

# 3. *Weather patterns and climate change*

Climate change is a global priority. At this stage, it is clear that the climate is changing. There is scientific consensus that climate change is caused by greenhouse gas emissions resulting from human activity. The increase in greenhouse gas emissions is driven mainly by the use of fossil fuels, but agriculture, industry, transport, changes in land use, etc. also play a role. The average temperature in Europe has increased by nearly 1 °C in the past century. A couple of degrees is all it takes to change the Earth's climate. The current internationally agreed objective is to keep the temperature rise below 2 °C which would minimise the impact. Climate change is a global issue with serious consequences for all. Climate change is manifested differently in different regions of the world. The most vulnerable are developing countries that are already suffering from shortages of food and water. The melting of ice and retreat of glaciers are the major changes that the world is facing, as well as the consequent rise of sea levels leading to the flooding of coastal areas. Extreme weather events, such as storms and heat waves, are expected to become more common; biodiversity will decline and ecosystems will change; diseases (such as malaria) will spread. For Estonia, climate change will mean more precipitation, increased temperature and a risk of flooding.



### 3.1 Weather patterns and climate

Climate is defined as the long-term average atmospheric conditions of an area. Climate is usually described in terms of the average and extreme periodic (monthly, seasonal etc.) values of meteorological parameters measured over the course of decades. It is also important to assess the frequency and range of extreme values of hazardous weather patterns and phenomena (such as extreme temperatures, storms, very dry or wet summers, etc.). Climate variables are calculated over 30-year periods as recommended by the World Meteorological Organization (WMO); the period 1961–1990 is the latest WMO baseline period.

Weather generally refers to a weather pattern characteristic of a shorter period. When considering the period 2009–2012, we can talk about the weather characteristic of that period. The meteorological variables characterising weather pattern and weather are compared with those of climate. In this report, Estonian weather in the period 2009–2012 is compared with the average and extreme values of the last 52 years (1961–2012).

#### 3.1.1 Air temperature

The average temperature in 2009–2012 was extremely varying. Both 2010 and 2012 were the coldest years this century, while the average temperature of 2010 (5.1 °C) was the lowest of the past 25 years, and even lower than the average of the past 52 years. The average air temperature in 2011 (7.0 °C), however, was the fourth warmest in the period 1961–2012. The temperature rise in the period 1981–2012 is slightly below the rise of temperature in the period 1961–2012 (Figure 3.1).

The air temperature of the warmest summer month (July) in 2009–2012 was 2.1 °C higher on average than the average of 1961–2012 and 1.5 °C higher than the average of the past four years (2005–2008). The average air temperature of all summer and spring months and the majority of autumn months of the past four years was above the average of the last 52 years, while the average air temperature of winter months was below the average of 1961–2012. The biggest differences between temperatures are observed in the case of the warmest summer month (July) and the coldest winter month (February) (2.2 °C for both) (Figure 3.2).

The heat record was set in August 2010 in Narva-Jõesuu in north-eastern Estonia where the temperature reached +35.4 °C, exceeding the previous record by 1 °C. A record for maximum air temperature was also set in July of the same year on the island of Vilsandi – +32.4 °C (the previous record temperature of +31.0 °C was recorded in 2003).

The map of the distribution of the average air temperature in February (Figure 3.3) shows the characteristic features of the Estonian climate – the typically warmer western Estonia and the islands and the colder eastern Estonia. The map shows the average and minimum air temperatures in February in the period 2009–2012.

The night frosts that occurred in central Estonia in July 2009 may be considered extraordinary – at 2 cm from the ground, the temperature fell to –1 °C.

