CLIMATE CHANGE IN EASTERN EUROPE

Belarus, Moldova, Ukraine

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This publication has been prepared by Zoï environment network (Geneva, Switzerland) in cooperation with UNEP/GRID-Arendal (Norway) and the Environment and Security initiative (ENVSEC). Numerous organisations and experts from Belarus, Moldova and Ukraine contributed to the publication. The financial support for the preparation has been provided by the Governments of Canada and Norway, the English edition has been published with the support of the Government of Finland through the Environment and Security initiative (OSCE-UNEP project 'Climate change and security scenarios for Eastern Europe').

The Environment and Security Initiative (ENVSEC) transforms environment and security risks into regional cooperation. The Initiative provides multistakeholder environment and security assessments and facilitates joint action to reduce tensions and increase cooperation between groups and countries. ENVSEC comprises the Organization for Security and Co-operation in Europe (OSCE), Regional Environmental Centre for Central and Eastern Europe (REC), United Nations Development Programme (UNDP), United Nations Economic Commission for Europe (UNECE), United Nations Environment Programme (UNEP), and the North Atlantic Treaty Organization (NATO) as an associated partner. The ENVSEC partners address environment and security risks in four regions: Eastern Europe, South Eastern Europe, Southern Caucasus and Central Asia.

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FOREWORD

Eastern Europe remains fertile ground for those who oppose mainstream climate science. There are several reasons for this. Generally critical thinking as well as the scepticism of recent years with regard to any sensational information ("again someone is trying to sell us hot air") appear to be supported by the objective reality of Eastern Europe. And the reality is that, at least in the next few decades, the impact of climate change here is likely to be less dramatic than in other parts of the world where sea level is threatening islands in the Pacific and Indian oceans, the Mediterranean coast is drying up, and the glaciers of Central Asia are melting ever more quickly. Added to these is the fact that there are many other environmental problems in Eastern Europe that are not linked to climate change, and even these fade into the background compared with the region's economic, social and political challenges.

Yet global climate change is a reality denied today only by hardened contrarians. All the countries of the world, including Belarus, Moldova and Ukraine, bear a share of responsibility for the changing global environment and climate. And even changes that happen beyond the boundaries of the region will have a direct impact upon it: not only environmental processes, but also migration, disease and food security challenges ignore national boundaries. The real consequences of global changes are already being experienced within the region: droughts in Moldova and in the south of Ukraine; more frequent and severe floods; more forest fires, summer heat waves, the absence of snow in winter; alien species and changing natural zones. All that is a reality that is becoming more obvious every day and every year.

The three countries of Eastern Europe are aware of the problems, but have not yet advanced very far in planning how to adapt people's lives, economy and infrastructure to these global changes. Our goal is to accelerate this movement.

This publication integrates available knowledge, primarily accumulated by scientists and practitioners in these countries, about climate change in Eastern Europe, its impacts, and the countries' attempts to cope with them. We have also used other material, including work by the international Environment and Security initiative (ENVSEC) on developing food security scenarios for Eastern Europe under climate change. Numerous experts from Belarus, Moldova and Ukraine provided truly invaluable help too, and we would like to express to them our sincere and deep gratitude.

We also hope that this publication will provide the whole international community and especially the neighbour-countries bordering Eastern Europe with a better understanding of the region's problems, and that it will motivate them for new joint actions – so that the climate of regional cooperation will warm up more quickly than the climate of the planet.

Nickolai Denisov
Zoï environment network, Geneva

Climate change in Eastern Europe: impacts, trends and projections

Sources: Fifth National Communication of the Republic of Belarus, 2009; Third, Fourth and Fifth National Communication of Ukraine, 2009; Second National Communication of the Republic of Moldova, 2009.

Produced by ZOI Environment Network, 2011.

Kyiv, Ukraine

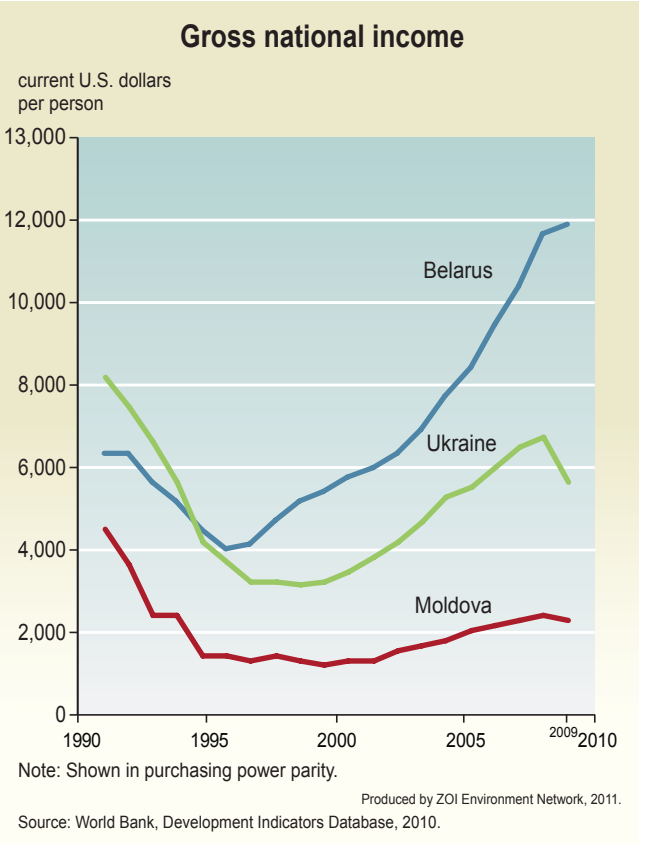
Eastern Europe: a bird's eye view

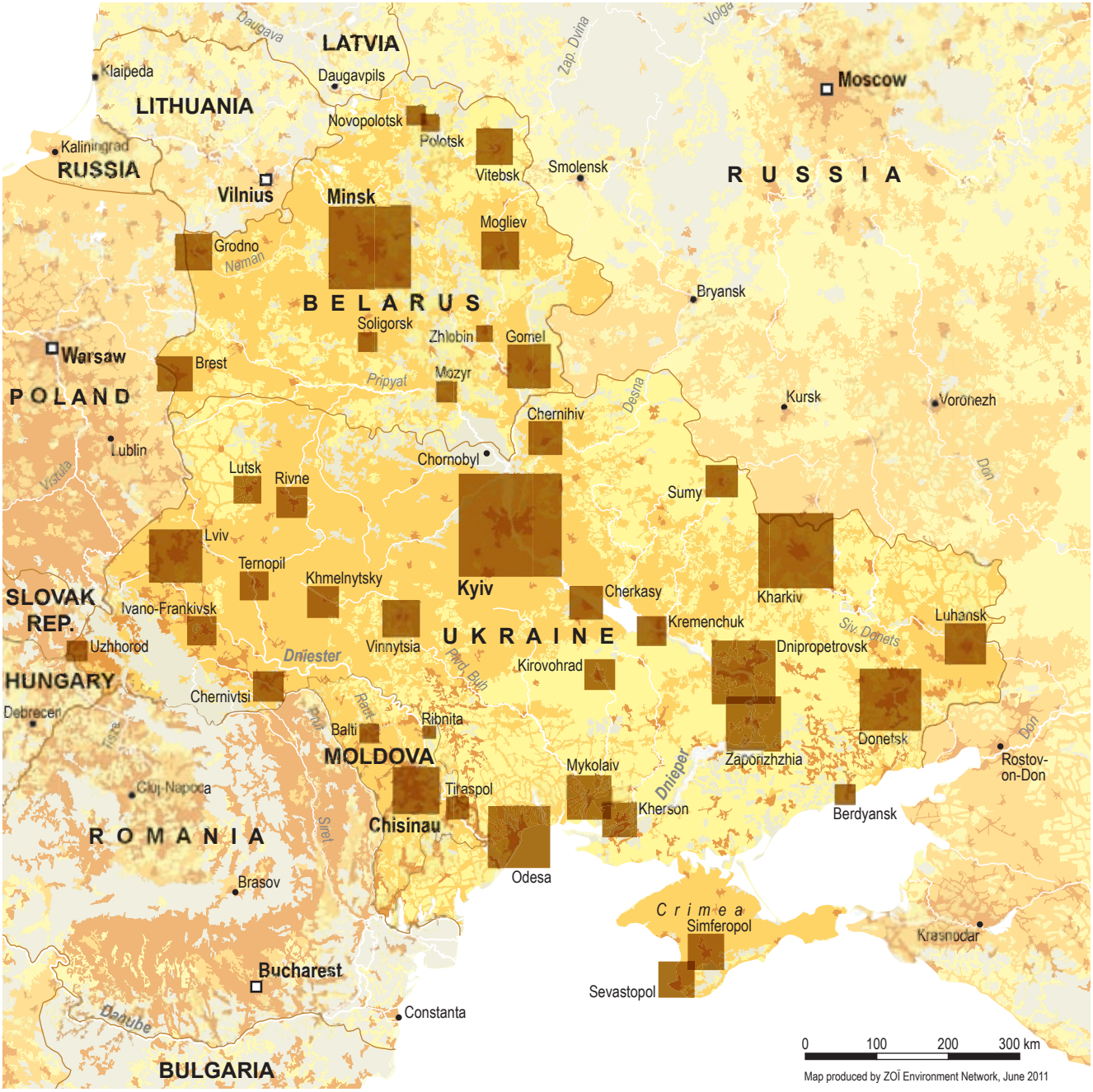

Baltic Sea
LATVIA
Daugava
Klaipeda
Daugavpils
LITHUANIA
Novopolotsk
Polotsk
Kaliningrad
RUSSIA
Vilnius
Vitebsk
Smolensk
Zap. Dvina
Volga
Moscow
R U S S I A
Minsk
Grodno
Neman
Mogliev
B E L A R U S
Bryansk
Soligorsk
Zhlobin
Warsaw
Brest
Gomel
Pripyat
Mozyr
Desna
Kursk
Voronezh
POLAND
Lublin
Chernihiv
Chornobyl
Vistula
Sumy
Don
Lutsk
Rivne
Kyiv Res.
Kyiv
Lviv
U K R A I N E
Kharkiv
Ternopil
SLOVAK REP.
Cherkasy
Ivano-Frankivsk
Khmelnytsky
Vinnytsia
Kremenchuk Res.
Kremenchuk
Siv. Donets
Luhansk
Uzhhorod
Dniester
Pivd. Buh
Dnieper
Dnipropetrovsk
HUNGARY
Chernivtsi
Kirovohrad
Donetsk
Debrecen
Prut
Raut
Kakhovka Res.
Zaporizhzhia
Tisza
Balti
Ribnita
Don
Rostov-on-Don
MOLDOVA
Cluj-Napoca
Tiraspol
Mykolaiv
Berdyansk
Chisinau
Kherson
ROMANIA
Siret
Odesa
Sea of Azov
Brasov
C r i m e a
Krasnodar
Simferopol
Bucharest
Sevastopol
Danube
Constanta
B l a c k S e a
BULGARIA
0 100 200 300 km
Map produced by ZOÏ Environment Network, June 2011
Bathymetry
Altitude in metres
-2 000 -1 000 -500 -100 0 50 100 200 500 1000

Their geographical location means that Ukraine, Belarus and Moldova occupy an important place in Europe. They are conventionally grouped into a single region, of Eastern Europe, located between the European Union and Russia and stretching from the northern coast of the Black Sea in the south (Ukraine) to the Baltic Sea basin in the north (Belarus) Its territory is 845,000 square kilometres and it has a population over 60 million people. The countries of the region have several joint borders and are located within the same water catchment basins. They are united by the similarity of their geography, a common history and culture, and economies with a similar infrastructure.

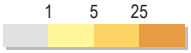
After the splitting-up of the Soviet Union, the three countries inherited natural resources depleted by unsustainable usage, a huge volume of toxic waste from mining and heavy industry, radioactive waste storage, the consequences of the Chornobyl catastrophe, depleted chernozems (once fertile black soils), and polluted water. In addition to complicated economic conditions over recent years, the people and economies of the countries have suffered from numerous natural disasters caused partly by climate change.

The signs of climate change are apparent in the region: extremes of temperature, an increase in the number of hot days, an overall reduction in atmospheric precipitation (although with a drastic rise in some areas), together with an increase in gales and rainstorms, catastrophic floods and droughts, forest fires and desertification. The consequences of these trends are having a negative impact on agriculture, forests, water and other sectors, as well as on people's health and safety.



