings were perfect for finding like-minded people – probably they had been by each other's side all the time. The events take place in a form of a voluntary gathering where everyone who has ideas or just the will to do something. People make connections, find resources and act together to implement their plans. The number of participants in the workshops varies from 10 to 50 people.

The open form of Idea Workshops facilitates social involvement, and the emphasis is on the idea that it is us who can change something. There have been Idea Workshops on topics such as 'How can we stop youth from emigrating?', 'How do we encourage people to get more involved in charity?' and 'How can we make relationships between bikers, car drivers and pedestrians on the streets more friendly?'. Everyone is free to participate in any Idea Workshop and to organise one.

Together with other organisations, The House of Ideas also put their effort to create a youth vision of the development of Latvia, participating in the preparation of the Sustainable Development Strategy of Latvia 2030. They propose sustainable, original and innovative recommendations for the development of Latvia. While preparing the document, students participated in organizing an essay competition and youth forums in different cities to involve as many young people in Latvia as possible in creating the vision. The recommendations were presented in a session of the Council for National Development, led by the Prime Minister of Latvia. The Prime Minister promised that the government would give its support to continue the preparation of the proposals. The Strategy was adopted on June 10, 2010.

Another successful example of how students have engaged in activities is the organisation *S-putns* ('S-bird'). S-bird was originally founded by students to organize summer camps for young people. Participants learn about environmental questions connected to lifestyle and daily decisions with the aim to boost the understanding of how human economic activities interact with the environment. They are also motivated to study natural sciences in the future.

S-bird also supported small Latvian farms by organizing a campaign to encourage people to support local agriculture and to buy fresh and ecological food more frequently.

Figure 14.2. **Will Rīga become a bicycle-friendly city? If it does, it will happen thanks to the student initiative**

S-bird and The House of Ideas are deeply involved in making Rīga a bicycle-friendly city. They helped organise such events as the Critical Mass, when all bicyclers in Rīga were invited to ride the streets in a parade. S-bird members have also researched the possibilities of developing bicycle routes in Rīga and submitted an official letter with this project proposal to Rīga City Council.

One of the founders of S-bird reveals the experience gained while working in other environmental NGOs as one of the reasons for founding the new organisation, along with the frustration at the lack of professional knowledge of organizers leading to inefficient campaigns and inaccurate information on environmental issues in the mass media that creates misunderstanding in society. The founders felt an organisation is needed that, instead of expensive and ineffective information campaigns, deals with simpler problems evident in our surroundings.

14.3.3 CEMUS: STUDENT-RUN EDUCATION FOR A BETTER PLANET

How can university education promote the skills, knowledge and understanding we need to deal with the complex and interdisciplinary issues that will shape our lives? At Uppsala University, students took on the challenge to define what they need to learn and to organise their own university education. This resulted in CEMUS (abbr. from Swedish) – Centre for Environment and Development Studies – a centre for student-run education which is a collaboration between Uppsala University and Swedish University for Agricultural Sciences. CEMUS is an interesting example of student involvement because it shows that it is possible for students to influence their education in profound and structural ways. All it takes is some courage, persistence and hard work.

In the early 1990s, two students – Niclas Hällström and Magnus Tuvendal – came to Uppsala

University hoping to find courses that would give them an interdisciplinary understanding of global environmental and development problems. They did not find what they were looking for: Uppsala University did not offer such courses at the time. Subjects that did not belong to a specific discipline were nowhere to be found: the pressing issues of our time were not discussed anywhere.

Niclas and Magnus contacted the University administration and talked to key people at different departments. They proposed a new, interdisciplinary course about the global environment and development issues. The President of the University agreed and tasked them with preparing the study course. The course, *Humanity and Nature*, was an immediate success, with around 150 students taking the course in their first year. The successful model was based on students defining what they wanted to learn, experienced academics from Uppsala's two universities supporting them in the process, and inviting guest lecturers from all over Sweden to teach subjects they were passionate about. Evening lectures allowed students from all disciplines to participate, and the form of the course was adapted to the needs of the students. Discussion and exchange of ideas between students and teachers was a central part of every lecture.

A few years later, students in Uppsala founded their own centre which eventually became CEMUS. Over a 15-year period, CEMUS has grown to the sise of a full-fledged university department, offering around 15 different courses. The CEMUS model for education includes four important components:

- **student course coordinators.** Two to three students are hired by CEMUS to plan, administer and lead a university course as a project. They often work with a course they have taken before, but sometimes they prepare a completely new course that CEMUS has decided to implement. The course coordinators plan the general structure of the course, find literature and invite guest lecturers. They lead seminars and work as administrators;
- **course workgroup**. For each course, the course coordinators form a course workgroup consisting of researchers, teachers and practitioners of different fields. Throughout the course, the workgroup comes up with suggestions for literature and lecturers and gives feedback on the structure, literature and schedule proposed by the course coordinators. The course workgroup is responsible for the examination of the course;
- **guest lecturers**. The course coordinators invite both guest lecturers from different academic fields as well as practitioners to teach the course. The aim is to get the best possible teacher in the field to teach a particular subject;
- **organisation** at CEMUS. CEMUS extensively supports the student course coordinators in their work, involving senior course coordinators, Director for Studies and Programme Director who have research and teaching experience.