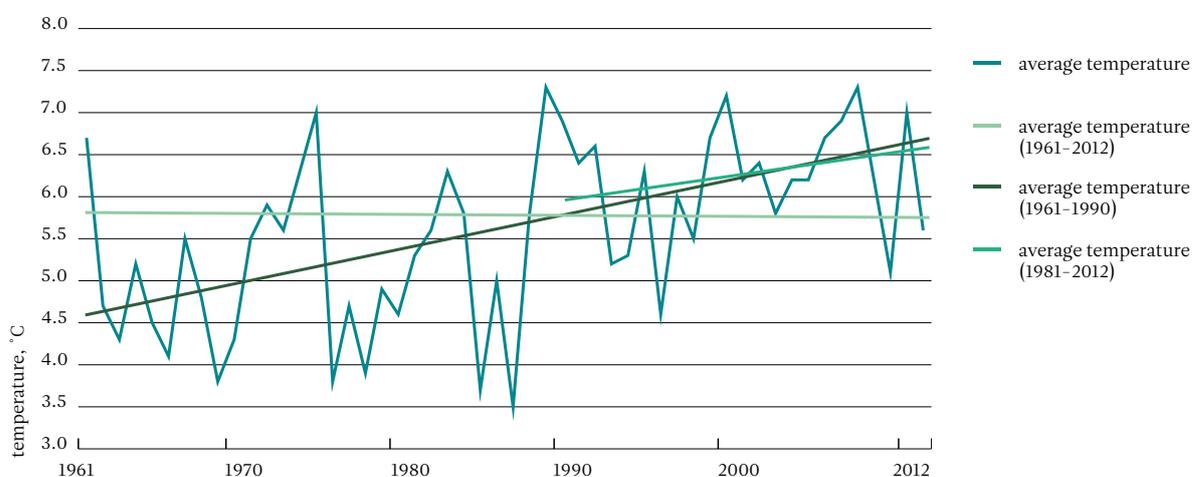


Figure 3.1. Average air temperature in Estonia in 1961–2012 and the trend. Data: ESTEA.

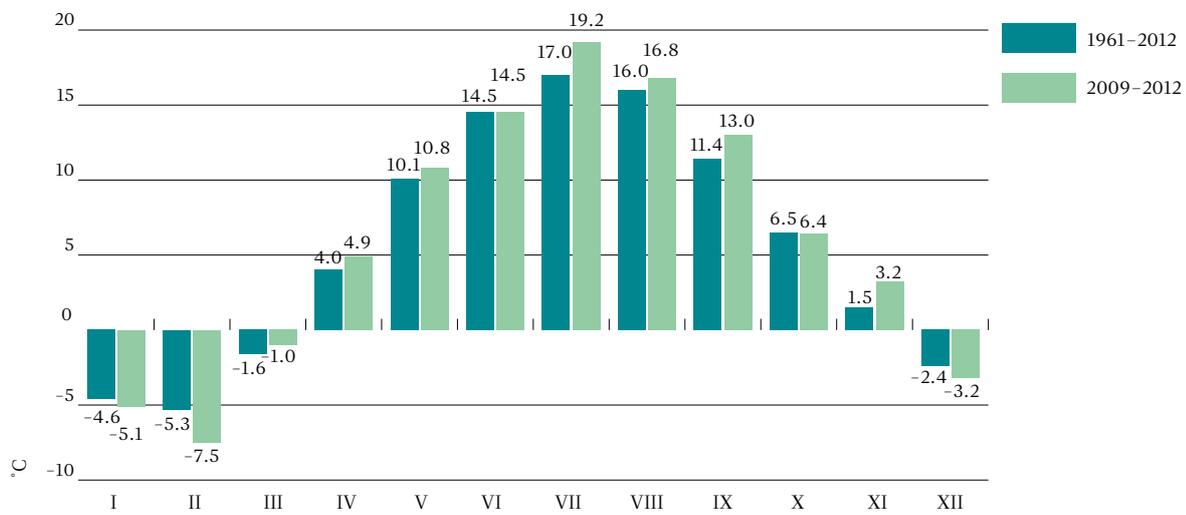


Figure 3.2. Monthly average temperature in 2009–2012 compared to the climate data. Data: ESTEA (the Estonian Environmental Agency).

