Strategic Framework for Adaptation to Climate Change in the Dniester River Basin

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This publication has been prepared within the context of the project 'Climate Change and Security in Eastern Europe, Central Asia and the Southern Caucasus' as part of the component 'Climate Change and Security in the Dniester River Basin'. This effort is also part of the UNECE programme of pilot projects on adaptation to climate change in transboundary basins.

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The Environment and Security Initiative (ENVSEC) transforms environment and security risks into regional cooperation. The Initiative provides multi-stakeholder 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), and the United Nations Environment Programme (UNEP). 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 BY THE REPUBLIC OF MOLDOVA

The Strategic Framework for Adaptation to Climate Change in the Dniester River Basin was prepared under the Environment and Security Initiative (ENVSEC) with financial support from the Austrian Development Cooperation and the European Union Instrument for Stability. The Framework was reviewed at various stages by the Ministry of Environment of the Republic of Moldova, with the participation of experts from the Moldovan Water Agency (Apele Moldovei), as well as the State Hydrometeorological Service and the Academy of Sciences of Moldova. In this connection, the Ministry of Environment of the Republic of Moldova, , wishes to express its agreement in principle with the approach and process employed in the development of the Strategic Framework, as well as its approval of the outcome of these efforts.

Within the context of adaptation to climate change at the basin level, problems directly related to the aquatic environment and changes in the water regime are of utmost importance and have the greatest urgency. Among all of the problems linked to climate change in the Dniester basin, the participants in consultations held within the framework of the bilateral Working Group on Flood Management and Climate Change Adaptation in the Dniester Basin assigned top priority to problems related to changes in the water regime, degradation of soil and agricultural land, as well as the consequences of climate impacts on human health and the water supply.

One of the critical impacts of climate change in the Dniester basin is a probable change in the volume and seasonal distribution of the water flow. Flooding in the basin is already causing significant losses for the economy and population of the Republic of Moldova, including the loss of human life. Catastrophic floods in 2008 and 2010 provided yet another reminder that the existing flood protection system is performing its functions only in part. As research performed in connection with the drafting of the Strategic Framework shows, further changes in the climate will most likely lead to a rise in the intensity and uneven distribution of precipitation – particularly heavy rains – accompanied by an increase in high water levels in the Dniester river.

At the same time, the document notes that the Republic of Moldova and Ukraine do have some – and in certain respects significant – resources for adaptation to climate change. Important mechanisms for adaptation in the sphere of water resources include the complex of hydraulic engineering installations on the Dniester river and flood control levees built along both banks of the river, primarily below the Dubasari reservoir. The Republic of Moldova has approved the Climate Change Adaptation Strategy, the Water Supply and Sanitation Strategy and the Programme for Development of Water Resources Management and Water Conservation. Optimization of the use of such instruments in the interests of the basin, including further development of the flood protection infrastructure and maintenance of this system in good working condition, is an important part of the document’s recommendations.

Another important adaptation mechanism is the performance of observations for state-of-the-art monitoring and forecasting of hydrometeorological processes in the Dniester basin. Specifically, the hydrometeorological services should have the technical ability to receive and transmit to neighbouring countries information about the threat of emergencies in the basin even in their initial stage. An example of the possible implementation of this sort of approach over the long term is the creation of a single system for the observation of precipitation (including the use of weather radar) and early warning of flood hazards through the forecasting of heavy rainfall in the basin. Further automation of monitoring, improvements in hydrological forecasting and enhanced data sharing in the Dniester basin are high priorities today for adaptation efforts.

The development of a common methodology for the assessment and recording of water resources in the Dniester basin, along with the calculation of the current and long-term water balance, are also necessary for the improvement of joint water resources planning by the Republic of Moldova and Ukraine, taking into account climate change.

As climate change becomes more pronounced, up-to-date ecosystem-based approaches to adaptation have an increasingly important role to play. These approaches include concern for the most vulnerable natural complexes (for example, floodplain meadows in the Dniester delta that are suffering from disruptions in water exchange with the main channel of the Dniester below the levee of the Mayaki-Palanca highway) and setting aside sections of the floodplain for flooding during high water levels in the Dniester.

The rapid entry into force of the Treaty between the Government of the Republic of Moldova and the Cabinet of Ministers of Ukraine on Cooperation in the Field of Protection and Sustainable Development of the Dniester River Basin is of particular importance in this regard, along with the approval of rules for the operation of the Dniester reservoirs.

This document, in our view, offers a comprehensive synthesis of the results of research performed and experience in the implementation of projects related to climate change in our region and is in line with the Republic of Moldova's Climate Change Adaptation Strategy and complements it. We believe that successful implementation of the recommendations contained in the document by the countries in the basin will make a contribution not only to the prevention and mitigation of adverse impacts of climate change, but also to the strengthening of stability and sustainable development in the Dniester basin as a whole. It should also help to improve transboundary cooperation among specialized organizations, not just in the area of water resources, but also in the areas of environmental protection, agriculture, energy and other key economic sectors of Moldova and Ukraine.

Further, we expect that the practical implementation of the Strategic Framework for Adaptation will play a useful role in promoting the efforts by the Republic of Moldova to meet the commitments it has made under the Association Agreement with the European Union, which was ratified last year.

Sergiu Palihovici
Minister of the Environment
Republic of Moldova

FOREWORD BY UKRAINE

Climate change is causing significant shifts in the distribution of water resources over space and time, and this in turn is leading to a massive increase in the scope and frequency of natural hazards.

Over recent years Ukraine has felt the full force of consequences arising from changes in the hydrological regime of rivers – there has been an increase in both the number of natural disasters and in the costs associated with recovery. At the same time, there has also been an increase in the frequency and duration of droughts that are causing serious losses for the population and virtually all sectors of the economy. Adaptation to climate change is therefore not only a social imperative, but an economic one as well.

Ukraine and Moldova are united not just by common borders and a long history of friendly ties, but also by the Dniester River basin, whose waters serve as a life-giving resource for more than 10 million people in the two countries. Some 7 million of these people live within the basin itself. Considering the transboundary status of the Dniester basin, we welcome the activities of the Environment and Security Initiative, under which efforts were undertaken to prepare the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin, with a view to coordinating adaptation measures and also bringing in stakeholders to participate in adaptation measures at all levels. International cooperation in the Dniester basin has already produced tangible results. A number of projects have been completed, and the results are being incorporated into the practical activities of water management, environmental protection and other organizations.

Ukraine views the following as top priorities in the context of ensuring sustainable development: cooperation with reputable international organizations such as the United Nations Economic Commission for Europe, the Organization for Security and Co-operation in Europe, and the United Nations Environment Programme; expansion of the geography of international cooperation; and the establishment of direct contacts with governmental and non-governmental foreign partners. Joint work within the Dniester basin under the Climate Change and Security in Eastern Europe, Central Asia and the Southern Caucasus project offers such an opportunity and provides a new impetus for the further strengthening of professional ties with colleagues from the Republic of Moldova. The implementation of concrete adaptation measures also helps to reduce the risk that conflicts will arise in the process of coordinating flood and drought forecasting, prevention and recovery activities in the basin, as well as activities related to the use and distribution of scarce water resources.

The interests of all of the stakeholders in the water resources management and environmental sector were taken into consideration in the discussion of the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin and in the introduction of concrete adaptation measures. The priorities that were chosen are those that will have a truly practical impact, including an impact on management decision-making.

They will also help to improve the ecological status of the basin and the living conditions for people on the banks of our common river. The Ministry of Ecology and Natural Resources of Ukraine endorses the outcome of the development of the Strategic Framework for Adaptation and it is planning to apply these results in its own work.

Last year was an important year for Ukraine, since our country, like the Republic of Moldova, signed and ratified an Association Agreement with the European Union. The agreement covers a broad range of issues, including issues related to climate change and the protection and sustainable use of water resources; it also provides for a number of strict commitments, including deadlines for compliance with them.

We are grateful for the support provided by the United Nations Economic Commission for Europe and the Organization for Security and Co-operation in Europe within the context of this project, and we see it as an important contribution to the fulfilment of Ukraine's commitments to deepen cooperation with the European Union.

Igor Shevchenko
Minister of Ecology and Natural Resources
Ukraine

FOREWORD BY UNECE AND OSCE

The picturesque Dniester River is one of the most important transboundary rivers in Eastern Europe. The Dniester originates in the Ukrainian Carpathians and flows through the Republic of Moldova before it again reaches Ukraine near the Black Sea.

Starting in 2004, at the request of both riparian countries, the Organization for Security and Co-operation in Europe (OSCE) and the United Nations Economic Commission for Europe (UNECE) have supported the development of cooperation on the river. The bilateral negotiations for a Dniester River basin treaty to strengthen transboundary cooperation on conservation and sustainable development in this river basin were initiated in 2008. After four years of negotiations and dialogue, with the involvement of a wide range of stakeholders and the continued support of OSCE, UNECE and the United Nations Environment Programme (UNEP) within the framework of the Environment and Security Initiative (ENVSEC), the Treaty on Cooperation on the Conservation and Sustainable Development of the Dniester River Basin was signed by the Republic of Moldova and Ukraine in November 2012 at the sixth Meeting of the Parties to the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention).

Effective transboundary cooperation is crucial to address the frequent floods and droughts in the basin and will become even more important in the future, as climate change is expected to affect the volume and seasonal distribution of the river flow, to increase the frequency and intensity of floods and droughts and lead to the challenges associated with water scarcity, including the deterioration of water quality and ecosystems in the Dniester basin. Such impacts pose a potential risk to the security of the 7 million people living in the river basin and the more than 3 million people outside the river basin who rely on the water from the Dniester.

Within the framework of ENVSEC, and as part of the UNECE programme of pilot projects on climate change adaptation in transboundary basins under the Water Convention, UNECE and OSCE are supporting the Republic of Moldova and Ukraine in addressing these challenges, among others, through the development of the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin with the involvement of a broad spectrum of governmental and non-governmental stakeholders in both countries. The Strategic Framework will support the countries in their joint action to reduce climate change risks at basin level, to substantiate and rank priority investment needs for the river basin in the context of climate change and to enhance transboundary cooperation in general.

The Strategic Framework was developed within the framework of the project “Climate Change and Security in Eastern Europe, Central Asia and the Southern Caucasus” as part of its Dniester component. We express our sincere gratitude to the European Commission that has supported the project through the Instrument for Stability (IfS) and the Austrian Development Cooperation for their generous contribution as donors of the project.