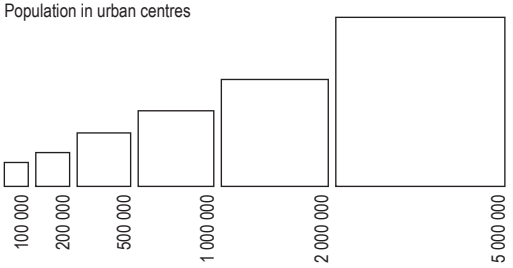

LATVIA
LITHUANIA
RUSSIA
BELARUS
POLAND
SLOVAK REP.
HUNGARY
ROMANIA
MOLDOVA
UKRAINE
BULGARIA
Crimea
RUSSIA
Daugava
Klaipeda
Daugavpils
Novopolotsk
Polotsk
Vitebsk
Smolensk
Moscow
Kaliningrad
Vilnius
Minsk
Mogliev
Grodno
Neman
Bryansk
Soligorsk
Zhlobin
Gomel
Warsaw
Brest
Pripyat
Mozyr
Kursk
Voronezh
Chernihiv
Desna
Lublin
Vistula
Chornobyl
Lutsk
Rivne
Sumy
Don
Lviv
Ternopil
Khmelnytsky
Kyiv
Cherkasy
Kharkiv
Ivano-Frankivsk
Kremenchuk
Luhansk
Uzhhorod
Dniester
Vinnytsia
Pryp. Buh
Dnipropetrovsk
Siv. Donets
Kirovohrad
Debrecen
Chernivtsi
Prut
Ribnita
Balti
Donetsk
Zaporizhzhia
Rostov-on-Don
Mykolaiv
Dnieper
Cluj-Napoca
Tiraspol
Kherson
Berdyansk
Siret
Chisinau
Odesa
Brasov
Simferopol
Krasnodar
Bucharest
Sevastopol
Danube
Constanta
0
100
200
300 km
Map produced by ZOÏ Environment Network, June 2011

Population in Eastern Europe



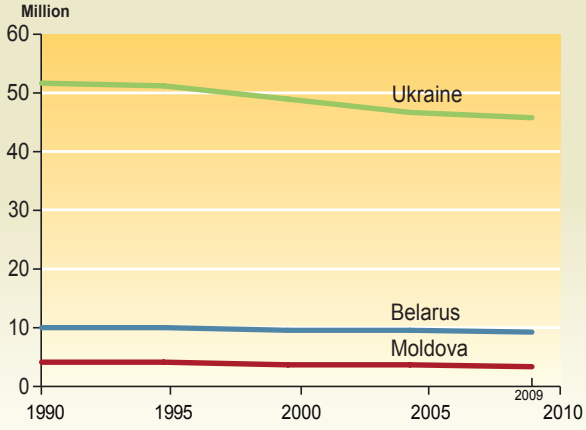
Population density
(inhabitants per km²)

Population in urban centres



Sources: LandScan Global Population Database 2007, Oak Ridge, TN, Oak Ridge National Laboratory (→ www.ornl.gov/sci/landscan); World Gazetteer 2011 (→ www.world-gazetteer.com)

Population dynamics in Eastern Europe



Produced by ZOI Environment Network, 2011.

Source: World Bank, Development Indicators Database, 2010.

Yaremche, Ukraine © Lesya Nikolayeva

Leuseni, Moldova
© Martin Roemers

Climate change in the region

"Tropical nights"

Growth in the number of days with "tropical nights"
Difference between 1961-1990 and scenario for 2071-2100

10 20 30 40

Map produced by ZOÏ Environment Network, June 2011
Source: European Environment Agency
(www.eea.europa.eu/data-and-maps/figures/modelled-number-of-tropical-nights-over-europe-during-summer-june-august-1961-1990-and-2071-2100)

Projections and scenarios of climate change in the region

According to projections based on various models, by the end of the 21st century the average global air temperature will increase by 2.5-5°C. It is expected that the speed of the temperature rise will be the highest in mid-century when the population of the planet is predicted to reach its maximum. Experts predict that global climate changes will be most significant in the polar and sub-polar regions, and in tropical and subtropical deserts.

According to the Intergovernmental Panel on Climate Change (IPCC), the countries of Eastern Europe are less vulnerable to climate change than island or high-mountain states. However, significant changes in temperature and in the amount of precipitation, with the natural hazards of recent decades, provide evidence that the problem also concerns the European region. The impacts of climate change mainly have affect agriculture, water and forests. So Moldova, with its economy predominantly based on agriculture, is the country most vulnerable to climate change in Eastern Europe.

The longest period of warming in Eastern Europe over more than 120 years of instrumental observations happened at the end of the 20th and beginning of the 21st centuries. On average, between 1988 and 2007, the air temperature increased by 1.1-2.0°C, and according to projections a gradual increase will continue in the future. The number of days with so-called "tropical nights", when the temperature after sunset does not fall below 25°C, has also increased.

If greenhouse gas emissions are not reduced, by mid-century the air temperature in Moldova is expected to increase by 1.7-2°C compared to 1961-1990, and by 4-5°C by the end of the century. In Ukraine, due to its large size, the changes will be different in different parts of the country, as well as throughout the year. Scientists predict that the temperature increase will be between 1 and 5°C in various parts of the country by 2100. It is mainly the winter and spring months that will become warmer. Some researchers believe that a tropical climate will reach Moldova and Ukraine, and that the subtropical zone already present in both countries will further expand.

Although there is no unequivocal prediction of expected changes in the regime and amounts of precipitation, it is certain that these changes will be different in different parts of the region and at different times of year. Over almost all of Eastern Europe the amount of precipitation will increase in winter and decrease in summer and autumn, especially in Moldova and the south of Ukraine, thus raising the risk of droughts in these regions. The amount of precipitation is expected to be higher than the norm of long-term observations in the northern part of Belarus and lower in the southwest e of the country.

Climate change in Europe

- More precipitation
- Less precipitation
- Sea-level rise concerns and affected major cities
- Changes in ecosystems
- Impact on mountain regions
- Forest fires
- Negative agricultural changes
- Melting of glaciers
- Present permafrost
- Permafrost in 2050
- Climate change hotspot

Map produced by ZOÏ Environment Network, May 2011
Source: Intergovernmental Panel on Climate Change (IPCC)(→ www.ipcc.ch) Adapted for Second Assessment of Transboundary Rivers, Lakes and Groundwaters. UNECE, 2011.

Temperature

Change of annual temperature by 2050
Model: Ensemble Average, SRES emission scenario A2

2.2 2.3 2.4 2.5 2.6 2.7 2.8

Map produced by ZOÏ Environment Network, July 2011
Source: Climatewizard (→ www.climatewizard.org)

Between 1980 and 2011 the average air temperature in Eastern Europe has been 0.48°C higher than between 1950 and 1980. Scientists also say the speed of warming has gone up over the last decade.

Some facts:

- In Belarus between 1988 and 2007 the temperature was 1.1°C higher than between 1961 and 1990, with the warming most obvious in the north-western part of the country. Six out of the seven highest temperatures were recorded during the last 20 years. A new agroclimatic zone has developed in the south of Belarus as the temperature is higher and the growing season is longer there compared to the rest of the country;

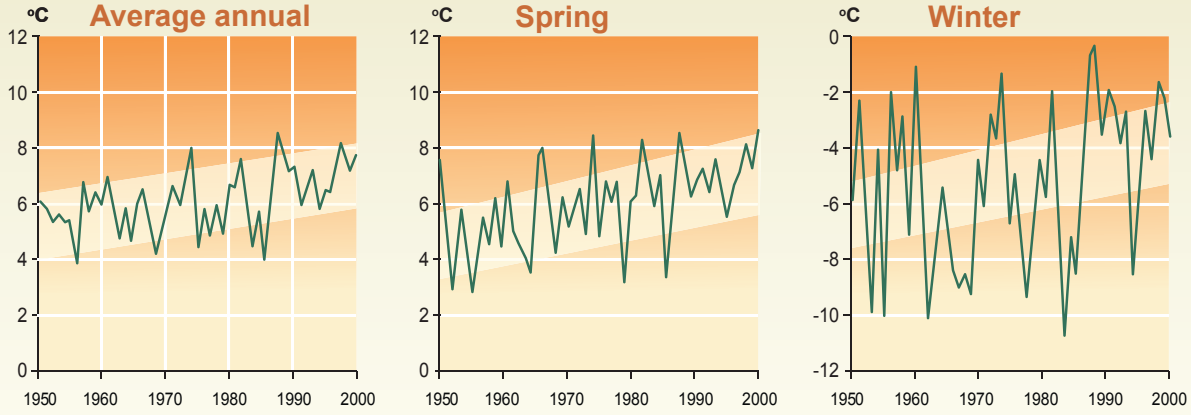
- In Moldova the average annual air temperature over the decade from 1997 rose by 0.6°C compared to 1985-1996, most significantly in the central part of the country;

- In Ukraine the air temperature between 1980 and 2001 increased by an average of 0.5-0.6°C compared to 1950-1980, with the warming most significant in the south of the country and along the Black Sea coast.

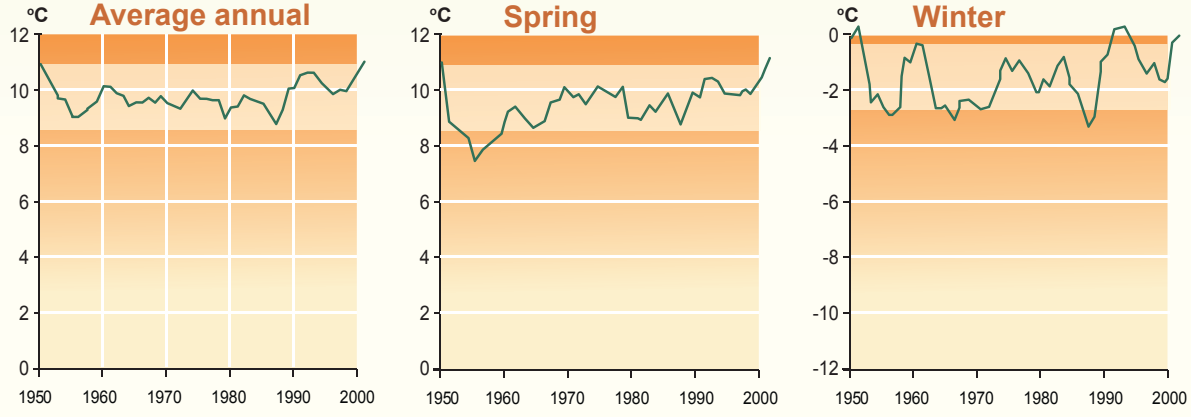
Between 1991 and 2010 many average monthly air temperature (minimum and maximum) records for the last 100 years were recorded in Ukraine. The repetitiveness and length of the summer heat periods (with air temperature above 25°C or 30°C) rose. Droughts became more frequent and tended to cover bigger areas. In the past, they happened once every two to three years and covered from 10 to 30% of the country, but between 1989 and 2010 their frequency doubled, and the droughts started to spread through a wider area that previously had sufficient precipitation.

Nine droughts were recorded in Moldova between 1990 and 2007. The catastrophic drought of 2007 covered 80% of the country and caused economic damage valued at USD 1 billion. The number of days with temperatures above 30°C or 35°C has also grown over the last decade.

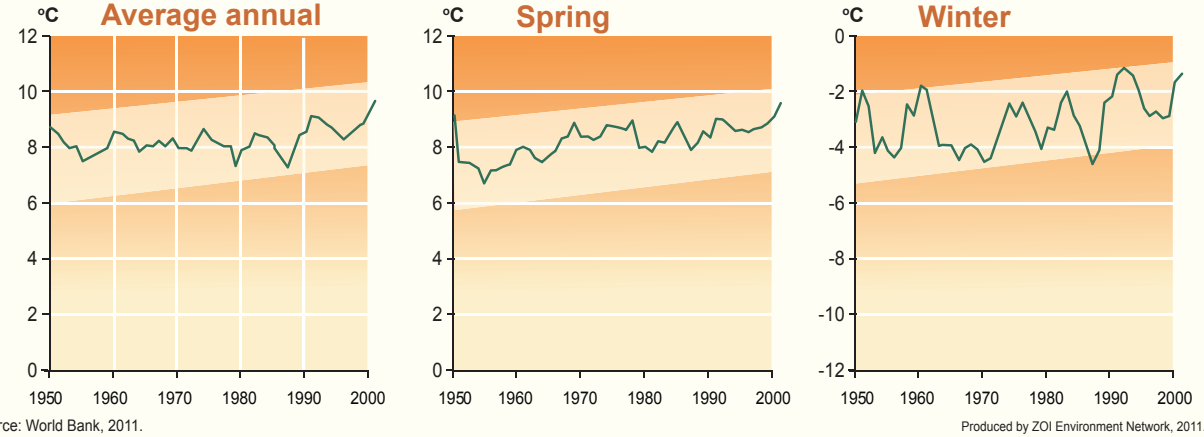
Air temperature in Belarus



Air temperature in Moldova



Air temperature in Ukraine



Source: World Bank, 2011.

Produced by ZOI Environment Network, 2011.