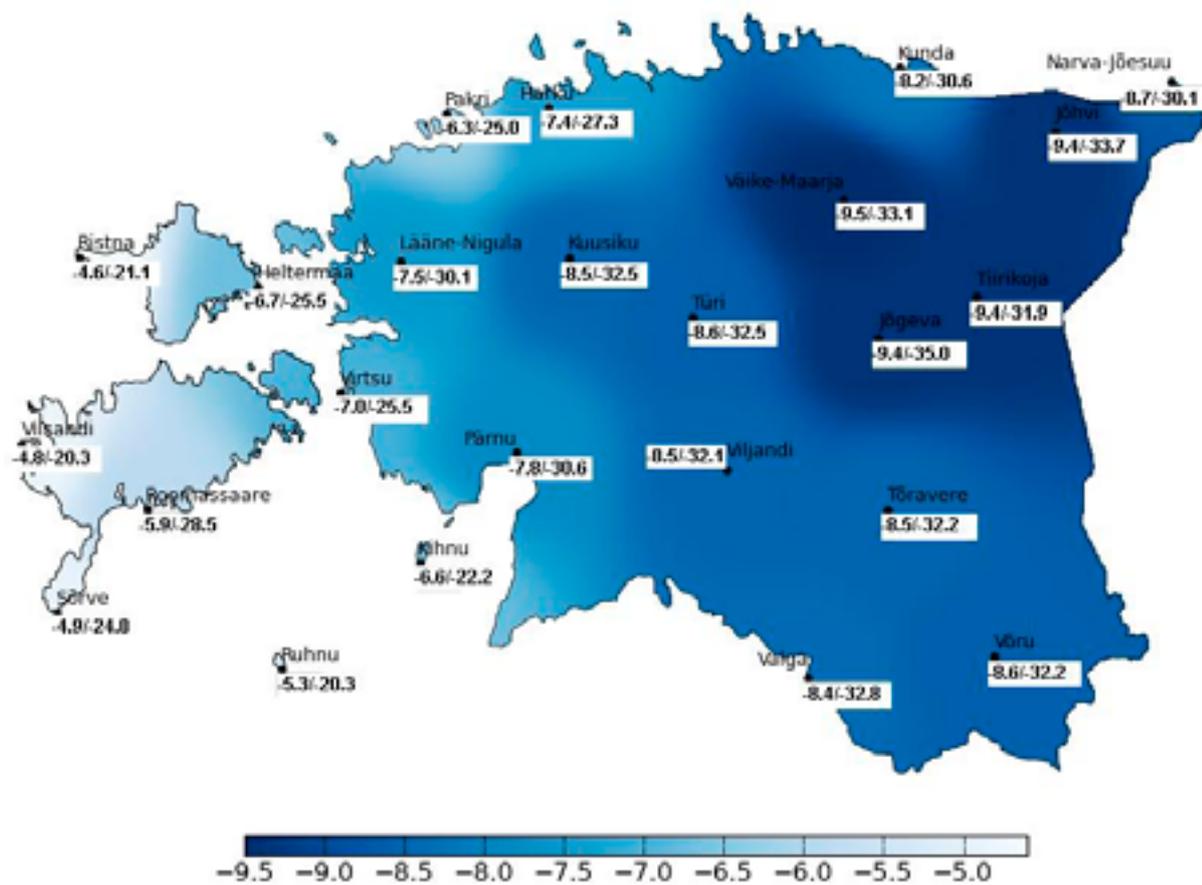


Figure 3.3. The distribution of average air temperature in February in the period 2009–2012; average and minimum air temperature at meteorological observation stations. Data: ESTEA.

### 3.1.2 Precipitation

Similarly to air temperature, the average annual precipitation for Estonia is increasing. The period 2009–2012 was the wettest four-year period since 1961, while 2012 was the wettest year in the period 1961–2012 (Figure 3.3).

Each year, August and December stood out with high precipitation. December 2011 was also extraordinary as the amount of precipitation exceeded that of all the other months of the year, setting a record for December in the

period 1961–2012. South-western and mainland western Estonia experienced the highest precipitation (Figure 3.4).

In 2010, the following record snow depths were recorded in north-eastern Estonia: 78 cm in Jõhvi in February 2010; 82 cm in Jõhvi and 65 cm in Narva-Jõesuu in February–March 2011. On 8 August 2010, several tornadoes were reported in various locations. In July 2012, a tornado was seen in Jõgeva county.