We hope that the translation of the Strategic Framework into action will significantly enhance the adaptive capacity of the Dniester basin, contribute to the implementation of the new Dniester Treaty following its entry into force and facilitate the implementation of the European Union Water Framework Directive and other relevant international commitments of both countries.

Marco Keiner
Director, Environment Division
UNECE

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Coordinator of OSCE
Economic and Environmental Activities

EXECUTIVE SUMMARY

The Strategic Framework for Adaptation to Climate Change in the Dniester River Basin is the result of joint efforts by international experts and organizations – the United Nations Economic Commission for Europe (UNECE) and the Organization for Security and Co-operation in Europe (OSCE) – and experts and organizations from Moldova and Ukraine with an interest in the protection and sustainable use of natural resources in the transboundary Dniester River basin under the conditions of a changing global climate. The work, which was performed in 2013–2015 with support from the European Commission and the Austrian Government, drew on previous results and experience in the Dniester basin, with the participation of partner organizations of the Environment and Security Initiative.

This document is based both on numerous publications in the countries themselves and abroad, and on research organized specifically for this purpose regarding the potential impact of climate change on the natural environment and economy of the basin. Regular consultations among experts from Moldova, Ukraine and international organizations through the bilateral Working Group on Flood Management and Climate Change Adaptation in the Dniester Basin also played a major role in the preparation of the report.

The Strategic Framework for Adaptation brings together the data available today on the current and possible future trends in climate change in the Dniester basin, which are characterized in general by higher air temperatures in the basin, drier conditions in the southern part of the basin and increased intensity and more uneven distribution of precipitation. One can assume, with a fairly high degree of probability, that these shifts will aggravate problems with the aquatic environment that already exist: periodic and increasingly frequent floods caused by catastrophically high water levels; a decline in the flow of water available for use in parts of the basin that are not directly connected to the main channel of the Dniester; a deterioration in water quality and a worsening of adverse impacts on the basin's ecosystem.

On the other hand, the existing natural, technical and organizational capacities of the basin for adaptation to climate change, given their reasonable and appropriate use, will make it possible to neutralize the undesirable trends to some extent. The system of reservoirs on the Dniester has a special role to play here: although they frequently have a contradictory impact on the environmental condition of the basin, the reservoirs nevertheless could become an important instrument for its adaptation to climate change. The natural potential of the basin's ecosystems, especially in the middle and lower reaches of the Dniester, could also be used for effective adaptation. This will require, however, constant and closer attention to the protection and restoration of vulnerable natural complexes. Finally, the ratification and entry into force of the Treaty on Cooperation on the Conservation and Sustainable Development of the Dniester River Basin should promote fuller realization of the potential offered by cooperation between Moldova and Ukraine for the joint resolution of problems in the basin.

On the basis of research and extensive consultations, the Strategic Framework for Adaptation offers a set of measures, the joint and coordinated implementation of which will make it possible to respond to the coming changes in a timely manner and even to get out ahead of the process. Some of the proposed measures can be implemented effectively only in coordination with other existing processes and programmes and those that are being planned – at the sector, national, interstate and international levels. The Implementation Plan, which supplements the Strategic Framework for Adaptation to Climate Change in the Dniester Basin and elaborates upon it in more concrete detail, will be devoted to an analysis and optimization of this coordination process.

01. INTRODUCTION

When research began in 2009 on how future climate change might affect the situation in the Dniester basin, there was little comparable work under way elsewhere in the world. Discussions about specific considerations related to climate change adaptation in basins of transboundary rivers were just beginning in the scientific community and at international forums, and the Dniester basin was one of the first included within the framework of UNECE pilot projects. This work was also supported by the OSCE, which has been working with UNECE since 2004 to strengthen transboundary co-operation in the Dniester basin.

Thanks to the initiative of the countries in the basin – Moldova and Ukraine – and numerous stakeholders from both countries, as well as systematic support from international organizations and donor countries, today, five years later, the Dniester remains one of the leading experimental sites for studying problems and solutions in the area of adaptation of transboundary river basins to climate change. Moldova and Ukraine have succeeded in gaining unique experience in the joint analysis of problems, and in seeking concrete solutions and putting these solutions into practice. This experience is broadly relevant, and the results of the work have already been presented a number of times at international events, from Geneva and Vienna to Nairobi and Buenos Aires.

As a result of the joint work, a strong community of organizations and experts has been created. They have an in-depth understanding of the topic and are prepared to help address the relevant problems at various levels: at the city, district and oblast levels; in sectors of the economy and social life; at the national level and at the level of the entire basin as a whole. An ongoing dialogue about the problems of climate change in the Dniester basin is helping to bring about mutual understanding in a broader context as well, including critical issues related to optimization of the operation of the Dniester reservoirs and ratification of the Treaty on Cooperation on the Conservation and Sustainable Development of the Dniester River Basin that was signed by the Government of the Republic of Moldova and the Cabinet of Ministers of Ukraine in Rome in 2012.

The purpose of this document, the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin, is to present the current vision of the countries in the basin, and to support and guide their joint actions with regard to:

- Understanding the basin as a single ecological system in the context of climate change and other types of impacts on water resources;

- Fulfilment of international commitments under the United Nations Framework Convention on Climate Change, the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes and other international agreements;

- Alignment of national adaptation plans , integrated management of sections of the basin and other similar management tools in the field of adaptation to the maximum extent possible with the demands of transboundary climate change adaptation, while avoiding “unilateral” adaptation to the detriment of other countries and parts of the basin;

- Validation and establishment of a hierarchy of investment needs for management of the transboundary Dniester basin in a changing climate, using governmental and other resources, as well as international cooperation mechanisms;

- Measures to promote improved management and transboundary cooperation in the basin as a whole.

The Strategic Framework for Adaptation takes into account the views of a broad range of stakeholders in Moldova and Ukraine, which were obtained through regular consultations with representatives of various agencies, organizations, sectors of the economy, groups and territories within the basin. The consultations were supplemented by an ongoing sharing of ideas and experience and review of the document in the process of its development.

The Strategic Framework for Adaptation to Climate Change in the Dniester River Basin has received the support of environmental protection and water resources management agencies and organizations in Moldova and Ukraine, and it was drafted with their participation. The organizers of the process hope that the document will become an informal guide for the strategic planning of joint work in the basin over the coming years and decades, and that it will become part of the action programme of the future Commission on Sustainable Use and Protection of the Dniester River Basin. The recommended approaches and results will also find a place in the integration of actions by Moldova and Ukraine with the policies of the European Union, including the EU Strategy on Adaptation to Climate Change that was adopted in 2013.

02. ENVIRONMENT OF THE DNIESTER BASIN: STATUS, PROBLEMS, OUTLOOK

The content of this reference chapter has been drawn largely from previously published materials, both surveys that have already become classics[1], as well as new publications, including those prepared within the context of this work[2]. References to many of them and a large volume of additional information are also available at the www.dniester-basin.org website, which is devoted to transboundary cooperation in the Dniester basin.

Geography and natural environment

The Dniester is one of the largest rivers in Ukraine and it is the largest river in Moldova; together with the Danube, the Dnieper and the Southern Bug it is part of the Black Sea basin. The overall length of the river is 1,350 km, and the surface area of the basin covers more than 72,000 km^2. The source of the Dniester is in the Carpathian Mountains at an elevation of 911 metres above sea level and the river flows into the Dniester Estuary, an inlet of the Black Sea, which is separated from it by a narrow spit. To the north-west the Dniester basin borders on the Vistula basin; to the north it is bounded by the Dnieper basin; to the south-east it shares a border with the Southern Bug basin; to the west and south-west it borders on the Danube basin, together with the Tisza, the Prut and small tributaries; and to the south it is bounded by the basins of small rivers that flow into the Black Sea.

The geological structure of the Dniester basin is complex, and in certain places the channel of the river cuts through rock of various ages and origins – from crystalline formations to loess, clay and limestone. Based on the nature of the rivers feeding into it, the water regime and topographical features, the course of the Dniester is divided into three parts: the mountainous Carpathian section (which accounts for approximately two-thirds of the river's annual flow); the Podolia section in the middle reaches of the river, with steep slopes and developed meanders; and the flat section near the Black Sea with branches (including the Turunchuk River), lakes and vast floodplains that are regularly inundated and are a valuable natural asset. One of the distinctive features of the Dniester's hydrographic network is the lack of large tributaries and the presence of a great number of small tributaries (more than 14,000 tributaries under 10 km in length). There are also 65 reservoirs in the basin, along with more than 3,000 ponds. The reservoirs include the Dubasari in Moldova and the hydroelectric power complex located farther upstream on the border between Ukraine and Moldova (see map), consisting of the main reservoir and buffer reservoir of the Dniester Hydroelectric Power Plant (HPP) and the filling reservoir of the pumped-storage HPP. Construction of the reservoirs that are part of the Dniester hydroelectric power complex significantly altered the ecological conditions in the basin, and from this standpoint they can be viewed as an additional border within the boundaries of the basin.

The mean water flow in the Lower Dniester is 311 m^3 per second and the mean annual flow is about 10 km^3. Approximately 60 per cent of the river's annual flow occurs in the summer and autumn, with 25 per cent occurring in the spring due to snowmelt and 15 per cent coming in the winter, primarily from seepage flow. The Dniester's flooding cycle is one of its distinctive features, with up to five floods occurring each year, when the water level in the river can rise by 3 to 4 metres, and sometimes more. The largest range of fluctuations in the water level – up to 9 or 10 metres – is seen at the Zalishchyky station above the Dniester reservoir. The maximum flow rates in the Dniester occur both in spring and summer, but the flood flows are considerably higher than the high-water flows: the largest flow of 8,040 m^3 per second was recorded at Zalishchyky in September 1941. The minimum flows typically occur during the winter low-water season and in September–October.

[MAP on page 16]

Following the construction of the Dniester reservoir, an environmental flow with a capacity of 80 m^3 per second has been established (2.4 billion km^3 per year)[3].