The amount and distribution of precipitation has also changed in Eastern Europe. A reduction in precipitation has been recorded in Belarus, mainly in the southern artificially-drained part of the republic whilst in the north there has been an insignificant increase. Over the last twenty years a reduction of precipitation has been observed in April (91% of the norm), June (93%) and especially August (88%). An insignificant increase above the norm has been observed in February, March and October.

Between 1950 and 2001 the level of precipitation in Moldova has hardly changed at all, with only an insignificant reduction of 0.003% per year registered. But high variability within and between different years has been noted.

Between 1990 and 2010 changes in annual precipitation have been variable. In some regions there has been a significant increase of 40mm, whereas in other regions there has been no change, or precipitation has decreased.

Natural disasters are one of the dangerous consequences of climate instability. Recently their number has increased in the region and in many cases they have been catastrophic, causing fatalities and leading to significant economic losses.

In Ukraine the frequency of extreme weather events that used to be observed only once in 50 or 100 years has increased by 1.5-2 times over the period between 1990 and 2010. These extreme weather events include gales, hail out of season and whirlwinds at an atypical place or time of year.

The most common natural disasters are associated with heavy rainstorms that may cause mudslides and flooding of large areas of agricultural land, houses and industrial buildings, as well as leading to other changes in the environment.

Precipitation

Change in annual precipitation by 2050, %
Model: Ensemble Average, SRES emission scenario A2

-10 -5 0 5 10 15

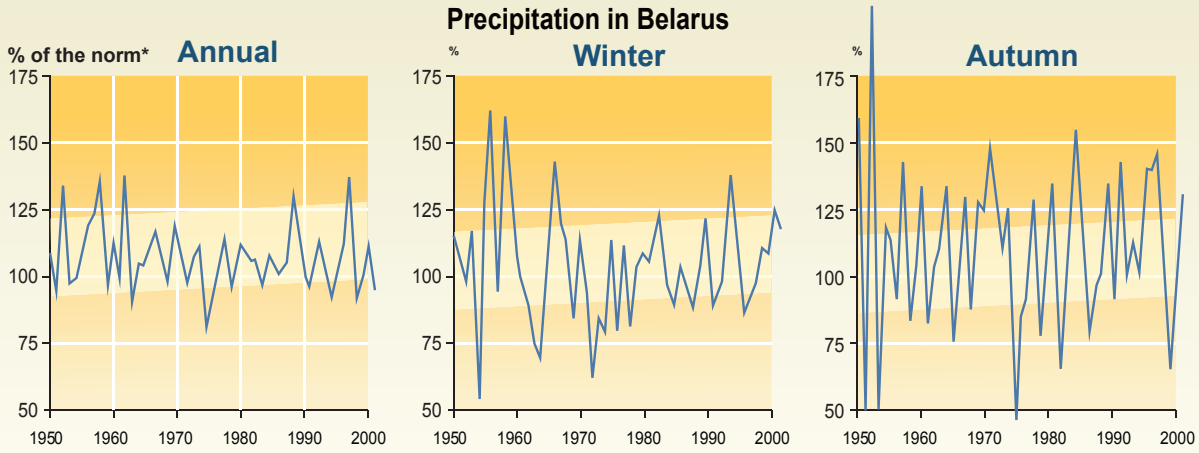
Changes in the contribution of heavy rainfall to total precipitation between 1961-2006

more

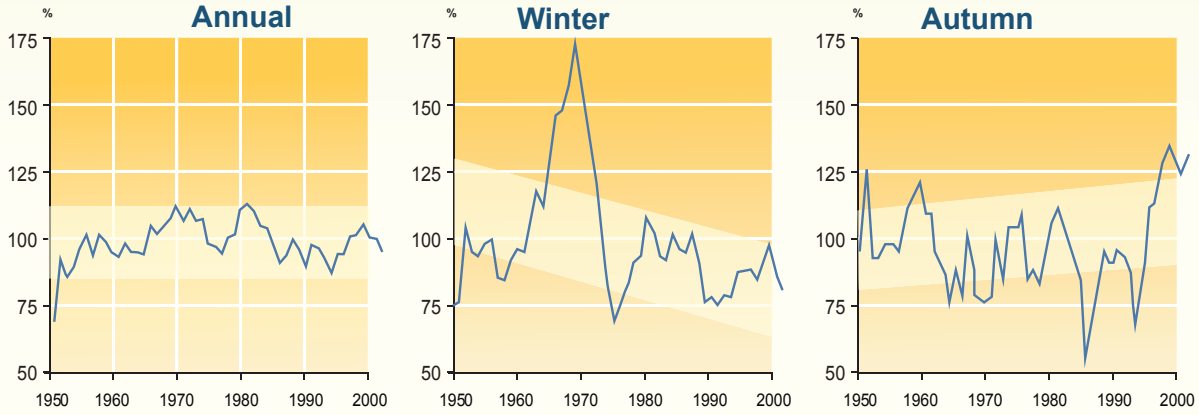
less

Map produced by ZOÏ Environment Network, June 2011
Source: Climatewizard (→ www.climatewizard.org)

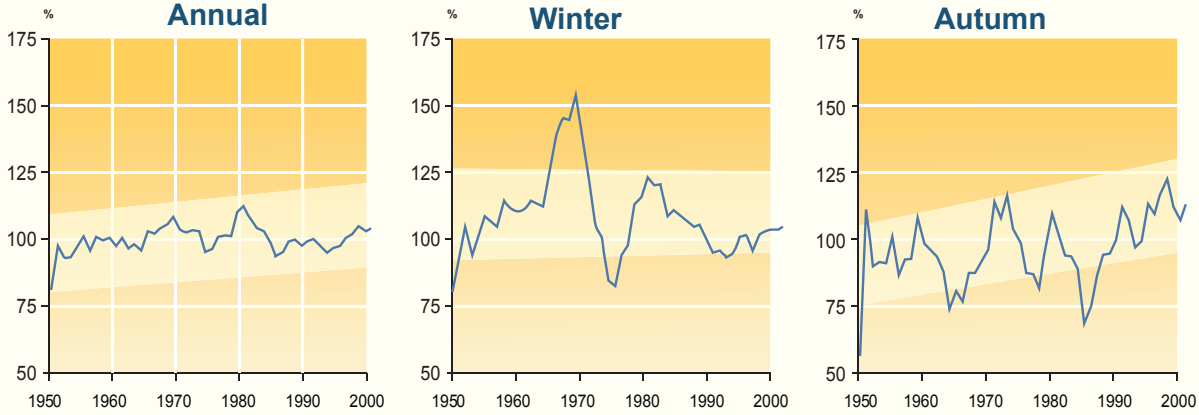
Precipitation in Belarus



Precipitation in Moldova



Precipitation in Ukraine



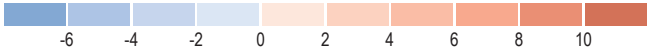
* 1961-1990

Source: World Bank, 2011.

Produced by ZOI Environment Network, 2011.

Heatwave summer 2010

Abnormal land surface temperature in July 2010 (°C)
Difference from the average July temperature in 2001-2010



Map produced by ZOÏ Environment Network, June 2011
Source: National Aeronautics and Space Adminstration (NASA) (→ http://neo.sci.gsfc.nasa.gov)

The abnormally hot summer of 2010

According to data from the hydrometeorological services of Ukraine, Belarus and Moldova, the summer of 2010 was the hottest of the last 100-120 years. The peak of the heat wave was in the European part of Russia, Moscow in particular, where the temperature reached 42-45°C. Scientists have linked this event strongly with climate change. The consequences included forest fires in Russia; catastrophic smog in Moscow; low water levels in the largest European rivers of Russia (with a fall of water level between 0.5 and 2 metres compared to average long-term readings); and a higher death rate due to increased air temperature.

In Moldova, the summer of 2010 saw rainstorms and associated floods along with fires related to the abnormally high temperatures. The absolute air temperature recorded in the second part of June peaked at +36°C. In addition, around 300% of the normal monthly precipitation fell in June: a record in the last 124 years. In August, there were 15 days with air temperature above +35°C, something that has never been recorded before. Abnormally high temperatures were also observed in 1946 and 2007. In 2007 there were high temperatures, but also catastrophically low precipitation (only 35-80% of the norm) which caused a drought affecting 75-80% of the country and resulting in major crop losses and economic damage. And in 1946 about 10% of the population of the country died of hunger and thousands of people suffered from malnutrition as a result of the drought.

Abnormally high temperatures similar to the extremely hot summer of 1936 were experienced in Ukraine. From mid-July till the end of August the average daily temperature was 5-10°C and 11-12°C above the norm in north-eastern areas, reaching 25-28°C and 30-32°C on some days. In central, eastern and southern areas of Ukraine the maximum daily temperature was 30°C, sometimes reaching 40-42°C over a period of 35-40 days. The amount of precipitation did not increase more than 2-10 millimetres, although in some areas there were rainstorms. The storage of moisture in soils in agricultural areas was 20-30% lower than the long-term average annual reading.

In Belarus all temperature records were broken. The absolute maximum reached was nearly 39°C (the previous maximum of 38°C was registered in 1946), the highest ever recorded in Belarus. In Minsk the temperature reached 32.4°C; the previous record in the city (32.2°C) was recorded on the 6th of August 1994. Nearly all areas of Belarus suffered from forest and peat fires.

Sources: Hydrometeorological services of Ukraine, Belarus and Moldova, 2011.

Yenakiyeve, Ukraine

Greenhouse gas emissions and mitigation

Greenhouse gas emissions

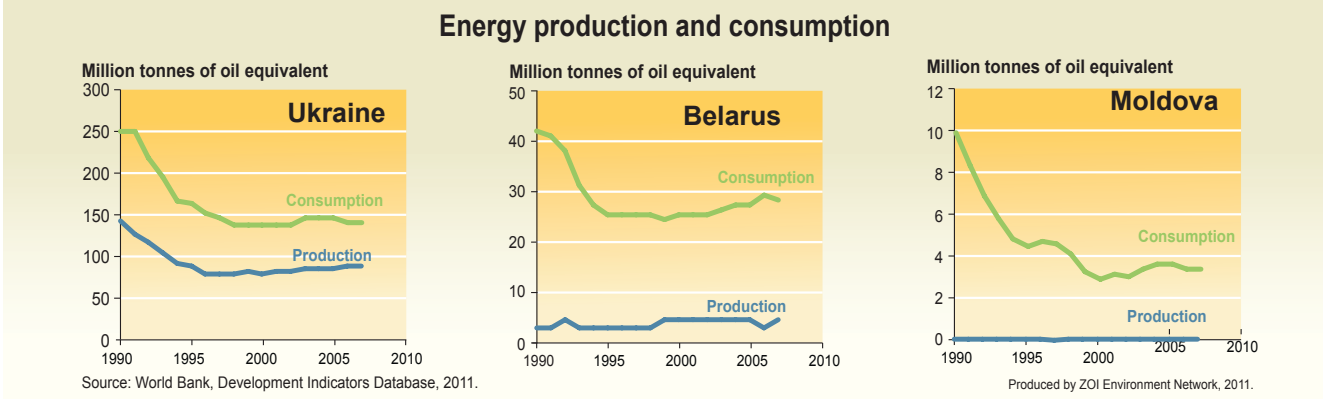
From 1990 to 2005 greenhouse gas emissions in Belarus, Moldova and Ukraine declined by roughly half, from 1,110 to 514 million tonnes of CO_2 equivalent. Emissions in Belarus fell by 38%, in Ukraine by 55% and in Moldova by 72%. The reduction happened gradually and was linked to a decrease in the economy growth rate after the end of the Soviet Union. The maximum reduction happened in 2000. After that emissions started to grow again and are continuing to rise.

At international climate negotiations Ukraine is classed as an "industrial country with its economy in transition" and thus agrees to reduce its emissions by 20% by 2020 and by 50% by 2050, taking 1990 as a baseline. And as a country with a transition economy it is allowed to engage in international financial mechanisms to reduce emissions.

