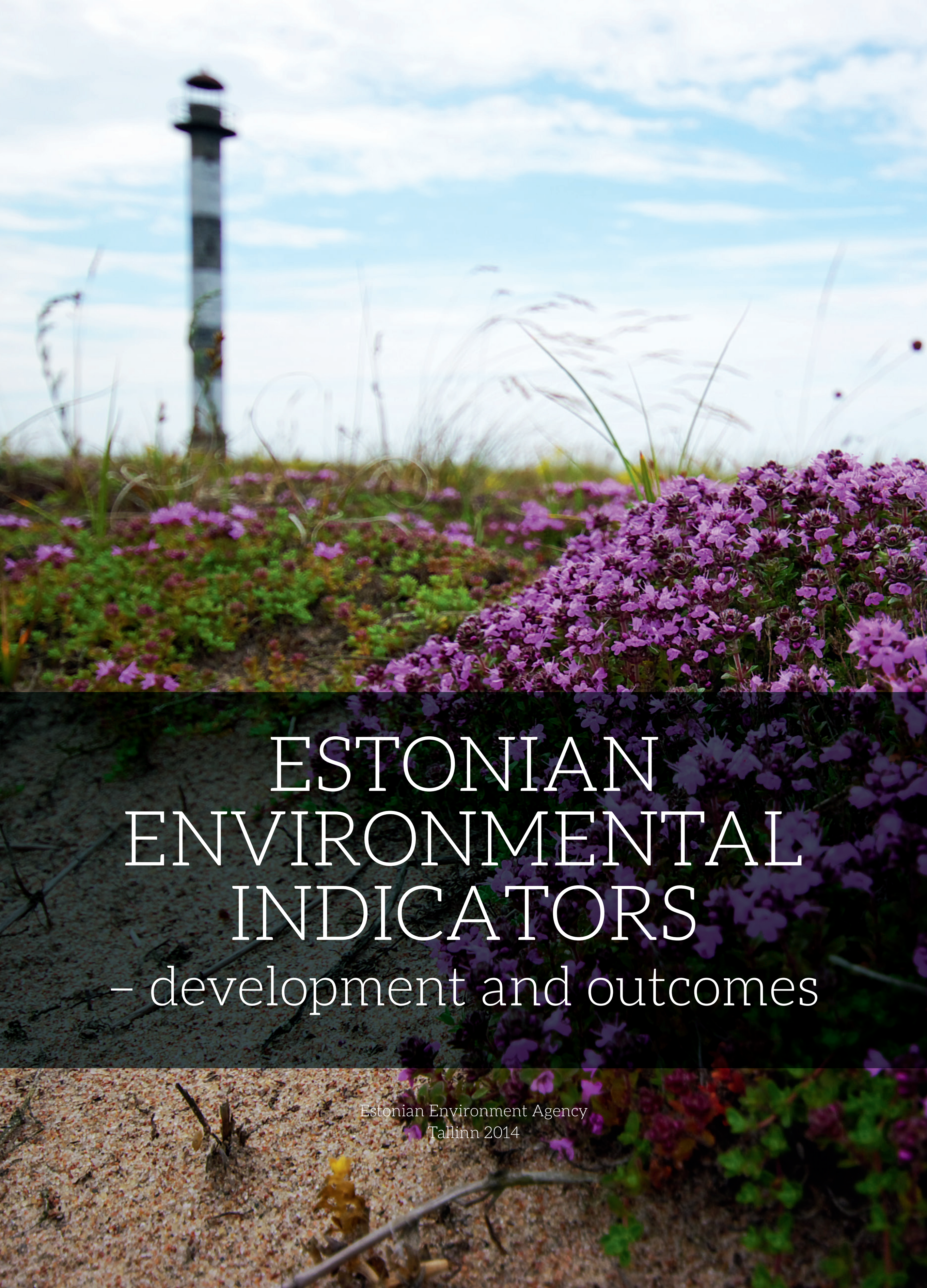

ESTONIAN ENVIRONMENTAL INDICATORS

– development and outcomes

Estonian Environment Agency
Tallinn 2014

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Editors: Marilis Saul, Kait Antso
Proof reader: Anu Rooseniit
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1. What are environmental indicators?

Kait Antso, Analysis and Planning Department,
Ministry of the Environment

The environment is a set of tightly connected biotic and abiotic factors. On the one hand, the environment is the medium surrounding an organism (such as air, water or soil), on the other hand, it is a set of external factors influencing that organism (such as climatic conditions). In order to assess the status of the environment, we need to know the complex interaction between environmental factors, including the biotic and abiotic components. The status of the environment cannot be assessed based merely on a couple of factors; we need a comprehensive system of environmental indicators, which together indicate the status of the environment. For this purpose, several environmental indicators have been introduced, the use of which allows us to get a comprehensive overview of the environment and the relations within it. The majority of the environmental indicator systems are anthropocentric – humans affect the environment and the environment affects humans. Therefore, it is important to monitor the impact of human activity on the environment as well as the effects of the contaminated environment on humans.

The term 'indicator' is often defined differently; therefore, it is reasonable to agree on the common definitions of key terms. An environmental indicator is defined here as a set of parameters, which reflects the complex interactions between the status of the environment and the factors affecting and being affected by it (including political, socio-economic and other factors). Thus, an environmental indicator includes various parameters. An environmental indicator can be defined as a measurable quality related to or affecting the population, economy, environmental status, etc. which describes the state of affairs or the changes that occur over time.

Increasing environmental awareness among people is generating interest in the data describing the state of the environment. The data that directly indicate the state of the environment or characterise the factors affecting the environment are collected in huge numbers; however, these data are scattered and difficult to interpret and compare. Environmental indicators fill that gap by providing a comprehensive overview of the state of the environment. In order to serve their purpose, environmental indicators must be scientifically justified, reflect the causal relationships between the measured factors, be representative, cover the environment and the factors affecting the environment and provide an unambiguous output which would enable us to monitor the environmental trends.

The history of Estonian environmental indicators dates back to 1998 when the first Estonian environmental indicator system was developed within the EU Data Management within Environmental Monitoring Programme (DADAM), funded by PHARE. The environmental indicator system was based on the DPSIR framework, adopted by the European Environmental Agency. DPSIR stands for the five elements that form the framework for reporting on environmental issues:

– **Driving** forces – indicators reflecting the factors leading to environmental pressures. These are mainly the anthropogenic factors describing social, demographic, economic, etc. developments (e.g. population size).

– **Pressure** – indicators reflecting the anthropogenic pressures on the environment (such as emissions, use of natural resources).

– **State** – indicators describing the quantitative or qualitative status of the environment (such as air quality, forest area, number of species).

– **Impact** – indicators describing the impact of the status of the environment on both ecosystems and humans (such as illnesses caused by the low quality of air, changes in populations and habitats caused by eutrophication).

– **Response** – indicators reflecting the measures taken to improve the status of the environment (such as pollution charges, protected areas). These indicators are often related to policy decisions.

The relationships between these indicators are normally illustrated as a causal chain (Figure 1) – any one event in the chain causes the next: driving forces lead to pressures on the environment, followed by impact on humans and ecosystems, followed by measures to alleviate these impacts, which in turn should reduce the environmental pressures caused by driving forces and improve the status of the environment as a whole. The diagram is no doubt a simplified one because the above relationships are not always clear and distinct. Because of the complexity of the relationships within the environment, they are not always distinguishable from each other; therefore, some simplification is inevitable.

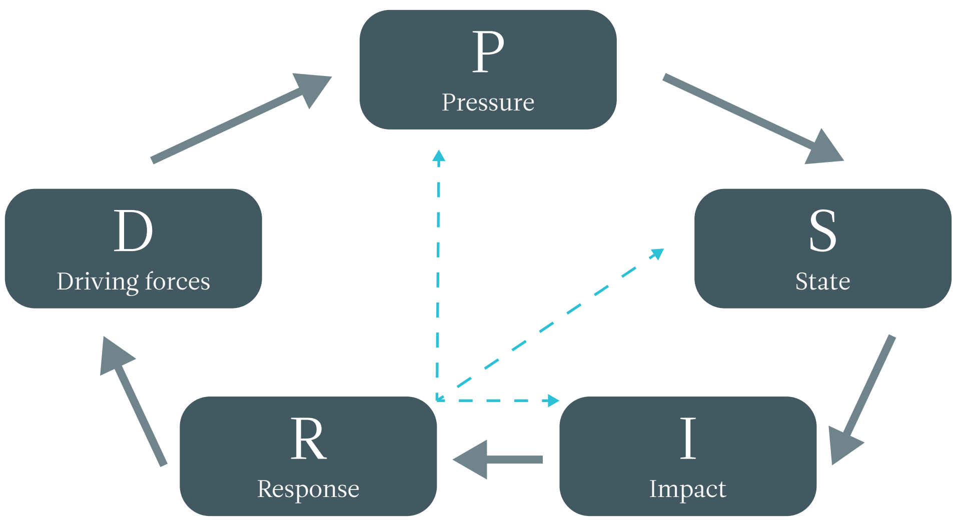


Figure 1. Relationships between the environmental indicators of the DPSIR framework.

The status of the environment is constantly changing. Some environmental issues become irrelevant due to the measures implemented or new technology, while new circumstances cause new issues. Therefore, environmental indicators must be regularly reviewed and updated. Compared with 1998, when the first Estonian environmental indicator system was proposed, the environment, and the Estonian society as a whole, have changed significantly and a number of indicators have become obsolete. The focus of environmental assessment has also changed over the past 15 years. What is important today, is the concept of green economy, linking environmental indicators more closely with the economy and people's wellbeing, greater involvement of statistics, etc. In the light of this, the Estonian Environmental Agency launched the project "What is going on in the Estonian environment – the development, introduction and implementation of the Estonian environmental indicator system" in 2012. The main purpose of the project is to update the Estonian environmental indicator system. The project is funded under the environmental programme of the Environmental Investment Centre.

The priority areas of the Estonian environmental indicator system are based on the priority areas defined in the EU Environment Action Plan, which also serves as a basis for the Estonian environmental strategy. The priority areas are: natural resources, waste, climate, air, soil, water, habitats and ecosystems. Updating the environmental indicator system means supplementing and improving the existing system, rather than creating a completely new system. The improved environmental indicator system focuses on the driving forces, which were missing from the old system introduced in 1998. The development of environmental indicators was subcontracted to the Institute of Ecology of Tallinn University (priority areas: natural resources, waste, climate, air, soil and water) and the Institute of Agricultural and Environmental Sciences of the Estonian University of Life Sciences (priority areas: habitats and ecosystems).

The environmental indicators to be developed will be used to create a special website of Estonian environmental indicators and to continue issuing publications on the Estonian environmental indicators. All interested parties will have an opportunity to get a more comprehensive and easily understandable overview of the trends in and status of the Estonian environment.

2. Climate

Institute of Ecology, Tallinn University

Environmental issues in the priority area

A number of surveys and monitoring data confirm that the climate of our planet is constantly changing, much of which can be attributed to increased human activity. Both the monitoring data and the analyses of glaciers indicate that the concentrations of greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitric oxides (NO_X), in the atmosphere have steadily increased over the past couple of centuries. The effects of the rising concentrations of greenhouse gases are clearly seen in the changes occurring on land, in oceans and on glaciers. Over the last 100 years, the average global air temperatures above the land and oceans have increased and the mass of both Arctic and continental glaciers continues to shrink. The long-term monitoring data (up to 150 years) and the radar altimeter data of the last decades indicate that the world sea levels have also risen, which may be related to global warming. The model forecasts used in the most recent report by the Intergovernmental Panel on Climate Change (IPCC) project at least a couple of degrees of warming and a sea level rise of 0.5 metres by 2100.

Because of Estonia's geographical location, the climate varies significantly across the country. Estonia is also located in the region where, according to the report by IPCC (2001), the average air temperature has increased most over the last decades. For example, in the second half of the last century, the annual average temperature in Estonia increased by 1.0–1.7 °C, mainly due to higher temperatures in the period from January to May. Milder winters mean that the number of winter storms has also increased – our weather is affected by cyclones and the average atmospheric pressure in winter has decreased. The increased occurrence of storms may cause more frequent and large-scale floods in coastal areas. The possible climate changes may also have an adverse effect on agricultural productivity. However, its effect on forest biomass is positive.

A number of international agreements have been signed to curb global warming. These agreements mainly focus on reducing the emissions of greenhouse gases caused by human activity. Estonia signed the United Nations Framework Convention on Climate Change in 1992 and joined the Kyoto Protocol in 1998. Estonia committed to reducing greenhouse gas emissions by 8% compared to 1990 when 40.8 million tonnes of CO_2 equivalents were emitted into the atmosphere. By today, emissions have dropped by approximately 50% compared with the reference year, mainly due to the drastic drop in emissions in the early 1990s – the time of transition from a planned to a free market economy.

The main greenhouse gas (GHG) emitted in Estonia is carbon dioxide (CO_2), which accounts for nearly 90% of total emissions. Other major GHGs are methane (CH_4) and nitrous oxide (N_2O), the shares of which in total emissions are almost equal. The major part (90%) of emissions are generated by the oil-shale based energy sector. The use of carbon-intensive oil-shale is also the reason for high per capita emissions, which exceed the EU average by 1.6 times. Globally, however, Estonia's share in generating GHGs is very small. For example, Estonia's contribution to total emissions generated by EU Member States is only 0.36%.

Main criteria for the selection of environmental indicators in the priority area

One of the most important factors affecting climate change is the concentration of greenhouse gases in the atmosphere. The increasing concentrations are caused by constant GHG emissions, both natural and anthropogenic, which exceed the volume of nature's sequestration capacity. The main anthropogenic GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases, or F-gases. The emissions of all these GHGs are measured in CO_2 equivalent tonnes, because the relative contribution to the enhanced greenhouse effect by different GHGs is different. GHGs are produced mainly by the energy sector, i.e. as a result of electricity generation. GHG emissions depend significantly on the agricultural and transport sectors, i.e. on the amount of liquid fuel used. This in turn depends on the economic performance (gross domestic product - GDP) and population size of Estonia.

The primary greenhouse gas is carbon dioxide (CO_2), which is produced as a result of the combustion of fuels and is also released into the air during the processes of breathing and decomposition. In nature, the concentration of carbon dioxide depends on the decomposition of organisms, the development stage and species composition of vegetation, forest fires, volcanic activity, etc. Since the beginning of the Industrial Revolution, atmospheric concentrations of carbon dioxide have increased due to an exponential growth in the overall need for energy which is satisfied by burning fossil fuels. CO_2 is released as a result of burning fossil fuels, such as coal, oil, oil shale, natural gas and peat. Carbon dioxide constitutes nearly 90% of the total GHG emissions in Estonia because between 80 and 90 percent of electricity is produced from oil shale. Therefore, the main pressure factor relating to GHG emissions is the production and consumption of electrical energy. While a large part (ca 20%) of the CO_2 emitted is absorbed by natural ecosystems, the balance was still positive in 2011 - more than 14 million tonnes of CO_2 were added to the atmosphere.

The second most important gas contributing to the greenhouse effect is methane (CH_4), which accounts for 20% of the enhanced greenhouse effect. While the global emissions of methane are significantly lower than those of carbon dioxide, methane plays an important role because of its global warming potential (GWP characterizes the impacts of greenhouse gas emissions on climate change in terms of carbon dioxide equivalents) is 21 times greater than that of carbon dioxide. Methane is released from natural wetlands and bogs and through the digestive process of livestock, etc. The main anthropogenic sources of methane are agriculture, municipal waste, natural gas production and effluent. In 2011, methane accounted for 5.6% of total GHG emissions in Estonia.

The third greenhouse gas of global significance is nitrous oxide (N_2O), which accounts for 6% of total emissions. Despite low emissions, nitrous oxide has an important role due to its high global warming potential, which is about 310 times greater than that of carbon dioxide. While more than half of nitrous oxide emissions are of natural origin, we should not underestimate the importance of anthropogenic emissions. Compared with the period before the Industrial Revolution, N_2O concentrations in the atmosphere have increased by 15%. While the main source of anthropogenic nitrous oxide emissions is agriculture, the burning of fossil fuels by the transport and industrial sectors also contribute. In agriculture, the main source of nitrous oxide emissions is the use of nitrogen-rich fertilisers, followed by N_2O released from manure. In 2011, nitrous oxide accounted for 5.9% of total GHG emissions in Estonia.

Other important greenhouse gases are fluorinated gases or F-gases. F-gases are mainly released as a result of the use of refrigeration equipment, aerosols and air conditioning equipment. Globally, F-gases account for about 10% of the enhanced greenhouse effect. While the emissions of F-gases are relatively small compared with other GHGs, their global warming potential is very high, for example the GWP of SF6 (sulfur hexafluoride) is 23,900. In 2011, F-gases accounted for 0.95% of total GHG emissions in Estonia. The share of F-gases has constantly increased in Estonia, because ozone-depleting substances, such as CFCs, HCFCs and halons, formerly used in refrigeration and air conditioning equipment, have been largely replaced by F-gases. F-gases are dangerous due to their inertness, i.e. they can persist in the atmosphere for a very long time.

The main climate indicators indicating the state of the environment, which can be affected by GHG emissions and are therefore monitored in Estonia, are air temperature and amount of precipitation. Because the rise in the average air temperature, which has occurred in Estonia over the last decades, is related to higher temperatures during winter, the important indicator is the average winter temperature. Because the method of measuring precipitation volumes has changed over the last decades, it is difficult to say how the volumes of precipitation have changed. However, it is very likely that the volumes of precipitation have increased, especially in winter.

One issue which can be attributed to climate change is the increasing number of stormy days in Estonia. The number of extreme storm days is particularly important because the extent of damage caused by storms in coastal areas is growing exponentially as the wind speed goes up. The increasing number of stormy days and higher average air temperatures in winter increase the duration of the ice-free period, which in turn increases the likelihood of storm damages in coastal areas during winter. For example, during the cyclone Gudrun, which ravaged Estonia in January 2005, extreme gusts of 38 m/s were recorded and the water level reached 295 cm above the Kronstadt zero benchmark. Increasing average temperatures may also have an adverse effect on the total agricultural yield. Modelling suggests that an increase of a couple of degrees in temperature may reduce the yield of barley, which accounts for nearly half of the annual grain production of Estonia, by more than 40%.

The main objective of the fight against climate change and the greenhouse effect is to decrease greenhouse gas emissions. Longer-term objectives are to achieve zero emissions of carbon dioxide, i.e. to achieve a situation where the amount of carbon dioxide from human activity does not exceed the amount sequestered by ecosystems. Estonia has reduced GHG emissions by nearly 50% compared with 1990. The main way to reduce GHG emissions is undoubtedly increasing the efficiency of energy consumption. Emissions from the energy sector can be reduced by modernising the existing production facilities and bringing them into compliance with the environmental requirements, as well as by introducing renewable and other alternative energy sources. The greatest effect can be achieved by introducing emission-free energy sources, such as hydro and wind energy, the share of which has steadily grown in recent years. Reducing the overall consumption of primary energy is also important. However, energy must be produced in volumes which satisfy the needs of Estonia. We must develop diverse energy production technologies which are based on various energy sources and exert less pressure on the environment, while enabling to produce energy for export.