The natural ecosystems in the Dniester basin are comprised of forest, steppe and floodplain complexes. The best preservation of terrestrial vegetation can be seen in the Carpathian Mountains, where fir and mixed forests are predominant in the mountainous regions and deciduous forests are common in the foothill areas. In the rest of the basin, which is mostly flat and is covered by grey forest soils, black earth soils (up to one metre deep in Moldova) and in the arid south, chestnut soils, the natural vegetation has been only partially preserved. Hornbeam and oak forests are found in Podolia and Moldova; shrubs are widespread in the river valleys; "gully" forests, with mostly oak trees, have been preserved in the ravines in the steppe zone and at the mouth of the Dniester. Poplar and willow trees are common in the floodplains, which are covered with grasses. The average percentage of forestland in the basin is 14 per cent in Ukraine (reaching about 30 per cent in Chernivtsi Oblast) and 9 per cent in Moldova (forests cover more than 24 per cent of the land in the Kodry uplands, while the Balti steppes and the southern part of the left bank of the Dniester have the least amount of forest cover).

There are three regions in the basin that have the highest degree of biodiversity: the Khotyn Hills in Ukraine's Chernivtsi Oblast; the Unguri-Holosnita wetlands in northern Moldova and the adjacent areas in Ukraine; and the lowlands near the mouth of the Dniester. In addition to the steppes and predominantly mountain forests, the Dniester floodplains also provide habitat for a large number of rare and endangered species of plants and animals, including many species of birds. The significant ecological integration of Moldovan and Ukrainian lands within the basin is worth noting. Many of the protected species of birds (the glossy ibis, herons) that nest in Ukraine feed in the fields and pastures of Moldova, for example. The spawning grounds of fish populations in the Lower Dniester are in the Moldovan part of the river, while the mouth of the river, which is in Ukraine, is their main feeding area. One of the world's important corridors for the transboundary migration of migratory birds is along the Dniester and for this reason a large part of the delta and the Unguri-Holosnita section mentioned above have been entered in the List of Wetlands of International Importance[4].

Population, economy and politics

Of the total area of the Dniester basin, 73 per cent is within the borders of Ukraine, almost 27 per cent falls within the borders of Moldova and less than one-half of one per cent (232 km^2 in the upper reaches of the Strvyazh River, a left-bank tributary of the Dniester) belongs to Poland. In Ukraine, the basin takes in a significant part (between 13 per cent and 80 per cent) of the territory of seven oblasts (Lviv, Ivano-Frankivsk, Chernivtsi, Ternopil, Khmelnitsky, Vinnytsya and Odesa). In Moldova, the basin covers a large portion (59 per cent) of the country's territory (19 districts and the Transdniestrian region are entirely or partially within the Dniester River basin). There are 62 cities in Ukraine that are located within the basin (including the oblast centres of Lviv, Ivano-Frankivsk and Ternopil, and the industrial cities of Drohobych, Boryslav, Stryi, Kalush and Stebnyk), as well as 95 urban-type settlements. In Moldova there are two municipalities and 41 cities (including Chisinau, Balti, Soroca, Orhei, Ribnita, Dubasari, Tiraspol and Bender) within the basin. Some 7 million people live within the Dniester basin, and more than 5 million of them are in Ukraine. The population is comprised of various ethnic groups. Outside the basin itself, another 3.5 million people use water from the river, including residents of Chernivtsi and Odesa.

In economic respects, the upper part of the Dniester basin in Ukraine is home to a diversified economic complex, with a high concentration of enterprises in mining and extraction industries (potash, sulphur, natural gas, oil, building materials), the chemical industry, oil refining, machine building, the food industry and light industry. Forestry also plays an important role. In Moldova, the food industry and light industry are predominant, and there are also machine-building and metalworking operations, as well as chemical manufacturing and building materials enterprises. Among the major enterprises, it is worth mentioning the metallurgical plant in Ribnita, the cement factories in Ribnita and Rezina and the thermal power plant in Kuchurhan (the Moldova State Regional Power Station), which is one of the largest in Southern Europe with an installed capacity of 2,500 megawatts. In terms of agricultural activity within the basin, there are extensive livestock operations in both Ukraine and Moldova, as well as the cultivation of grain, sugar beets, vegetables and orchards, including production that relies on irrigation. In the 1990s the Moldovan and Ukrainian economies experienced a sharp decline in the economic output and financial revenues, which was partially overcome through new capital investments over the past 10 to 15 years.

Current political trends in Moldova and Ukraine and movement in the direction of European integration have significantly altered the countries' political and administrative mechanisms, including those related to the management of watersheds and their resources. There is still quite a lot to be done in both countries however, to bring their management mechanisms into line with the requirements of a modern democratic society. The economic situation remains complicated, and this makes it considerably more difficult to mobilize internal resources for the countries' development. In Ukraine, significant resources are being drained off by the need to resolve the military and political crisis in the south-eastern part of the country. As for the Transdniestrian region of Moldova, which has significant economic potential, resolution of a whole range of issues related to the Transdniestrian settlement process continues to be a critical matter.

Ecological status and problems

The Dniester and its tributaries are the principal source of water resources in the region, supplying water for agriculture, industry and population centres, including five oblast centres in Ukraine (Lviv, Ivano-Frankivsk, Ternopil, Chernivtsi and Odesa), the Moldovan capital of Chisinau, as well as the major industrial centres of Drohobych, Boryslav, Soroca, Ribnita, Balti, Tiraspol and Bender. Thanks to the Dniester, there is no shortage of water resources in the region as a whole at this time, although maintaining this status over the long term depends to a large degree on future changes in the river’s water regime and the development of the economic situation in Moldova and Ukraine.

Clearly, it would be an exaggeration at this point to talk about irreversible changes throughout the entire natural complex of the Dniester basin, which has still maintained its vast potential and biodiversity. The variety of plant and animal life that is typical of the Dniester’s unique wetlands and floodplains has been preserved, for example, and the same is true for the relationships among the various biogeographical complexes and the distinct ecological zones. But the ecosystems and their biological potential, especially under the conditions of a changing climate, can be preserved only if there is an ecologically sound regime for the management of the water resources of the river and the basin as a whole, for reducing the level of pollution and its impact on the environment, and also for protection of the environment in general.

A significant proportion of the basin’s territory has been ploughed up – agricultural land accounts for approximately 70 per cent of the total area. In addition to the alteration of the natural landscape, this leads to degradation and erosion of the soil and to the pollution of surface water and groundwater by run-off (including nitrogen and phosphorus compounds, pesticides and suspended substances). Point source pollution – from enterprises involved in livestock production, public utilities and industry – accounts for a large part of the water pollution. Most of the wastewater treatment systems are outdated and are in poor condition; they have been in operation for 25 to 30 years without seeing any renovation work and they do not meet technological requirements. The overgrazing of livestock in meadow pasturelands and illegal grazing in water protection zones along riverbanks definitely play a role in the pollution of the Dniester and its tributaries. In spite of this, practically everywhere except in the area around the mouth of the river, the quality of water from the Dniester still fully meets the requirements of virtually all of the users. The situation is much worse in the small rivers, especially in the middle and lower reaches of the Dniester. The low water levels in these rivers, coupled with intensive pollution from local sources (primarily population centres), make the majority of them unsuitable for any type of water use, including public recreation.

There are many environmentally hazardous enterprises located in the upper part of the basin, including large mining and chemical plants in Lviv and Ivano-Frankivsk Oblasts in Ukraine. Accidental releases of hazardous pollutants into the Dniester basin have occurred there in the past (the accident at the Stebnyk potash mine in 1983, as a result of which practically all of the fish along a 500 km stretch of the Upper Dniester died, was widely reported[5]), and the danger of new accidents remains a concern today (from the territory of the Kalush industrial district in Ukraine, for example[6]).

The natural disasters that are observed regularly in the basin are linked to catastrophic flooding on the Dniester and its tributaries and to droughts in years when water levels are low. The construction of a set of reservoirs along the course of the river between 1954 and 1983 partially eased the acute nature of both of these problems, while in turn creating new problems.

Experts note the impact of the reservoirs on changes in seasonal and daily flows in the Dniester, its temperature and oxygen regimes, as well as the turbidity and content of the water downstream. These changes have had a serious impact on the river's ecosystem, causing deterioration of the habitat, migration and spawning conditions for fish, interfering with the normal reproduction of plankton and doing significant damage to natural communities in the Dniester floodplains. There has also been an increase in the eutrophication of the river, including widespread excessive growth of aquatic vegetation along the entire course of the Dniester, which was previously seen only in the area around the estuary.

Additional factors that have contributed to the declining condition of fish populations include the drainage of vast areas of floodplains of the Dniester and its tributaries between 1950 and 1965, widespread construction of ponds and reservoirs on small rivers, and poaching. Only the Dniester Estuary on the whole has maintained a high level of productivity and species diversity among its fish populations, although even here a number of species have practically disappeared, and they have been replaced by other populations, including invasive species.

In the process of the utilization of the Dniester's reservoirs, the management of sediment run-off (sand and gravel) has also become a critical problem, since the natural replenishment of this material below the dams has practically ceased. At the same time, river sand and gravel have turned out to be an attractive draw for illegitimate businesses, which view them as a source of free building materials. As a result, the river's filtration capacity is declining, the stability of the river bed and banks is being undermined, and the remaining spawning grounds for fish, which use the sand and pebbles as a substrate, are being destroyed.

Finally, the continued illegal logging, grazing, and pollution of forests with household, construction and other waste, pose a serious threat to the forests in the basin, which perform an important role as regulators of the flow and water quality. Significant fragmentation of forest tracts and other remaining natural features (meadows, wetlands, steppes) can also be seen in the middle and lower reaches of the river.

Owing to the specific characteristics of the distribution of the territory among the countries in the basin, most of the environmental problems facing the Dniester are of a transboundary nature and can be resolved most successfully using transboundary cooperation mechanisms. The following analysis and recommendations are devoted to the resolution of those problems that are most likely to become more acute with global climate change.

03. CLIMATE CHANGE IN THE REGION AND BASIN: TRENDS AND UNCERTAINTY

Global and regional context

The most recent results obtained by the Intergovernmental Panel on Climate Change (IPCC) in the process of preparing its Fifth Assessment Report[7] broadly confirmed the existing ideas about probable climate change in Central and Eastern Europe by the mid- to late twenty-first century. (It should be noted that the new climate change projections developed for that report were based on a fundamentally new methodology, as described in the box below.)