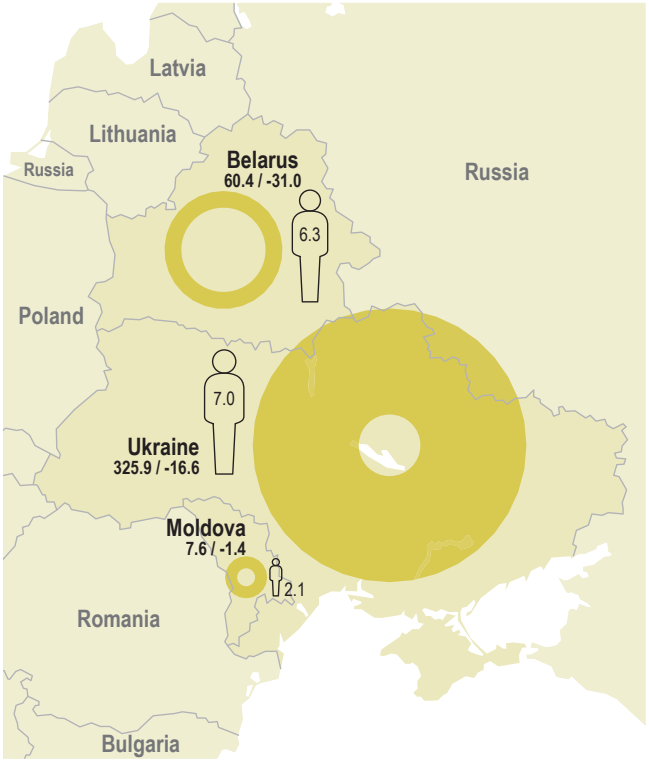
Moldova[1] is the region's leader in achieving both the greatest emissions reduction and the lowest per capita emissions: three tonnes of CO_2 per person. The reduction was achieved in 1990-2005 by a cut in Moldova's use of fossil fuel and the switch to natural gas for electricity production, in particular at the Dniester thermal power plant. The second equally important reason is the economic depression of 1990-2000 that led to a reduction of more than half in GDP. After 2000 economic growth has happened mainly as a result of an increase in domestic consumption and the service industry that now provides more than 60% of GDP. The contribution of agriculture and industry to GDP has reduced, which of course has had an impact on the volume of emissions. Energy production capacity in Moldova is relatively limited. The country has just three thermal power plants producing electricity and heat and one hydropower station. About 80% of generating capacity is located in Transnistria and is not in fact controlled by the central Government. Moldova relies heavily on imported energy resources, mainly from Russia.

In Ukraine and Belarus the economy remains quite energy-intensive, with 8.9 and 8.7 tonnes of CO_2 equivalent emissions respectively per capita in 2005. (The average global figure is about 4.6 tonnes per capita. For comparison, in 1990 - before the Soviet break-up - this indicator was 9.8 tonnes per capita for Moldova, 13.8 for Belarus and 17.8 for Ukraine.)

GHG emissions from land use, changes in land use and the forest sector totalled 9% in 1990 and 12% in 2005 of the region's total emissions. In Belarus this indicator is higher due to the bigger area occupied by forests.



1 The official statistics of emissions in Moldova used in this report do not take into account the data for the Transnistrian region, which is not controlled by the central Government and where the major industries are situated including the Moldovan thermal power plant, the biggest in the country.



Carbon dioxide emission and absorption

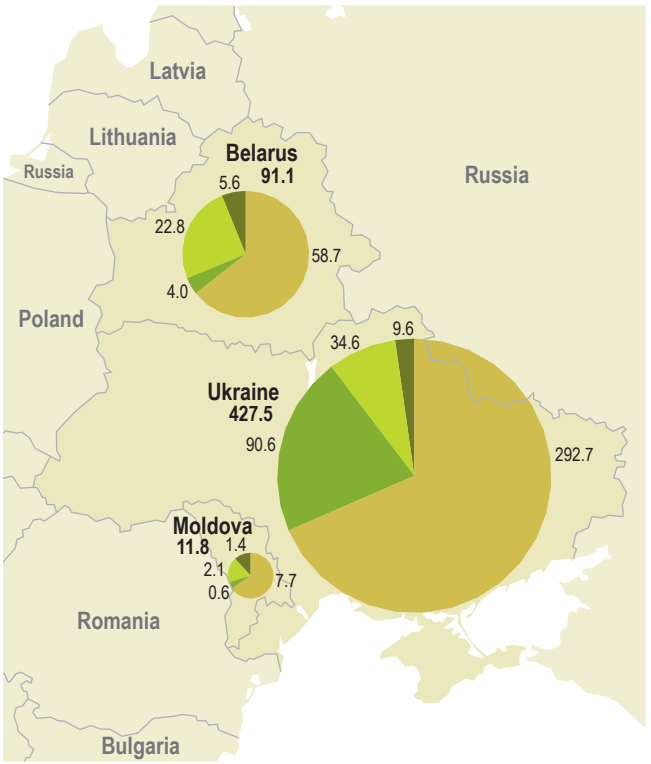
Total CO_2 emissions 2008 (million tonnes)*
CO_2 absorption by forests (million tonnes)

200
100
50
20
10

Emission of carbon dioxide per capita 2008 (tonnes)

*The graphics are based on latest available national data. Data for Moldova are for 2005.

Map produced by ZOÏ Environment Network, June 2011
Sources: Fifth National Communication of Republic of Belarus, 2009; Fifth National Communication of Ukraine, 2009; Second National Communication of Republic of Moldova, 2009; World Gazetteer (→ www.world-gazetteer.com)



Greenhouse gas emissions by sector

Total greenhouse gas emissions in 2008* (million tonnes of CO_2 equivalent)

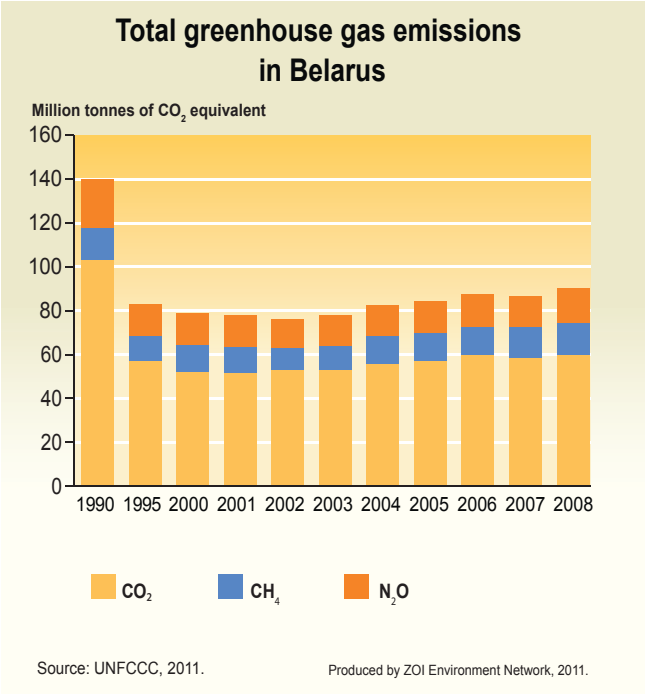
400
200
100
50
20

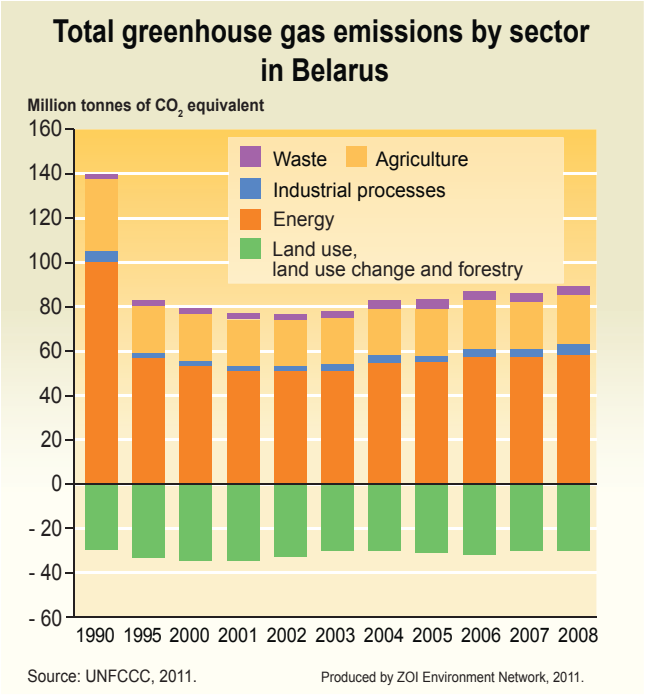
Energy
Industry
Agriculture
Waste

*The graphics are based on latest available national data. Data for Moldova are for 2005.

Map produced by ZOÏ Environment Network, June 2011
Sources: Fifth National Communication of Republic of Belarus, 2009; Fifth National Communication of Ukraine, 2009; Second National Communication of Republic of Moldova, 2009


LATVIA
RUSSIA
LITHUANIA
BELARUS
POLAND
UKRAINE
Daugava
Siauliai
Daugavpils
Panevezys
Velikiye Luki
Drysviaty Lake
Braslav Lakes
Novopolotsk
Polotsk
Postavy
Glubokoye
Vitebsk
Zap. Dvina
Kaunas
Vilnius
Marijampole
Smolensk
Novolukoml
Vila
Tolochin
Orsha
Molodechno
Borisov
Gorki
Lida
Minsk
Dnieper
Grodno
Neman
Mogilev
Mstislavl
Roslavl
Berezino
Cherven
Stolbtsy
Marina Gorka
Bykhov
Berezina
Bialystok
Slonim
Baranovichi
Bobruysk
Slutsk
Rogachev
Zhlobin
Klintsy
Soligorsk
Pruzhany
Svetlogorsk
Kobryn
Gomel
Brest
Rechitsa
Dnieper-Bug Canal
Pinsk
Petrikov
Mozyr
Stolin
Pripyat
Shatsk Lakes
Chernihiv
Sarny
Kovel
Chornobyl
Kyiv Reservoir
Korosten
0
50
100
150 km
Map produced by ZOÏ Environment Network, June 2011
Altitude in metres
100
150
200
250
300





Belarus

- Between 1990 and 2007 total GHG emissions fell by 47%, from 119 to 63 million tonnes of CO_2 equivalent.
- In 1990 total emissions of CO_2, the main greenhouse gas emitted by Belarus, were 104 million tonnes, or 74% of total GHG emissions (disregarding absorption by land use and forests). By 2007, emissions of CO_2 had reduced by 44% to 58 million tonnes - 67% of total emissions.
- Methane emissions (CH_4) have second place in total emissions, and in 1990 were 15 million tonnes of CO_2 equivalent or 11% of total emissions. By 2007 methane emissions had reduced by 9% to 14 million tonnes of CO_2 equivalent – 16% of total emissions.
- In 1990 emissions of nitrous oxide (N_2O) were 21 million tonnes of CO_2 equivalent or 15% of total GHG emissions. By 2007 the level had decreased by a third to 15 million tonnes of CO_2 equivalent - 17% of total emissions.
- The major contribution to GHG emissions is accounted for by the extraction, production and consumption of energy (65%); agriculture (25%); waste-related emissions (6%); industrial processes (5%); emissions from solvents and other sectors (0.1%).
- From 1990 to 2007 the absorption of greenhouse gases by forests rose by 13%: from 22 to 25 million tonnes of CO_2 equivalent.


Kamyanets-Podilsky
Novo-Dniester Reservoir
Uman
Mohyliv-Podilsky
Chernivtsi
Briceni
Donduseni
Synyukha
Privd. Buh
Edinet
Soroca
Costesti-Stinca Reservoir
Drochia
Camenca
Pervomaysk
Riscani
Floresti
U K R A I N E
Dniester
Kodyma
Glodeni
Botosani
Balti
Ribnita
Suceava
Rezina
Singerei
Falesti
Tylihul
Moldova
Siret
Jijia
Raut
Dubasari Reservoir
M O L D O V A
Orhei
Transnistria
Ungheni
Calarasi
Ichel
Kuchurhan
Ser. Kuyalnyk
Vel. Kuyalnyk
Dubasari
Bistrita
Iasi
Straseni
Nisporeni
Grigoriopol
Pietra-Neamt
Roman
Chisinau
Bic
R O M A N I A
Prut
Hincesti
Tighina
Tiraspol
Slobozia
Bacau
Vaslui
Kohylnyk
Botna
Causeni
Dnestrovsc
Cimislia
Stefan-Voda
Leova
Odesa
Oit
Barlad
Basarabeasca
Dniester Lyman
Comrat
Trotus
Barlad
Sarata
Ceadir-Lunga
Bilhorod-Dnistrovsky
Ialpug
Cahul
Taraclia
Focsani
Vulcanesti
Black Sea
Siret
Galati
Izmayil
Braila
Danube
Buzau
Buzau
Tulcea
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75 km
Map produced by ZOÏ Environment Network, June 2011
Altitude in metres
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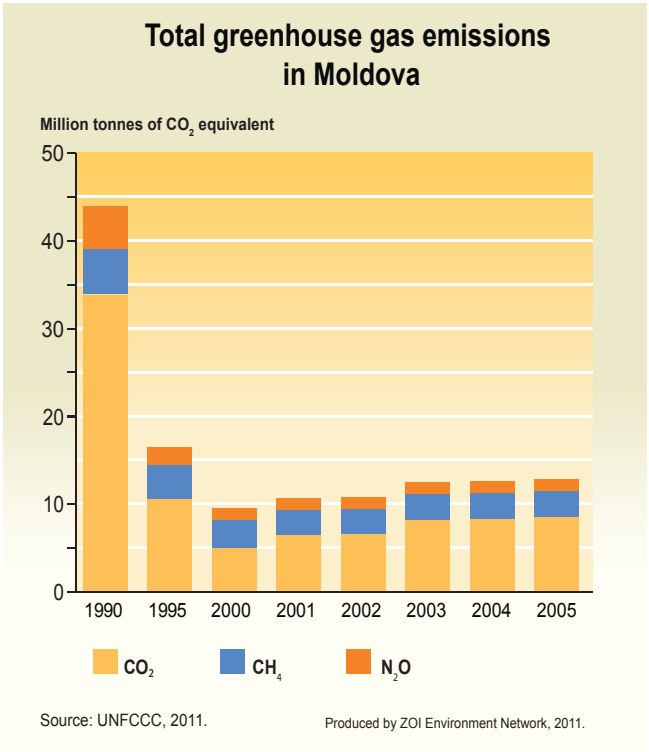