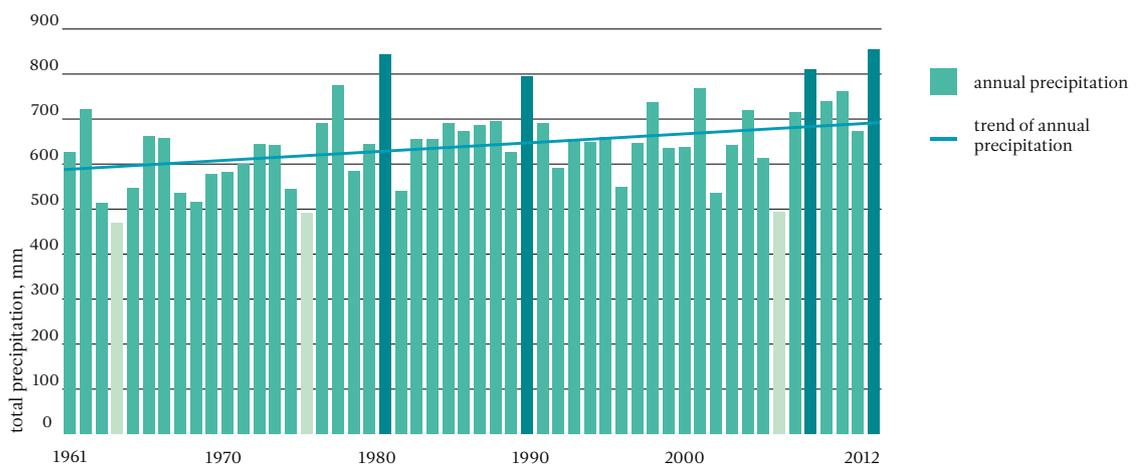


Figure 3.4. Average annual precipitation of Estonian meteorological stations and the trend in 1961–2012. Data. ESTEA

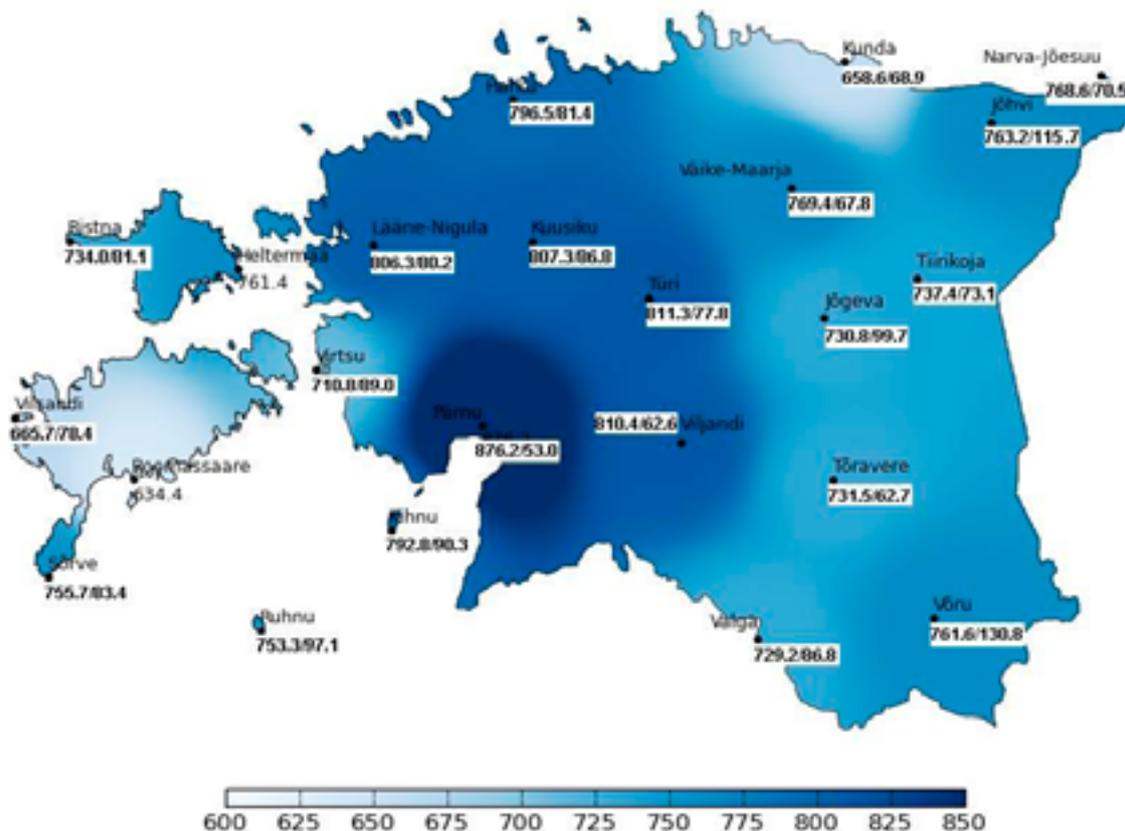


Figure 3.5. Territorial distribution of precipitation in 2009–2012; maximum daily precipitation.