In order to curb GHG emissions, the EU has introduced an emissions trading system, in which Estonia has acted as the potential "seller" of emissions. Various environmental charges, such as the ambient air pollution charge, and fees for mining rights at deposits are also aimed at curbing emissions. Overall increase in environmental awareness motivates people to consume less energy and to accept the national tax policy and legislative decisions, which also results in decreased emissions. Reducing electricity and heat losses by modernising energy systems and making buildings more energy efficient also helps to reduce energy consumption. The development of public transport and the building of cycle and pedestrian paths play an important role in reducing the traffic burden caused by motor vehicles.

Division of climate indicators

Driving forces	Population indicators
	Economic indicators
	Social indicators
	Transport
	Energy
	Land use
	Innovation
	Environmental awareness
Pressure	CO_2 emissions
	N_2O emissions
	CH_4 emissions
	F-gas emissions
State	Average annual air temperature in Estonia
	Average air temperature in winter
	Average annual precipitation
	Water temperature in the Baltic Sea
Impact	Storms
	Water level
	Duration of ice cover
	Yield of arable crops
	Invasive species
Response	Financial measures to reduce greenhouse gas emissions
	Production and consumption of renewable energy
	Greenhouse gas emission limits
	Price of emission allowances

3. Air

Institute of Ecology, Tallinn University

Environmental issues in the priority area

The main environmental issue in the area of air is air pollution due to human activity. Air pollution through energy production depends primarily on the fuel and combustion technologies used and on the efficiency of measures taken to limit emissions. Nearly 90% of air pollution originates from local pollution sources, such as energy production, industry, etc. Energy production from fossil fuels (coal, brown coal, peat, oil shale, oil and natural gas) contributes most to the pollution of air. Fossil fuels are the main sources of anthropogenic emissions of SO_2 and NO_X as well as of particulate matter. Incomplete burning of fuel produces CO, volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). Energy production also releases heavy metals (cadmium, mercury, nickel, vanadium, arsenic, etc.) into the atmosphere. The emissions of SO_2 and NO_X have decreased in Estonia significantly after 1990, mainly because of decreased consumption of electricity. Energy producers have also switched from nitrogen-rich heavy fuel oil to natural gas and wood; the use of low nitrogen oil shale and light fuel oil has also increased. The sources of SO_2 pollution are mainly local, while motor vehicles account for more than one third of NO_X sources. The power stations in Estonia have renovated some energy blocks, replacing pulverised fuel technologies with fluidised bed combustion technology, which has significantly reduced the oil shale consumption and SO_2 emissions.

Various industrial processes also constitute an important pollution source; therefore, air pollution remains a problem in areas where chemical, metal, paper and other plants are located. In Estonia, high air pollution levels have been measured in industrial towns of North-East Estonia (Kohtla-Järve and Kiviõli) – the location of oil shale chemical plants, nitrogen fertiliser plants and chemical plants. A significant part of total organic compound emissions (except for methane) comes from industrial processes, energy production and the use of solvents.

Transport affects the environment by generating air pollution and noise. The transport sector accounts for more than 40% of total nitric oxide (NO_X) emissions and for a significant part of CO and VOC emissions.

The main pollution sources in cities and towns are traffic (passenger cars, lorries, buses, etc.), energy production (central heating, industrial facilities, local heating) and street dust. Human health is endangered mainly by SO_2 and NO_2, ground-level ozone and the concentration of particle matter in the air. Increased levels of fine particles in the air of cities are mainly caused by motor vehicles; an important source of PM_{10} is local heating by wood and household waste.

The deterioration of air quality puts the whole biota at risk. Air pollution has an adverse effect on the water environment, causing eutrophication of water bodies, deposition of acid compounds in soil and acidification of biota. Acidification is caused by sulphur dioxide (SO_2), nitric oxide (NO_X) and ammonia (NH_3) emissions of anthropogenic origin. These pollutants react with water vapour in the air and fall on the ground in the form of acidic rain, damaging wildlife and objects of cultural heritage. In Estonia, the greatest SO_2 emissions originate from the energy and industrial sectors,

NO_X emissions come mainly from the transport and energy sectors and the most important source of ammonia (NH_3) is agriculture (use of fertilisers) and animal husbandry.

Air pollution irritates eyes, upper respiratory tract and lungs (aggravates and causes asthma and other allergic respiratory diseases). Particles less than 10 micrometres in diameter (PM_{10}), which originate mainly from the soil, road covering and dusty industrial facilities, are inhaled, pass the nose cavity and throat and accumulate in the lungs, posing a health concern. Fine particles less than 2.5 micrometres in diameter ($PM_{2,5}$) originate from exhaust gases, various combustion processes (boiler houses, local heating, industrial facilities) and chemical reactions occurring in the atmosphere. These particles are sufficiently small to penetrate the deepest part of the lungs such as the bronchioles or alveoli. The inhaled fine particles are absorbed into the circulatory system and transported to the heart. High concentrations of PM_{10} continue to be an issue in Estonia. According to the Estonian Environmental Strategy until 2030, the average number of days in urban regions on which the concentrations of particulate matter exceed the permitted level in urban areas must be reduced (the reference level is 16 days/year) as must be the annual average concentration of PM_{10} in urban air.

Despite the fact that many ozone-depleting substances (ODS) are being phased out throughout the world, ozone depletion continues to be a problem because their lifetime can extend to hundreds of years, which means that even if we stop using CFC products completely in the near future it may take hundreds of years for the negative effects to be nullified. Freons and halons are believed to pose the greatest threat to the ozone layer. These substances are called either chlorofluorocarbons (CFC) or hydrochlorofluorocarbons (HCFC), depending on the elements contained in the compound. The latter were developed as the first major replacement for CFCs because they are considered to break down more easily and be somewhat less destructive to the ozone layer. HCFCs are being substituted by hydrofluorocarbons (HFCs) which do not deplete the ozone layer but have a very high global warming potential. Since 1st January 2010 it has been illegal to use virgin HCFCs in the production of, or for the maintenance of products and equipment, in particular to refill installations within the EU. Reclaimed/recycled HCFCs can still be used for the maintenance of equipment from 1 January 2010 until 1 January 2015. There will be a ban on the use of all HCFCs from 1 January 2015.

Damage to the ozone layer increases our natural exposure to UVB radiation and has a negative effect on biota. Exposure to UVA and UVB radiation may cause non-melanoma skin cancer. UVB radiation increases the incidence of eye related diseases, lens deformation and myopia.

Main criteria for the selection of environmental indicators in the priority area

The level of air pollution is directly dependent on energy consumption, at least while the prevailing energy sources are from fossil fuels. Improved quality of life intensifies industrial activity and energy consumption, which in turn increases the production of primary energy and consumption of liquid fuels. Economic growth results in increased investments, including investments in sustainable environment measures, which help to reduce pollution. One of the biggest pollution sources in urban areas is traffic (motor vehicles), followed by the production of heat and electricity. In recent years, the volume of freight transport has decreased due to the economic downturn. Passenger transport, on the other hand, has grown slightly, spurred by more active travelling. While the total number of people using public transport is decreasing, the free-of-charge public transport policy implemented in Tallinn and the purchase of new electric and diesel trains may change this trend. The number of passenger cars, which has quickly increased over the last couple of decades, indicates that public transport is not popular.

The most important indicators of the pressure exerted on the air are the concentrations of the substances listed in the Geneva Convention on Long-range Transboundary Air Pollution (sulphur dioxide, nitrogen compounds, ozone, ammonia, heavy metals and volatile organic compounds). Estonia joined the Convention in 2000.

Sulphur and nitrogen compounds and many other pollutants are released into the atmosphere as a result of both human activity and natural processes. Sulphur dioxide (SO_2) is released into the atmosphere as a result of using fossil fuels (coal, oil shale, black oil) and industrial processes as well as decomposition processes (oxidation of H_2S). As a result of various reactions in the atmosphere, sulphur dioxide turns into sulphuric acid (H_2SO_4). Some of the sulphuric acid is deposited by precipitation, causing acid rains; the rest reacts with ammonia or sea salts in the air, forming sulphate aerosols. Similarly to acidic precipitation, acid aerosols pose a risk to human health, wildlife and materials. Some sulphate aerosols may end up in the stratosphere where they may drastically increase ozone depletion. Aerosols and other particles in the atmosphere may reduce visibility, which may affect air traffic. Sulphur dioxide is a toxic gas that irritates eyes and the respiratory tract (causing breathing difficulties and bronchitis); it is also linked to cardiovascular disease.

While the main cause of acidification of the environment is sulphur dioxide, nitrogen oxides and ammonia also play a role. Acidification affects forest ecosystems mainly by deteriorating the soil conditions (nutrients are leached out and toxic metals (Al, Hg) start to move). Sulphur dioxide damages leaves and the needles of trees - cells transform, leaves wither, turn brown and fall to the ground; plants stop growing. The pH level of surface water bodies may decrease, causing changes in water biota.

Of all nitric oxides (NO_X), the most important pollutants are NO and NO_2. Nitric oxides are produced as a result of combustion; the main anthropogenic sources are energy production and traffic. Globally, naturally occurring NO_X emissions exceed the anthropogenic emissions, but in industrial and urban regions, the concentrations of nitric oxides are hundreds of times higher than in unpolluted areas. Nitric oxides acidify in the atmosphere into nitric acid (HNO_3), which causes acid rainfall. Nitric oxides also participate in reactions which result in photochemical smog and the formation of ground-level ozone. NO_X poses a risk to human health because it reduces the resistance of the body to upper respiratory infections (flu, pneumonia). Children, asthma sufferers and smokers are especially susceptible to nitrogen dioxide (NO_2). Nitrogen dioxide hinders plant growth; more sensitive species develop visible leaf damage.

Ammonia (NH_3) is released into the atmosphere mainly as a result of the breaking down of organic substances due to agricultural activities (animal husbandry, manure storage, fertilisation of fields). While NH_3 found in the air acts as a neutraliser of acids (HNO_3 and H_2SO_4), when it reaches the ground it is a potential acidifying agent. Excessive deposition of nitrogen may cause eutrophication. Eutrophication or a process where water bodies receive excess nutrients as a result of human activity has become a serious problem. Eutrophication may be caused by excessive deposition of nitrogen compounds from the atmosphere, which causes excessive phytoplankton and aquatic plant growth, anoxia and deterioration of water quality. Excessive deposition of nitrogen on land may reduce the number of species in communities which have developed in nutrient-poor conditions (e.g. marshes) on account of less competitive species. This may cause host or food plants to disappear.

Anthropogenic volatile organic compounds (VOC) found in the atmosphere originate mainly from oil processing and the use of oil products (transport, solvents). In nature, volatile organic compounds are released by vegetation. The release process may be very intensive, exceeding anthropogenic emissions. Volatile organic compounds contribute to the formation of ground-level ozone and photochemical smog. These compounds, which enter the organism through the respiratory tract, may cause headache, coordination disorders, nausea, irritation of mucous membranes and damage to the liver, kidneys and the nervous system.

Ozone is a very active oxidant which is harmful to organisms even in low concentrations. The formation of ozone depends, besides the intensiveness of solar radiation and NO_X and VOC concentrations also on the ratio of VOC and NO_X (ozone is formed and depleted at the same time in the immediate vicinity of NO_X sources). High concentrations of ozone may cause respiratory illnesses and weaken the immune system. While children, asthma sufferers and smokers are especially susceptible to ground-level ozone, it may pose a risk to the health of people working and exercising outdoors. Ozone stunts plant growth and causes damage to leaves.

The main anthropogenic sources of heavy metals are the metal industry (including mining) and burning of fossil fuels. The concentrations of heavy metals have grown significantly as a result of human activity. Heavy metals enter into living organisms through air, water, soil or food and since they accumulate in the organism, their concentrations are particularly high at the top of the food chain. Heavy metals have an adverse effect on metabolism, reproduction capacity and the central nervous system.

Particulate matter (PM_{10}) consists of the particles from the abrasion of road surface, brake wear and tyre wear as well as from burning. Fine particles less than 2.5 micrometres in diameter ($PM_{2,5}$) originate from exhaust gases, various combustion processes (boiler houses, local heating, industrial facilities) and chemical reactions occurring in the atmosphere. Fine particles cause respiratory and cardiovascular diseases.

Ozone-depleting substances (hydrochlorofluorocarbons, halons, carbon tetrachloride, 1,1,1-trichloroethane, methyl bromide, bromochlorofluorocarbons, chydrochlorofluorocarbons, chlorobromomethane) mainly enter the atmosphere in the following ways:

- improper handling and disposal of products and equipment containing ozone-depleting substances (refrigerating and air conditioning equipment);
- use of solvents, paints and fire fighting equipment containing ozone-depleting substances;
- use of methyl bromide in pest control.

Emissions of ozone-depleting substances can be reduced by environmentally safe collection, storage and recycling, as well as the phasing out of such substances.

Damage to the ozone layer increases UVB radiation in the air near ground and has a negative effect on biota. Exposure to UVA and UVB radiation may cause non-melanoma skin cancer. UVB radiation increases the incidence of eye related diseases, lens deformation and myopia.

Emissions from the energy sector can be reduced by modernising the existing production facilities and bringing them into compliance with the environmental requirements, as well as by introducing renewable and other alternative energy sources (e.g. emission-free hydro and wind energy). Reducing the overall consumption of primary energy is also important. However, energy must be produced in volumes which satisfy the needs of Estonia. We must develop diverse energy production technologies which are based on various energy sources and exert less pressure on the environment, while enabling to produce energy for export.

Emissions of sulphur and nitrogen compounds can be reduced by increasing investments in technologies which reduce the emissions of those substances. The use of sulphur-free liquid fuels (diesel fuel, fuel oil) has the same purpose. An overall increase in environmental awareness motivates people to consume less energy, which reduces air pollution, and to accept the national tax policy and legislative decisions, which also results in decreased emissions. Reducing electricity and heat losses by modernising energy systems and making buildings more energy efficient also helps to reduce energy consumption.

The development of public transport and the building of cycle and pedestrian paths play an important role in reducing the traffic burden caused by motor vehicles. The motor vehicle excise duty has the same purpose. The practice of constantly increasing the motor vehicle excise duties, implemented in the European Union, has an important role in reducing the consumption of motor fuels, coupled by increasing oil and energy prices in the world market.

We are surrounded by sounds which may also constitute noise and cause noise damage (loss of hearing, stress, speaking disorders and reduced understanding of speech, rest, sleep disorders, irritability, effects on the cardiovascular system). Because noise levels are measured only randomly and health problems caused by noise are very complex (it is difficult to ascertain that a disorder was caused by noise), it is more practicable to use the number of complaints and total length of noise barriers to measure noise levels.

Division of air indicators

Driving forces	Population indicators
	Economic indicators
	Social indicators
	Transport
	Energy
	Land use
	Innovation
	Environmental awareness
Pressure	Greenhouse gas emission limits
	Emissions of ozone-depleting substances
	Emissions of substances causing acidification
	Emissions of other substances reducing the quality of ambient air
	Emissions of pollutants in ground-level ozone equivalent
	Emissions of pollutants in acidification equivalent
	Emissions of pollutants in PM_{10} equivalent
State	Quality of urban air
	Air quality at monitoring stations
	Air quality in Northeast Estonia (Ida-Viru County)
	Concentration of heavy metals in mosses
	Concentrations of ground-level ozone
	Thickness of the ozone layer above Estonia
Impact	Acidity and chemical composition of precipitation
	Acidity of soil
	Loss of leaves and needles
	Solar UV radiation
	Ecological status of water bodies
	Ecological status of standing water bodies
	Ecological status of coastal waters
Response	Financial measures to reduce emissions of pollutants
	Reducing the number of cars
	Reuse of ozone-depleting substances
	Production and consumption of renewable energy
	Air pollutant emission limit values
	Investments in projects aimed at the protection of the atmosphere

4. Water

Institute of Ecology, Tallinn University

Environmental issues in the priority area

Thanks to its climatic conditions and geographical location, Estonia's fresh water resources are sufficiently large. The majority of Estonian urban communities and companies extract groundwater for their own use. Tallinn and Narva as well as some industrial plants (including in Sillamäe, Kohtla-Järve and Kunda) use mainly surface water. A total of 1.6 billion cubic metres of water is extracted in Estonia annually, which makes us one of the biggest users of water in the European Union. A major part of water extracted each year (1.5 billion cubic metres) is water used for industrial purposes (mining and cooling water; taken mainly from the Narva River and reservoir). Cooling water accounts for about 80% of the total volume of water used; most of it is used by power plants in Ida-Viru County (Balti Elektrijaamad and Eesti Elektrijaamad). It should be noted, however, that while cooling and mining water increase the water use indicators, they are not counted as water consumption, because mining water is discharged into natural water bodies after use. While power plants use huge volumes of water, they are not big consumers of water – cooling water is taken from the Narva River and discharged back into the river without changing its chemical composition. Cooling water does not need to be treated and the temperature rise is also marginal Water used by households, industry, agriculture and other sectors accounts for 6% of total water use; half of that volume is consumed by households.

About 80% of the extracted groundwater is pumped out of mines, the so-called mining water, and discharged into surface water bodies. Water pumped out of dry quarries may have a significant impact on the hydrological and hydrochemical indicators of artificial recipients, ground water levels and also on the levels and ecological status of surface water bodies.

The general condition of the majority of Estonian groundwater bodies is good, except for the Ordovician groundwater body of the Ida-Viru oil shale deposit, which is characterised by increased concentrations of sulphates, minerals and hazardous substances (phenolic compounds and oil products) as well as by the hardness of the water. Limited pollution of groundwater is also found in unprotected Silurian-Ordovician groundwater bodies and Quaternary groundwater bodies across Estonia. Since 2006, the concentrations of nitrates have increased in the Adavere-Põltsamaa nitrate sensitive area (an area where agricultural activity has increased or may increase nitrate concentration in groundwater over 50 mg/l or where eutrophication occurs in surface water bodies or surface water bodies are at risk of eutrophication due to agricultural activity). The main reason is agricultural production and also meteorological conditions (excessive precipitation during the fertilisation period), which have facilitated the leaching of nitrates from soil to both surface and groundwater.

According to studies, the status of Estonian coastal waters is poor and it is not expected to improve rapidly, taking into account the slow replacement of water. The poor status of coastal waters is caused by nutrient loads from the territories of Estonia and neighbouring countries and the pollution that has accumulated over decades, which have led to the eutrophication of the Baltic Sea. It is also believed that the status of coastal waters has changed because the data and methods used for assessment have changed. The runoff of nitrogen and phosphorus into the marine environment depends on the amount of precipitation and on how environmentally friendly is the management of the river basin. Agriculture and untreated waste water are the main sources of nitrogen and phosphorus pollution in Estonian coastal waters.

Estonian internal water bodies are divided into two categories: watercourses and standing bodies of water. In order to get an overview of the status of internal water bodies and changes in their status, monitoring is carried out annually. In the course of monitoring, the ecological status of selected watercourses and standing bodies of water is assessed, taking into account both physical and chemical as well as biological factors, such as phytobenthos, macrophytes, benthic fauna, fish fauna, etc.

About 31% of watercourses which have been declared to be important are strongly affected by human activity. The quality of water in the majority of Estonian watercourses is either good or very good. The ecological status of the following watercourses is very good: the Peetri, Kaave, Punapea ja Rõngu rivers and lower reaches of the Valgejõe river. In recent years, the quality of water in Estonian rivers has improved mainly due to new and reconstructed waste water treatment systems. The status of three quarters of Estonian rivers can be considered to be good. A negative trend is an increase in nitrogen concentrations in the rivers located in areas of intensive agricultural production.