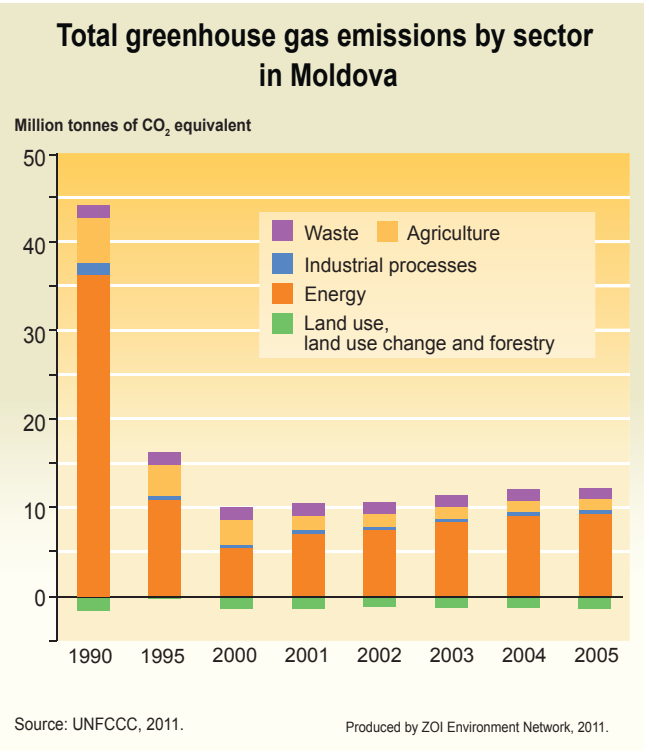

Moldova

- Between 1990 and 2005 total GHG emissions declined fourfold: from 41 to 11 million tonnes of CO_2 equivalent. CO_2 emissions fell most significantly (by 80%), with methane down by 40% and nitrous oxide by 58%.
- The energy sector, the main source of GHG emissions, varied between 80 and 65% in the period from 1990 to 2005.
- The second major source of emissions is agriculture whose contribution to total emissions was 12% in 1990 and 18% in 2005. The share of the waste sector was 4% in 1990 and 12% in 2005 and the share of industry 3% in 1990 and 5% in 2005.
- In 2005, absorption by forests slightly declined compared to 1990, from 1.7 to 1.4 tonnes of CO_2 equivalent.


RUSSIA
Vitebsk
Smolensk
Vilnius
Minsk
Mogliev
Grodno
Neman
BELARUS
Bryansk
RUSSIA
Soligorsk
Zhlobin
Gomel
Brest
Pripyat
Mozyr
POLAND
Desna
Kursk
Voronezh
Shostka
Chernihiv
Lublin
Kovel
Chornobyl
Konotop
Sumy
Don
Lutsk
Novohrad-
Volynsky
Nizhyn
Romny
Rivne
Kyiv
Res.
Kyiv
Pryluky
Chervonohrad
Zhytomyr
Ohtyrka
Kharkiv
Lviv
UKRAINE
Lubny
Ternopil
Bila Tserkva
Poltava
Izium
Khmelnytsky
Cherkasy
Ivano-Frankivsk
Vinnytsia
Kremenchuk
Kremenchuk
Res.
Siv. Donets
Uzhhorod
Dniester
Uman
Pivd. Buh
Dnieper
Luhansk
Dnipropetrovsk
Horlivka
Chernivtsi
Kirovohrad
Dniprodzerzhinsk
Donetsk
Tisza
Prut
Raut
Balti
Ribnita
Yuzhnoukrainsk
Kryvyi Rih
Kakhovka
Res.
Nikopol
Zaporizhzhia
Rostov-
on-Don
MOLDOVA
Mariupol
Cluj-Napoca
Iasi
Chisinau
Tiraspol
Mykolaiv
Melitopol
Berdyansk
Siret
ROMANIA
Kherson
Sea of
Azov
Odesa
Brasov
Izmail
Crimea
Kerch
Krasnodar
Yevpatoriya
Simferopol
Sudak
Novorossiysk
Bucharest
Sevastopol
Yalta
Danube
Constanta
Black Sea
BULGARIA
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200
300 km
Map produced by ZOÏ Environment Network, June 2011
Altitude in metres
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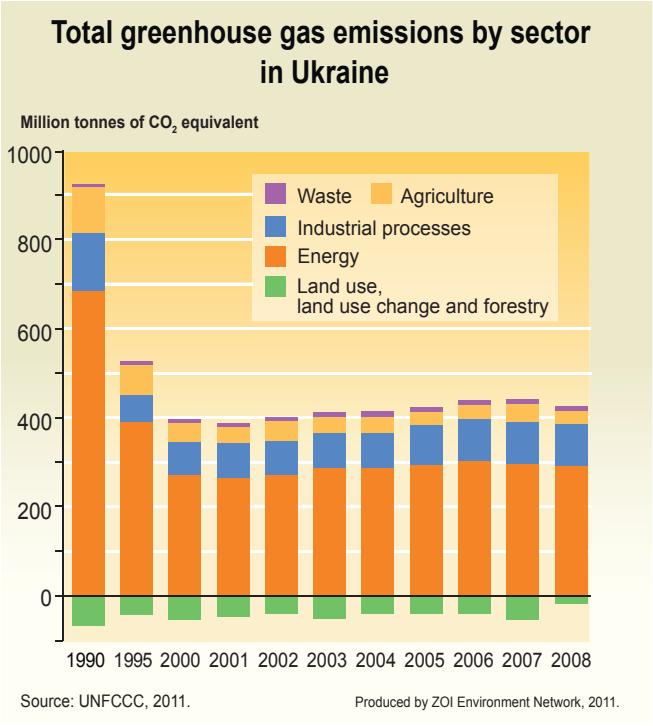


Ukraine

- In 2007 total emissions were 2.2 times lower than in 1990, having declined from 853 to 393 million tonnes of CO_2 equivalent.
- Between 1990 and 2007 emissions of CO_2 also decreased 2.2 times (from 643 to 297 million tonnes of CO_2 equivalent), with methane halved from 151 to 73 million tonnes and nitrous oxide 2.5 times lower (from 59 to 24 million tonnes).
- CO_2 accounted for the biggest share of GHG emissions in 1990 at about 75% of the total, with methane at 18% and nitrous oxide 7%. By 2007 that distribution had hardly changed: CO_2 stood at 76%, methane 18% and nitrous oxide 9%.
- The biggest contribution to total GHG emissions is the extraction, production and consumption of energy. From 1990 to 2007 this varied between 76 and 86%. The reduction of energy sector emissions from 1990 to 2007 of 54% was the greatest sectoral reduction.
- In 1990 net absorption of GHG by forests was 73 million tonnes. But by 2007 this had fallen to 44 million tonnes of CO_2 equivalent.
- The Donetsk Oblast has one fifth of the country's industrial potential and is the leader in the emission of harmful substances into the air. In 2009 it accounted for 42% of methane emissions in Ukraine.

Energy

- Gas pipelines
- Major gas pipelines
- Projected gas pipelines
- Major oil and gas areas
- Oil pipelines
- Areas of high wind potential
- Wind turbines (in operation or projected)
- Coal reserves
- Projected hydro powerplants
- Projects to produce electricity from biogas
- Areas with high potential for electricity production from biomass

Source: Fifth National Communication of Republic of Belarus, 2009; Fifth National Communication of Ukraine, 2009; Second National Communication of Republic of Moldova, 2009; Pipeline Infrastructure Map of Europe and the CIS, The Petroleum Economist Ltd., London (→ www.petroleum- economist.com)

Trends by sector

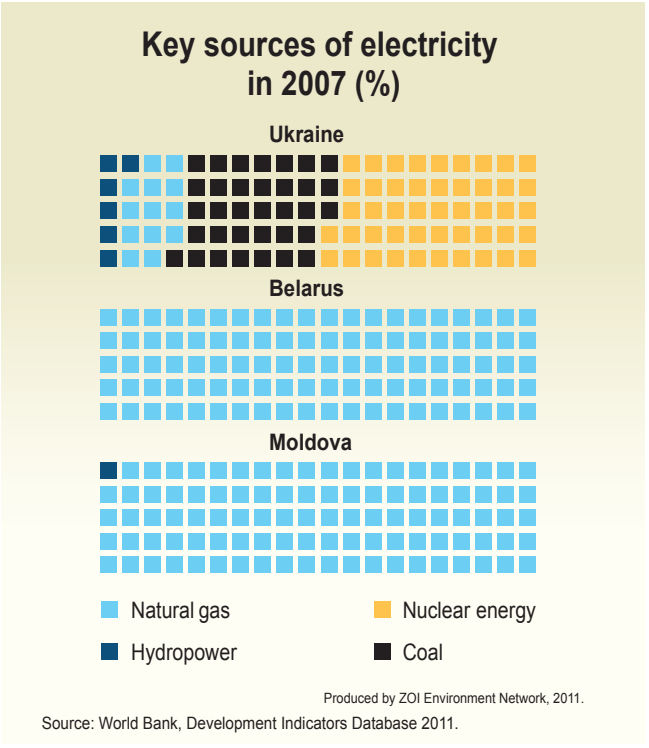
The economy of Eastern Europe is characterized by high energy intensity in relation to GDP. So the region's environment is likely to get worse as the economy develops and GDP grows. The countries of the region have planned for this challenge and are taking action.

According to the Belarus's Concept of Energy Security, the Government plans to reduce the energy intensity of GDP by 50% by 2015 and by 60% by 2020 from a 2005 baseline. The Strategy on Energy Potential Development in Belarus for 2011-2015 and for the Period until 2020 is another planning tool of the Government. Its implementation should result in a reduction in energy intensity of GDP, bringing Belarus closer to developed countries with a 2.5-3 times lower energy intensity (0.24 kg of oil equivalent per USD).

According to the Energy Strategy of Ukraine for the Period until 2030, consumption of energy resources per unit of production should reduce in such a way as to decrease the energy intensity of GDP by 26% by 2020 in comparison to 2007. In Ukraine, industry comes second in the share of GHG emissions after the extraction, production and consumption of energy. Between 1990 and 2007 the share of industry in total emissions was 13-25%, with the highest levels registered from 2001 to 2007, the years which saw the rapid recovery of the metallurgical and mining sector. GHG emissions from industry have reduced by 24% (from 128 million to 98 million tonnes of CO_2 equivalent) between 1990 and 2007.

Unlike Ukraine, in Belarus and Moldova the second place in GHG emissions belongs to agriculture. In 1990 its share in Moldova was 12% but in 2005 that had reached 20%. In the same year in Belarus emissions from agriculture reached 25% of total emissions.

GHG emissions from agriculture in Ukraine between 1990 and 2007 made up 7-14% of the total. The reduction of 70% in emissions from agriculture between 1990 and 2007 has been much more significant than reductions in other sectors. Emissions fell from over 100 to just 29 million tonnes of CO_2 equivalent. This fact is explained by a major decline in livestock, a reduction in the area of cultivated land and in fertilizer use, as well as changes in manure collection, storage and usage. In Ukraine manure is sometimes used as an alternative fuel. For example, since 2009 the Ukrainian Dairy Company in Kyiv oblast has been using a biogas plant that currently produces 635 kW of electricity and 662 kW of heat. It plans to increase capacity by 330 kW of electricity and 395 kW of heat.



Mitigation of impact on climate

All three countries have signed and ratified the United Nations Framework Convention on Climate Change that has as its main goal the stabilization of GHG concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system". All three countries are also parties to the Kyoto Protocol which commits industrialised countries to reduce emissions. Ukraine and Belarus are classified as countries with economies in transition and are included in Annex 1 of the Protocol, listing countries committed to reducing emissions to their 1990 level. Moldova, as a developing country, is not included in Annex 1[2].

The energy policy of these countries is focused on modernization, the development of production potential and infrastructure, diversification of energy resources, increased efficiency of energy use, greater use of local fuel, and alternative and renewable sources of energy. Measures also include the technical re-equipping and modernization of industry through the integration of advanced energy and resource saving, as well as the use of environmentally friendly technologies.