There are several reasons why the CEMUS model has proved to be a very efficient way to implement Education for Sustainable Development. One reason relates to the policy and ethics of learning: who decides what we learn? As students, we need to become seriously involved in the content and organisation of our education because we are the main stakeholders in the world our education takes part in creating. The challenges we face today are generational issues that will influence us more than the professors and university administrators who usually define what we should be learning.

The responsibility of students to prepare courses as projects has also proved to be a very effective model for running university education. The model gives us the flexibility cutting edge studies need. It allows us to invite an array of people and create courses with a clear structure and such content and form that is not possible in the regular way of university work.

CEMUS approach to education is unique in Sweden and most parts of the world. However, the model for student-run interdisciplinary education has been tested over many years and is proven to work very well. CEMUS now employs around 20 course coordinators, and around 500 students participate in one or more of 15 CEMUS courses each year (mostly part-time). CEMUS also serves as an arena for collaboration between universities and society, and hosts an interdisciplinary research forum where PhD students of different disciplines

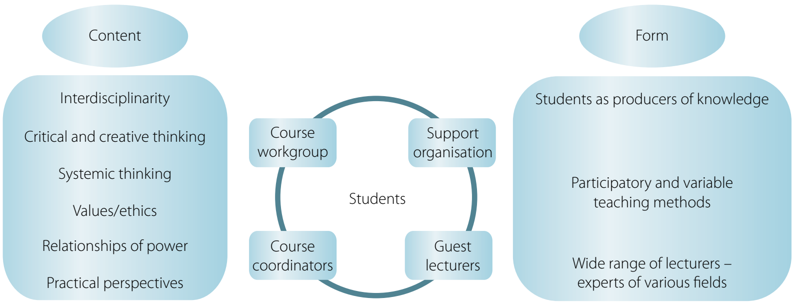

Figure 14.3. **Formation of student-run education and its operational model**

Figure 14.4. **Timeline of the development of the Centre for Environment and Development Studies at Uppsala University in Sweden**

meet and run courses. Since 1992, when the course *Humanity and Nature* was run for the first time, CEMUS has built an extensive network of academics of all fields as well as of professionals working towards sustainable development in practice who take part in CEMUS courses as lecturers and members of workgroups.

The example of CEMUS shows that it is absolutely possible that students prepare courses on topics they find important. All we have to do is to find and cooperate with like-minded students, lecturers and university administrators to get their support. We have to begin with little, with a course or just part of a course, and then the only limit is imagination.

14.3.4 HOW DREAMS COME TRUE, OR HOW TO START A STUDENT ORGANISATION AT A UNIVERSITY

Being a student is not only about studying; it is the time when we dream, risk and which we refer to as the best years of our life, and our achievements will certainly be what we remember and are proud of. Below is the story of how five students one day said 'yes' to their ideas and started a student organisation.

The eco-club 'Green Wave' at the National University of Kyiv-Mohyla Academy in Kyiv, Ukraine, was founded by five environmental science students with the support of two faculty members in 2006. It has grown to 30 members in three years. The founders started a couple of projects simultaneously, inviting friends and fellow students to join.

The first project accomplished was the plan of waste separation on the university campus. The idea received strong support from environmental science students, but it took some time and effort to make other students and the staff accept the new

Figure 14.5. **Study process at CEMUS (Uppsala University, Sweden)**

arrangements. The project team organised a broad information campaign with a number of posters explaining the necessity of recycling and the way it should be done, and had personal talks with staff members.

A number of constraints arose during the project. Finding money to buy containers was one of the hardest tasks. Starting on their own, students soon found a company that financed the purchase of recycling containers. Difficulties appeared in the communication with the university administration – at the time, sustainable development was not a priority and the university did not want to allocate either human or economic resources to move the project from a student initiative to the university level. Even though the university bureaucracy won the first time (the project still awaits the decision), students involved in it gained their first real-life work experience and raised a discussion among the decision-makers of the future: today's students.

As the eco-club matured, it defined the goals and formulated the following statues:

- to create opportunities for the students of the National University of Kyiv-Mohyla Academy to gain professional experience;
- to assist environment-minded students in their personal growth as well as to unite the student community around sustainability principles;
- to improve the University's image as the first 'green' educational institution in Ukraine.

After the first projects, the organisational structure has naturally emerged. Its strength lies in its simplicity (Figure 14.6).