The ecological status of about 2/3 of the monitored small lakes is either good or very good. The status of one third of small lakes is poor, mainly due to excessive concentrations of nutrients. Nutrients enter the water environment mainly from point sources, such as industrial facilities, waste water treatment plants and landfills, and diffuse pollution sources, such as fertilisers used in agriculture. The status of our largest standing bodies of water – Lakes Peipsi and Pihkva – is poor and bad, respectively. The deteriorating status of those lakes is caused by the abundance of nutrients. A major part of the nutrients are carried to Lake Pihkva from the Velikaya River, which in turn affects the status of Lake Peipsi. However, internal loads, or the amount of phosphorus resuspension compared to the influx of substances, play a bigger role than direct loads. A large nutrient load causes blue-green algae blooms and decreases the transparency of water, which is a big problem in particular in Lake Pihkva. Although far from ideal, the Estonian water bodies are among the first ten in Europe in terms of their ecological status.

Main criteria for the selection of environmental indicators in the priority area

While the volume of surface water abstracted per capita is significant, it does not have a direct impact on the environment because the power plants' cooling water is taken from the Narva River and discharged back into the river without changing its chemical composition. High levels of groundwater abstraction are also due to the pumping of mining water (about 80% of total groundwater abstraction). While this water is not directly consumed, the pumping exerts both direct and indirect pressure on the environment. The water used by urban communities and industry account for the major part of surface and groundwater actually used. While a large number of people use surface water as drinking water (e.g. in Tallinn and Narva), the majority of smaller urban communities and companies extract groundwater for their use. Groundwater abstraction affects groundwater bodies. Therefore, in order to ensure sufficient supply and sustainable use of groundwater, its levels have to be measured regularly. Extraction of water intended for human consumption, which forms a significant part of total water extraction, is directly related to the number of consumers, i.e. it depends on the population size.

Because a major part of the extracted water is used by the energy sector, the most important driving force behind water use is energy requirements, expressed in the production and consumption of primary energy. Similarly to the consumption of water intended for human consumption, the consumption of primary energy depends directly on the number of consumers, i.e. population size, and also on the volume of industrial production, which is expressed in GDP trends.

Excessive water extraction may lower the level of groundwater, which will lower the level of groundwater-fed water bodies, which in turn will change natural conditions in, and the ecological status of, water bodies – as a rule, for the worse. Habitats (including key biotopes) may disappear and landscapes may change so that their (economic, recreational, etc.) value for people will deteriorate. More often than not, such changes are irreversible – ecosystems may not recover from excessive use of water resources (changes in lake trophicity due to drastic changes in the levels of small lakes). The lowering of the level of groundwater leads to the deterioration of the status of wetlands. Changed natural conditions lead to problems for people. To raise awareness about those problems and reduce environmental pressure, the quality of swimming water and water levels in bore wells are measured, and dried out wells are registered. In light of commitments to the European Union, the decreasing area of the habitats of the Habitats Directive, with the possibility of fines for derogations, remain a problem.

As regards the status of water bodies, nutrients, such as phosphorus (P) and nitrogen (N) play the most important role in long term pollution. Abnormally high levels of nutrients in water bodies, standing bodies of water in particular, may increase water trophicity in those water bodies, i.e. it can cause eutrophication. A high concentration of nutrients trigger a rapid growth of phytoplankton and algae as well as algal blooms, reduce the transparency of water, which in turn will reduce the number of hydrophyte species and the biomass of hydrophytes. This will destroy zooplankton habitats, non-predatory fish start to dominate and the status of the water body may deteriorate even more. This is a circulatory process and restoring the earlier balance is complicated, if not impossible. The poor status of Estonian coastal waters is also caused by nutrients and pollutants which have accumulated or been discharged into the sea over decades and contributed to the eutrophication of coastal waters.

The greatest sources of diffuse pollution are agriculture and animal husbandry. The main source of pressure is the excessive use of (mineral and organic) fertilisers – nitrogen and phosphorus, which cause the eutrophication of water bodies, may leach into the aquatic environment. The amount of nutrients that end up in water bodies each year due to the use of fertilisers is unknown. Although records are kept on the amount of fertilisers used on arable land and the amount of nutrients removed from land with agricultural produce, the balance does not indicate the amount of nutrients leached directly from arable land. As regards the assessment of the impact of livestock farming on Estonian internal water bodies, the situation is even worse because we do not have an overall assessment of possible pollution loads. The situation is made even worse by the fact that livestock are not necessarily kept in the location where they are registered. Taking into account the extent and intensity of livestock farming, it is necessary to assess the diffuse pollution from this activity.

Nutrients are discharged into the aquatic environment also from point sources (industrial facilities, waste water treatment plants and landfills). Pollution loads from these sources are easier to measure than loads from diffuse sources. The Estonian Environmental Strategy 2030 provides that in order to achieve a good status of surface water (including coastal waters) and groundwater or to maintain the good or very good status of water bodies, point source pollution loads need to be reduced (besides reducing diffuse pollution loads).

The composition of mining water differs significantly from that of natural water. The discharge of mining water into natural water bodies causes the influx of suspended solids and water, the chemical composition (including pH) of which is not characteristic of a natural water body, which may change or even cause a shift in the ecological status of the recipient water body.

In order to ensure sustainable water use and as good as possible status of water, we need to plan the use and protection of water. The use and protection of surface water and groundwater is planned and organised by river basins based on catchment areas. One way to regulate water abstraction and consumption is to change the price of water. Overall increase in environmental awareness motivates people to consume less water and to accept the national tax policy and legislative decisions. The implementation of fees for the special use of water and pollution charges as well as the phasing out of the policy of subsidising water prices have increased the cost of water consumption. These measures have been quite effective and both the population and companies have started to use water more sustainably. This has also motivated people to monitor their water consumption and install new pipes and sanitary ware. The use of water for human consumption per capita has decreased and reached the optimum level, while increased water prices have forced people to adopt more sustainable consumption habits. Investments in waste water treatment plants and sewerage systems constitute a measure which is directly aimed at reducing pollution loads from point sources. Pollution loads are also kept under control by pollution charges and more strict requirements for waste water treatment. According to the Environmental Charges Act, charges concern the following pollutants: biochemical oxygen demand, total phosphorus, total nitrogen, suspended solids, sulphates, monophenols, oil, oil products, mineral oil and liquid products of thermal processing of solid fuel and other organic substances as well as other hazardous substances within the meaning of the Water Act. Reducing point source pollution loads will affect directly the Estonian internal water bodies and the quality of river water in particular.

Division of water indicators

Driving forces	Population indicators
	Economic indicators
	Social indicators
	Energy
	Land use
	Innovation
	Environmental awareness
Pressure	Water abstraction
	Use of water resources
	Land improvement
	Agricultural intensity
	Pumping of mining water
	Point source load
	Diffuse load
State	Chemical and quantitative status of bodies of groundwater
	Concentration of nitrates and pesticides in bodies of groundwater
	Quality of water in rivers
	Quality of water in standing water bodies
	Quality of water in coastal waters
	Pollutant runoff
Impact	Ecological and chemical status of standing water bodies
	Ecological and chemical status of watercourses
	Ecological and chemical status of coastal waters
	Ecological status of wetlands
	Area of mire habitats
	Quality of drinking water
	Quality of swimming water
Response	Financial measures to reduce water pollution
	Waste water treatment
	Water pollution limits
	Investments in water management projects

5. Waste

Institute of Ecology, Tallinn University

Environmental issues in the priority area

Estonia generates an average of 14 tonnes of waste per capita (including industrial waste) each year. This is a record amount in Europe. More than 80% of all waste is generated by the industrial sector, with 76% of total waste comprising waste generated by the oil shale industry and energy sector, followed by the building sector, manufacturing of building materials and wood industry.

The total amount of waste has increased in recent years due to the waste generated by the oil shale sector. However, recycling of waste has also increased. A significant part of recycled waste is oil shale mine waste and crushed limestone produced from that waste. The generation of hazardous waste has also increased, in particular in the oil shale sector. While large amounts of waste indicate that natural resources are not used efficiently, the harmfulness and toxicity of waste reflects its impact on the environment and human health.

The major part of hazardous waste (approx. 98%) is generated by the oil shale and energy sectors. However, the amounts of waste (mainly waste oil and liquid fuels) generated by the transport sector (marine, rail and road transport) should not be underestimated. Another waste-intensive sector is cement production, a by-product of which is cement clinker dust that is used to reduce the acidity of the soil, mainly in South Estonia. Hazardous waste is also generated as a result of the production of rare earth metals (acid residue) and in other sectors (including households).

From an economic point of view, the large volume of industrial waste is worrying because waste is a resource that could be reused or recycled. From an environmental point of view, the discharge of waste into the environment or incineration remains a huge problem. If waste is discharged in the environment, hazardous substances may leach into groundwater and surface water. Incineration of waste generates greenhouse gases and toxic gases. Moreover, there are not suitable processing methods for all hazardous materials and substances.

On a positive note, waste generation per capita has decreased in recent years. An average of 290 kg per capita of municipal waste is generated annually, which is among the smallest amounts in the EU. In 2007, the same indicator was 425 kg. About 68% of all municipal waste is deposited in landfills. One reason why the amount of municipal waste has decreased is the complex economic situation of recent years. Provided that the Estonian economy will continue growing, the amount of municipal waste can be expected to increase in the future. Also, the expected decrease and ageing of the population will also have an effect on the amount of municipal waste. Both the generation and recovery of packaging waste has increased since 2001, while the volume of mixed waste has decreased. Increased generation of packaging waste suggests that environmental pressure and the use of natural resources have increased. In light of such developments the generation of packaging waste should be avoided and as much as possible of the generated packaging waste must be recovered to ensure sustainable development. In the collection and recovery of packaging waste, Estonia implements the producer responsibility. Separate collection of municipal waste has reduced the amount of waste deposited in landfills. The separate collection of waste facilitates the recovery of municipal waste, a major part of which is biologically recycled, while garden and park waste is composted and used to for soil amendment.

However, because a major part (95%) of the waste deposited in landfills comes from oil shale mining and oil shale based energy production, landfilling is likely to remain the main method of waste disposal in Estonia – at least as long as oil shale is mined to produce energy and shale oil. Waste generated as a result of thermal processes – oil shale ash, fly ash and cement clinker dust from the Kunda cement plant – accounts for 50% of all waste deposited in landfills. However, the amount of waste deposited in landfills has decreased somewhat in recent years, accounting for 55–60% of all waste generated.

Main criteria for the selection of environmental indicators in the priority area

Consumption inevitably generates waste. Waste generation is directly linked to the overall economic situation — the faster the growth, the more waste is generated due to increased consumption and industrial activity, while economic downturn reverses the process. Increased production of primary energy also adds to the volume of waste because Estonia uses mainly oil shale energy which generates most of our waste. Provided that the Estonian economy will continue growing, the amount of municipal waste can be expected to increase in the future. Also, the expected decrease and ageing of the population will also have an effect on the amount of municipal waste.

In order to get the whole picture of waste generation and to analyse the trends, data on hazardous, municipal and packaging waste must be collected separately. The most waste-intensive sectors in Estonia are oil shale mining and oil shale based energy production as well as the building sector (including the manufacturing of building materials) and wood industry. The generation of hazardous waste has increased, in particular in the oil shale sector. Hazardous waste accounts for less than half of all waste. While large amounts of waste indicate that natural resources are not used efficiently, the harmfulness and toxicity of waste reflects its impact on the environment and human health. Water-soluble particles may be released from mining waste and oil shale waste into the environment and end up in groundwater and soil, changing natural conditions.

As a result of depositing waste in landfills, the area of ruined landscapes and areas under landfills will increase and more hazardous substances are released into air and water. Depositing waste in landfills poses a risk to the environment – leachate from landfills may reach rivers, rain helps bacteria to seep into the soil and groundwater. Incineration of waste generates greenhouse gases, which contributes to air pollution. Landfill sites may also emanate foul smell. As the intensity of foul smell from landfills is only measured occasionally, a more precise indicator is the number of complaints.

In order to maintain an acceptable living environment and use natural resources sustainably, we need to reduce the amount of waste and collect and handle the generated waste in an environmentally friendly way. This is ensured by the recovery and recycling of waste. Reducing the amount of waste deposited in landfills has become a priority. From 1 January 2008, all landfills are banned from accepting non-separated municipal waste, which means that separated collection of municipal waste is compulsory. Packaging waste, electrical waste and electronic equipment, end-of-life motor vehicles, accumulators and batteries are subject to the producer responsibility principle. The aim of the implementation of that principle is to reduce the amount of waste deposited in landfills and increase the recovery of waste. One method of recovery is the incineration of waste for the purpose of energy generation. The recovery of packaging waste is increasing mainly thanks to the implementation of the excise duty on packaging.

The Environmental Charges Act provides the rates of the pollution charge on waste disposal, which should ensure that those who generate waste have an economic incentive to recover waste and thus reduce the amount of waste deposited in landfills.

The increased environmental awareness of the public means that people consume less and in a more sustainable way, thus reducing the amount of waste generated, and accept the national tax policy and legislative decisions aimed at more environmentally friendly handling of waste.

Division of waste indicators

Driving forces	Population indicators
	Economic indicators
	Social indicators
	Transport
	Energy
	Material flows
	Innovation
	Environmental awareness
Pressure	Total waste generation
	Hazardous waste generation
	Municipal waste generation
	Packaging waste generation
State	Total volume of waste deposited in landfills
	The depositing in landfills of municipal waste
	Number of landfills
	Area of landfills
Impact	Chemical status of bodies of groundwater
	Chemical status of watercourses
	Chemical status of standing water bodies
	Greenhouse gas emissions from landfills
	Foul smells emanating from landfills
	Waste fly-tipped in national forests
Response	Financial measures to reduce waste generation
	Recovery of waste
	Number of waste collection facilities
	Treatment of landfill leachate
	Investments in waste handling projects

6. Natural resources

Institute of Ecology, Tallinn University

Environmental issues in the priority area

The main problem is inefficient use of natural resources, in particular economically useful and easily available natural resources, which means that non-renewable natural resources are exhausted and renewable resources are not sustainable any more. Excessive use of resources leads to the pollution of and damage to the environment (altering landscape and land use).

Growing stock

The area and growing stock of forests has increased over the last 50 years. In 2012, forest land accounted for 48.2% of the territory of Estonia (excluding the area of Lake Peipsi).

The most common species of trees in Estonia are pine, birch and spruce; aspen, grey alder and black alder are less common. In terms of age, Estonian forests are distributed unevenly and forest management has been sporadic. Pine are characterised by older stands and despite intensive logging, spruce forests contain many stands that are mature and already deteriorating. In the near future, the most abundant generation of birch forests will reach felling maturity. There are also many mature and over-aged aspen and grey alder stands which will require regeneration cutting. The big proportion of mature forest stands means that more trees could be felled.

The share of conifer stands has decreased over the last couple of decades, while the share of deciduous forests has increased. The share of conifer forests has decreased mainly on account of mature spruce forests which have been actively felled, while clearings have been filled with deciduous trees. Deciduous trees have been cut significantly less than the optimum cutting volume. If such a situation continues, the share of high-quality commercial species will decrease. This in turn will affect the profits of forest owners and the competitiveness and, in long term, the sustainability of the forestry sector.

Forestry is closely related to the use of wood for the generation of renewable energy. The use of deciduous trees (e.g. the grey elder) is expected to increase in line with the growing demand for the use of wood in energy production. Regular management of forests (maintenance, thinning and regeneration cutting) will ensure the sustainability of forest resources.

Forests have a significant role in preserving endangered species and biodiversity; therefore, it is important that we have a network of strictly protected forests and buffer zones.

Fish and game

The condition of fish populations and diversity of fish species depends on fishing activities which may have an adverse effect on the whole water ecosystem. The management of fishery resources must be based on the ecosystem as a whole. The main issue regarding fishery resources is potential overfishing. Besides the damage caused to nature, overfishing can harm the economy, i.e. with fishery resources dwindling more resources are used to catch the same amount of fish. In Estonia, commercial fishing is limited by quotas which are based on the estimated condition of fishery resources.

The sustainability of game animal populations depends on the balance between animal species, which is regulated by natural mortality and hunting. The most common method of regulating the populations of game animals (roe deer, wolf, lynx, wild boar, brown bear, red deer, elk) is hunting. In order to avoid negative effects on nature and the economy, it is important to monitor regularly the populations of game animals and their habitats as well as to take measures based on the identified changes.

Mineral resources

Reasonable extraction and use of oil shale, peat and mineral resources used in construction depends directly on the sustainability of the Estonian economy and society.

Because the deposits of oil shale – one of the most important mineral resources used for the production of energy – are limited, this puts increasingly severe pressure on the cost of energy production. Over 90% of Estonia's electricity is produced from oil shale.

Peat is used mainly in the production of heat but also in gardening and agriculture. An average of a million tonnes of peat is extracted in Estonia in a year. Taking into account its slow regeneration, peat can be considered to be a non-renewable natural resource. Natural recovery is a long process which may take decades. All the Estonian natural mires produce about half a million tonnes of peat in a year. Currently, peat extraction exceeds growth and regeneration and is therefore not sustainable.

The extraction of mineral resources used in construction depends on economic cycles. The main environmental problems related to the extraction of mineral resources are the depositing of waste, depletion of groundwater and surface water and destruction of natural habitats.

Soil

So far, too little attention has been paid to soil as a natural resource – both in Estonia and in other European countries. Urbanisation, including the construction of new dwellings and industrial facilities, has reduced the area of fertile arable land. Planning should take into account the location of the areas fertile soil. Windy coastal areas suffer from the deflation (wind erosion) of sandy soils, which decreases the fertility of land. On uplands the main problem is erosion, the extent of which is affected by the area of cultivated grassland. Therefore, it is important to use agricultural methods that suit the specific soil conditions.

Landscape

The development of society inevitably leads to the expansion of cities as economic and cultural centres. Attraction centres grow mainly on account of arable land close to towns where new infrastructures have been created. The technical infrastructure built for the transport network is also important as it cuts through the landscape and habitats.

Main criteria for the selection of environmental indicators in the priority area

Growing stock

The sustainability of forests as a natural resource depends on the regular management of forests, economic growth, production and consumption of primary energy as well as industrial and forestry outputs. Improving living standards and increasing demand for wood both in the domestic and external markets increased wood production. Economic growth leads to increased investments in production technologies, which helps to use the resource more sustainably.

The main pressure is forest cutting. The development of the wood industry depends on the stability and accessibility of raw material. The market situation is important because it determines the price of and demand for wood. In order to ensure a comprehensive overview of the sector, it is important to monitor the state of forests by using different indicators, such as total prescribed cut, area of final cutting, share of cut forests in the total growing stock, total growing stock, area of forest land and area of mature forests.

Total prescribed cut shows the intensity of cutting in Estonia, which in turn determines the volume of growing stock. According to the Estonian Forestry Development Plan until 2020, the maximum short-time use of wood should be, based on the age distribution of Estonian forests, 22 million m^3 per year, while the long-term sustainable objective is 12–15 million m^3 per year. Therefore, it is very important that this resource is managed sustainably because wood has the highest potential as a biofuel used for the production of heat and electricity. Forest management is closely related to the National Renewable Energy Action Plan, according to which the share of renewable energy should grow to 20% by 2020.