### 3.1.3 Water levels and flow rates

Wet cycle period started in 2008 and is still continuing. In 2009–2012 average drainage exceeded long-term average in Estonia, whereby the water richest year was 2012, when drainage of hydrological year exceeded long-term even 50%. Years 2009–2012 can be described by high levels of spring high water, but no historical records were broken in hydrological stations. Due the precipitation the floods occurred in summer, autumn and winter, on account of which in many hydrological stations the maximum water level of the month was exceeded. In this period of time there were a lot of snow-rich winters and water bodies had relatively long ice cover periods, which incurred springtime high water. Almost 3 years in the row (from September 2008 until August 2011) the water level of Võrtsjärv and also lake of Peipsi exceeded long-term average.

## 3.2 Greenhouse gas emissions and protection of the ozone layer

### 3.2.1 Legal background

By signing the United Nations Framework Convention on Climate Change in 1992 and the Kyoto Protocol in 1998, Estonia committed itself to reducing greenhouse gas emissions in the period 2008–2012 by 8% compared to 1990. In the second period of the Kyoto Protocol (2013–2020), Estonia and other EU Member States have undertaken to cut greenhouse gas emissions by 20% from the 1990 baseline.

The first international environmental agreement on the protection of the ozone layer is the 1985 Vienna Convention (entered into force in 1988). It was the basis for the start of negotiations on combating the use and spread of halogenated carbons. In 1987, representatives of 31 countries signed an agreement – the Montreal Protocol – that entered into force in 1989. According to the agreement, only reclaimed and recycled hydrochlorofluorocarbons (HCFCs) may be used from 2010 to 2015. From 1 January 2015 it will be illegal to use any HCFCs. In 1996, Estonia ratified the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer.

Besides the Montreal Protocol and the Vienna Convention, the use of substances that deplete the ozone layer is governed by Regulation (EC) No 1005/2009 of the European Parliament and of the Council on substances that deplete the ozone layer.

Internal legal acts that govern ozone issues include the Ambient Air Protection Act and the relevant regulations of the Minister for the Environment and the Government of the Republic.

### 3.2.2 Greenhouse gas emissions and their reduction

Total greenhouse emissions have declined by 50% from the 1990 baseline. The total volume of greenhouse gases (GHGs) was 40.5 million tonnes in CO<sub>2</sub> equivalent in the baseline year and 21 million tonnes in CO<sub>2</sub> equivalent in 2011 (not taking into account land use, its changes and absorption by the forestry sector). This means that GHG emissions had declined by nearly 50% by 2011 compared to the baseline year. Such a considerable reduction was due to the restructuring of the economy in the early 1990s. Today, the main factors influencing the volume of emissions are economic downturns and upturns.

The highest contribution to total emissions comes from the oil shale-based energy sector, which accounted for 89% of emissions in 2011 (including transport which constituted 11% of the total emissions). The agricultural, industrial and waste management sectors follow with 6%, 3% and 2% respectively.

The impact of land use, its changes and forestry activity varied in 1990–2010. The latter affects the greenhouse gas emissions balance as a CO<sub>2</sub> sink, but its impact was the opposite in 2000–2003 (due to extensive prescribed cuts).

The main greenhouse gas emitted in Estonia is carbon dioxide (CO<sub>2</sub>), which accounts for 90% of total GHG emissions. Both methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) account for 5% of total emissions, while F-gases account for 1%.

The annual average GHG emissions per inhabitant is 15.6 tonnes in CO<sub>2</sub> equivalent, which is 1.7 times higher than the EU average (9.2 tonnes in CO<sub>2</sub> equivalent per inhabitant). The main reason is the use of carbon intensive oil shale in the energy sector.<sup>1</sup>

Various measures are proposed to decrease greenhouse gas emissions.

Because the majority of emissions originate from the energy sector, that sector also has the greatest potential in decreasing the emissions.

The reduction of GHG emissions is facilitated by the wider use of renewable energy (such as wind energy) and biofuels.

The introduction of renewable energy and efficient co-generation are supported through investment aid and subsidies. In 2012, wind turbines generated 448 GWh of electricity, i.e. about 5.5% of total electricity consumption.

<sup>1</sup> Greenhouse gas emission trends and projections in Europe 2012. Tracking progress towards Kyoto and 2020 targets. EEA Report No 6/2012.