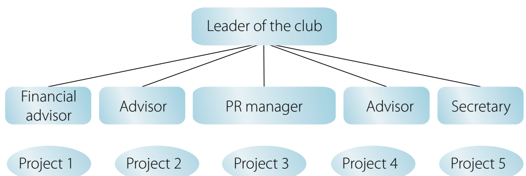

Figure 14.6. **Organisational structure of the eco-club**

While the organisation is small, members have to play two to three roles: an advisor can be a project leader or a member of the project team. At the early stages of development, a PR manager is an unnecessary complication, but with time, the need for coordination of information flows arises. Gradual change of members challenges the organisational stability in the long run. Students have to be open to new ideas and attract new members by enthusiasm and readiness to support. Otherwise there is a high risk from the organisation will disappear from the university.

With time, the eco-club has become a forum and a meeting place for those with a vision and those who are not sure what they would like to do. The motto of the club is: 'Green light to the green ideas'. Add genuine creativity and passion for innovation and once you have arrived, you will definitely stay.

In 2008, the eco-club launched the project ReArt, focusing on students of non-environmental backgrounds. Seven master-classes showed how things we tend to call garbage could be reused. Students designed their own eco-bags, created accessories from keyboard letters, buttons and strings, learned how to make postcards from recycled paper and give second life to old furniture.

Another attractive and easy way to start a project is Green Cinema: once a week the eco-club holds a movie screening on a topic related to man and nature. It took three years to collect more than 300 movies, and now one can find movie for any taste at the club.

Universities differ and, as you can see, so do the approaches to start a student organisation. The special traits of the eco-club have formed on the basis of the personalities of its members. In other words, the general image of an organisation depends on the people it consists of and the values they share. The eco-club's trademark is a family atmosphere based on improving the skills of its members, learning from each other, enriched by creativity in whatever they do. Since the club is a volunteer organisation, its overall performance is everyone's responsibility, and it is most important to understand one's colleagues, their mood and needs. There is no graduation from the eco-club. Even if people are no longer students, they successfully collaborate with the club, working in companies. The most important feature of the years at the eco-club is the long-term relationship and support. This is what family style is about.

Figure 14.7. **Courage, creativity and the things important to each of us make up the contents of our life (picture by the Ukranian artist Oleg Lubimov)**

14.4 LET'S GO!

It is time to move on now. We do not have much time left, and we can no longer allow laggards to get in our way. It is time to leave them behind and agree with people on ideas that will actually move the humanity forward – towards a future that is attractive, fair and sustainable, a future shaped by us, not by the people that have a vested interest in maintaining the status quo.

The journey will be difficult but fun. What we do counts. The question is how we will use the very short time we have on this planet. The fact is that most people spend much of their time doing either meaningless or downright destructive things. Therefore, we have to reflect carefully on what we are doing and which future we are creating. To be at the forefront means facing constant scrutiny, being wrong at times, to learn from our mistakes but always to remember our goals. Andri Magnason (2008) notes:

> Many of the best ideas provoke scandal, derision, are said to be 'unthinkable', ridiculous: they are laughed out of court, banned or suppressed, and it takes them decades to become an accepted part of the scenery. They threaten the status-quo and attack the roots and the world views of obsolete and moribund ideologies. It is not as if everyone just said 'What a clever idea!' when women first started demanding equal rights.

What is unthinkable now will be mainstream in fifteen years time. The mainstream will be shaped by us, and by what we choose to do during our few years as students. We are extremely privileged to be students at European universities. Not many people have the opportunity to discuss and learn about global issues and the survival of humanity. Most people on this planet have more pressing matters – like their own survival – to think about. With privilege comes responsibility. It means stepping out and expanding our moral horizons to encompass everyone. It means that when we are innovating and finding solutions, we have to keep everyone in mind, not only a privileged few. What shall we do? What kind of citizens should we educate? What technologies shall we develop? What cities shall we build?

We hope that the examples in this chapter will be helpful to you when you go on with your studies. It is easy to get involved, and it will help us acquire skills, knowledge, understanding and contacts that are important now as they will be in our future careers.

We can influence our own education through raising important questions at seminars and through our choice of subjects for essays and work on our Master's thesis. In this chapter we have seen how students have proposed interdisciplinary courses on sustainable development prepared by themselves, which has lead to CEMUS, a centre for student-run education at Uppsala University.

We can join a network to get new perspectives, valuable friends and contacts and exchange information. The Baltic University Programme is just one example of an organisation that offers many networking activities for students: there are many more. If we cannot find what we are looking for, we can always start our own network that is suited to our particular purposes.

We can join or start student organisations where we can apply the theoretical knowledge we get at our universities in practice. Through student organisations, we can work to improve our universities' sustainability performance, as we have seen in the case of the eco-club in Kyiv, Ukraine. We can also work with our local community through campaigns and public events, as The House of Ideas and S-bird do in Latvia.

With the tools we have at our disposal, with vision and networking, truth-telling, learning and love, we are sure our generation can change the world towards a better future.

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