Estonia has a significant volume of unused wood in mature and over-aged deciduous forests (in particular in aspen and grey alder stands), the use of which enables to improve the structure of cut species and use fully the high potential of deciduous forests.

Intensive use of forests affects biodiversity and habitats; therefore, our priority is the specification of the objectives and areas of forest protection and diversification of protection measures and forest management methods. The protection of biodiversity supports public benefit. Besides imposing nature conservation restrictions, the Forest Act establishes the requirements for the protection of biodiversity and the environment. Thus, the important measures are the protection, management and regeneration of forests.

Fish

The sustainability of fishery resources depends on both the economic growth and fishing industry output. The main pressure is fishing that is affected by both the domestic and external market. The Estonian fishing industry is export-oriented because export ensures competitive prices for producers. Therefore, it is important to monitor the state of fishery resources in the Baltic Sea (sprat, cod, Baltic herring) and in internal waters (pike, perch, perch pike). Excessive fishing impairs the recovery of fishery resources.

The regulated fish species in the Baltic Sea are Baltic herring, sprat, codfish and salmon. A Regulation of the European Commission establishes annual fishing quota for the Member States. Estonian quotas are divided between trawling companies based on historical fishing rights. The sprat and Baltic herring resources in the Baltic Sea are also affected by the cod population; therefore, these species should be considered together. Cod resources depend strongly on the inflow of salty and oxygen-rich water through the Danish straits. In Estonian waters, cod fishing is not economically profitable and cod is only caught as a by-catch. Because young, 1–2 years old sprat account for a relatively large part of the catch in commercial fishing (a branch of fisheries dealing with catching fish and other aquatic organisms for human consumption), catch sizes may fluctuate significantly based on how big a given generation of fish is. Fishery resources in Lake Peipsi have increased, mainly on account of perch pike, perch and European whitefish.

The abundance of fish and catch depend mainly on natural conditions; therefore it is important to monitor the ecological status of surface water bodies (discharge of hazardous substances into the sea). In the Väinamere area, the recovery of coastal fish stocks and the volumes of catches have been affected by the increase in the cormorant (Phalacrocorax carbo) populations. The fishing gear used in coastal waters is obsolete and partially non-selective. In order to improve the situation, we need to review the fishing quota and environmental charges and modernise waste water treatment plants, if necessary, also to implement new waste water treatment technologies. Raising consumer's environmental awareness is also important.

Game animals

The sustainability of game animals as a natural resource depends primarily on the economic growth. Improving living standard means that besides traditional hunting there is an increase in hunting tourism, which exerts pressure on hunting quotas. For most game animal species, the changes in relative abundance are assessed, not their abundance in absolute numbers. Therefore, it is important to monitor the status of populations and to maintain their good status. This enables to determine the hunting quota and structure.

In order to ensure normal recovery of age groups, we must avoid hunting only certain age or gender groups of game animals and take into account the differences between counties when organising hunting. Too large populations of bi-ungulates have an adverse effect on forest management. The population concentration of wild boar remains very high in Estonia. Therefore the risk of damage to arable and cultivated lands remained high in 2013.

Hunting must be organised so as to maintain a balance between predators and prey animals. All hunting areas should strive for hunting all game animals so that the age and gender balance is maintained as naturally as possible. The main problem caused by wild animals is damaged forests which entails significant economic losses. In the future, hunting quota and structure should be monitored in control areas as opposed to hunting areas.

Mineral resources

Increasing demand for electricity, heat and construction materials means that our priority is to use mineral resources in an environmentally friendly and economically expedient way. The Estonian National Development Plan of the Energy Sector stresses that oil shale is a strategic mineral resource and producing electricity from oil shale is specific to the Estonian energy sector. The National Renewable Energy Action Plan until 2020, however, foresees that the share of renewable energy sources must increase and emissions from energy production systems must decrease.

The share of oil shale in energy production has somewhat decreased over recent years. Mining alters the water regime in the water bodies located in mining areas. Hundreds of millions of cubic metres of water is pumped each year from mines and quarries into rivers. The drainage of mines reduces the level of groundwater. Only a small part of waste generated as a result of oil shale mining is recovered. Hills of ash, mine waste and semi-coke are formed, from which toxic substances escape into the environment. These substances can destroy life and contaminate both groundwater and surface water. The use of oil shale must be regulated in order to ensure that the oil shale deposits which we are aware of last for as long time as possible and pollute the environment as little as possible.

The most important measure to reduce oil shale mining is increasing the efficiency of energy production and consumption. Oil shale mining can be reduced by modernising the existing production facilities and bringing them into compliance with environmental requirements, as well as by introducing renewable and other alternative energy sources. Reducing the overall consumption of primary energy is also important. However, energy must be produced in volumes which satisfy the needs of Estonia. We must develop diverse energy production technologies which are based on various energy sources and exert less pressure on the environment, while enabling to produce energy for export.

Other important mineral resources are peat, clay, gravel, sand, limestone and dolomite, the extraction volumes of which depend on the demand in the domestic and external markets. Peat resources are distributed unevenly and restoring the natural state of old peat extraction areas is a long and complex process. Mining alters the water regime in the water bodies and habitats located in mining areas. The drainage of mines reduces the level of groundwater. Mining reduces the aesthetic and recreational value of landscapes and the areas suitable for gathering forest goods. Mining can be limited by implementing a fair system of mining rights and environmental charges, re-cultivation of abandoned mining areas and nature conservation restrictions.

Soil

Soil is strongly affected by human activity, such as building, road construction, agriculture and forestry. These activities exert a significant pressure on the quality of soil and may change the natural status of soil. The state of soil in natural areas depends on natural soil generation processes. Forestry increases the risk of soil erosion, nutrient runoff, topsoil destruction, changes in the water regime and soil compression. Soils eroded by water are concentrated in South Estonia, mainly in four counties (Võru, Valga, Põlva and Tartu). Areas affected by wind erosion are mainly found in coastal counties and near Lakes Peipsi and Võrtsjärv.

Agriculture is the most important factor that causes changes in the structure of soil. Other industrial and economic activities have an indirect impact on soil. Land use depends on the fertility of soil. More fertile areas (leached and sandy-clay soils) are suitable for agriculture and less fertile soils for forestry activities.

More attention must be paid to the fertile areas that remain under urban areas and technical infrastructure. The indicators that should be monitored are: area of fertile soils, thickness of humus layer and area of destroyed arable land. The pressures are mainly related to the acidification and alkalinisation of soil, destruction of habitats and deterioration of soil fertility. Therefore, it is important to use suitable agricultural technologies and fertilisation. We must increase land owners' awareness in order to keep high quality soils in agricultural use and to maintain the fertility of soil. Construction activities must also take into account the fertility of soil. Knowing the nature of soil helps to improve and adjust agricultural methods to the specific soil conditions.

Landscape

Landscape as a natural resource is affected by various factors: the agricultural, forestry, transport and dwelling sectors, which all use land and change its natural state and function. It is important to monitor the use of and changes in different land cover types (forest land, agricultural land, wetlands, grassland, populated areas). Inexpedient use of those areas may change the water regime, destroy soil, decrease the number of species, cause the ecological status of surface water bodies to deteriorate, cause air pollution and generate waste. Because many land uses are related to economic activity, special attention should be paid to agricultural lands and to the construction of new roads and utility systems in the transport and building sectors, in particular to how these activities change the environment (obstructing the migration paths of animals by roads and water engineering structures). Also, intensified construction activities in coastal areas are destroying many natural habitats. We need to implement different measures to address these issues: construct filters to protect groundwater, implement nature protection measures, provide support for the maintenance of different land cover types (cutting grass, grazing of animals) in order to reduce the negative human impact on the environment.

The increased environmental awareness of the public means that people consume less and in a more sustainable way, thus reducing the use of natural resources, and also accept the national tax policy and legislative decisions aimed at promoting a more environmentally friendly lifestyle.

Division of natural resource indicators

Driving forces	Population indicators
	Economic indicators
	Social indicators
	Transport
	Energy
	Land use
	Material flows
	Innovation
	Environmental awareness
Pressure	Cutting
	Fishing
	Extraction of mineral resources
	Hunting
	Agricultural intensity
State	Area of forest land and growing stock
	Tree species and age structure of forests
	Status of fishery resources in the Baltic Sea and internal water bodies
	Reserves of extractable mineral resources
	Number of game animals or litters of game animals
	Status of soils
Impact	Area of natural forests
	Endangered species in forest ecosystems
	Number of top marine predators
	Area of quarries
	Impact of mineral extraction on habitats and water bodies
	The depositing in landfills of oil shale waste
	Damage caused by wildlife
	Degradation of soils
Response	Area of protected areas
	Fisheries quota
	Fees for mining rights at deposits
	Re-cultivation of quarries
	Hunting quotas
	Cleaning and rehabilitation of residual pollution areas

7. Biota and landscape

Mart Külvik and Kalev Sepp, Estonian University of Life Sciences

Environmental issues in the priority area

Estonian wildlife and landscapes are very diverse and we have preserved many landscapes that have disappeared in Europe. We have an abundance of various wetlands which are in a good condition (fens and transition mires, floodplains, coastal lagoons), virgin forests, semi-natural habitats (coastal and wooded meadows, alvars). The Estonian coastal waters with small islands, bays and coastal meadows offer stopover sites for migratory birds on their way from nesting to wintering grounds. Millions of birds migrate through Estonia each spring and autumn. About a half of the Estonian mainland is covered by forests and nearly one tenth by mires; these habitats have been preserved in their natural form and are home to hundreds of lynxes, bears and wolves.

The abundance of high quality habitats creates preconditions for species richness. It is believed that there are more than 40,000 species of wildlife, of which about 27,000 (or 60%) are known species. Semi-natural habitats or natural heritage communities are especially rich in species. For example, 76 species of plants were counted on one square metre on the Laelatu wooded meadow in Western Estonia. However, because of its geographical location, Estonia is a geographic range limit for many species which makes them especially sensitive to environmental changes. About one fifth of the species found in Estonia are endangered and 570 species are protected by legislation. Some uniquely Estonian plant varieties and animal breeds, such as Estonian native cattle, are also considered to be endangered species. Wildlife and plant habitats are located on landscapes and depend on the condition of those landscapes. Estonian landscapes are very diverse and come in different types and patterns of landscapes, created by both natural processes (e.g. retreating glaciers) and human activity (agriculture). Besides mires and hilly moraine landscapes, Estonian coastal landscapes are also remarkable.

While Estonia is considered to be a country with relatively well preserved nature, landscapes and the environment as a whole, the intensive management methods used during the Soviet era altered landscapes and destroyed many habitats; some of these trends persist even today. Below, we will give an overview of the trends in biodiversity by main habitat classes.

Agricultural landscapes

As regards diversity, the growing of traditional Estonian crops continues to decrease. As a positive trend, the share of organic farming (which is rather small) is growing steadily. Some aboriginal breeds of animals and plant varieties have become quite rare and are considered to be endangered: the Estonian native cattle, the Estonian native horse, the Estonian draft horse and the Tori horse. We do not have comprehensive information on many native plant varieties, such as fruit trees.

Past and current changes in land use are important. Intensively cultivated lands continue to homogenise, the number of crops decreases and cultivation methods become more standardised. The temporary "going organic", caused by the economic situation in the 1990s, has reversed and shifted towards intensive agriculture. The area of agricultural lands is decreasing. Cultivated lands are replaced by buildings (in urban areas) or brushes and forests (in peripheries). The main factors threatening biodiversity in agriculture is the relatively low profitability of agricultural production and the impact of the EU agricultural policy which limits market output and facilitates intensive production , but also causes lands to be underused or removed from use. The vanishing of heritage breeds and varieties unique to Estonia is related to the disappearance of the economic reasons for their emergence as well as to the fact that their socio-economic role has changed from a source of subsistence to an object of heritage culture. And last but not least, an indirect cause of changes in agricultural biodiversity is globalisation, while global transport of agricultural produce is a direct influencing factor. In the context of the ecosystem services available to society we can say that people are not aware of the role of rural lifestyle and changing landscape in culture, their attitudes being inevitably influenced by urbanisation.

Semi-natural grassland populations, which exist only thanks to human activity (grass cutting, grazing) can also be classified as agricultural landscapes. When humans stop their activity, such grasslands sooner or later turn into forests. Those heritage populations are the most rich in species, best studied and best known ecosystems in Estonia that support biodiversity. Besides being rich in plant species, grasslands offer habitats for a number of wildlife species and their being overgrown with bushes and scrubs has a direct effect on biodiversity. One of the direct reasons for the disappearance of heritage grasslands is that they are no longer economically profitable; therefore, the present communities can be preserved only by implementing nature protection measures.

Forest landscapes

While forests remain the prevailing use of land in Estonia (approx. 50%), the proportion of forest land has decreased in recent years. It can be said that similarly to the rest of Europe, Estonian private forest owners have somewhat lost interest after a period of intensive use. There are between 16,000 and 20,000 multicellular species in Estonian forests, including about 10,000 species of insects. The number of species that have become extinct is relatively low (we know about a couple of dozen) compared with the number of species that have been declared endangered or potentially endangered due to the destruction of habitat.

Of the current trends, which are likely to intensify, climate change is the one that may affect the number of species in our forests. In light of this scenario, forest owners decide in favour of species that are climatically more suitable (broadleaved trees) when they make decisions about reforestation. However, climate change may increase the number of invasive species, which will change the composition of communities and destroy habitats.

The number of people who go to forest (in particular to pick mushrooms and berries) is decreasing, which may deteriorate people's quality of life. On the other hand, funds from the state budget are used to create recreational infrastructure and provide more opportunities for recreational activities in private forests.

Mire landscapes

Peaty areas account for about 1/5 of the territory of Estonia. 40% of this is covered by mires. Mires are divided into fens and transition mires. Quite a large part of mires are under protection for historical reasons, while less than 30% of the mire areas still function as mire ecosystems. According to Jaanus Paal and Eerik Leibak, the area of mires in their natural state was less than 250,000 ha in 2013 – less than 5% of the total territory of Estonia. While the possibilities to restore mires have been studied, no clear solution has yet been found.

A positive change regarding mire ecosystems is that alkaline pollution levels have decreased. Mires can affect the well-being of humans. If the area of functioning mire ecosystems decreases, it may affect the water regime, i.e. the quality of drinking water will suffer.

River and lake landscapes

The ecosystems of internal water bodies are extremely diverse in Estonia as compared with other locations because most water bodies are still in their natural state. However, many water bodies, including Lakes Peipsi and Võrtsjärv, suffer from eutrophication. Eutrophication generally promotes excessive plant growth and decay, which leads to oxygen deficiency and causes a severe reduction in water quality.

Alien species that have reached a number of water bodies pose a major threat to biodiversity as does the nutrient load from agricultural activities. Overfishing is a problem in Lake Peipsi. The economic relevance of the lake has decreased significantly in recent years – even to the extent that it has started to threaten people's staple diet and lifestyle on the shores of the lake.

Sea, coastal and island landscapes

The length of coastline in Estonia is 1,240 km on the mainland and 2,540 km on the islands. There are also about 1,500 islands, 80% of them small islands. 60% of the islands are located in the West Estonian archipelago. Coastal areas, coastal waters and islands/islets are very important from the perspective of biodiversity. Agricultural land use has altered coastal areas that have been traditionally affected by human activity – coastal landscapes shaped by grazing cattle and haymaking. Today, more and more summer houses are built on the coast and human pressure continues.

The Baltic Sea, especially the Gulf of Finland, suffers from eutrophication and the spreading of invasive species. Limited fish resources and catch quota affects, among other things, people's traditional activities.

Changes in the status of biota

The above was a description of the status of biota in Estonia. As regards the trends affecting biota, we should focus on pressure indicators, measures taken to change the status of biota and the overall driving forces behind those changes. Below are the most important biota-related trends specified in the DPSIR framework "Estonian National Environmental Strategy until 2030".

Driving forces

- Most members of society tend to consume imported goods, which contributes to their alienation from the natural environment and its traditional use.
- People are not able to appreciate biodiversity as a natural resource which is fundamental to achieving a better quality of life.

Pressure on biota

- As a result of changes in social and economic conditions, non-productive agricultural land has been excluded from production, and intensive agricultural production activities have been concentrated in certain regions.
- The management of commercial forests which is becoming more intense on a growing basis renders it more difficult to accord consideration to the need of ensuring biological diversity.
- Increasing urbanisation has led to a situation where towns spread over larger areas, encroaching on natural and agricultural landscapes.
- The proportion of renewable energy must be increased; however, it will also increase pressure on the environment and biodiversity because extensive cultivation of monocultures, such as forest energy or rape, significantly affects biotic communities and the composition of landscapes.
- Intensive agriculture and pressure on landscapes continues to destroy habitats and fragment landscapes, which in turn reduces the number of species.
- The introduction and spreading of alien species continues because people's awareness about the possible consequences is low.

Response

- The EU Natura programme increases the efficiency of the protection of landscapes and biodiversity. So far, nature conservation has focused on single objects or territories. The modern approach to nature conservation is to treat Estonia as a comprehensive network of habitats and valuable landscapes.
- Areas of high recreational value (especially coastal areas) are being excluded from public use (private owners ignore the "everybody's right" and make such areas inaccessible).
- There is little awareness about the potential risks arising from genetically modified organisms (opinions are controversial and create numerous pseudo problems).

In general, the problems related to Estonian landscapes are mainly related to one driving force – changes in land use. Changes in land use lead to the following pressures and changes in the status of landscapes (the Estonian Environmental Strategy 2030):

- destruction and fragmentation of valuable landscapes and biotic communities, including habitats;
- formation of wastelands (swamped areas, areas overgrown with scrub);
- prevalence of high density population in coastal areas;
- littering of landscapes (a big number of abandoned technological sites – buildings, agricultural and military sites);
- polarisation of the use of land (some of the land is disused, while some is used too intensely (in terms of technology used per hectare, incl. urban sprawl, pressure from building activities and visitors in coastal areas).

Main criteria for the selection of environmental indicators in the priority area

If the objective is to get a scientifically justified, comprehensive and understandable overview about the environmental issues and the state of the environment and its changes in Estonia, the system of indicators must take into account a wider context, not just the environmental sector, and not be limited to the existing environmental objectives. We must also take into account the important thematic nature protection targets (e.g. the Aichi Biodiversity Targets 2011–2020; the Estonian Nature Conservation Action Plan), while a broader, ecosystem-based approach that takes into account ecosystem services should ensure balanced assessment of the status of the environment, impact of human activity and other factors as well as the efficiency of the implementation of protective measures.

Ecosystem services are the benefits people obtain from ecosystems. The definition helps us to assess in economic terms the benefits humans obtain from natural systems. The concept of ecosystem services enables experts to explain to policy-makers and the public why a certain object should be protected and what are the consequences of not protecting that object. The UN Millennium Ecosystem Assessment (2005) distinguishes four categories of ecosystem services (Figure 2):

Ecosystem services

Provisioning services

- food
- fresh water
- raw materials (wood, fuel, etc.)
- biochemicals
- genetic resources

Regulating services

- climate regulation
- regulation of natural disasters
- water regulation
- cleaning of water, air and soil
- regulation of erosion and trophicity of soils
- pollination

Cultural services

- recreational services
- eco tourism
- aesthetic values
- inspiration in art, technology and science
- educational and research materials
- carrier of cultural identity

Supporting services
(ecosystem services)

- ensuring nutrient cycling
- soil generation
- preservation of food chains and webs
- photosynthesis
- spatial structure
- primary production

Figure 2. Division of ecosystem services.