### International trading of Assigned Amount Units

Trading in Assigned Amount Units (AAUs) is carried out in the form of green investment schemes. This means that the proceeds from AAU sales should be channelled to the development and implementation of the projects that actually result in the reduction of CO<sub>2</sub> emissions. Many projects under the green investment scheme are related to increasing energy efficiency, such as the renovation projects of public buildings, blocks of flats and private houses. The proceeds from AAU trading have also been used to support the renovation of the utility lines of boiler houses. Investments have been made in the development of public transport and the introduction of electric cars.

### Joint Implementation

Estonia uses one of the two project-based mechanisms of the Kyoto Protocol – Joint Implementation – to reduce greenhouse gas emissions. We are working with Finland, Denmark, The Netherlands, Sweden and Austria. Under joint implementation, an investing country reduces its emissions in another country at a lower cost than would be possible in their own country.

As a result, both countries benefit from the project, as the recipient country will have access to new technology and expertise and earn from the sale of greenhouse gas emissions.

Currently, twelve joint implementation projects have been approved in Estonia, while wind farms contribute most to reducing greenhouse gas emissions.

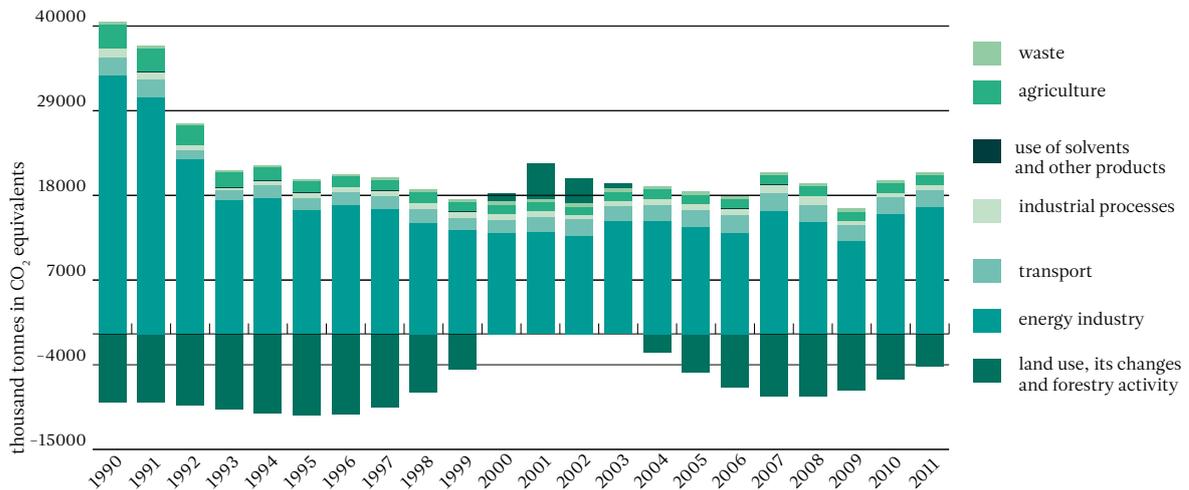


Figure 3.6. Greenhouse gas emissions and absorption by sectors in 1990–2011.

Sources:

- Greenhouse Gas Emissions in Estonia 1990–2011. (2013) National Inventory Report under the UNFCCC and the Kyoto Protocol. Submission to the UNFCCC secretariat. Tallinn.

### 3.2.3 Use and emissions of ozone depleting substances

The phase-out of ozone depleting substances should be completed soon. This means that the use of chlorofluorocarbons (CFCs) has been completely phased out and the use of hydridochloridofluoridocarbons (GCFCs) has been minimised.

The ozone layer is a shield that protects the Earth by reflecting away incoming solar radiation. If the ozone layer didn't exist, ultraviolet radiation would destroy all life on Earth. In this regard, it is interesting to note that the ozone layer is not a uniform stratum. It extends chaotically throughout the stratosphere, about 10–50 kilometres above the planet. The ozone layer is so thin that if ozone molecules were compressed under normal conditions (0 °C and 1 atmosphere pressure), it would be only 3 mm thick. But for us that thin layer is crucial as it protects the environment against harmful ultraviolet radiation. The concentration of ozone in the atmosphere varies naturally, depending on temperature, weather conditions, latitude and longitude. Human activities also have an effect on the ozone layer. Ozone-depleting substances are compounds containing chlorine (Cl), bromine (Br) or fluorine (F). These compounds have great ozone depletion potential (ODP).