2 Depending on which Annex to UNFCCC countries are listed on, the Kyoto Protocol offers three market-based, "flexible" mechanisms to reduce emissions: emissions trading, the Clean Development Mechanism, and Joint Implementation. Ukraine and Belarus have the right to undertake emissions trading and JI projects; Moldova can use only the CDM. Yet unfortunately Belarus is not able to use the "flexible" mechanisms until it is also included in Annex B to the Kyoto Protocol, which provides for quantitative reduction obligations; the country is working hard to make this happen.

Belarus

The various GHG emissions reduction scenarios demonstrate that the country has only restricted potential to achieve low-cost action, and substantial financial investments are required. Belarus can not manage this investment on its own. If it were included in Annex B of the Kyoto Protocol then part of the funds could be attracted through CO_2 quota trading for the period 2008-2012.

UNECE and UNDP have both implemented several projects in Belarus with the aim of increasing energy efficiency and reducing GHG emissions through the use of timber as fuel. It is expected that emissions will be reduced by 12.8 million tonnes by these and other projects carried out between 2006 and 2010 to improve the efficiency of energy use, replace gas and fuel oil with local fuel and use alternative sources of energy. The exploitation of areas of high wind alone could guarantee 7-8 billion kWh of energy annually. This could replace 1.9-2 million tonnes of conventional fossil fuel. The experience of wind generation in the Minsk oblasts where turbines with a capacity of 270 and 600 kWh are working demonstrates the effectiveness of wind energy production in Belorussian conditions. In 2006, UNDP and the Global Environmental Fund (GEF) carried out a project entitled Biomass energy for heating and hot water supply in the Republic of Belarus. Its goal was to convert 100 boilers of various capacities from fossil fuel (peat) to wood waste. In recent years, a project to construct the first nuclear power station in Belarus has been developed, with mixed reactions.

Transport is another substantial source of GHG emissions. Between 1995 and 2008 the volume of passenger transport has fallen by 17%, while freight transport has doubled. Over the same period the total quantity of motor vehicles has risen from 1 to 3.5 million. A state programme in Belarus was implemented between 2006 and 2010 in order to combat the negative impact of transport on the environment.

Despite large-scale exploitation in the 1990s, plenty of peat-bogs have been preserved in Belarus. Peat bogs occupy 8% of the country's territory and are one of the most effective terrestrial ecosystems for capturing and storing atmospheric carbon. A project by UNDP, GEF and the Ministry of Forestry to restore wetland ecosystems in 17 disturbed and worked-out peat bogs with a total area of 40,000 ha could lead to the saving of 300,000 tonnes of CO_2 emissions a year and a decline in the number of peat fires.

Moldova

The Energy Strategy of the Republic of Moldova up to 2020 says that renewable sources should eventually provide 20% of total energy needs. Currently renewable energy provides around 3-4% with no significant improvement since the strategy was adopted in 2007.

However, Moldova has good experience of implementing projects devoted to the use of the renewable energy. In 2006-2007, six rural schools were equipped with boilers that use straw, while another project used biogas produced from manure for heating and electricity at a number of farms. These are isolated examples, but recently the similar programmes have begun under the auspices of international organizations including the World Bank and the European Bank of Reconstruction and Development.

Since 2010 Moldova has been a member of the Energy Community Treaty of the EU, which aims to integrate European legislation and standards in the sectors of energy production, transmission and consumption, energy efficiency and development of renewable energy. Moldova has also conducted negotiations to join the energy distribution system of the EU.

Ukraine

Production of electricity in Ukraine is expected to increase mainly due to the opening of new nuclear power plants, modernization of thermal power stations and an increase in the capacity of the distribution network. Besides, between 2015 and 2020 it is planned to connect the energy system of Ukraine to the distribution network of the EU. This will lead to a substantial increase in electricity exports as well as helping to improve the technical state of the energy system in Ukraine (with new investments in the sector). However, with Ukraine as well as Moldova adhering to the EU Energy Community Treaty, they will have to take into the account the requirements of the new energy strategy adopted by the EU at the end of 2010. This strategy foresees the expansion of low carbon fuel use and stricter requirements on the "cleanliness" of the electricity provided.

Ukraine has large shale deposits where natural gas could be extracted. In 2010 the Government started negotiations with western energy companies on the exploration and extraction of shale gas. This will not solve environmental problems as the extraction method causes water pollution, but it would reduce the dependence of the country on imported energy.

Among renewable and other alternative energy sources in Ukraine, biomass has the highest potential, followed by coalmine methane, wind and solar energy, and the production of hydroelectricity on small rivers. Only wind energy receives state support.

In 1998, GEF initiated a project to utilize coalmine methane in Ukraine but because the project progressed slowly due to a variety of factors, including Ukraine's failure to meet financial obligations, it was closed in 2000. Joint Implementation projects, including a revised coalmine methane project, have been carried out in Ukraine between 2008 and 2012. Total CO_2 emissions from the coalmines should be reduced by 18 million tonnes, though currently this figure is only 3 million. Methane emissions should fall by 9 million tonnes (5 million so far).

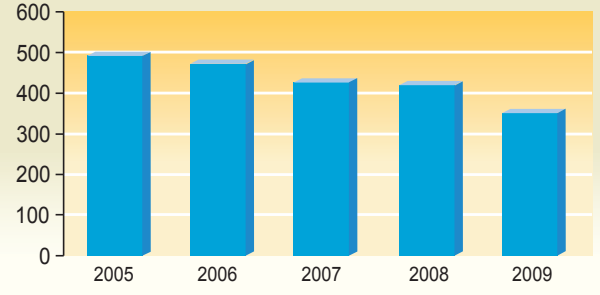
The potential of Ukraine's small hydropower stations

Total hydroelectric production in Ukraine is around 4.7 GW, of which 70% is generated by the four biggest hydropower stations on the Dnieper and Dniester rivers, with a total combined capacity of 3.3 GW. The share of production of Ukraine's small hydropower stations is about 28% of the total (12.5 billion kWh). Although small hydropower plants do not have a leading role in Ukraine's energy balance, in some areas and especially in remote rural regions they can potentially solve a series of problems. Small, mini- and micro-hydropower stations could largely solve the issue of energy supply in Western Ukraine, and in particular fully provide with energy a number of areas in Zakarpatska and Chernivetzka oblasts, at the same time protecting them from devastating floods.

Source: Fifth National Communication of Ukraine on Climate Change, 2009.

The first wind-power unit in the USSR, and at the time the biggest in Europe, was built in Crimea in 1931. Ukraine has significant resources for the development of wind energy, with a potential of about 30 billion kWh, saving 20-30 billion tonnes of conventional fuel per year. The areas with high wind energy potential include the coasts of the Azov Sea and the Black Sea, the southern coast of Crimea, the Carpathian and Crimean mountains, and the Donbas region. The National Energy Programme of Ukraine envisages the construction of wind farms with an aggregate capacity of 2,000 MW. It is planned that from 2015 alternative energy sources would produce 5 billion kWh of electricity and save around 2 million tonnes of conventional fuel. The potential for solar energy in Ukraine is around 17 billion kWh of thermal power a year giving the opportunity to save 2.5 million tonnes of conventional fuel per year. The south of the country has the most potential for solar energy.

Methane emissions in Donetsk oblast



Produced by ZOI Environment Network, 2011.

Source: State Department of Environment and Natural Resources in Donetsk oblast, 2011.

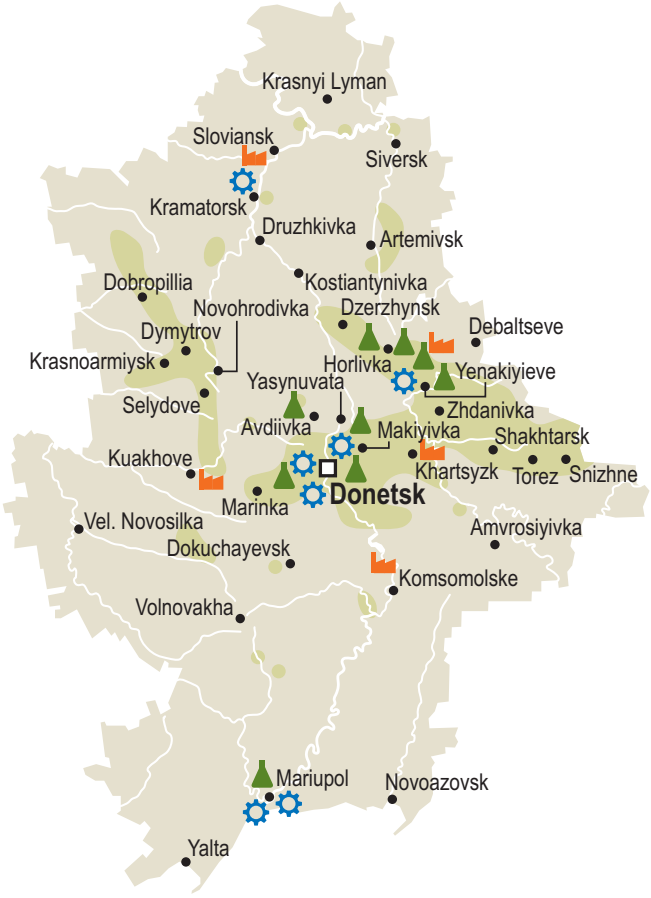
Donetsk, Ukraine © Alban Kakulya

Donetsk oblast and climate change

Donetsk oblast occupies only 4.4% of Ukraine's territory, but accounts for more than a half of the country's coal reserves and production of steel, coke and pig iron. One fifth of industrial potential is concentrated here with more than a thousand enterprises in the mining, metallurgical and chemical industries, the energy sector and heavy machinery. There are about 300 deposits of mineral resources. As a result around 78% of the industry in Donbas may be considered environmentally hazardous. The biggest share of harmful emissions into the air are of carbon dioxide, methane and sulphur dioxide. In 2009 methane emissions in the oblast totalled 350,000 tonnes, or about 42% of the total emissions in Ukraine.

A combination of modern resource-saving technologies and the introduction of automatic monitoring systems at enterprises in the oblast would lead to a decline in GHG emissions. Unfortunately, about 70% of large industrial enterprises are still not able to reduce GHG emissions in practice. Yet Zasyadko coalmine, the largest in Ukraine, is a positive example of the integration of new technology through the Kyoto Protocol's financial instruments. Equipment for methane utilization has been installed, and a co-generation power plant started operation as a result of contracts with Australian and Japanese companies. The system is also able to measure methane concentrations and the speed of their build up in the mine, helping to prevent accidents (20 to 55 miners annually die at the mine). Currently about 41 million cubic metres of methane are processed at the mine, and 194 million kWh of electricity and 168,000 Gcal of thermal energy produced. Other mines have also implemented methane utilization projects. Donetsk oblast has obtained official support for 25 joint implementation projects under the Kyoto Protocol, with a total volume of 33 million tonnes of carbon equivalent.

Source: Ministry of Environmental Protection of Ukraine, *The Land of our Concern*, Donetsk 2010.



Industry in Donetsk oblast

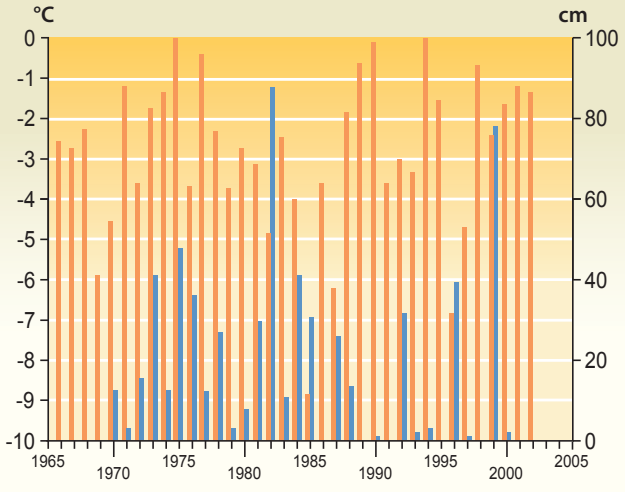
Thermal power plants
Coal and chemical industry enterprises
Metallurgical works
Mines, mining enterprises and open pits

Map produced by ZOÏ Environment Network, July 2011
Source: Ministry of Environmental Protection of Ukraine, *The Land of our Concern*, Donetsk 2010

Balyauka, Belarus
© Martin Roemers

Impacts of climate change and adaptation

Winter air temperature and snow depth in Ukrainian Carpathians



Produced by ZOI Environment Network, 2011.

Source: Carpathian mudflow station, Yaremche, Ukraine, 2011.

Impacts of climate change

According to World Bank research, due to the size of its territory and diversity of landscape Ukraine is more susceptible to the impacts of climate change than other Eastern European countries. Moldova and the south of Ukraine are the most vulnerable, whilst Belarus has the highest potential for adaptation.