- Provisioning services – products obtained from ecosystems, such as food, water, timber;
- Regulating services that affect climate, water quality, water resources;
- Supporting services, such as nutrient cycling, photosynthesis, entomophily;
- Cultural services – aesthetic and mental pleasures and recreational opportunities offered by nature.

Based on the concept of ecosystem services, the priority area of landscapes and biodiversity indicators was divided into four sub-areas.

The first sub-area "Functions of landscapes and biodiversity" covers the supporting and regulating services. Supporting functions created preconditions for the provisioning, regulating and cultural functions. The regulating function arises from the capacity of natural and semi-natural ecosystems to affect the main ecological processes. This function provides important services, such as the cleaning of air, climate regulation, protection against floods, water treatment, restoring the fertility of soil and biological control of diseases and pest.

The following four categories of indicators should describe the functions or overall functioning of Estonian landscapes and biota: ratio of natural to artificial; diversity and spatial connectedness; endangered species and their protection and the volume of ecosystems the functions of which have been restored. We can give an assessment of how natural is our country if we know the area and proportion of the prevailing natural communities – forests and wetlands. The number and area of semi-natural communities, such as wooded meadows, alvars and meadows is also an important indicator. Information about landscapes and biota affected by human activity is provided by agricultural, housing, mining and transport land indicators. The diversity and coherence of landscapes is best characterised by a number of landscape ecology indices, such as the Simpson's diversity index, and also by less complex indices, such as the level of road disturbance or changes in the economic land use. We can get a relatively good overview of the threats to landscapes and biota and their protection by assessing the threats to different taxonomic groups (e.g. mire plants, fish, birds, etc.) by habitat types (e.g. forests, mires, water bodies, etc.) and by assessing the areas of major types of conservation units by the same habitat types. To assess the volume of ecosystems, the functionality of which has been restored, we must know the number of semi-natural communities and how many of them are regularly maintained. The number of recultivated quarries, improved lakes and river stretches with restored fish passes provide information about the restoration of destroyed communities.

The second sub-area "Productivity of landscapes and biodiversity" concerns the provisioning services, i.e. resource production services in natural ecosystems, such as forests, and also in ecosystems with a heavy human impact, such as agricultural lands. From the perspective of humans as the consumers of products provided by landscapes and biodiversity it is important not to consume more than nature can provide. Therefore, we must make sure that the critical limit of resources is not exceeded, especially in case of forest and fish resources. Forests constitute one of the most important natural resources; therefore, they should be monitored closely in terms of volume (total volume and volume per hectare) and intensity of use (proportion of cut in total volume) by most important forest sites and species of trees (e.g. fresh boreo-nemoral forests, fresh boreal forests, spruce forests, pine forests, aspen forests, etc.). In case of landscapes producing biological resource we can monitor the degree of sustainability of the process. For example, a relatively simple and at the same time indicative method is assessing how much of the forest land has been ecologically certified or how much of the agricultural land is used for organic farming. The size of Estonia's ecological footprint could be used as a more general indicator that characterises production and the provisioning service provided by ecosystems.

The third sub-area "Culture-carrying capacity of landscapes and biodiversity" concerns the respective cultural services. Ecosystem cultural services are the non-material benefits people obtain from ecosystems. Such services are, for example, enjoying wildlife and landscapes, ecotourism, recreational activities and spiritual and historical information. The volume of ecosystem cultural services is indirectly but rather well expressed by the state of the development of educational infrastructure. For example, a good indicator is the number of visitor centres and the length of educational nature tracks of the State Forest Management Centre (SFMC). Cultural services are also characterised by how much cultural value is placed on landscapes. For example, changes in the proportion of valuable landscapes and areas of cultural and environmental value in the territory of a local government unit tell us how much we appreciate the cultural and environmental values of the landscapes surrounding us and the related ecosystem cultural services. Another important indicative aspect is how much do we value the bioculture that is characteristic of Estonia, i.e. how aware are we about and how do we protect aboriginal plant varieties and animal breeds.

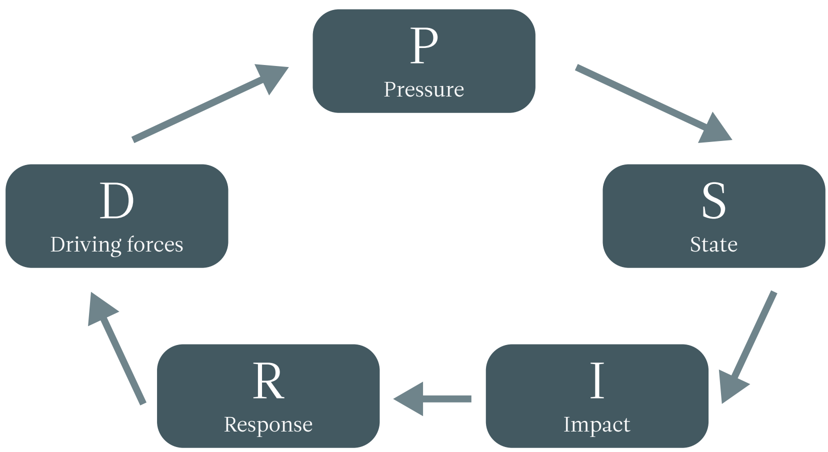
Based on the Aichi biodiversity targets and the priorities of the Estonian Nature Conservation Action Plan, we have identified a fourth indicator "Environmental awareness" because this area is not sufficiently covered by other sub-areas. This indicator is designed to monitor overall public awareness of biodiversity, both in objective terms (what do people know about biodiversity) and subjective terms (self-reported awareness - what do people think they know about biodiversity). It is also important to monitor the trends in attitudes towards nature and the environment. For example, the number of visitors to nature conservation objects or the consumption of all natural products and organic food.

An environmental indicator should include multiple parameter which together enable to assess different aspects of an environmental issue: pressure on the environment, expression of impact, status of the environment and efficiency of alleviating measures as well as the socio-economic processes affecting pressure factors. Therefore, all indicators are selected so as to ensure that they cover different sections of the DPSIR framework.

Distribution of the biota and landscape indicators

Functionality of landscapes and biodiversity	Natural/artificial character of landscapes and habitats
	Diversity and connectedness of habitats
	Endangered species in ecosystems
	Restoring ecosystems to their natural state and improving the state of ecosystems
	Protection of ecosystems
	Distribution of invasive alien species
Productivity of landscapes and biodiversity	Critical biodiversity (renewable natural resources)
	Share of ecosystems used sustainably
	Total growing stock and yield
	Intensity of the use of forests
	Size of ecological footprint
Culture-carrying capacity of landscapes and biodiversity	Existence of nature education infrastructure
	Landscape
	Appreciation of the biological culture characteristic of Estonia
Awareness about nature	Awareness about biodiversity
	Self-reported environmental awareness
	Number of visitors to nature conservation objects
	Consumption of organic food

8. A selection of environmental indicators under DPSIR-framework



– Driving forces – indicators reflecting the factors leading to environmental pressures. These are mainly the anthropogenic factors describing social, demographic, economic, etc. developments (e.g. population size).

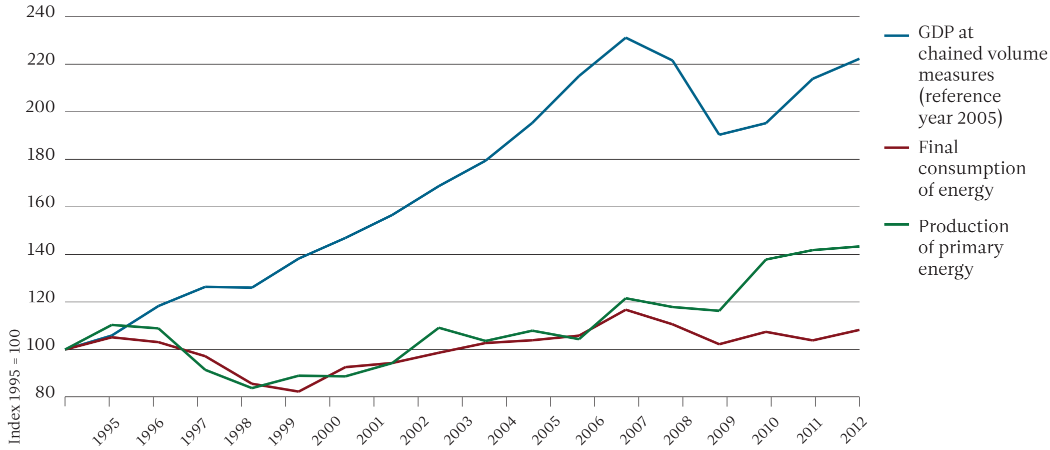
– Pressure – indicators reflecting the anthropogenic pressures on the environment (such as emissions, use of natural resources).

– State – indicators describing the quantitative or qualitative status of the environment (such as air quality, forest area, number of species).

– Impact – indicators describing the impact of the status of the environment on both ecosystems and humans (such as illnesses caused by the low quality of air, changes in populations and habitats caused by eutrophication).

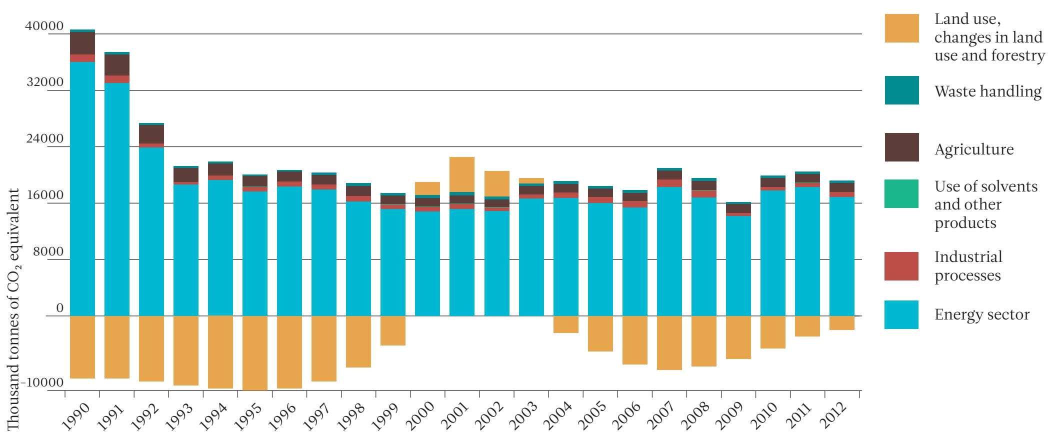
– Response – indicators reflecting the measures taken to improve the status of the environment (such as pollution charges, protected areas). These indicators are often related to policy decisions.

8.1 Climate



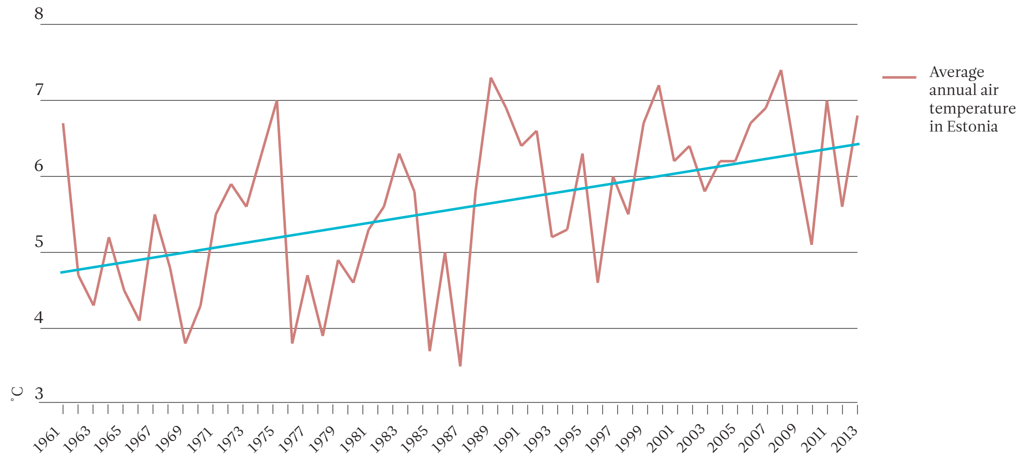
Production and final consumption of primary energy in the context of GDP (chain index). Data: Statistics Estonia.

Driving forces: It is a popular opinion that global warming is caused by human-induced greenhouse gases. Greenhouse gas emissions are arising from energy production and consumption. Estonia is among the countries with the highest levels of energy intensities in Europe. The demand for primary energy and final consumption of energy decreased significantly due to the economic changes in the early 1990s. Energy production and consumption started to grow again in 2000, spurred by increased consumption, economic growth and increasing living standards.

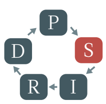


Greenhouse gas emissions and sequestration by sectors in 1990–2012. Data: Ministry of the Environment.

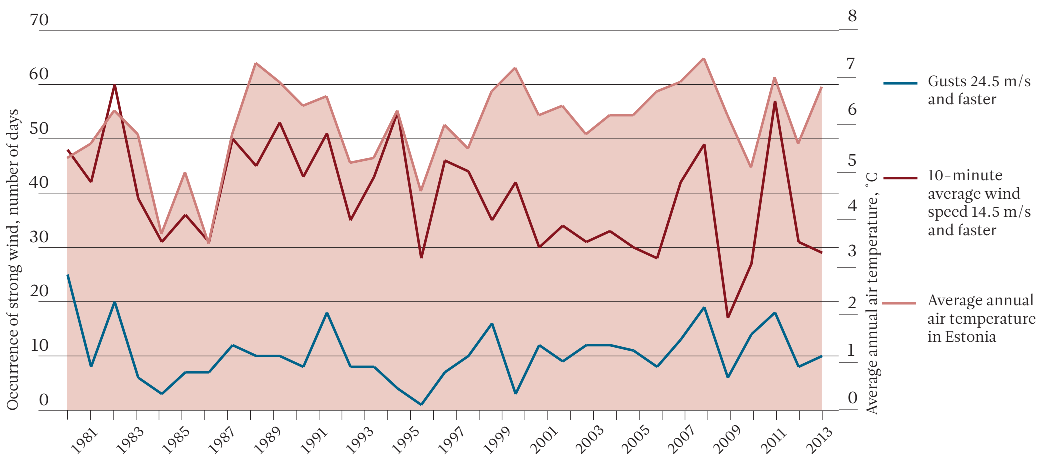
Pressure: Total greenhouse gas emissions have decreased by half compared to the reference year (1990). The largest contributor to GHG emissions is the oil-shale based energy sector (88% in 2012). Total emissions decreased in the early 1990s mainly due to the restructuring of the economy; after that, the main factor affecting emissions has been the fluctuation of the economy.



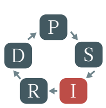
Average annual air temperature in Estonia in the period 1961–2012. Data: Estonian Environmental Agency.



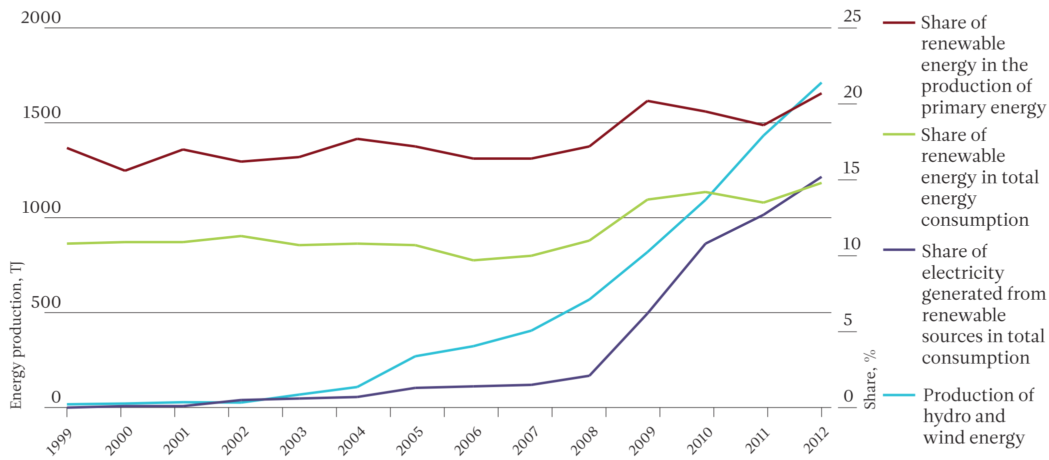
Status: While the average air temperatures vary greatly , the average annual temperatures recorded in the period 1961–2013 indicate that air temperature is increasing. Recently, the warmest year was 2008 with the average annual temperature of 7.4 °C. The lowest average temperature was recorded in 2010 (5.1 °C).



Occurrence of strong winds (based on maximum gust) in the period 1980–2012. Data: Estonian Environmental Agency.



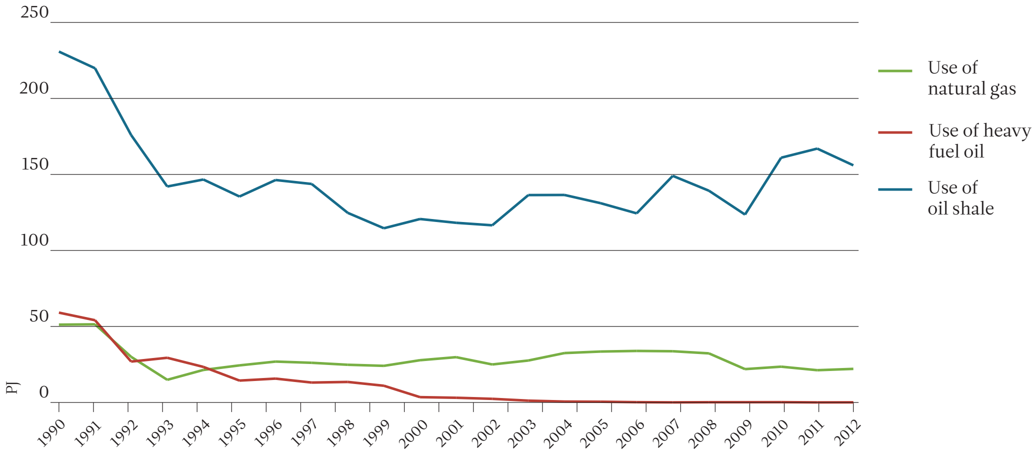
Impact: There is a scientific consensus that global warming will increase the occurrence of storms and storm-related damage. However, there is no clear link between global warming and the increased occurrence of storms – natural fluctuation has a much more important role here. According to climatologists, the 1980s were particularly stormy in Estonia.



Share of renewable energy in total energy production and consumption. Data: Statistics Estonia.