Representative Concentration Pathways of atmospheric greenhouse gases: the new IPCC approach

Unlike the previous climate change projections that were based on certain scenarios for the development of the global economic system[8], the approaches used in the IPCC Fifth Assessment Report (IPCC 2013) are based on the so-called Representative Concentration Pathways (RCPs) of atmospheric greenhouse gases. They directly indicate the changes in the mean content of greenhouse gases in the Earth's atmosphere over time depending on the presumed dynamics of greenhouse gas emissions and other factors. The four pathways chosen – RCP2.6, RCP4.5, RCP6 and RCP8.5 – are named according to the change that would occur under these scenarios in the balance between incoming and outgoing radiation in the Earth-atmosphere system by the end of the twenty-first century compared to the pre-industrial period (by 2.6, 4.5, 6.0 and 8.5 watts per square metre). For RCP2.6 to occur, global greenhouse gas emissions would have to begin to decline after 2010–2020. RCP4.5 assumes a decline in emissions starting in 2040, and RCP6 after 2070. For RCP8.5 to occur, emissions would have to rise throughout the entire century.

Scenarios of global greenhouse gas emissions

[graphs on page 21]

In a comparison of the greenhouse gas emissions scenarios previously used by the IPCC, which were developed for the Special Report on Emissions Scenarios, or SRES (see endnote 8), the dynamics of the emissions under the SRES B1 scenario turn out to be close to RCP4.5, for A1B they are similar to RCP6, and for the combination of A1F1 and A2 they are comparable to RCP8.5. The RCP2.6 pathway is "milder" than any of the SRES scenarios, since it is achieved as a result of a negative balance between emissions and absorption of greenhouse gases.

Sources: USGCRP/GlobalChange.gov, UHMI 2014, Wikipedia.

[figures on page 22]

Projected climate change in Europe

[accompanying note:]

Estimates for 2071–2100 compared 1971–2000 based on the EURO-CORDEX ensemble under RCP4.5, RCP8.5 and emissions scenario A1B.

Source: Jacob et al., 2014, with revisions.

Under the majority of the scenarios in the IPCC Fifth Assessment Report, a definite rise in mean annual air temperature is expected in Central and Eastern Europe, with an increase in the southern part of the region of 2˚–3˚C by the end of the century given a "milder" course of events and 3˚–4˚C under the more "radical" scenarios. There may be a negligible change in the overall amount of precipitation, but the "radical" estimates point to the possibility of a decline in precipitation during the summer by 20 to 30 per cent compared to the period between 1971 and 2000. At the same time, the amount of heavy precipitation, which has a direct effect on surface run-off in Eastern Europe, will increase substantially by the end of the century.

The latest conclusions by the IPCC coincide for the most part with the content of its previous reports (see maps), which served as the methodological basis for the development of the majority of the regional projections and estimates of future climate change, including those performed for the Dniester basin and the territories of Moldova and Ukraine[9].

Future climate in the Dniester basin[10]

For the reasons described above and in the section dealing with the causes and consequences of uncertainty, it is virtually impossible to provide a reliable projection of future climate changes in a specific area. One can only attempt to identify qualitative trends. A detailed analysis of climate change in the Dniester basin in the historical past and over the shorter term of 2021–2050[11], performed under the leadership of the Ukrainian Hydrometeorological Institute (UHMI), on the whole identified trends similar to the general European trends.

An analysis of the ensemble of regional climate models based on the "moderate" A1B scenario for global greenhouse gas emissions showed that compared to 1981–2010, by the middle of the century one can expect the mean annual, maximum and minimum air temperatures to rise by 1.0°–1.2°C (see table and map). The increase in the minimum temperature will most likely be greater than the rise in the maximum temperature, as a result of which the monthly and annual amplitudes will decline. The most significant warming should be expected during the colder parts of the year, especially during the winter months. There could also be a change in precipitation patterns in the Dniester basin by the middle of the twenty-first century. Although the overall annual quantity of precipitation will not change significantly (under the given scenario an increase and decrease in precipitation are equally likely), there could be a substantial redistribution of precipitation among the seasons and months. It is likely that there will be longer stretches without rain, but there will be an increase in the intensity and frequency of heavy precipitation (heavy rains in particular) and the distribution of precipitation throughout the basin will be more uneven. On the whole, milder and wetter winters can be expected in the basin, as well as hotter and drier summers; September is expected to be warm and wet, while the autumn months should be drier and warmer. An analysis of the changes expected by the middle of the century compared to 1971–2000 shows the same trends (see table), although the quantitative parameters of these changes differ somewhat owing to differences in the climatic characteristics of the two baseline periods.

The REMO regional climate model and the ECHAM5 global model were used to gain an understanding of the possible distribution of expected climate change trends within the Dniester basin. There is little variation in the expected changes in mean annual and seasonal temperatures within the basin, although the most pronounced increase will be in the lower part of the basin. Also worth noting is the decline in precipitation in the summer in the Lower Dniester (by 4–7 per cent compared to 1981–2010) and in the autumn in the lower and middle reaches (by 6–11 per cent compared to 1981–2010). There could be a substantial increase (of up to 20 per cent) in the maximum intensity of precipitation as well.

Projected change in mean air temperature and precipitation in the Dniester basin in 2021–2050 compared to 1981–2010

	Basin as a whole	Upper	Middle	Lower
Year as a whole	**+1.1°C** **+0.2%**	**+1.0°C** **+1.0% to +1.8%**	**+1.1°C** **-0.9%**	**+1.2°C** **-2.8% to -1.7%**
Winter	+1.2°C +9%	+1.1°C +10%	+1.2°C +6% to +7%	+1.2°C +8% to +11%
Spring	+0.7°C -0.6%	+0.7°C +0% to +1.5%	+0.7°C -1%	+0.8°C -3%
Summer	+1.0°C -1.0%	+1.0°C -1.0%	+1.0°C -1.0% to -0.2%	+1.2°C -7% to -4%
Autumn	+1.3°C -5.0%	+1.3°C -2.8% to -1.5%	+1.3°C -10% to -7%	+1.4°C -11% to -6%

The top number refers to air temperature and the bottom number refers to the amount of precipitation. Seasonal and annual mean values are indicated, and multiple values refer to the range for different sections of the basin. Calculations are based on the REMO-ECHAM5 model ensemble and the A1B emissions scenario. Source: Data from UHMI 2014 (rounded values).

Projected change in mean air temperature and precipitation in the Dniester basin in 2021–2050 compared to 1971–2000

	Basin as a whole	Upper	Middle	Lower
Year as a whole	**+1.4°C** **+1%**	**+1.4°C** **+2% to +3%**	**+1.1°C to +1.4°C** **+2% to +3%**	**+1.5°C** **-2% to 0%**
Winter	+1.5°C *-2% to +6%*	+1.3°C to +1.5°C *+2% to +12%*	+1.4°C to +1.6°C *-5% to +8%*	+1.6°C *-5% to +2%*
Spring	+1.1°C *+5% to +6%*	+1.0°C to +1.2°C *+2% to +7%*	+0.8°C to +1.1°C *+4% to +10%*	+1.2°C *+2% to +8%*
Summer	+1.4°C *-9% to +4%*	+1.3°C to +1.7°C *-10% to +5%*	+0.8°C to +1.4°C *-11% to +12%*	+1.6°C to +1.7°C *-10% to +1%*
Autumn	+1.4°C *-5% to +12%*	+1.3°C to +1.4°C *-5% to +15%*	+1.1°C to +1.5°C *-1% to +12%*	+1.5°C *-5% to +10%*

The top number refers to air temperature and the bottom number refers to the amount of precipitation. Seasonal and annual mean values for temperature are indicated, while monthly (in italics) and annual mean values for precipitation are shown. Multiple values refer to the range for different months or sections of the basin. Calculations are based on the REMO-ECHAM5 model ensemble and the A1B emissions scenario. Source: Data from UHMSRI 2012 (rounded values).

[map page 25]

A1B emissions scenario, REMO-ECHAM5 model ensemble.
Source: Data from UHMI 2014.

These trends are also confirmed by the results of future climate modelling performed recently for the Moldovan part of the basin using the methodological approaches of the new IPCC Fifth Assessment Report and the EURO-CORDEX regional climate model[12]. Under the RCP2.5 scenario, a slight increase in mean air temperature by 0.2°–0.3°C is expected over the course of the century. Under the RCP8.5 worst-case scenario, a rise in temperature by 1.5°–2°C is expected by the middle of the twenty-first century and an increase by more than 4°C is seen by the end of the century. Under any of the scenarios, the increase or decrease in the amount of annual precipitation is estimated to be in the range of 5 per cent to 7 per cent, although seasonal changes could be significant (with a decline by as much as 10 to 20 per cent in the summer). For a section of the basin below the Dubasari reservoir that is almost identical to that used in the research by the Ukrainian Hydrometeorological Institute, the results of the calculations in the two studies are entirely comparable (see figure).

[Figure on page 26]

Estimates for 2021–2050 compared to 1971–2000.
Source: data from UHMSRI 2012, Corobov et al. 2014.

An analysis of trends in extreme weather events was performed on the basis of these same assumptions (emissions scenario A1B, comparison with the years 1970–2000). This analysis showed that the following trends, which have been observed in the Dniester basin since the end of the last century, will in all likelihood continue up to the middle of this century: a rise in maximum air temperature, and especially in minimum air temperature; a decrease in the number of days with frost and with very low overnight temperatures; an upward trend in the number of hot days; and an increase in the quantity and uneven distribution of extreme precipitation. These events will also occur with greater frequency. Within the basin, one can expect an increase in the number of rainy days in the upper and middle reaches of the river, and in the number of dry days in the lower part of the river, as well as an increase in the average amount of precipitation per day and in the average maximum daily precipitation. The greatest changes may occur during the warm periods of the year, especially during the summer months in the Lower Dniester. The most significant increase in average and maximum daily precipitation may occur in the upper course of the river during the autumn months. These changes may lead to a substantial rise in the amount of precipitation during heavy rains (by more than 10–20 mm per day). The largest increase in the frequency of intense precipitation can be expected in the Lower Dniester.

Causes and consequences of uncertainty

In spite of an overall increase in certainty in the results of current climate change research, there is still a high degree of uncertainty in the specific calculations of global trends, and of regional trends in particular. This is linked to what is still an insufficiently complete understanding of how the global climate system operates; the dependence of climate projections on the specific models and scenarios that are chosen for social development, and accordingly, for emissions of greenhouse gases into the atmosphere; and also the considerable difficulty of scaling global conclusions down to the regional level.

Although the trends in climate change are already fairly well understood, generally speaking, there is still a lack of clarity about the degree and speed of these changes. Therefore, the climate projections for both Europe and the Dniester basin presented above reflect only the basic trends in potential changes; they do not offer an exhaustive picture of these changes in all their diversity, nor do they tell us what the future will actually look like. The uncertainty of climate change projections will continue into the future and even under the best of circumstances this uncertainty will be eased only in part as new knowledge is gained and events and changes continue to emerge.