Ozone-depleting substances are divided into two classes: fully halogenated chlorofluorocarbons (CFCs) and hydridochloridofluoridocarbons (GCFCs). These substances are used as freezing agents in household and industrial refrigerators, commercial refrigerators, cold storage plants, etc. They are also used in air-conditioning units, as foam-blowing agents, in aerosols and solvents.

Halons (bromine-containing fluorocarbons) have even greater ozone depletion potential. They are between three and ten times more destructive to the ozone layer than CFCs or HCFCs. Nowadays, halons can only be used for critical purposes.

The use of substances that deplete the ozone layer is governed by Regulation (EC) No 1005/2009 of the European Parliament and of the Council on substances that deplete the ozone layer. Pursuant to that regulation, CFCs have been completely banned since 2010. From 2015, the ban is extended to HCFCs, which means that the use of those substances is prohibited. Various chemicals, which are much more ozone-friendly, have been developed as alternatives to ozone-depleting substances. The use of hydrofluorocarbon (HFC), carbon dioxide (CO<sub>2</sub>), propane, ammonia (NH<sub>3</sub>), hydrocarbons (HC), etc. is gaining ground.

#### Estonia's accomplishments in protecting the ozone layer

- The sale of ozone-depleting substances decreased significantly in 1999–2008: 50,520 kg of CFCs and 23,284 kg of HCFCs were sold in 1998, while no CFCs were sold in 2008 and the sale of HCFCs dropped to 23,000 kg; the total sale of those substances decreased from 73,804 to 23,000 kg.
- Halons, which are particularly harmful to the ozone layer, have been removed from all stationary equipment and Estonian flag vessels; an inventory of critical halon-containing objects has been taken and they are continuously checked.
- Alternative substances are mainly used in refrigeration equipment.
- Only CFC-free inhalers are used to treat asthma.
- The use of methyl bromide in pest control and ozone-depleting substances as foam blowing agents has been abolished.
- A national ozone layer depleting substance handling and storage centre was opened in Suur Sõjamägi, Tallinn, where the type and chemical composition of ozone-depleting substances can be determined, such substances are safely disposed of and transported and refrigeration units are dismantled, including the removal and storage of refrigerating agents.
- Competency requirements for persons handling products, equipment or containers based on or containing ozone-depleting substances and the requirements for handling ozone-depleting substances have been laid down by a regulation of the Minister for the Environment.

### Ozone depletion potential (ODP)

Various substances deplete the ozone layer at different rates. The harmful effect a substance can have on the ozone layer is considered in terms of the relative amount of degradation to the ozone layer it can cause or ODP. The ODP of CFC-11 is fixed at 1 and the ODP of all other compounds is expressed in relation to it.

Table 3.1. Comparison of the ODP of various substances. Source: EERC

Substance	ODP
Chlorofluorocarbons (CFCs)	0,6–1,0
Halons	3–10,0
Carbon tetrachloride CCl <sub>4</sub>	1,1
1,1,1-trichloroethane (methyl chloroform) CH <sub>3</sub> CCl <sub>3</sub>	0,1
Methyl bromide CH <sub>3</sub> Br	0,7
Hydrobromofluorocarbons (HBFCs)	0,02–7,5
Hydrochlorofluorocarbons (HCFCs)	0,02–0,11
Chlorobromomethane	0,12

### 3.3 Adaptation to climate change

Decisions adopted at a conference of the parties to the UN Framework Convention on Climate Change call for all parties to the convention, including Estonia, to address the issue of adaptation to climate change, including to plan, prioritise and implement measures of adaptation. Estonia has committed, at international level, to the obligation to tackle adaptation, i.e. to assess the impact of climate change on different sectors and, if necessary, take measures to cope with the inevitable consequences of climate change.

The EU policy is to integrate the adaptation to the consequences of climate change in sectoral policy documents, such as the Common Agricultural Policy and nature conservation policy. Activities related to assessing and managing the risk of flooding are regulated by a special directive and adaptation is also reflected in the general regulation concerning EU funds 2014–2020. In the context of the White Paper “Adapting to climate change: Towards a European framework for action”, an EU adaptation strategy was adopted in April 2013, which increases the European region’s ability to cope with the effects of climate change and includes a set of very specific recommendations for EU Member States.