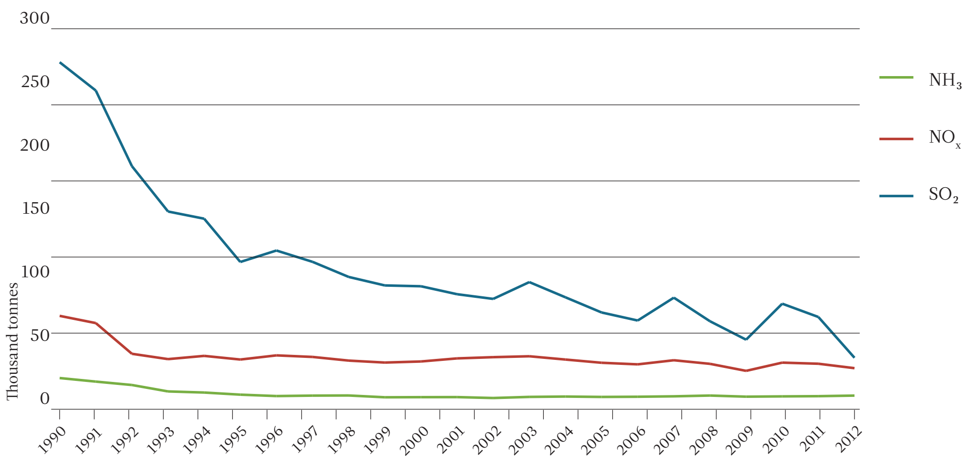
Response: As the oil-shale based energy sector is the largest source of greenhouse gas emissions in Estonia, it also has the biggest potential for reducing emissions. In order to reduce the negative effect of oil-shale based energy production, more and more renewable energy sources (biomass, hydro and wind energy) are used. The proportion of renewable energy in electricity production, which was very low for a long time, has significantly increased since 2009, reaching 15% in 2012.

8.2 Air



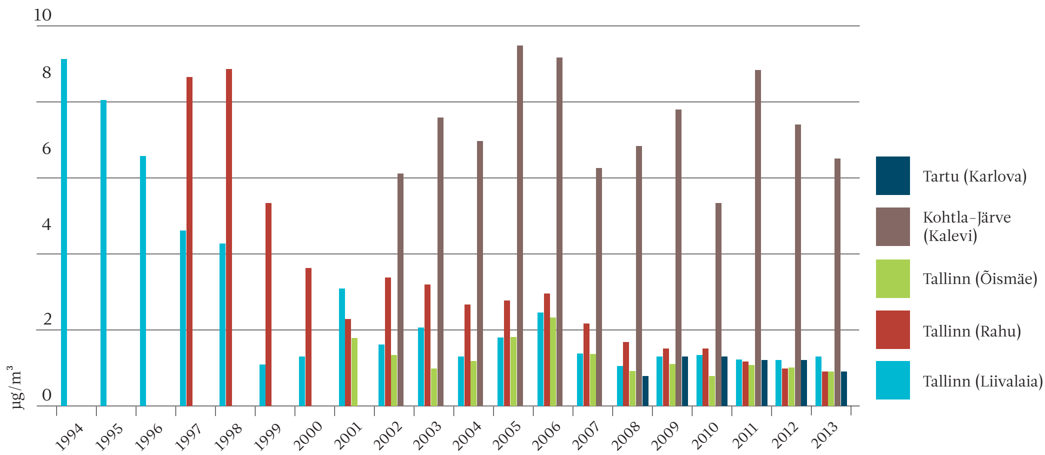
Use of fuels. Data: Estonian Environmental Agency.

Driving forces: Acidification is caused by sulphur dioxide (SO_2), nitric oxide (NO_X) and ammonia (NH_3) emissions of anthropogenic origin. The main sources of pollutants causing acidification (SO_2 and NO_x) are oil shale, natural gas and heavy fuel oil. While the emissions of pollutants causing acidification occasionally increased in the period 1990–2012, the emissions have significantly decreased compared with 1990.

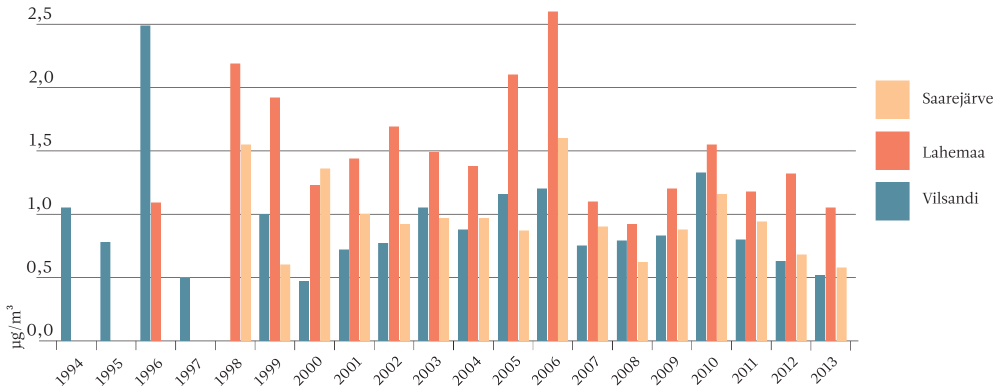


Emissions of pollutants that cause acidification (sulphur dioxide, nitric oxides and ammonia).
Data: Estonian Environmental Agency.

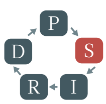
Pressure: Sulphur dioxide emissions, which depend on the consumption of fuels, have decreased due to decreased consumption of electricity and fuels (oil shale, natural gas) and the introduction of new technologies by the industrial sector. There has also been a shift from high-sulphur heavy fuel oil to natural gas, wood and low-sulphur oil shale and light fuel oil.



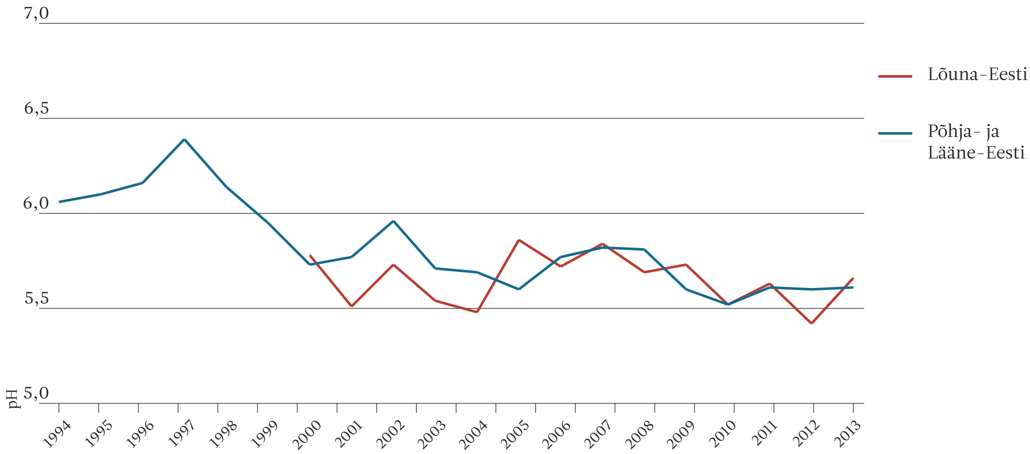
Average annual concentration of sulphur dioxide (SO_2) in urban air. Data: Estonian Environmental Agency.



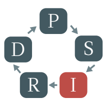
Average annual concentration of sulphur dioxide (SO_2) at monitoring stations. Data: Estonian Environmental Agency.



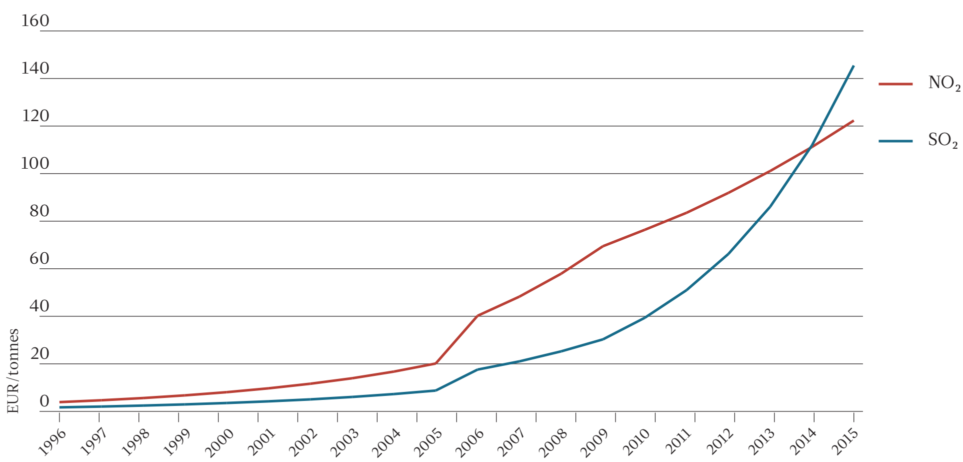
Status: Emissions affect the quality of air, expressed in pollutant concentrations. Sulphur dioxide concentrations in air have steadily decreased year on year. The relatively high concentrations of sulphur dioxide remain a problem in Kohtla-Järve and its surroundings. This is the region where large chemical plants and oil shale-fired thermal power stations are located. High sulphur dioxide concentrations were also recorded at the Lahemaa monitoring station. Lahemaa is strongly affected by the industrial region of Northeast Estonia.



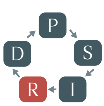
Precipitation pH in North and South Estonia. Data: National Environmental Monitoring Programme.



Impact: Sulphur and nitrogen compounds mix with the moisture in the air to form acids that fall to the earth as acid rain. The acidity of precipitation is determined on the pH scale. The pH of precipitation in North and South Estonia has decreased in the period 1994–2013 and the acidity of precipitation has risen. The reason for this is that alkaline pollution from oil shale production and oil shale-based energy production as well as from cement production has decreased. In South Estonia, the pH of precipitation has been more stable. In Estonia as a whole, the level of pH in precipitation is close to natural.



Pollution charges on the discharge of pollutants into ambient air. Data: Environmental Charges Act.



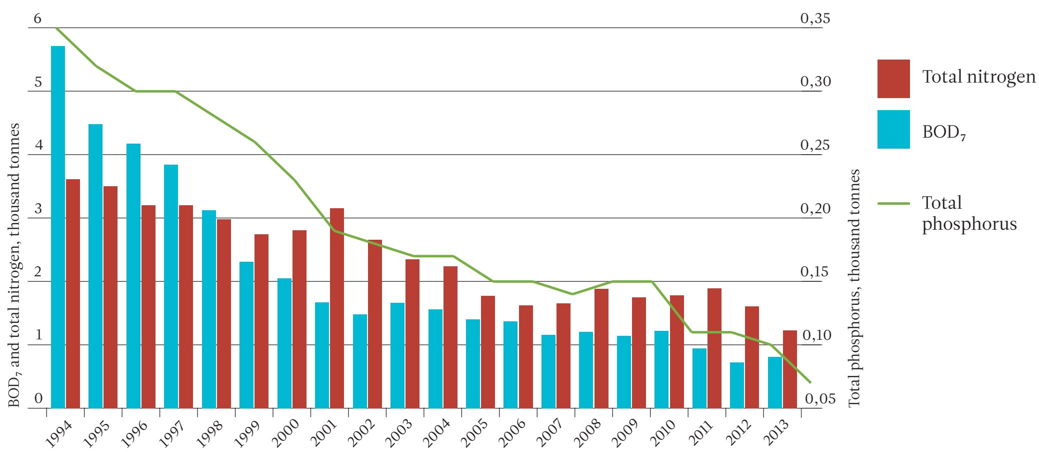
Response: Estonia has applied the air pollution charge since 1991 in order to prevent and reduce the potential damage related to emissions of pollutants into the air. The rates of most air pollution charges were doubled in 2006 in order to bring them in line with the principles of the ecological tax reform. The pollution charge rates on sulphur dioxide emissions have been raised by 20% each year and from 2010 by 30%.

8.3 Water

Driving forces: Water pollution is divided into two categories: diffuse pollution and point source pollution. The main driving force behind diffuse pollution is agriculture. The main driving forces behind point source pollution are urbanisation and industry. The consumption of water by urban communities and industrial facilities is a source of pollution loads and therefore waste water has to be treated.

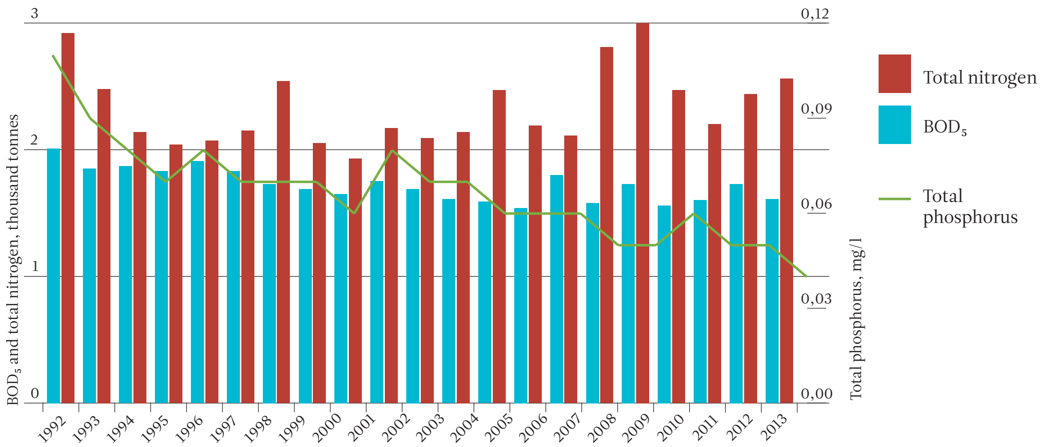
In recent years, a number of new waste water treatment plants and sewerage systems have been built and the existing ones have been modernised. The share of households connected to the public sewerage system has increased, reaching 80%. 15% of all households have a local sewerage and 5% do not have any.

In the 1990s, industrial production plummeted in Estonia. While in 1991 industrial production accounted for nearly one third of the Estonian gross domestic product, today it accounts for 17–18%. Decreasing industrial production and the introduction of more environmentally friendly technologies reduces pollution loads.



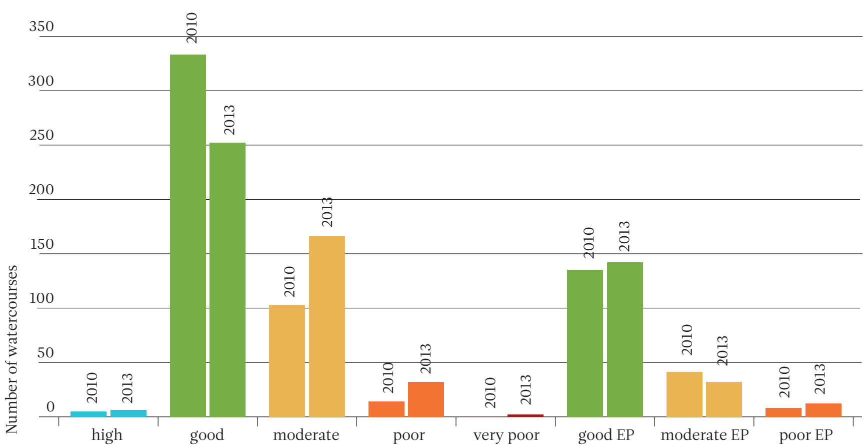
Point source load by pollutants in the period 1994–2013. Data: Estonian Environmental Agency.

Pressure: Point sources are, for example, industrial facilities, waste water treatment facilities and landfills – the sources of pollution load on the aquatic environment. Pollution loads have decreased significantly since 1994. The overall pollution load has decreased mainly because of the decline in industrial production since the 1990s and the major investments into waste management infrastructure in the last decades.



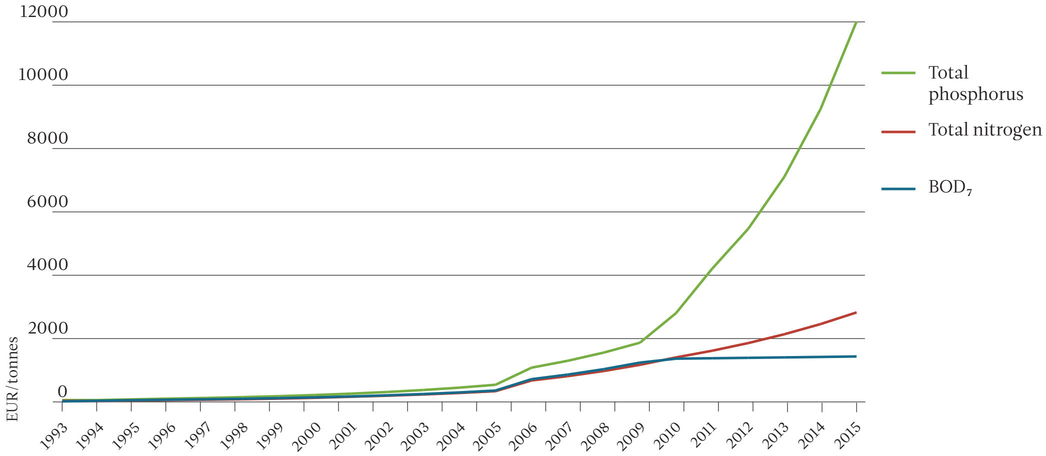
Concentrations of total nitrogen, total phosphorus and BOD_5 in watercourses in the period 1992–2013.
Data: Estonian Environmental Agency.

Status: The quality of water in rivers, lakes and coastal waters depends on the pollution loads from diffuse and point sources and is expressed in total nitrogen, total phosphorus and BOD_5 concentrations in water. The concentrations of nitrogen in rivers increased in the period 1992–2013, reflecting the impact of agriculture. The highest concentrations were measured in 2007–2008. Total phosphorus concentrations have decreased by nearly 60% compared with 1992, while BOD_5 concentrations have changed relatively little.

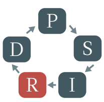


The ecological status and potential (EP) of watercourses in 2010 and 2013. Data: Estonian Environmental Agency.

Impact: Achieving and maintaining a good ecological status of water bodies is very important because water is not merely a resource but also a habitat and living environment. In general, the ecological status of Estonian watercourses is good and the quality of water good or very good because pollution loads have decreased significantly over years. The main factors that have a negative effect on the ecological status of watercourses are land improvement and barriers that prevent fish from migrating.



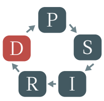
Pollution charges on the discharge of pollutants into water bodies, groundwater and soil. Data: Environmental Charges Act.



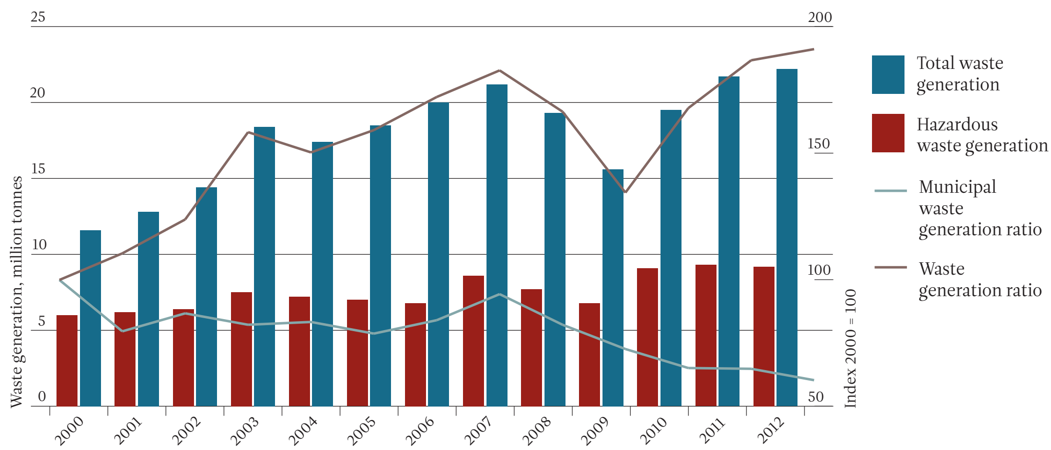
Response: Pollution charges are designed to reduce pollution loads. The purpose of environmental taxes is to prevent or reduce the potential damage caused by the use of natural resources, discharge of pollutants into the environment and waste disposal. The pollution charge rates have increased steadily and imposing a fee for the use of water has had a positive effect – pollution loads have decreased.