At the point that these changes occur, however, there may be neither the time nor the resources remaining for adaptation to them. For this reason it is essential to plan now for adaptation, and not only with respect to the changes in climate parameters that can already be predicted. Adaptation plans also need to be put into place that account for the possibility that the behaviour of the climate system will be difficult to predict, that it will change in ways that are still unknown. This requires, on the one hand, that the measures being implemented provide a larger "margin of safety" that allows for functioning within a broad range of potential future climate change scenarios, and on the other hand, the ability to apply these measures in a flexible way, depending on what actually happens with the climate. In order to ensure this flexibility, it is essential to have constant observations of climate parameters and parameters derived from them, as well as mechanisms for the effective sharing, analysis and use of this information for decision-making.

04. IMPACT OF CLIMATE CHANGE ON THE WATER FLOW, NATURAL ENVIRONMENT, ECONOMY AND POPULATION IN THE DNIESTER BASIN

Vulnerable resources and sectors of the economy

Future climate change will have an impact both on the natural resources and ecosystems of the Dniester region and basin, and on the population and economy. In recent years a number of special studies and surveys of these consequences have been performed[13]. The table below presents the main projections regarding the impact of climate change on natural resources and sectors of the economy within the basin.

Resources and sectors of the economy in the Dniester basin most vulnerable to climate change
Water resources Increased variability in the flow regime and volume, especially in the middle and lower parts of the Dniester. Deterioration in the quality of surface water as a result of higher temperatures, a decline in flow and anthropogenic pollution. Continued decline in groundwater levels. Further deterioration in the condition of small rivers.
Forest resources A likely shift in the species composition and a change in the altitude range limits of tree species (in the Carpathians). Disappearance of certain moisture-loving species in the middle and lower parts of the Dniester. Probable emergence of new diseases and pests.
Ecosystems and wetlands Decline in biodiversity, shrinking of the geographical range of native species as a result of the drying up of habitats, deterioration in water quality and appearance of invasive species.
Ichthyofauna Reduction in the number of fish species, disappearance or shrinking of spawning grounds, increase in the impact of invasive species.
Agriculture Increase in the frequency and intensity of droughts and other extreme events. Shortage of water for irrigation. Decline in soil fertility as a result of salinization, erosion and landslides. Reduction in productivity and degradation of pasturelands. Appearance of new crop pests and livestock diseases.
Water supply Drop in groundwater levels, drying up of wells and springs, which are the principal water sources in rural areas. Possible shortage of accessible water resources in the lower part of the basin and decline in water quality.
Infrastructure Possible deterioration as a result of direct climate change impacts (such as high summer temperatures, heavy precipitation, flooding).
Population Risk to human life as a result of extreme weather and hydrological events. General vulnerability owing to low income levels among the population, social stratification, deterioration of the demographic situation, decline in the quality of education.

Source: Corobov et al. 2013, with revisions based on consultations in Ukraine (Kyiv, December 2012) and Moldova (Chisinau, July 2013)[14].

[Figure on page 30]

Based on the results of consultations in Moldova and Ukraine.
Source: UNECE, OSCE, UNEP 2013.

Within the context of the development of the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin, a series of consultations was also organized with experts and organizations in Moldova and Ukraine. The figure presents the results of an analysis of the relative importance and likelihood of the occurrence of problems that have been identified in the Dniester basin. This analysis was performed in collaboration with representatives of environmental protection, water resources management and other agencies; hydrometeorological and emergency services; regional administrative bodies; and scientific and non-governmental organizations in Moldova and Ukraine. Of all of the problems related to climate change in the Dniester basin, those involving changes in the water regime, degradation of the soil and agricultural land, as well as the impact of climate on human health were identified as the ones with the most serious consequences and the highest likelihood of occurring. According to the general principles of risk analysis[15], these are the kinds of problems that require the most urgent solutions. Problems with serious consequences but a lower likelihood of occurring (in the Dniester basin a deterioration in water quality and a change in groundwater levels were included in this group) require, first and foremost, constant monitoring in order to identify signs that the situation is worsening. Problems with a high likelihood of occurring but less serious consequences (damage to ecosystems and irrigation, erosion of riverbeds) need to be addressed gradually as part of multipurpose efforts to reduce the negative impact of various factors, including climate factors.

Problems related to the aquatic environment

There is no question that within the context of climate change adaptation at the basin level, problems directly related to the aquatic environment and to changes in the water regime and in the condition of water resources are of the greatest interest. In the Dniester basin, a probable change in the volume and seasonal distribution of flow stands out as one of the critical consequences of climate change. The expected change in flow could lead to a deterioration in water quality as well. A number of other problems related to climate change in the Dniester basin are also determined to a large extent by changes in the water regime and in the condition of water resources (see table), although with the exception of water supply, other climatic factors also play a major role here.

Impact of changes in the aquatic environment on various sectors and resources

	1. More water (flooding and inundations)	2. Less water (decline in flow, droughts)	3. Water quality (including as a result of 1 and 2)	4. Effects not related to the aquatic environment
Agriculture				
Water supply				
Infrastructure				
Health and welfare				
Ecosystems				

Weak connection Moderate connection Strong connection

The groups of problems that are directly related to changes in the water regime and in the condition of water resources (see below) and that form the basis for the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin (Chapter 6) are highlighted in the table.

Flooding and inundations

Flooding as a natural phenomenon has always occurred and will in all likelihood continue in the future. In principle, flooding is a beneficial thing for the health of the river and floodplain ecosystems. But the annual economic toll from inundations in Moldova and Ukraine runs to millions of dollars and dozens of lives are lost each year. The catastrophic floods of 2008 and 2010 in the Dniester basin provided yet another reminder that the flood protection complex in place today is performing its functions only in part.

The effectiveness of the current flood protection system will decline with the expected increase in water levels involved in catastrophic flooding in the future.

Based on the results of modelling for Mohyliv-Podilskyi, one of the Ukrainian towns along the middle reaches of the Dniester that experiences regular flooding, given a hypothetical 15 per cent increase in the water volume of a 100-year flood[16], the maximum water level there would rise by 1.3 metres (or 13 per cent) and the area of flooded land would increase by 20 per cent compared to the area subject to flooding today[17].

An increase in the volume of water in catastrophic floods could lead to similar consequences in the towns and villages of Moldova[18].

[Figures on page 32]

Source: Kolomiets et al. 2012, with revisions.

Source: Corobov et al. 2013, with revisions.

The estimates[19] for global emissions scenario A1B show that although the number of days of high water levels occurring per year in the catchment basins of the Dniester and its tributaries may decline over all by the middle of the century, during warm periods it may increase by 20 to 30 per cent in the upper reaches of the river and by 10 to 20 per cent in the middle part of the river. In the summer it may increase by as much as 40 per cent in the upper section of the river, by 20 to 30 per cent in the middle and by 10 to 20 per cent in the Lower Dniester. Throughout virtually the entire territory of the Dniester basin one can expect a significant increase in the intensity of floods during warm periods, with a particularly marked increase in the upper reaches (by 30 to 40 per cent) and in the lower part of the river (by as much as 65 per cent). A substantial increase in the intensity of floods can be expected in the summer in the middle reaches of the river (by as much as 80 per cent), while the biggest changes can be expected in September, when in certain tributaries of the upper (Stryi), middle (Smotrich) and lower reaches (Raut, Botna) the intensity of local floods may increase by a factor of 2 or 3[20].

[Figure on page 33]

Estimates for 2021–2050 compared to 1970–2000. A1B emissions scenario, REMO-ECHAM5 model ensemble.
Source: Data from UHMSRI 2012, with revisions.

Droughts and water scarcity

Southern Ukraine and Moldova are traditionally considered to be high-risk farming areas. Local watercourses are prone to low flow, becoming very shallow in extremely dry years, as observed in 2007, for example. (According to World Bank estimates, the drought in Moldova at that time affected an area with a population of 1 million people, and 30,000 people in 156 population centres felt the effects of the drought particularly acutely[21].) Within the Dniester basin, with the warming of the climate, by the end of the last century the boundary of the territory with a scarcity of water resources reached the most densely populated regions (the cities of Tiraspol and Bender, in particular)[22]. Further climate change will shift this boundary even farther to the north.

Droughts in the Dniester basin[23]

Extremely dry years are a fairly frequent phenomenon in Moldova and southern Ukraine. Over the past 120 years there have been more than 70 droughts, and seven of them have occurred since independence.

The year 2007 was one of the warmest and driest years on record. Temperatures were unusually high over a period of 11 months, with air temperatures reaching 35°–40°C and surface temperatures in the range of 50°–60°C. There was no precipitation for two months, the annual precipitation in the Dniester basin was between 30 and 70 per cent of normal levels, and the river's annual flow was less than 6 billion m^3. The flow into the Dniester reservoir for July–October was just 50–70 m^3 per second. There was significant shoaling in the upper reaches of the Dniester, some tributaries dried up completely, the water quality declined in terms of all of the indicators and there were widespread algae blooms. Water quality problems caused complications with the operation of water intake facilities and there were problems with the water supply. Below the Dniester reservoir the water supply problem was solved through drawdowns to the lower pool, with consumption in the range of 130–150 m^3 per second. This made it possible to maintain the water supply to Chisinau, towns in the Transdniestrian region and Odesa Oblast. The level of the Dniester reservoir was lowered by more than 5 metres during this process. A similar situation occurred on the Dniester in 1992 and 2003.

Prior to the creation of the Dniester reservoir, the supply of water to Moldova and Odesa Oblast in Ukraine was not guaranteed, and even less severe droughts caused significant losses in the harvest. Today, at least agricultural enterprises that irrigate their land using water from the Dniester are protected against drought to a significant extent. Water users who depend on other sources continue to suffer from droughts, however. On the whole, droughts are continuing to cause significant economic losses for the countries in the basin. In Moldova, the losses from the 2007 drought are estimated at US$1 billion, while the losses from the 2012 drought are put at US$1.25 billion.

Source: Savchuk 2009, UNECE 2014.