The topic of adaptation to climate change is also included in the EU Baltic Sea strategy and HELCOM Baltic Sea Action Plan. Estonia does not yet have a single vision and strategy document concerning the adaptation to climate changes, but some measures have been implemented, such as under the Nature Conservation and Forestry Development Plan until 2020, National Public Health Development Plan 2009–2020, Rural Development Plan, Water Act and Emergency Situation Act and national emergency risk analyses. As the effects of climate change may hamper the achievement of the objectives of the water framework directive, the new water management plans, which should be updated by 2015, will also deal with the potential effects of climate change. The water management plans will explain how the effects of climate change have been taken into account in assessing pressures and impacts as well as in preparing monitoring plans and choosing measures. Adaptation to climate changes has also been included in the Development Plan of the Ministry of the Environment for 2013–2016 (Sub-measure: Mitigating the effects of climate change and ensuring radiation and nuclear safety; Objective of the sub-measure: organisation of the adaptation to the effects of climate change in the best possible way; Policy: adaptation to climate change; Priority activities: analysing the effects of climate change in Estonia; finding cost-effective measures for adapting to the effects of climate change and preparing strategic instruments for implementing objectives and measures).

Besides mitigating the effects of climate change and reducing emissions, adapting to climate change is important for transition to a resource efficient economy. When planning adaptation measures, it is important to adopt a cross-sectional approach that is based on the resilience of ecosystems, protection of habitats and biodiversity and ecosystem services.

Estonia has not yet drawn together the knowledge about the effects of climate change, but several projects of climate change have been or are being carried out, such as Astra<sup>2</sup>, Baltadapt<sup>3</sup>, Baltcica<sup>4</sup>, Baltclim<sup>5</sup>, RADOST<sup>6</sup>, etc. Based on the studies conducted to date we can say that although the effects of climate change are not so extreme in Estonia as in many other countries (including Central and South Europe), we too may experience changes in weather and economy caused by climate change:

a) **a rise in temperature** (and the resulting melting of ice, summer heat waves, periods of drought and extreme rainfall, changes in vegetation, invasion of foreign species, including new pests and pathogenic organisms; unfrozen and wet forest land which results in felling limits; changes in energy consumption in winter and in summer (the need to smooth the consumption peaks caused by the connection of numerous cooling systems to the grid in summer); increase in illnesses (especially in the elderly); increase in the volume of services in the tourism sector, etc.);

b) **an increase in the volume of precipitation** (especially in winter) which increases the volume of road maintenance works in winter and in general; seasonal flooding which increases the volume of the maintenance and construction of drainage systems; riverbank erosion, which increases the volume of bank protection works; increase in the volume of water pumped out of mines, etc.;

c) **increased sea level** and the resulting disappearance of coastal areas and seashore erosion, danger to structures on the shore, pressure to relocate buildings and structures, etc.; storms and increased wind velocity and the resulting changes in the requirements for buildings, structures, overhead lines and for the ability to remove the consequences of storms.

Although Estonia does not have a national strategy for adaptation to climate changes, the work on preparing such a document has already started. The Ministry of the Environment has applied for funding under the EEA/Norwegian financial mechanism 2009-2014 in order to prepare a draft national strategy for adaptation to climate changes and the implementation plan. The purpose of the project is to analyse climate data and prepare Estonia for both short and long term climate change scenarios (for 2050 and 2100) based on the existing data and available models. The project will aggregate the existing knowledge base concerning the effects of climate change in different sectors of the economy, assess their vulnerability to climate changes and develop measures for adapting to climate changes. The outcome of the project – a national strategy for adaptation to climate changes – is due for submission to the Government of the Republic for approval in 2016. Various stakeholders and experts of various fields will be included in the preparation of the national strategy for adaptation to climate changes.

<sup>2</sup> Interreg III. <http://www.astra-project.org>

<sup>3</sup> European Regional Development Fund. <http://www.baltadapt.eu>

<sup>4</sup> European Regional Development Fund. <http://www.baltcica.org>

<sup>5</sup> German Federal Ministry for the Environment. <http://www.bef-de.org/unsere-themen-en/projects/baltclim>

<sup>6</sup> <http://klimzug-radost.de/en>; [http://ec.europa.eu/clima/policies/adaptation/what/documentation\\_en.htm](http://ec.europa.eu/clima/policies/adaptation/what/documentation_en.htm)