8.4 Waste

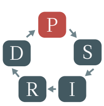
Gross domestic product at chained volume measures (reference year 2005) – ratio. Data: Statistics Estonia



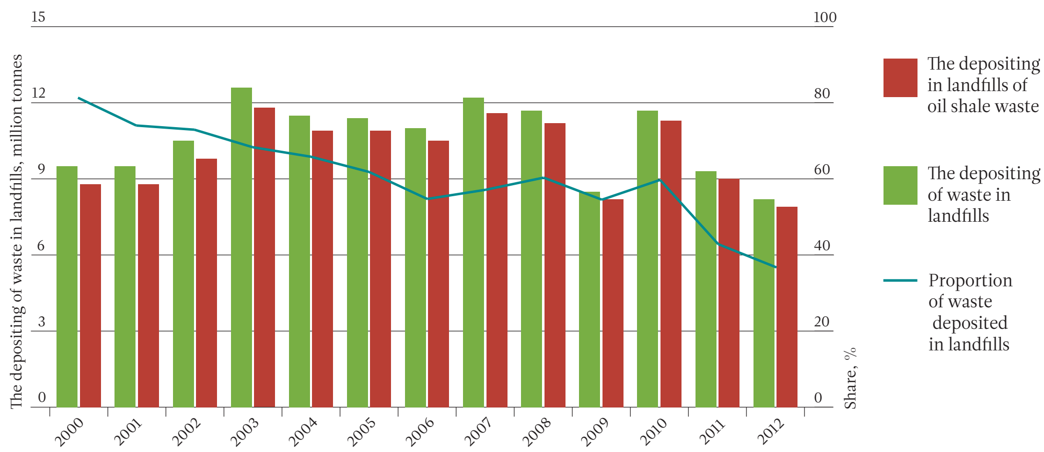
Driving forces: Waste generation depends on the general state of the economy, expressed by GDP. When national income rises, so does consumption (including energy consumption) industrial activity, which in turn increases the amount of waste generated.



Waste generation in 2000–2012. Data: Estonian Environmental Agency.

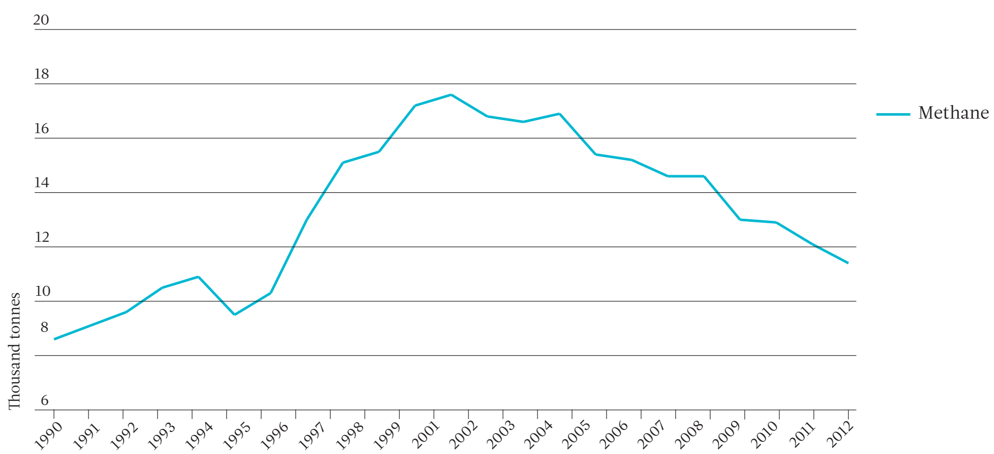


Pressure: Waste generation reflects the changes in the economy. A major part of waste generated in Estonia comes from the industrial sector, most of it (an average of 76%) from the oil shale and energy production. Waste generation increased until 2007. The economic downturn that started in 2009 reduced the volume of waste but in recent years waste generation has been on the increase again. The generation of hazardous waste has been quite stable and remained at 7.5 million tonnes per year.



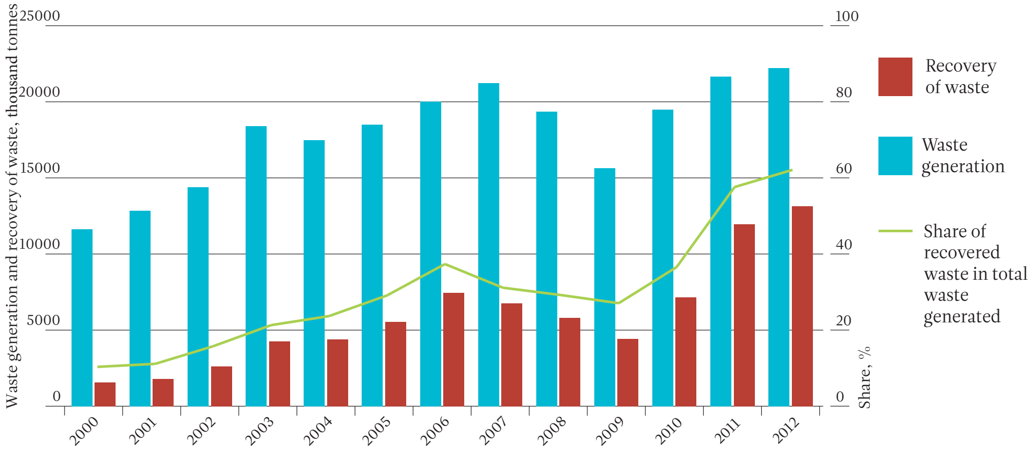
Deposition of waste in landfills in 2000–2012. Data: Estonian Environmental Agency.

Status: Because of the waste-intensity of the oil shale sector, the depositing of waste in landfills is the main method of waste disposal used in Estonia. However, the share of waste deposited in landfills has significantly decreased – from 81% in 2000 to 37% in 2012. While the amount of waste generated has increased, the recovery of waste is on the increase and this has kept the amounts deposited in landfills stable – at an average of 11 million tonnes per year.

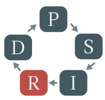


Emissions of methane from waste handling in 1990–2012. Data: Ministry of the Environment.

Impact: A major problem related to the depositing of waste in landfills is the release of greenhouse gases (GHG). The emissions of methane – the main GHG released from landfills – have decreased since 2000. This period is characterised by more careful waste handling – new, modern landfill sites have been created and many landfill sites that did not meet the environmental requirements have been closed and rehabilitated.

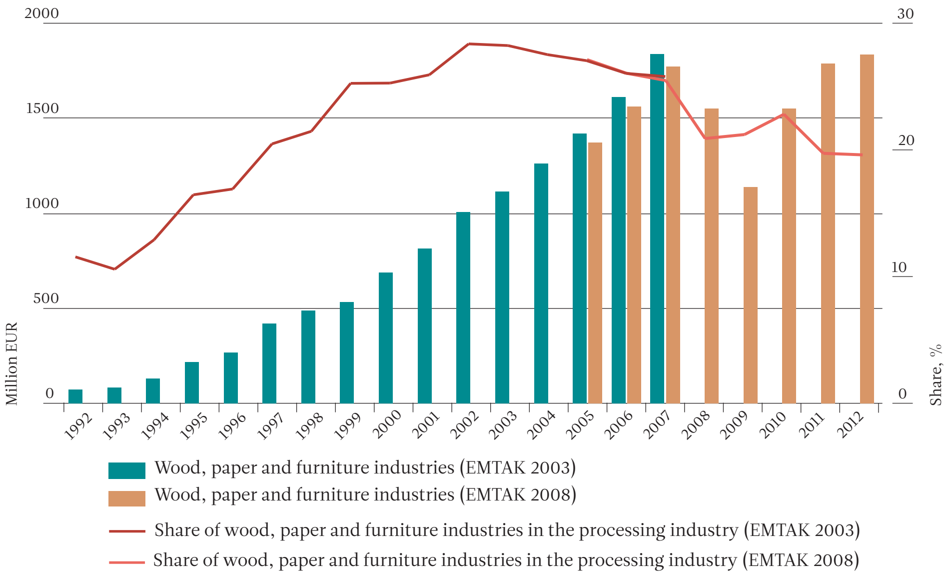


Recovery of waste and the share of recovered waste in total waste in 2000–2012. Data: Estonian Environmental Agency.



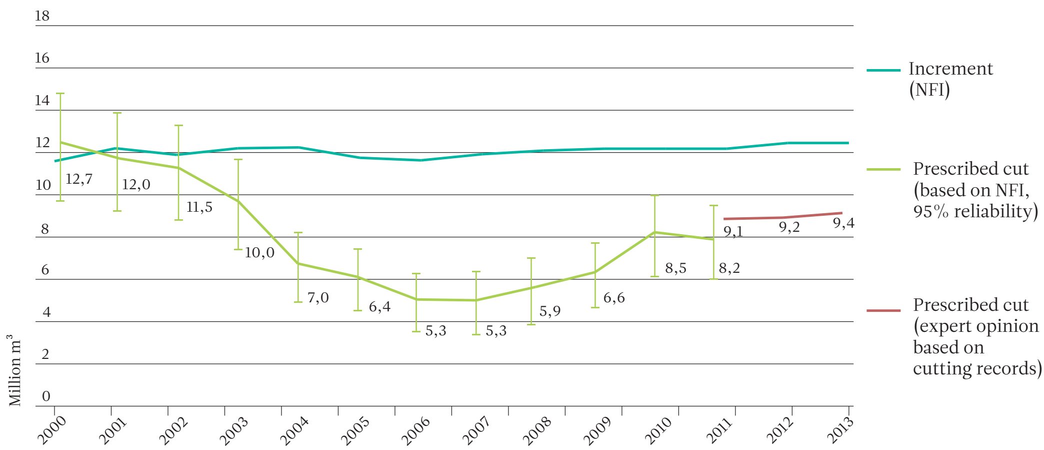
Response: The priority is waste recovery in order to reduce energy and water consumption, air pollution and the amounts of waste deposited in landfills; another priority is the reduction of waste generation. The preferred option of waste recovery is preparing waste for re-use, followed by recycling as a material or raw material. Only then other options, such as energy recovery, should be considered. The recovery of waste is increasing in Estonia. More than 50% of waste was recovered in 2011 and 2012.

8.5 Forest

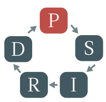


Wood, paper and furniture industries and their share in the processing industry. Data: Statistics Estonia.

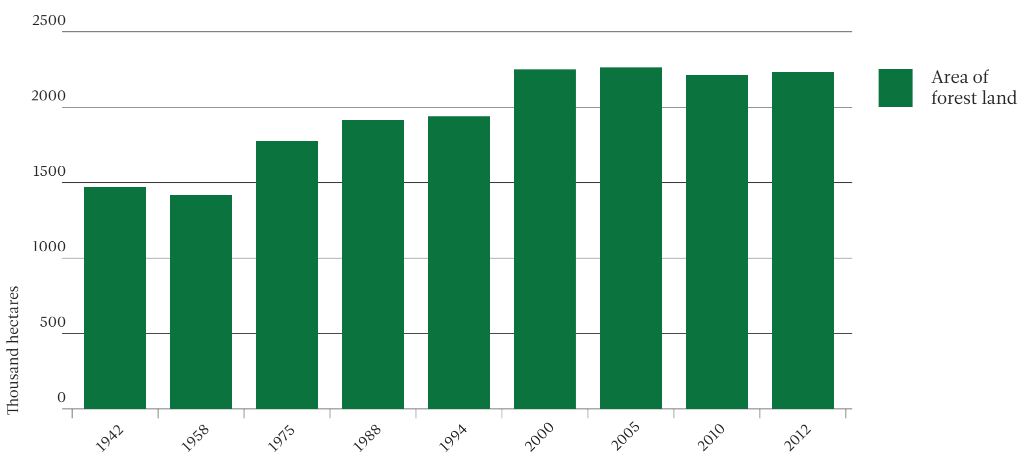
Driving forces: Nearly 80% of the timber from Estonian forests is used for industrial purposes. Therefore, the wood, paper and furniture industries constitute a major factor affecting the logging activities in Estonia. Similarly to other economic sectors, the production volumes of the wood, paper and furniture industries have increased year on year. However, their share in total industrial production has declined since the early 2000s.



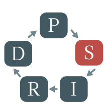
Forest cutting and increment in 2000–2013. Data: Estonian Environmental Agency, national forest inventory (NFI).



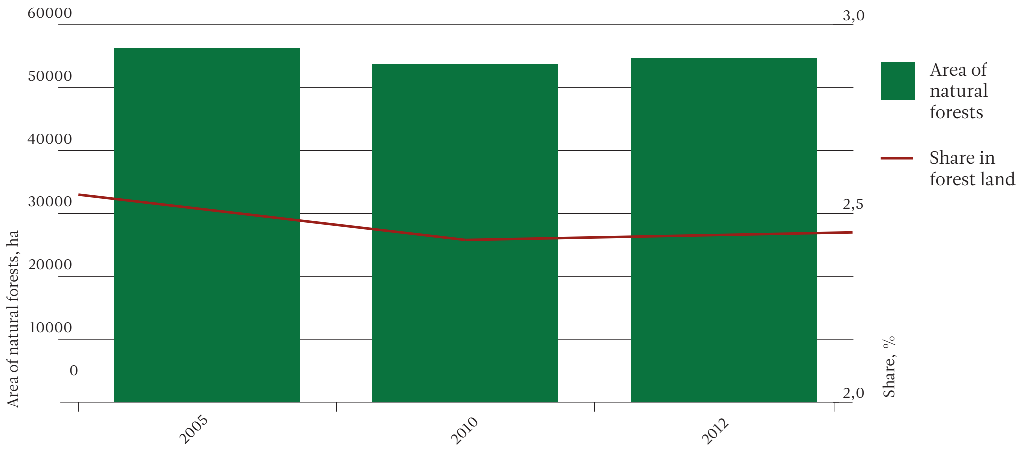
Pressure: The demand for wood as a resource is expressed in the prescribed cut. The annual prescribed cut does not exceed the estimated increment of Estonian forest. The last time the prescribed cut was equal to the increment was in 2000 when a large number of private forests were taken into use as a result of the land reform. After that, the prescribed cut has decreased, mainly due to rapid changes in market prices and decreased demand on the markets. According to expert opinion, 9.4 million m³ of forest was cut in 2013 – about 75% of the annual increment.



Changes in the area of forest land in the period 1942–2012. Data: The Academic Forest Society (1942); forest inventories of 1958–1994; the Estonian Environmental Agency, NFI (2000–2012).

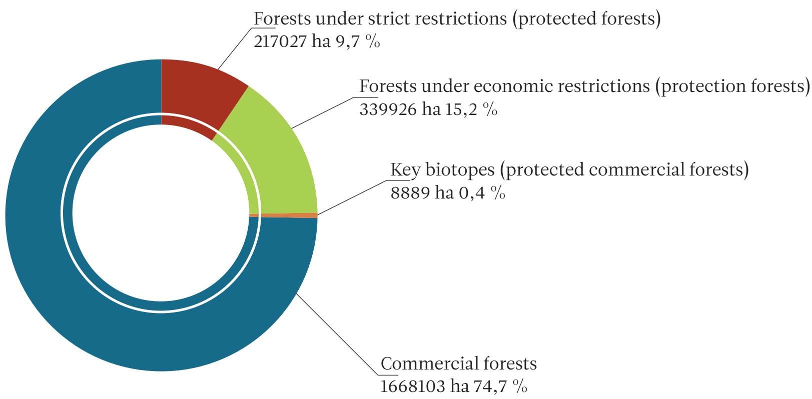


Status: The area of forest land is assessed in the course of forest inventories. Over the last decades, the area of forest land in Estonia has been in the range between 2.2 and 2.3 million hectares, covering nearly half of the mainland territory of Estonia. Despite intensive deforestation, the spread of urban communities and the construction of infrastructures in the last couple of decades, the area of forest land has increased 1.5 times over the last 50 years.



Area of natural forests and their share in total forest land. Data: Estonian Environmental Agency, NFI.

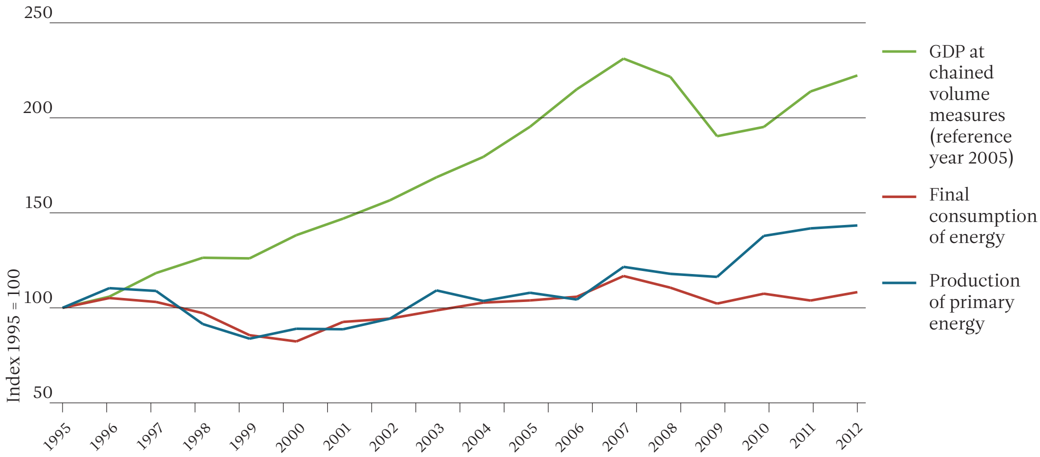
Impact: A natural forest is a forest which has not been affected or has been very little affected by any human activity, containing trees of different species and different ages and a sufficient amount of fallen or standing dead trees. The more extensively people manage forests, the less there are natural forests. The area of natural forests has been measured and recorded in Estonia since 2005. Natural forests account for between 2.4 and 2.5 percent of Estonian forests.



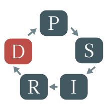
The share of protected forests in Estonia in 2012. Data: Estonian Environmental Agency, NFI.

Response: In order to ensure the diversity of forests and to maintain the good status of indigenous species, about one tenth of the total forest land has been placed under protection. The protection of forests is organised pursuant to the Nature Conservation Act and the Forest Act. While the area of strictly protected forests has increased, their typological representativeness needs to be improved in order to preserve forests types characteristic of Estonia.