Impacts of climate change can already be seen in the region today, primarily in the agriculture, forestry and water sectors. On the one hand warming has led to increased productivity by boreal forests, but against that there has been an increase in hazardous forest and peat fires, a disruption of the stability of ecosystems, replacement of some species, and a growing probability of population explosions among forest pests.

Over the last decade changes in the depth of snow cover and the irregularity of snowfall have been observed in the Carpathian mountains, the large tourist centre of Ukraine. It is now more common for snow to fall in November-December and then again in February after extremely strong frosts in January. The snow sometimes melts and then falls again in March. Strong cold spells in late spring have also become more common. Although no specific research has been done on the relationship between the number of tourists and snow cover at the ski resort of Bukovel, it appears that, so far, there has not been a significant decline in the quantity of tourists. Snow cannons are used if additional snow cover is needed. However, the resort is disrupted by winter rain which, as a consequence of climate change, has become more frequent over the last five years. This is potentially a real threat to the number of tourists in the Carpathians, and could in the long-term cause financial losses for local residents for whom tourism is the main source of income.

Agriculture and food security

Agriculture is an important component in the economies of Eastern Europe. It has the potential to become globally important. The sector employs about 17% of the working population of Eastern Europe (10% in Belarus, 17% in Ukraine and 33% in Moldova). Agriculture contributes between 9 and 15% to national GDP. Rising temperatures are likely to have a favourable effect on the development of agriculture in Belarus and in the north of Ukraine. At the same time, Moldova and southern parts of Ukraine will experience a negative impact with the provision of water, already a problem, becoming more acute.

It is also predicted that natural hazards will become more frequent in the Polesie, Prykarpattya and Zakarpattya regions. Over the last decade, catastrophic floods and high water have become the main threat to normal human activity in these areas.

Climate change impacts on agriculture

- Decreased yield of winter wheat
- Increased yield of winter wheat, potato and corn
- Increased yield of potato
- Decreased yield of early spring crops
- Possibility of growing cotton
- Decreased sugar content and reduced grape harvest for table wine
- Possible droughts

Map produced by ZOÏ Environment Network, July 2011
Sources: Fifth National Communication of Republic of Belarus, 2009; Fifth National Communication of Ukraine, 2009; Second National Communication of Republic of Moldova, 2009.

Belarus

In general, climatic changes will have a favourable effect on the agriculture of Belarus as it will be possible to grow new warm-season crops. However, negative impacts are also expected.

The most challenging weather events for agriculture in Belarus include: unpredictable precipitation with alternating periods of drought and rainfall; abnormally high or low temperatures; frost spells; thaw periods; ice bursts; thunderstorms, whirlwinds and gales; as well as a once continuous winter split into two distinct parts with a warmer period between, as has often happened in the last decade. There are grounds to suppose that the rise of the average annual air temperature will cause more frequent extreme heat and humidity levels that will have a negative impact on agriculture, with the yield of the main agricultural crops possibly declining by 50-60% or even more. The impact of weather conditions on agricultural crops is especially strong during the growing season, but the main yield loss of winter, orchard and green crops is related to mid-season abnormal weather conditions. The warmer winters that have happened more and more often over the last few years have already changed the conditions for winter crops. In the future, the likelihood of crops being damaged or killed by flooding, asphyxiation or snow rot may increase.

Climate change will have an impact on the flora, fauna and landscapes of Polesie: the area of wetlands will shrink, becoming partially overgrown by forest with the result that valuable flora and fauna species will disappear. There is a concern that Polesie may become an area where farming is increasingly difficult.

Moldova

Agriculture is the basis of the Moldovan economy. Over the last ten years its contribution to Moldova's GDP ranged from 11 to 15%. Over half of the country's population live in rural areas (59%) and more than 33% of the working population is employed in the agricultural sector.

The volume of agricultural production between 1991 and 2008 varied significantly from year to year. High levels were reached in 1993, 1997, 2004 and 2008, with lower production in 1992, 1994, 1996, 2003 and 2007. The catastrophic drought of 2007 affected 90% of the country and 80% of the rural population. Material injury to the economy of the country was around USD 1 billion, with major losses in agriculture: significant declines in yields of sweetcorn, sunflower, grain and other crops.

It is predicted that climate change will have a negative impact on the production of wheat, the crop that is the basis of the country's food security. Wine growing, also an important economic activity, may also experience the negative effects of climate change.

The expected higher frequency of droughts requires the establishment of a new system that will use restricted water resources efficiently. If measures to adapt agriculture to climate change are not taken and alternative sectors of the economy to engage the rural population are not developed, the level of poverty in rural areas of Moldova will rise and the rural population will decrease.

Ukraine

According to IPCC data the growth of productivity of agricultural crops is possible in Ukraine, but the higher concentration of carbon dioxide in the air would decrease grain quality (causing a lower content of nitrogenous matter and proteins), thus reducing the nutritional value of the products.

About one third of Ukraine's productive means and infrastructure are in agriculture, and the sector employs about a quarter of the working population and produces over 13% of GDP. According to data from the Hydrometeorological Centre of Ukraine, the productivity of winter grain can fluctuate from the norm by 20 to 50%, and of spring grain by between 35 and 75%, depending on the weather. In some years crop losses from changeable weather conditions can be up to 50%.

Until 1980 the loss of winter grains as a result of frost ranged from 15 to 30% of the harvest. Since then winter conditions have improved with the rising temperature, and current losses as a result of frost do not exceed 3-6%. The year of 2003 was an exception as the alternation of thaws and cold spells created a covering of ice on the fields that destroyed 70% of the crops.

Between 1991 and 2010, days without frost have come 15-20 days earlier in spring, and with frost 1-6 days later in autumn than between 1961 and 1990. Consequently the duration of the frost-free period has increased by 4-10 days in Polesie and the forest steppe, and by 17-26 days in Crimea and in the Dnieper lowlands. This stimulates the earlier growth of vegetation but increases the danger of late-spring cold spells for crops planted early.

The increasing intensity of droughts is related to rising air temperatures and the irregularity of rainfall during the growing season. Over the last 20 years, droughts have been twice as frequent in southern areas and in Crimea, where the population and economy are suffering from a shortage of water resources and the poor quality of drinking water. The tendency of droughts to become more prevalent in areas that used to have sufficient precipitation is quite worrying, as it can lead to a greater fragility of farming in these areas and even desertification.

River flow trends

Predicted change in annual river flow for 2071-2100 compared to 1961-1990

River basin borders

Source: European Environment Agency (→ www.eea.europa.eu/data-and-maps/figures/projected-change-in-mean-seasonal-and-annual-river-flow-between-2071-2100-and-the-reference-period-1961-1990)

Water resources: floods and high water

Apart from water supply problems in Moldova and in the south of Ukraine, the situation has been aggravated by an increase in floods. About 27% of the territory of Ukraine (165,000 square kilometres) and nearly one third of the country's population are in areas affected by them. The Carpathian mountains and foothills are the most vulnerable in this respect. Over the last 20 years, strong floods occurred in 1980, 1992, 1993, 1995, 1997, 1998, 2001 and 2008.

The catastrophic flood in July 2008 confirmed the most pessimistic predictions of the Ukrainian National Academy of Sciences, which said that after the flood of 1998 we should get ready for more dangerous natural hazards linked to abnormal water flows and hazardous geological processes. The flood of 2008 in Western Ukraine on the rivers Dniester, Prut, Siret and Tisza took the lives of 37 people. The zone of natural disaster in Zakarpatska, Ivano-Frankivska, Lvivska, Ternopilska and Chernivetska oblasts covered 41,000 houses, 334,000 hectares of agricultural land, 360 roads and 561 foot-bridges. The damage came to about USD 1 billion. In Moldova, officials said, the total damage was USD 120 million, 20% of it being damage to the road and transport infrastructure, 15% to agricultural land, and 65% to buildings and property.

A project to reduce vulnerability to extreme floods and climate change in the Dniester river basin started in 2010 under the Environment and Security initiative. The goal of the project is to reduce the risk from possible climate change impacts, identify the most problematic areas in river basins, and improve capacities for adaptation in Ukraine and Moldova.

The Pripyat

The Pripyat is one of the longest rivers in Europe and the main tributary of the Dnieper. The length of the Pripyat is 761 kilometres and the water catchment area is 121,000 square kilometres. The average annual discharge is 13 cubic kilometres. It is a transboundary river, with 57% of the river basin belonging to Ukraine and 43% to Belarus.

The Pripyat and its tributaries are characterized by their high flood frequency because of snow melt and high rainfall. On average, floods on the upper Pripyat happen every 2-3 years, and over the last 50 years 12 catastrophic floods have been recorded. These caused significant economic damage in both countries, including the destruction of buildings and the flooding of settlements, factories and agricultural land. People also lost their lives.

Detailed maps of flood hazards in the basins of two Pripyat tributaries, the Styr and the Prostyr, where floods pose a threat to Belorussian and Ukrainian villages, have been developed under the Environment and Security initiative. A NATO programme, Science for Peace and Security, has installed several automated stations along the rivers to monitor the water level and to provide early warning of possible floods on both sides of the border.

Source: UNEP (http://enrin.grida.no/pripyat) and NATO project documentation (http://www.nato.int.science/), 2011.

The Tisza

The Tisza (Tisa) is the longest tributary of the Danube. The river rises in the east of Ukraine's Zakarpatska oblast, and in some areas it forms Ukraine's border with Romania and Hungary. The length of the river is 966 kilometres (201 kilometres within Ukraine), the basin occupies 157,000 square kilometres (including 11,300 square kilometres within Ukraine), and the average flow is 800 cubic metres a second.

Over the last 60 years, more than 150 floods have been recorded in the Tisza basin, the major ones happening in May 1970, October 1974, July 1980 and March 2001. The reason for the catastrophic flood in spring 2001 was the powerful cyclone that resulted in 132 millimetres of rain and 70 millimetres of melt waters, more than 200 millimetres of precipitation in total within three days. The situation was worsened by the fact that the ground in the mountain areas was still frozen. The speed of the flood waters on the river was about 11 km an hour, and the water destroyed dams in Khust, Tyachiv, at the Palad canal and in the Hungarian village of Tarpa. More than 32,000 hectares, including 6,000 within Ukraine, were flooded.

High water in 2000 caused the accident at the goldmine at Baia Mare in Romania near the border with Ukraine's Zakarpatska oblast. The pollution of the river with heavy metals and cyanide led to extensive fish deaths: the fish were falling apart and their scales were peeling off in the hands of local fishermen.

Source: EU TACIS project Flood Management in Zakarpatska Oblast, 2006.

The Prut river, Ukraine
© Volodymyr Frygovych

The Black and Azov seas

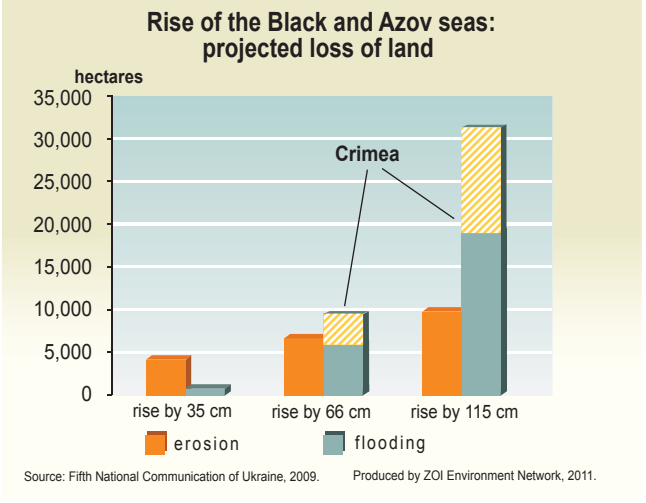
Global warming is expected to lead to an increase in the levels of the Azov and Black seas by between 22 and 115 centimetres by 2100. This will result in an intensification of coastal erosion, flooding, soil salinization and waterlogging along the Black Sea coast, and is likely to cause drastic changes in the estuary ecosystems of the Danube, Dnieper and Dniester.

A sea level increase of about 22 centimetres is considered most probable. If this happens, the coastal erosion would become stronger, although the coastline in general would be preserved. If the increase reached 115 centimetres, widespread action to protect coastal areas would be required to prevent drastic consequences. Those might include degradation of the Danube, Dnieper and Dniester deltas, destruction of 10,000 hectares of land, flooding of 19,000 hectares of coastal lowlands, increased water level in estuaries and near settlements, the complete disappearance of many resort villages, destruction of spits, salinization of all estuaries joining the Black and Azov seas and of thousands of hectares of agricultural land. It might also activate dangerous geological processes in Crimea and along the Black sea coast.

The speed of the increase in the level of the Azov sea in the 20th century averaged around 1.5+/-0.69 millimetres per year after taking into account tectonic movements. This corresponds to the overall trend in the rise of the world's oceans. Evidence of a significant reduction of ice in the Azov sea from 1978 to 2008 is provided by the available data such as the number of days when fast ice forms along the coast, its thickness, and the duration of the period when the sea is ice-covered.