From the standpoint of the basin as a whole, there is no reason today to talk about a scarcity of water resources, since under any realistic economic forecast up to the middle of the twenty-first century, the basin's overall water needs will be met by the Dniester's existing flow except during years of acute drought[24]. The situation nevertheless varies from one part of the basin to another. During dry years, there is no guaranteed water supply for consumers who depend on the flow from small rivers (in southern Moldova the local flow practically disappears during drought years, and many small rivers dry up completely[25]) and on the level and condition of groundwater. (About 50 per cent of the population in Moldova uses shallow aquifers, and this led to a widespread depletion of wells during the droughts of 2007 and 2012[26].)

Estimates[27] under emissions scenario A1B for the Dniester basin show a likely decline in the mean and minimum flow in the middle and lower reaches of the Dniester by 2050 (accompanied by an increase in flow in the upper part of the basin, so that the overall flow remains unchanged). Modelling for the entire territory of Moldova[28] also points to a likely decline in local flow in the middle and lower parts of the river. In areas that are dependent on local flow (including those that use water from tributaries, rather than from the Dniester itself), the decline in mean flow, and in minimum flow in the summer in particular, will place an extra burden on agriculture and on water supply systems serving population centres due to a further drop in surface water and groundwater levels and a deterioration in water quality. Aquatic and wetland ecosystems and ichthyofauna, whose existence is linked directly to the hydrological regime of stream flows and bodies of water, will also suffer from a decline in water levels and water quality. A drop in groundwater levels will increase the vulnerability of forest ecosystems.

Even in the absence of a significant change in the overall volume of flow in the basin in the future, the expected rise in mean and summer temperatures and increased frequency of droughts will inevitably have an impact on the water needs of both natural ecosystems and the economy (including agriculture and irrigation-based farming). This will aggravate the situation in drought years and, coupled with the expected long-term redistribution of flow in the basin as a whole in favour of the upper reaches, will make the natural environment and the economy in the Lower Dniester even more dependent upon the operation of the Dniester reservoir system.

[Figure on page 35]

Estimates for 2021–2050 compared to 1970–2000. A1B emissions scenario, REMO-ECHAM5 model ensemble.
Source: Data from UHMSRI 2012, with revisions.

Water quality

Although the Dniester's water quality on the whole meets the requirements for practically all types of water use at this time, only the ecosystems in the very uppermost reaches of the river are not experiencing the effects of a heavy anthropogenic load. The water quality in the Lower Dniester in terms of the content of suspended substances, acidity, the oxygen regime and the levels of organic and biogenic substances can be classified as average or poor based on the values of the tropho-saprobiological criteria. A decline in water quality as a result of an increase in concentrations of biogenic and organic matter has been observed near the drinking water intake facility in the town of Bilyayivka that supplies water to Odesa. Water in the lower reaches of the river has also been polluted by hazardous compounds such as petroleum products, chlororganic pesticides and polycyclic aromatic and volatile hydrocarbons[29]. As already noted, the pollution of small rivers in the Dniester basin is significantly higher, in part because of the low water levels resulting from evaporation in excess of precipitation in the lower reaches. Groundwater has also been polluted, evidence of which can be seen in the poor water quality in rural wells. Drinking water that falls short of health standards can be blamed for up to 20 per cent of illnesses in Moldova (including acute intestinal illnesses, chronic diseases of the digestive and immune systems, kidney and bladder stones and dental fluorosis)[30].

In the majority of cases, surface water pollution is caused by public utilities (waste water treatment plants, the discharge of untreated wastewater from public sewage systems, inadequate handling of solid waste from commercial activity), agriculture (animal waste, improper storage of mineral fertilizers and pesticides) and the energy industry (oil storage tanks, petrol stations), as well as other sources of ongoing pollution. Precipitation washes additional pollutants from the soil and they then enter streams and bodies of water in the form of run-off.

[Figure on page 36]

A1B emissions scenario.
Source: Data from Bejenaru 2012.

[Map on page 37]
Source: GRID-Arendal/Zoï 2012, with revisions.

With a decline in the mean and minimum flow by the middle of the century, one can expect an overall deterioration in water quality due to a reduction in the dilution capacity of streams, including those in the lower reaches of the Dniester. Small rivers, in which a decline in inflow cannot be compensated for by drawdowns from reservoirs, will be particularly affected by this process (see, for example, the forecast for the Raut, as well as the section on droughts and water scarcity). A rise in water temperatures and a decline in the flow velocity and water exchange will lead inevitably to a drop in the oxygen content (see figure) and an increase in adverse processes within bodies of water (eutrophication of the Dubasari and Kuchurhan reservoirs[31] already became a reality some time ago).

Intensification of precipitation and flooding and higher temperatures in the winter could also lead to the additional flow of pollutants into the water with rain and snow run-off.

Aquatic and wetland communities and ecosystems[32]

In spite of significant changes in the nature and distribution of wetland communities related to the construction and entry into service of the Dubasari and Dniester hydroelectric plants at the end of the last century, floodplain forest sections of willow, poplar and oak have been preserved in the middle and lower parts of the basin. They are growing in narrow bands along the course of the river in areas that are flooded on a regular basis. Communities of wet and dry meadows are also found in the river valleys. The functioning of these ecosystems depends directly on the hydrological regime of the floodplain, the future of which will be determined by climatic and water resource management parameters. Among other things, a significant and prolonged deterioration in the flooding regime in the floodplain could lead to a drop in groundwater levels and the partial or complete drying up of certain wetland zones along the Dniester, the surface water balance of which at this time is already assessed as negative or close to zero. As a result of a worsening of the vegetation conditions and possible degradation of the soil cover, there could be a decline in the biological productivity and sustainability of forested areas and certain species. A number of native species could be crowded out by aggressive invasive species that are more resistant to a dry climate.

The basin's unique natural complexes include the vast wetlands of the Lower Dniester, with native ecosystems that have been preserved in their natural state, restored floodplain forests and water meadows, overflow lands and lakes, and the adjacent river terrace ecosystems. The shrinking area of floodplain meadows at the mouth of the Dniester and the degradation of the remaining sections of these meadows caused by changes in the hydrological regime as a result of the construction of the Dniester hydroelectric power plants and vacation cottages, have already sharply reduced the numbers of migratory birds and led to the disappearance of spawning grounds for carp and habitat for the European fire-bellied toad, the European pond turtle and a rare species of leech called *Trocheta subviridis*. In the event of the further degradation or complete disappearance of shallow water meadows, it will be virtually impossible to ensure further preservation of the historical habitats of many wetland birds (the glossy ibis, the spoonbill, the squacco heron and purple heron), amphibians and reptiles.

Shallow-water ecosystems will be the most vulnerable to changes in the hydrological regime: with a steady decline in flow and water levels, they will be threatened by a total drying out of their environment, and in principle adaptation may not be possible for them. Floodplains and meadow ecosystems are also threatened by a change in precipitation patterns and an increase in the erosion and sedimentation effects of storm floods, inundation by higher floodwaters with periods of standing water that are longer than the existing plant communities are able to tolerate, and a likely increase in fluctuations in groundwater levels. It is not possible to cope with these changes without regulating the flooding conditions in order to bring them closer to the natural patterns[33].

A decline in local flow, rising air temperatures and more intense evaporation from the water surface will mean a deterioration in habitat in bodies of water and watercourses as a result of changes in their thermal, hydrological and hydrochemical regimes. Aquatic communities are sensitive to changes in temperature, which affects their distribution and structural and functional organization (growth, development, productivity, competitive relationships and so on). In addition, the impacts of climate change may result in a simplification of the structure of communities of aquatic organisms, as well as a reduction in their species diversity and in the populations of many species, including the disappearance of rare species. Climate change may also be associated with a decline in oxygen content and the appearance of biogenic pollution in water bodies due to large-scale algae blooms.

Among the consequences of the overall impact of climate change on ecosystems, particular mention should be made of the shift in seasons (earlier arrival of spring, later onset of autumn). While ecosystems that are supplied with water are most likely to see an increase in their primary production with a longer vegetation period, when there is a scarcity of water the impact of the shift in seasons on the status of many species could be quite negative. A change in the phenological time periods for the development of plants could cause disruptions in the spatio-temporal parameters of ecological niches of invertebrates and could have an impact on the species richness and diversity of communities. A local shortage of food plants and increased activity of pests and pathogens are also possible.

Climate change, including changes in temperature patterns and the related dynamics of hydrological processes (for example, a decline in water levels in the river and in overflow systems), is one of the key factors in altering the ichthyofauna of the Dniester. Higher water temperatures could have a negative impact on the reproduction and development of many fish species – especially rare species (including the cold-water Black Sea salmon, which has almost disappeared). This would be accompanied by the appearance of warm-water invasive species (some experts believe that climate is one of the factors contributing to the appearance of goldfish and stone moroko in the Dniester)[34]. A decline in the number of phytophilic species, including the common roach, carp, crucian carp and several others, can be explained by the swallowing and shrinking of the area of floodplain lakes during the increasingly frequent drought years. A further decline in the level of the Dniester or its tributaries could lead to the loss of the remaining meadow spawning grounds[35].

Each of the processes mentioned here reduces the resilience of ecosystems, which taken together form the foundation of the ecological resilience of the natural component of the Dniester basin in the face of climate change. These changes are coupled with adverse processes that are not related to climate, which undermine even further the viability of ecosystems and their natural adaptive capacities.

Climate change “hotspots” in the Dniester basin

The map on the next page illustrates the distribution of the expected impact of changes in climate parameters throughout the Dniester basin by the middle of the century. It is clear that most of the problems are concentrated in the middle and lower reaches of the river, with the Lower Dniester being particularly sensitive to changes. This is where the decline in the mean and minimum flow will be the most pronounced; this is also where the increase in the height and intensity of floods due to rain will be the greatest, and where the aggravation of water supply problems as a result of a decline in water levels and water quality will be the worst. The most vulnerable floodplain and wetland ecosystems are also found in the Dniester delta and the lower reaches of the river. Regardless of what happens with the aquatic environment, higher temperatures will also have a direct impact on the human population, the economy and the natural environment, and this impact will be felt more strongly in the lower part of the basin as well.

A partial or complete resolution of some of these problems is entirely possible through isolated efforts undertaken by the individual countries in the basin. The keys to resolving other problems are frequently found on different sides of state borders, however, and a comprehensive solution to the problems of flooding, water scarcity, declining water quality, and the condition of floodplain, wetland and aquatic ecosystems requires a long-term basin-wide approach.

[map on page 41]

The estimate of the change in flow for 2021–2050 compared to 1971–2000 is based on the A1B emissions scenario and the REMO-ECHAM5 model ensemble.