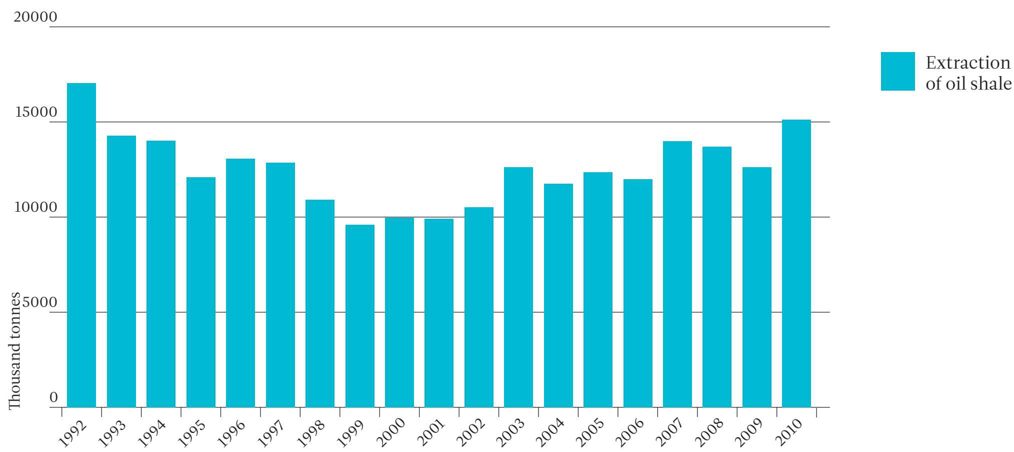
8.6 Mineral resources



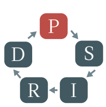
Production and final consumption of primary energy in the context of gross domestic product (chain index). Data: Statistics Estonia.



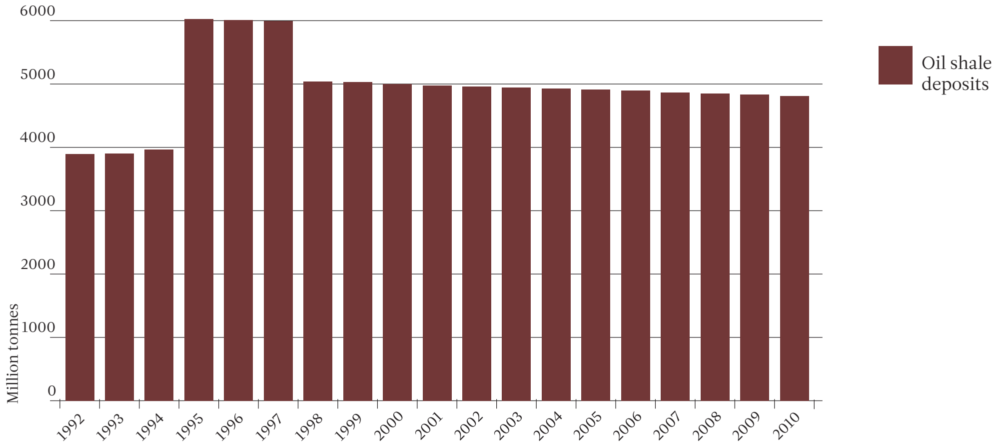
Driving forces: Mineral resources are extracted to satisfy the demand for heat and electricity. Estonia is among the countries with the highest levels of energy intensities in Europe. The demand for primary energy and final consumption of energy decreased significantly due to the economic changes in the early 1990s. Energy production and consumption started to grow again in 2000. Energy consumption was mainly spurred by overall consumption, economic growth and improved living standards.



Oil shale production in 1992–2010. Data: Statistics Estonia.

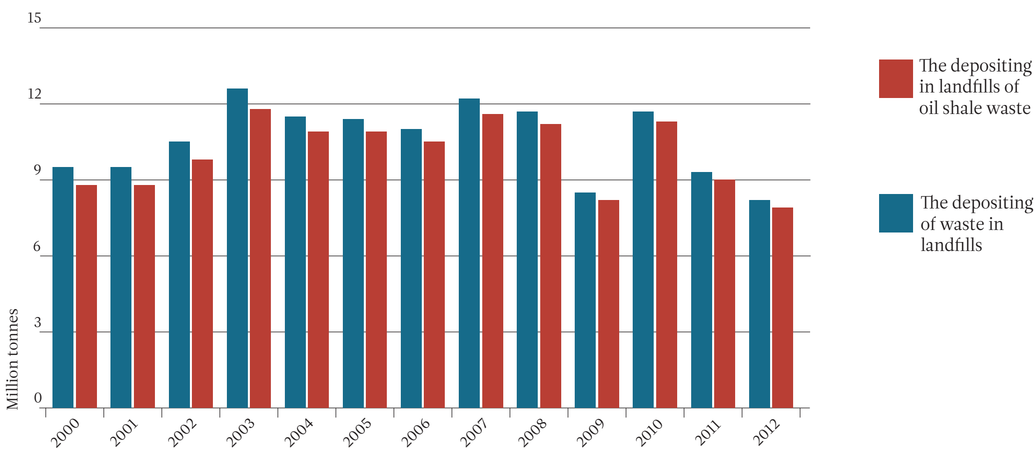


Pressure: The most important energy-containing mineral resource in Estonia is oil shale and its extraction volumes are determined by the demand for energy. Oil shale is also used to produce heating oil, oil coke, pitch, bitumen and other by-products. While the amounts of oil shale extracted in Estonia have increased since 1999, the level of 1992 has not been reached (according to the data of 2010). On the one hand, the increased use of oil shale is caused by an increase in the production of electricity; on the other hand, the demand for oil shale as a raw material used in the production of oil and chemical products has seen steady growth.



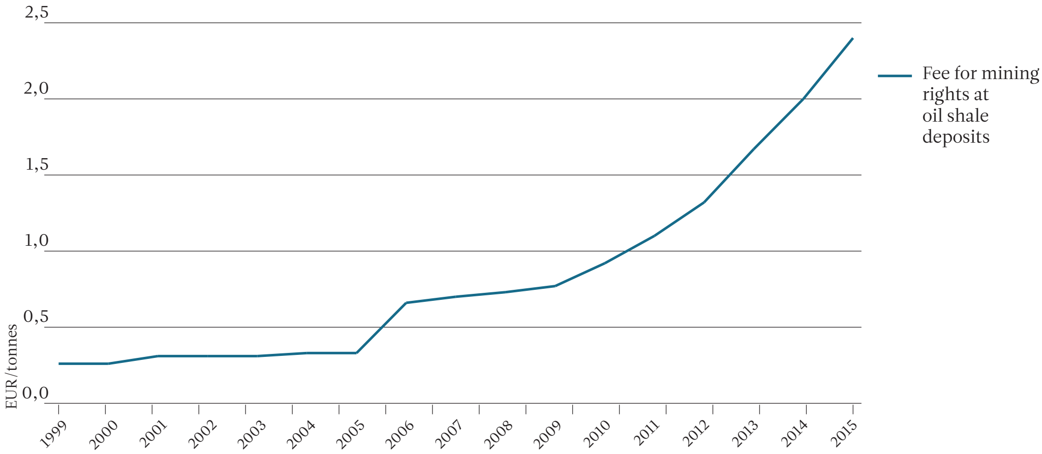
Oil shale deposits in 1992–2010. Data: Statistics Estonia.

Status: As the size of oil shale deposits is determined by using different methods and expert opinions, the data vary from year to year. When calculating the size of oil shale resources it is important to take into account the possible changes in the economic expediency and technologies and also the environmental restrictions imposed on extraction. Our oil shale resources have decreased in recent years mainly due to extraction.

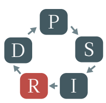


Depositing of oil shale-related waste in landfills. Data: Estonian Environmental Agency.

Impact: An average of 95% of all waste deposited in landfills is generated by the oil shale industry. While the extraction volumes have increased in recent years, the amounts of oil shale waste deposited in landfills has decreased since 2011, reaching 7.9 million tonnes in 2012. The share of oil shale waste deposited in landfills has decreased, while the recovery of waste is on the increase.

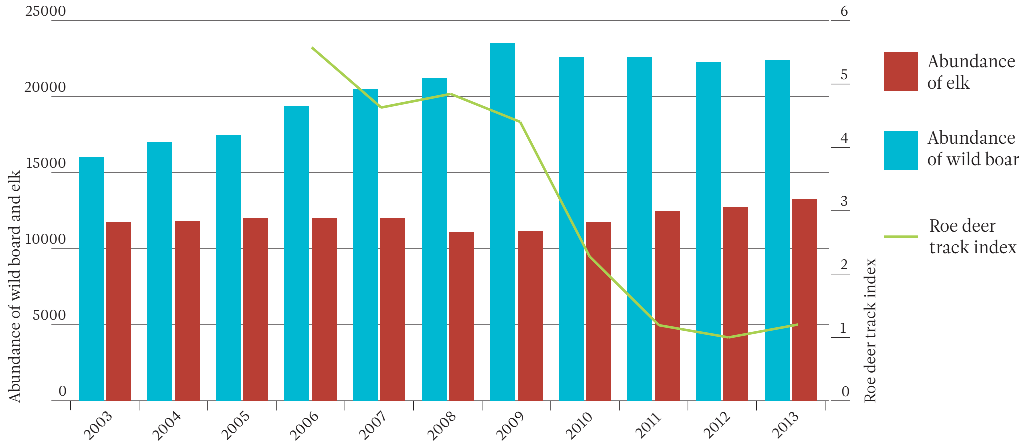


Fee for mining rights at oil shale deposits. Data: Fee for mining rights at deposits of mineral reserves owned by the state.

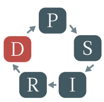


Response: The fee for mining rights at deposits is implemented in order to regulate sustainable use of mineral resources. The fee is used to cover the expenses of improving the status of the environment and to compensate the possible damage caused by mining. The fee for mining rights at oil shale deposits has been raised to the level where it may act as an incentive to protect the environment.

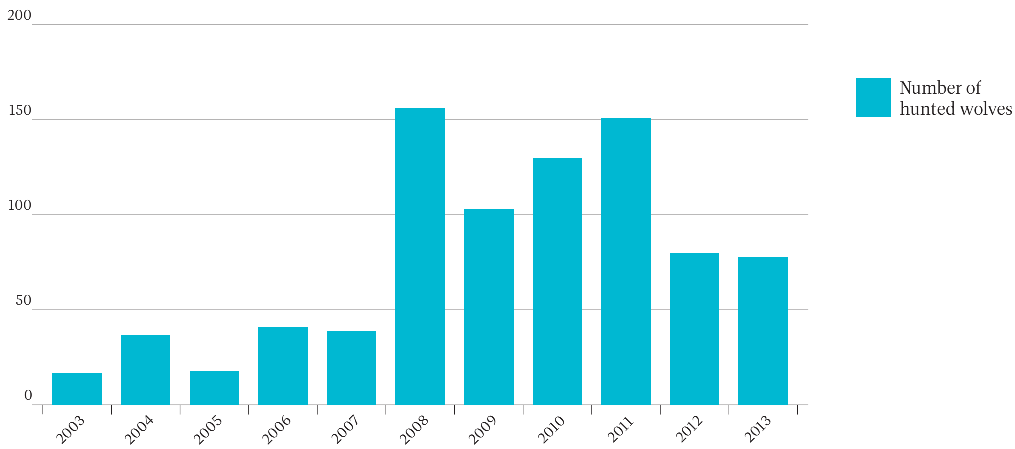
8.7 Game animals (example of a wolf)



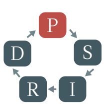
Abundance of wild board and elk in the period 2003–2013 and roe deer track index in the period 2006–2013. Data: Estonian Environmental Agency.



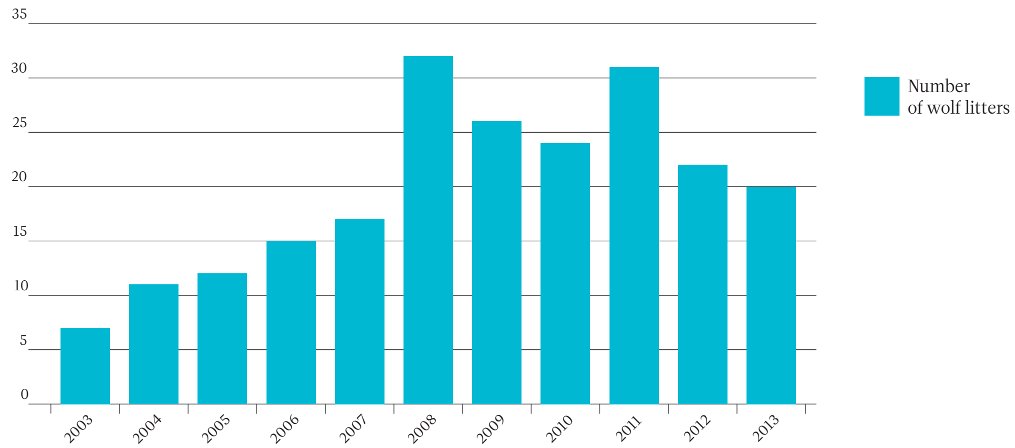
Driving forces: Main prey for wolves are elks, roe deer and wild boars. A high number of prey animals created favourable conditions for the number of predators to increase. While the number of wild boars has increased and the number of elks has been stable, the number of roe deer, expressed in the roe deer track index, has dropped significantly. This was caused by extreme snowy conditions in the winters of 2009/2010 and 2010/2011.



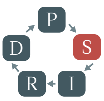
Number of hunted wolves in 2003–2013. Data: Estonian Environmental Agency.



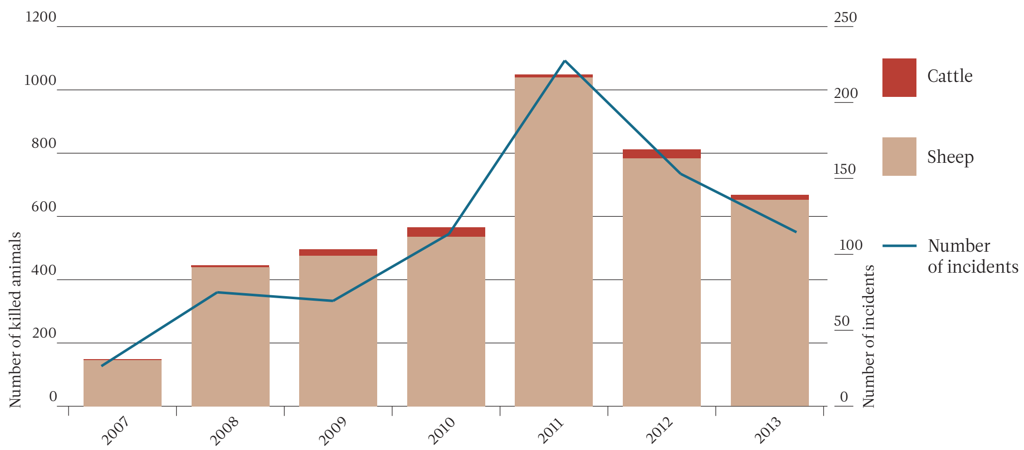
Pressure: The number of wolves is regulated by hunting. The aim of hunting is to maintain the favourable status of communities and to keep the damage caused by wolves at an optimum low level. The hunting quota are determined based on the number of wolves. In years when the number of wolf litters is bigger, the hunting quota is also bigger.



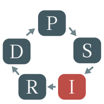
Number of wolf litters in Estonia in 2003–2013. Data: Estonian Environmental Agency.



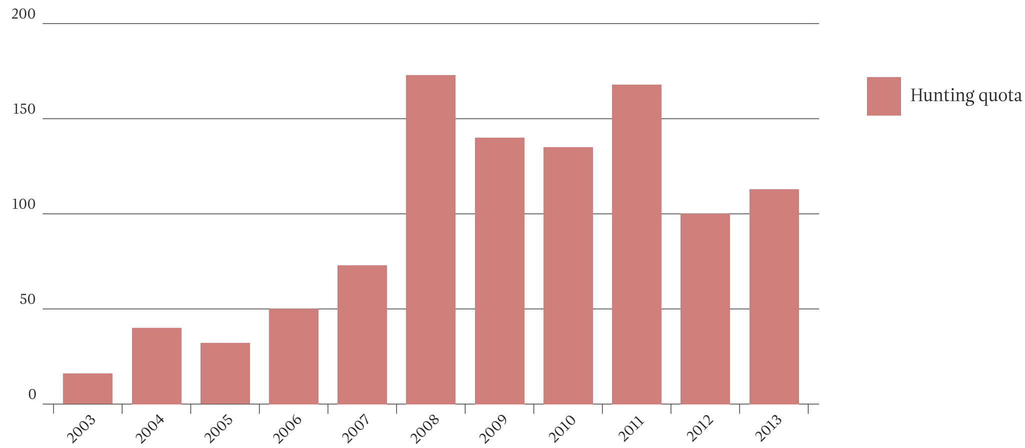
Status: The number of prey animals and the intensity of hunting have a direct impact on the number of wolf litters. It is important to take into account that the number of litters characterises the number of animals prior to the hunting season. Since 2011, wolf litters have been discovered on the islands of Saaremaa and Hiiumaa. In mainland Estonia the number of wolves has decreased.



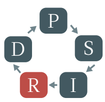
Number of cattle and sheep killed by wolves. Data: Estonian Environmental Agency.



Impact: The bigger the number of wolves, the bigger the damage caused by wolves. Wolves caused significant damage in 2011, when there was a record high number of wolf litters. In the last couple of years, the number of wolf litters has decreased and so has the level of damage caused by wolves.



Hunting quota for wolves in 2003–2013. Data: Estonian Environmental Agency.



Response: The number of wolves is regulated by the hunting quota. The bigger the number of wolves, the more hunting permits are issued. Therefore, the hunting quota for wolves has increased since 2003, being the highest in 2008 and 2011 when the number of litters was the biggest. In most cases the hunting quotas are not fully achieved.

8.8 Biodiversity

Driving forces: Because the relations within ecosystems are very complex, we cannot highlight any direct cause-and-effect relationships. Therefore, the biodiversity indices must be looked at from a broader perspective. The driving forces behind the human-induced changes in the status of biodiversity can be divided into two categories: spatial and socio-economic. The spatial forces include, for example, population concentration – the bigger the number of people per surface area unit, the heavier the pressure on biodiversity. The socio-economic forces are expressed in the people's living standard, convenience and consumption habits which exert pressure on the surrounding environment.

Pressure: Similarly to driving forces, pressures on biota can be looked at from two different aspects: spatial and economic. The spatial aspect is reflected by how people take over the environment by their activities. This includes, for example, turning natural landscapes into artificial landscapes (land designated for transport, developed land, mining areas, etc.). Economic pressures include the use of mineral resources. For example, forest is an economic resource and at the same time a natural habitat. The use of natural resources for economic purposes inevitably destroys habitats and exerts pressure on biodiversity.

Status: The status of biodiversity is reflected by the natural state of landscapes and vitality of species. Natural landscapes must be preserved primarily as the habitats of various species. The encroachment of artificial landscapes fragmentises habitats, isolates populations and reduces the viability of species. Therefore, it is important to preserve the so-called natural green infrastructure and areas of high natural value, such as natural forests, natural meadows, mires with weak or no drainage impact, water bodies with medium or low trophicity, etc.

Impact: Changes in the natural state of landscapes and vitality of species are expressed by the status of ecosystems. Each ecosystem is a community of living organisms in conjunction with the non-living components of their environment, interacting as a system. Here, we should also monitor two aspects: the spatial threat to ecosystems and the threat to biodiversity within those ecosystems. The spatial threat to ecosystems is expressed in the fragmentation of ecosystems and changes in their structural diversity. The threat to biodiversity within ecosystems shows the suitability of the ecosystem as a habitat for species.

Response: The measures taken to maintain biodiversity include, on the one hand, spatial protection of ecosystems and on the other hand, the environmental or pollution charges implemented to restore/improve the living conditions of endangered species or ecosystems. Spatial protection of ecosystems is not just the preserving of the status quo by restrictions but also the maintaining and restoring of ecosystems (e.g. maintained meadows, restoring peat extraction areas, etc.).

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