Warming in the winter period has also led to changes in the ice regime in the north-western part of the Black sea. From 1986 to 2008 ice formation in the shallow areas and bays happened 1-5 days later and in the open sea up to two weeks later than it used to. Over the last 20 years there have been 5-8 fewer days with ice on the western and northern coasts and in the Dnieper-Buh estuary, and 24 fewer ice days in Karkinitskiy Bay.

Changes in the abundance of the main species of fish have already been observed. In the middle of the previous century about 50 species (including sturgeon, grey mullet, mackerel and halibut) were caught in the Black sea near the coast of Ukraine. Over the last 20 years most of the yield has consisted of pelagic species of sprat and anchovy, with other species providing only 2-5%. The volume of yield for most valuable commercial species has fallen two to three times and some have totally disappeared. The Azov sea, which used to be first in the world for its fish production, has now lost its industrial potential. The main factors that have damaged the ecosystems of the Azov and Black seas include constant pollution, overfishing, aggressive alien species, the physical destruction of fish habitats and the construction of reservoirs on the rivers. These factors have masked the possible impact of global warming on the marine ecosystems in the region.



Black and Azov seas coastline vulnerability

Potential inundated areas if water level rises:

by 2 metres

by 5 metres

Sea level increase in 1992-2007 (mm)

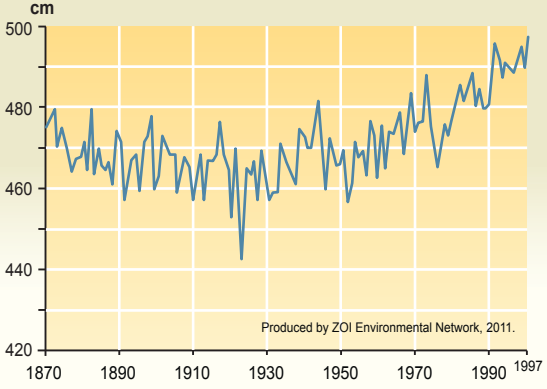
5 5.5 6 6.5

Industrial centres

Source: European Environment Agency (→ http://www.eea.europa.eu/data-and-maps/figures/sea-level-changes-in-europe-october-1992-may-2007)

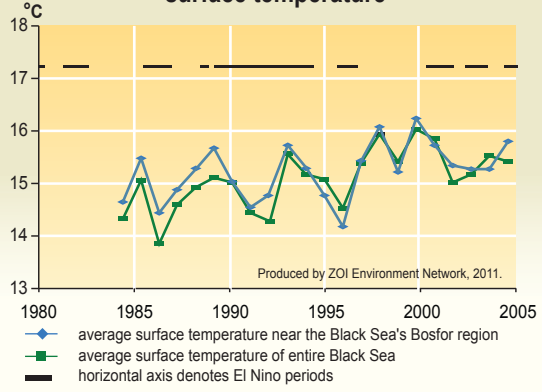
Black sea level changes

according to instrumental observations in Odesa



Source: Implications of Black Sea level rise in Ukraine, 2000.

Variability of average Black sea surface temperature



Source: Variability of surface temperature and the level of the Black, Marmara and the Aegean Sea from satellite measurements 2007.

Forestry

Climate change and the increase in the frequency of extreme weather events will change forestgrowing conditions and affect the physiological processes of forest flora and fauna. Assuming that a 1°C increase of temperature makes natural boundaries in the region move by 160 kilometres, and the fact that the average temperature in Eastern Europe has risen over the last decade by 0.3-0.6°C (and by 0.8°C over the last century), the movement of the borders of natural zones is already becoming a reality. This is demonstrated by the appearance of unfamiliar species of flora and fauna.

The rise in temperature also affects forest fires. For example, 90 fires were recorded in Moldova in 2007 during the catastrophic drought which affecting 683.3 hectares of forest. For comparison there were only 3-15 forest fires a year between 2000 and 2008 in Moldova.

Fires in the forests polluted by radiation after the explosion at the Chornobyl nuclear power station are of special concern. There were many forest fires in the exclusion zone after the catastrophe, with the biggest number (52) occurring in 1992 when 4,000 hectares were affected. The burning of timber on the territory polluted by radionuclides is an open source of ionizing radiation, whose products are easily carried by the wind for significant distances.

The widespread desiccation of spruce forests has been observed in the Ukrainian part of the Carpathians. This process can be related to a change of microorganisms present in forest ecosystem, caused in turn by climate change. Other researchers however suggest that the reason is the large-scale planting of spruce at the end of the 19th and the beginning of the 20th centuries in areas which used to be covered by beech forests. Beeches were replaced by spruce because the latter grows faster and is more profitable. The mass desiccation of spruce is a dangerous trend as dry forest is under greater threat of flash fires, diseases and pests. To cope with the problem, one would be well advised to remove spruce, which is not a characteristic species for this area, and to restore native beech and fir forests.

Impacts of climate change on forests and ecosystems

- Forest
- Reduced area of spruce
- Degradation of black alder and ash forest
- Overgrown by shrubs
- Desertification
- Drying of spruce
- Subtropical thorn woodlands
- Increasing forest productivity, especially birches, pines, spruces, oaks and ashes
- High water and floods
- Increase in forest fires

Map produced by ZOÏ Environment Network, July 2011
Sources: Fifth National Communication of Republic of Belarus, 2009; Fifth National Communication of Ukraine, 2009; Second National Communication of Republic of Moldova, 2009;
Global Land Cover 2000 database. European Commission, Joint Research Centre, 2003
(→ http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php)

The health of people

Changes in the environment can cause an increase in cardio-vascular, respiratory, infectious and other diseases, and cancer. Higher levels of precipitation and excess moisture in the soil can create conditions ideal for malaria and other mosquito-transmitted infections. Changes in air temperature can provoke fungal diseases. High temperatures in summer 2010 caused the number of dermatological diseases in Europe to increase, in Eastern Europe by 25% compared to 2009.

The habitat boundaries of the carriers of infectious diseases characteristic of warmer and more humid climates are moving northwards. For example, a longer hot season makes ticks more active, and hastens the spread of the infections they carry. Changes in temperature can provoke the appearance of new diseases.

Abnormally high temperatures are the most dangerous for elderly people, children and those suffering from cardio-vascular problems.

Adaptation

A balanced state policy of adaptation to climate change and the implementation of related measures are required to ensure the economic and environmental stability of the region. The table below presents some possible priority actions. The data have been taken from official sources, and expert opinions have been used where no data were available.

The practical development of adaptation plans has hardly started in any country of Eastern Europe, to say nothing of their implementation. International experience has shown that the development and implementation of effective adaptation measures, and even research for their scientific, technological and economic justification, requires significant financial resources. In the short term the allocation of sufficient financing for these goals without the use of international mechanisms is very unlikely in the countries of the region[3].

Adaptation requires long-term investment options in a situation of high uncertainty – explained by the absence of agreement on future regional climate change as current science is able to predict only the probability of hazardous weather events, not their actual occurrence.

Above all, adaptation requires political support and legislative provision. At the moment, the lack of both can be linked to the fact that there are many other priorities for governments, including urgent economic issues, and that awareness of the real hazards that will be caused by climate change remains poor.

3 Considering the transitional character of Eastern Europe's economies, the states are often unable to finance the activities they plan fully, or indeed at all. For example, the Climatic Programme of Ukraine in 1998-2002 was intended to define the main causes and consequences of climate change in the regions of Ukraine and to create the scientific basis for assessing the possible impacts of regional climate change on natural resources, economic development and the environment. However the actual funding provided for programme implementation was about 16% of the required amount, and the lack of funds has left many of the programme's objectives unfulfilled.

Priority actions on climate change adaptation in the countries of Eastern Europe

SECTOR	POLICY AND MEASURES	COUNTRIES		
		BELARUS	MOLDOVA	UKRAINE
AGRICULTURE	Upgrading agrometeorological monitoring network	■		■
	Risk insurance	■	■	■
	Introduction of environmentally safe plant protection agents	■		■
	Studies for expanding irrigated farming	■	■	■
	Modernization of irrigation systems	■	■	■
	Introduction of drought-resistant species and varieties	■	■	■
	Earlier spring-sowing time	■		
	Control of erosion and the use of low-productivity soils		■	
FORESTRY	Expansion of forest area		■	■
	Pest control and increasing the resilience of forest ecosystems	■		
	Reduction of risk of forest fires	■		
	Adaptation of forest management to changing natural boundaries	■		■
	Improved protection, restoration and use of forests	■	■	■
	Adaptation of forests to law or excessive moisture	■		
WATER	Upgrading hydrological monitoring networks	■		■
	Introduction of basin principles in water management		■	■
	Integrated flood protection	■	■	■
	Systematic afforestation in river basins	■		■
	Studies for constructing underground water reservoirs	■		
	More efficient use of available water resources	■	■	
	Broad introduction of water-saving technologies	■	■	
ENERGY	Implementation of energy-saving measures		■	■
	Increased share of local, alternative and renewable sources of energy	■	■	■
	More efficient use of fuel and energy resources	■	■	■
	Development of energy infrastructure and the diversification of energy supply	■	■	
TRANSPORT	Economic motivation of environmentally-friendly transport			■
	Upgrading transport infrastructure		■	
HEALTH PROTECTION	Upgrading health-care infrastructure			■
	Development of adaptation to extreme weather events and urgent responce capacities		■	

Sources: Fifth National Communication of the Republic of Belarus, 2009; the Action plan on mitigation and adaptation of the economy sectors to climate change in Moldova for 2009-2013, expert data.

Produced by ZOI Environment Network, 2011.

Environment and security issues related to climate change in Eastern Europe

Water resources

Food security

Biodiversity

Social issues

Soil and water

Soil salinization, the need for new irrigation systems, shortage of water, reduction of drinking water quality

Impact on livelihoods, competition for water

Sea and coastal area

Sea level increase, salinization of coastal areas, coastline changes, soil salinization, inadequate safe drinking water supplies, reduction in quantity and diversity of marine products, deteriorating conditions for tourism in the Azov and Black Sea regions, the Crimea and the Danube

Impact on livelihoods, worsening border conflicts and land disputes

Floods and high water

Catastrophic floods, mud slides, bank erosion, flooding of settlements (especially in lower reaches), pollution hazard by heavy metals, cyanide and radionuclides (Polesie, Carpathians mountains and foothills)

Impact on livelihoods, threats to the health and lives of people

Local and transboundary problems, social tension

Forests, flora and fauna

Displacement of natural boundaries, reduction and replacement of valuable timber tree areas by low value species, reduced sustainability and productivity of forests, increase of forest pests

Increase of forest fires (including on radioactively polluted territories)

Reduction and extinction of wetland, steppe and high-mountain species
Impact on livelihoods, damage to economy and people's health

Agriculture

Droughts, natural disasters, soil degradation, yield loss, increased risk of farming in some areas, reduced nutritional value of products , temporary increase of yield , displacement of boundaries and appearance of the new climatic zones

Impact on livelihoods and food security

Economic losses

Social issues

Climate-induced migration to Eastern Europe in transit to EU; long-term (e.g., due to shortage of water) and short-term (floods) displacement of people

Deterioration of people's health (infections, cardio-vascular diseases, heat stress)

Social tensions, threats to people's lives and health

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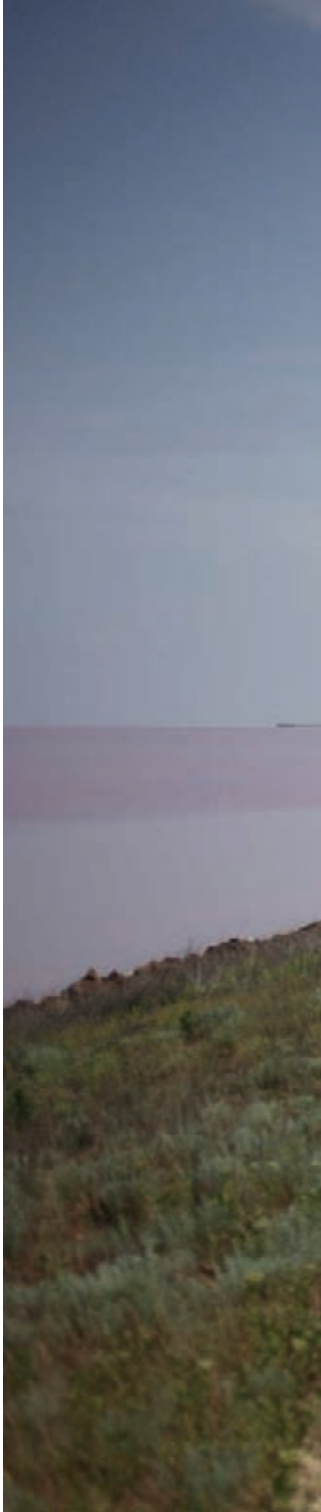

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