Source: Data from UHMSRI 2012, Corobov et al. 2013, UNEP/Zoï 2012, Botnaru and Kazantseva 2005, State Committee on Natural Resources of Ukraine 2005.

05. POTENTIAL FOR ADAPTATION TO CLIMATE CHANGE IN THE DNIESTER BASIN

Socioeconomic and institutional conditions

The countries in the Dniester basin do have some resources for adaptation to climate change, but compared to neighbouring countries in the European Union, Moldova and Ukraine's own capacities can be described as fairly modest (see map). Indeed, with a GDP per capita in Moldova and Ukraine of around US$2,000 and $3,800 in current prices[36], respectively, the internal financial resources potentially available to the countries are quite limited.

[map on page 43]

Source: Data from Fay and Patel 2008 (cited in World Bank 2009).

Nevertheless, the need to take future climate change factors into account has been recognized and addressed at the national level in both countries.

With the support of the United Nations Development Programme, Moldova has prepared a draft Climate Change Adaptation Strategy up to 2020. The cost of implementing this strategy is estimated at 2.7 billion lei (more than 120 million euros as of 2015)[37]. Sector-based adaptation strategies have begun to emerge as well: for example, a climate change adaptation strategy for water supply and wastewater management services in Moldova, at a cost of around 12 million euros, has been drafted with the assistance of the Organisation for Economic Co-operation and Development (OECD). (This cost represents less than 2 per cent of capital investments needed for the development of the sector as a whole)[38].

In Ukraine, on instructions from the Cabinet of Ministers, the third version of the National Climate Change Adaptation Plan for 2013–2017 was prepared with the aim of determining the levels and sources of funding for measures that have been assigned top priority. At this stage, the designers of the plan have identified the following as priorities: creation of the organizational prerequisites and scientific foundations for the implementation of government policy in the area of adaptation; implementation of adaptation measures at the national level and development of a regional policy; and determination of specific climate change adaptation measures in the health care sphere and in certain sectors of the economy[39]. Given the current political and economic environment, however, it is highly unlikely that significant government funding will be allocated in the near future for the implementation of these measures (with the exception of activities directly related to implementation of the European Union Association Agreement – see below).

For all practical purposes, no adaptation activities have been started at the oblast and district levels, although systematic efforts have been under way in Ukraine since 2012 to inform oblasts of the possible consequences of climate change and to develop methodological recommendations regarding adaptation for central and local government authorities[40]. Non-governmental organizations are also working at the local level. For example, the National Ecological Centre of Ukraine prepared an analysis of problems and possible adaptation actions for a number of Ukrainian cities, including Odesa and Lviv[41]. In the Transdniestrian region of Moldova, non-governmental organizations working with support from the United Nations Development Programme have also outlined basic approaches to regional adaptation to climate change[42].

Many problems in climate change adaptation are being addressed in practice within the context of sector-based strategies and development programmes and plans (including those concerned with environmental protection, the use of water resources, agriculture, energy, construction, transportation, emergency response and public health). Although many of these programmes are not fully funded, the total amount of funding, including government funding, is fairly high. The Ukrainian Flood Control Protection Plan for the Dniester, Prut and Siret River Basins can be cited as an example: of the original estimated cost of the programme's implementation in 2013–2021, which was 30 billion hryvnias, a total of 5 million hryvnias has been allocated from the state budget for its implementation[43]. In Moldova, the Programme to Develop Water Resource Management and Water Conservation for 2011–2020 was approved in 2011 with the aim of implementing the Conceptual Framework for National Policy in Water Resources and improving the performance of the water resources sector. Among other things, the programme calls for the repair of flood control levees in the Dniester basin covering a total distance of 210 km, with total expenditures of 90 million lei[44]. Similar measures are also being carried out in other sectors. It is sector-based programmes of this kind, in fact, that are responsible today for the bulk of practical adaptation activities, although far from all of them explicitly address potential climate change factors (see Chapters 6 and 7).

The performance of observations to allow for timely monitoring and forecasting of hydrometeorological parameters in the Dniester basin is a less expensive, but no less important mechanism for climate change adaptation. The modern observation network of the Moldovan and Ukrainian hydrometeorological services is fairly representative, and the most pressing issues today include automation of the network, as well as the reinforcement and systematic organization of the sharing of information obtained (including real-time sharing) between Moldova and Ukraine, and also among various agencies of the two countries. The use of this information in real-time hydrometeorological forecasting and emergency warning systems[45] is another priority.

With the agreements signed and ratified in 2014, the European Union association process involving Moldova and Ukraine will bring new opportunities for the development and funding of adaptation measures. Article 93 of the Association Agreement between Moldova and the European Union provides specifically for cooperation to promote measures in the area of adaptation to climate change, as well as research, development and diffusion of the relevant technologies, and education and training. Article 365 of the Association Agreement between Ukraine and the European Union calls for cooperation in the development and implementation of a policy on climate change, and Annex XXXI to Chapter 6 (Environment) refers directly to the need for Ukraine to develop a long-term action plan for a reduction in greenhouse gas emissions and adaptation to climate change.

Furthermore, implementation of the directives of the European Parliament and Council of the European Union with regard to the conservation of water, ecosystems, flora and fauna, as well as reducing pollution and preventing emergencies (see table), backed by the necessary financial support, will also undoubtedly contribute to climate change adaptation activities, including those in the Dniester basin.

Some European directives included in the Association Agreements between Moldova and Ukraine and the European Union

Implementation deadlines, years

Directive (abbreviated title)	Moldova	Ukraine
Water Framework Directive (2000/60/EC)	3–8	3–10
Floods Directive (2007/60/EC)	3–8	2–8
Urban Waste Water Directive (91/271/EEC)	3–8	3–8
Drinking Water Directive (98/83/EC)	3–6	3–5
Nitrates Directive (91/676/EEC)	3–5	3–4
Industrial Emissions Directive (2010/75/EU)	3–10	2–5*
Major Accident Hazards Directive (96/82/EC)	4–7	5
Waste Framework Directive (2008/98/EC)	2–5	5
Mining Waste Directive (2006/21/EC)	2–6	5
Landfill Directive (1999/31/EC)	3–7	6
Birds Directive (2009/147/EC)	2–5**	2–4***
Habitats Directive (92/43/EEC)	3–6	2–4

* In addition, the implementation deadlines for certain measures, which are different for existing and new production facilities, will be established by the Association Council.
** The timetable for the implementation of certain provisions will be agreed upon within the framework of the Energy Community Treaty.
*** Special measures for the protection of regularly occurring migratory species are to be introduced before January 1, 2015.
Source of data: eeas.europa.eu

The socioeconomic capacities of individual territorial units within Ukraine and Moldova in terms of adaptation to climate change are distributed unevenly throughout the Dniester basin[46] (see map). The industrially developed oblasts of Ivano-Frankivsk, Odesa, Lviv and Khmelnitsky in Ukraine have greater capacities for adaptation. In the Moldovan part of the basin, the major industrially developed territories in the Transdniestrian region and the districts of Chisinau and Balti have more potential for adaptation, while the predominantly agricultural districts of Telenesti and Singerei and part of Dubasari District have the lowest potential.

[map on page 46]

Source: Data from GRID-Arendal/Zoï 2012; UNEP/Zoï 2013; Corobov et al. 2013, 2014; Boiko 2012; 4G consite, MCC 2014; hydrometeorological services of Moldova and Ukraine (information on the Internet).

Regulating mechanisms at the basin level

The Dniester basin itself has a number of natural and semi-natural systems with capacities that can be used for adaptation. Forestlands, especially the forests of the Carpathian Mountains in the upper reaches of the river, assuming that they are preserved, have great potential for regulating flow from the standpoint of its distribution over time and maintaining a minimum flow during periods of low water levels. The floodplains of rivers and the wetlands in the lower reaches reduce peak flows during flood seasons. The lakes and artificial reservoirs in the basin play this same role (although if they are not properly managed, uncontrolled dams and holding ponds can, on the contrary, complicate management of the flow).

At the same time, the forestlands, floodplain ecosystems and wetlands themselves are vulnerable to climate change (see Chapter 4), so their preservation and restoration are essential for maintaining the basin's natural adaptation potential, among other things. Some of the natural complexes in the basin are being protected under the existing system of specially protected natural areas. With the exception of the lower reaches of the river, however, the density of the network of these protected areas is quite low. Within the basin (both in Moldova as a whole and in Ukraine), no physical unification of the protected areas into a single network has been developed, although both countries have adopted the relevant government programmes[47]. The task of transboundary development of protected territories is especially urgent for the Dniester delta, where the combined and coordinated efforts of Ukraine and Moldova (including the Transdniestrian region) are essential for the protection of natural and restored ecosystems.

Regulating mechanisms at the basin level include major hydraulic engineering structures, above all the reservoirs that are part of the Dniester hydroelectric complex (see Chapter 2) in the middle reaches of the river in Ukraine. The reservoirs, which are used primarily for the purposes of generating electricity and flood protection, also play an important role in regulating the water regime and flow of the Dniester throughout practically the entire territory of Moldova and Odesa Oblast in Ukraine (the part that falls within the basin). The reservoirs are managed in accordance with the Rules of Operation. The mechanism for the development of these rules requires that they be coordinated with stakeholders both in Ukraine and in a transboundary context. Respecting the often conflicting interests, including those of hydroelectric power and the needs of aquatic and wetland ecosystems, remains a complicated challenge.

The experience of the catastrophic flood of 2008 reinforced just how crucial strict observance of the agreed-upon rules is for the reduction of flood risks in lowland areas. By the same token, the seasonal regulation of drawdowns, including the minimum guaranteed flow to protect fish spawning areas in the Lower Dniester and the flooding of the river's overflow lands, is of vital interest for the entire southern part of the basin. It is also an important potential mechanism for adaptation to the expected decline in the natural flow.

In spite of the significant silting that has occurred up to this point, the Dubasari reservoir in Moldova has also retained some potential for regulating flow given the proper coordination of its drawdowns with drawdowns from reservoirs of the Dniester hydroelectric complex located upstream. (This sort of coordination requires, among other things, the application of up-to-date means and methods for automated data analysis and real-time forecasting for the entire complex of reservoirs on the Dniester.) At the same time, all of the Dniester's reservoirs are a source of heightened danger in the event that their dams are breached. None of them are equipped with an automatic warning system should a dam be breached. The installation of such a system is yet another potential risk-reduction mechanism in response to the expected change in climate and in the river's flow.

International and basin-wide cooperation institutions

There are still no permanent cooperation mechanisms in place today to address climate change issues, either within the Dniester basin or between Moldova and Ukraine in general. At the international level, certain aspects of this sort of collaboration and cooperation are governed by the two countries' participation in UNECE regional conventions (see Chapter 7). Certain provisions of these conventions, particularly the Convention on the Protection and Use of Transboundary Watercourses and International Lakes, may be used for the regulation of specific issues involving cooperation for joint adaptation to the impact of climate change on the resources of transboundary basins. Moldova and Ukraine are also parties to the United Nations Framework Convention on Climate Change.

The sharing of hydrometeorological information between Moldova and Ukraine is being carried out at the interstate level under a scientific and technical cooperation agreement between their hydrometeorological services[48]. Specifically, it requires that the neighbours provide each other with timely notification of the occurrence of flooding. In addition to the hydrometeorological services, water resources management authorities in Moldova and Ukraine also share hydrological information (see figure). On the whole, there are still significant opportunities for improving the information-sharing mechanisms at the state, interstate and regional levels[49].

Bilateral issues concerning the use and protection of water resources are addressed within the framework of an agreement between the governments of Moldova and Ukraine on the protection and use of boundary waters[50]. Plenipotentiaries of the governments of the two countries hold regular meetings to decide common issues, and there are several working groups operating under their auspices, including those dealing with the information-sharing issues mentioned above (in addition to hydrological information, regular sharing of data on water quality in boundary areas has also been organized[51]). The agreement's implementation mechanism, however, is not explicitly intended for addressing basin-wide issues outside of the boundary areas.

The Interagency Commission on Establishment of the Operating Regimes of Dnieper and Dniester Reservoirs under the State Water Resources Agency of Ukraine is in place to coordinate the practical aspects of regulating drawdowns from reservoirs that are part of the Dniester hydroelectric complex[52]. In addition to representatives of Ukrainian agencies and their regional offices, representatives of Moldovan water resources management and environmental protection agencies also participate in annual meetings to coordinate the environmentally sound drawdown of reservoirs[53]. This mechanism should be able to provide for the flexible consideration of the various interests, on the condition that all of the interested agencies and regions in the basin are represented and are given a real voice and vote in the deliberations.

The advisory Dniester Basin Council, comprised of representatives of Ukraine's various regions, has been in place in Ukraine since 2008. The council's tasks include the consideration of strategic issues involving the basin's development. The annual meetings of the council are open to the public and representatives of Moldova are allowed to participate[54]. The Dniester Basin District Committee was formed in Moldova in 2013[55]. Although the ability of these mechanisms to bring about a genuine resolution of strategic and transboundary issues has not yet been demonstrated, they are intended to be and could become an important platform for their discussion.

At the level of individual sections of the basin, the Ministry of Ecology and Natural Resources of Ukraine has launched an interesting initiative calling on the management of specially protected natural areas in different parts of the country to form associations for the sharing of information and for cooperation in the development of tourism and recreational opportunities. These efforts include the organization of joint events, tourism routes and programmes for monitoring the natural environment. The managers of protected areas in the upper part of the Dniester basin have begun a discussion of concrete steps to organize an Association of Dniester Parks. They have been conducting joint research and expeditions for some time now, they are preparing species protection plans, and on the whole they are coordinating their environmental protection and outreach efforts[56].

[Figure on page 49]

Source: UNEP/Zoï 2012.

Activities that are part of the Euroregion Dniester project, which was established by Vinnytsya Oblast in Ukraine and a number of districts in Moldova, are another interesting example of cooperation at the local level. Among other things, a draft bilateral action plan for rapid emergency response in the Dniester basin by Ukrainian and Moldovan civil defence services was prepared under the auspices of this project in 2013[57]. Generally speaking, not enough has been done yet to realize the potential for direct transboundary cooperation between the territories of Moldova and Ukraine, and in particular cooperation governed by the relevant agreement[58]. With the expansion of adaptation policy to the regional level, one can expect some interesting examples of this type of cooperation aimed at the joint resolution of climate problems.

Within the context of the association between Moldova and Ukraine and the European Union and the two countries' fulfilment of their obligations to implement the relevant directives, there are also increased opportunities for basin-wide cooperation. For example, implementation of the Water Framework Directive entails consideration of the interests of neighbouring countries in the development of management plans for parts of transboundary river basins that are within the borders of individual countries. This clearly is also entirely applicable to the planning of protection of transboundary waters under the conditions of a changing climate. A direct study of the experience gained through the work of basin commissions for transboundary rivers in the EU could be useful for the Dniester basin as well.

The Treaty between the Government of the Republic of Moldova and the Cabinet of Ministers of Ukraine on Cooperation on the Conservation and Sustainable Development of the Dniester River Basin, which has not yet entered into force[59], provides for the establishment of a Commission on Sustainable Use and Protection of the Dniester River Basin. This commission should become the body responsible for the integrated organization of basin-wide cooperation in the area of environmental protection. The measures to support implementation of the Treaty's provisions include the adoption of national and interstate basin management plans, action plans, systems and programmes aimed at sustainable water use, limiting water pollution, preventing and dealing with the aftereffects of emergencies, preserving biodiversity, as well as protecting and ensuring the responsible use of aquatic biological resources. In the event that the Treaty enters into force, the Dniester Commission (although its decisions will be of an advisory nature) could potentially become one of the key mechanisms for cooperation on environmental protection in the Dniester basin, including cooperation related to climate change issues.

06. PRIORITIES AND ACTIONS FOR CLIMATE CHANGE ADAPTATION IN THE DNIESTER BASIN

Principles of climate change adaptation in the Dniester basin

According to recommendations by the United Nations Economic Commission for Europe: "Transboundary cooperation is both necessary and beneficial in adapting to climate change. It is necessary throughout the entire process of developing and implementing an adaptation strategy. When planning adaptation across boundaries, riparian countries should focus on preventing transboundary impacts, sharing benefits and risks in an equitable and reasonable manner and cooperating on the basis of equality and reciprocity"[60].

While it is guided by the concept of managing a basin as a single system, basin adaptation does not, however, address all of a basin's problems, but only those related to climate change. Likewise, it is not intended to address all of the problems related to climate change within the territory of countries forming the basin, but only those that are directly related to the territory and interests of the basin as a single system.

The most effective basin mechanisms are those that concern problems directly related to the aquatic environment. Although consideration of the consequences of climate impacts within the territory of a basin that are not mediated by the aquatic environment is just as important and necessary for comprehensive adaptation, the effectiveness of efforts to address these problems is less dependent on the application of a basin-wide approach. Therefore, as a rule, measures related to these problems were outside the scope of this analysis and the proposed Strategic Framework for Adaptation to Climate Change in the Dniester River Basin.

The purpose of developing the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin is to propose actions that:

- are needed to reduce the vulnerability of the natural environment, the economy and the population in the basin to climate change;
- can and should be carried out at the basin level or with the participation of its institutions;
- are difficult or impossible to implement without basin-wide coordination and cooperation mechanisms.

The vast majority of adaptation measures affecting the basin will be carried out through the efforts of the countries, territories and sectors within the context of their own development and climate change adaptation strategies. The basin-wide approach complements these activities, focusing on the problems and needs of the basin as a whole, regardless of their geographical location, or the jurisdiction of agencies or territorial units. This approach also offers mechanisms for basin-wide cooperation to identify and address these problems.

The interests of other parts of the basin or the basin as a whole may suffer from the unilateral implementation of certain measures within the borders of individual countries and sections of the basin. On the other hand, the implementation of some measures may be more effective and economical if the interests and capacities of the entire basin are taken into consideration, rather than just those of individual parts of the basin. A basin-wide approach also provides for a broader perspective regarding the sources of risk and ways to resolve problems from the standpoint of common interests.

Strategic framework for adaptation: overview of proposed measures

The analysis and consultations with organizations and experts in the Dniester basin (see Chapter 4) indicate unequivocally that the principal and most pressing problem associated with climate change in the basin is the expected change in the amount, regime and distribution of the water flow. As a rule, the other sets of problems that are directly related to the aquatic environment all arise from these changes.

Given the extensive development of the hydraulic engineering infrastructure in the basin, the potential for direct regulation of the Dniester's flow is quite high[61], although the available technical and organizational capacities are by no means being used to the fullest extent possible. Coupled with the significantly lower potential for adaptation to the consequences of a change in flow that cannot be prevented through regulation by hydraulic engineering installations, this will lead to a decline in the availability of water for agriculture and a reduced water supply for certain parts of the basin, as well as a deterioration in water quality and heavier impacts on aquatic and wetland ecosystems.

All of these problems require adaptation not only to expected climate change trends, but also to the continuing high degree of uncertainty surrounding these trends. This means that the adaptation plans will need to be more flexible in terms of the traditional approaches (for example, shifting the emphasis from strictly engineering-based flood protection to restoration of the natural courses of rivers and floodplains, as discussed below). It also means that ongoing attention will need to be given to the organization and improvement of monitoring of hydrometeorological processes and signs of climate change impacts on the natural environment and the economy.

The groups of measures proposed within the context of the research that was conducted and the consultations that were held[62] are presented in a summary table in accordance with the components of the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin, namely:

- reduction in losses from extreme flooding;

- reduction in losses from a decrease in flow;
- reduction in losses from a deterioration in water quality;
- increase in the resilience of aquatic and wetland ecosystems;
- general measures for climate change adaptation in the basin.

Many of the measures included in the table have been developed in detail within the context of targeted scientific and practical research and are described in depth in the relevant literature[63]; some of them have also been included in analytical and strategic documents of the governments of Moldova and Ukraine.

Strategic Framework for Adaptation to Climate Change in the Dniester River Basin and groups of proposed measures

Risk forecasting and analysis measures	Risk prevention and reduction measures	Remediation measures
Reduction in losses from extreme flooding		
improved monitoring and forecasting of flow and information sharing inventory of flood protection infrastructure analysis and mapping of flood risk	updating and observance of rules for the operation of the Dniester's system of reservoirs updating of flood protection plans restoration and optimization of the system of flood protection structures and culverts	providing the public and local authorities with timely information about the flood risk updating and implementation of emergency response plans insurance of risks (including insurance provided with government support)
Reduction in losses from water scarcity		
analysis of the water balance in the basin improved monitoring and forecasting of flow and information sharing assessment and monitoring of the condition of forests	updating and observance of rules for the operation of the Dniester's system of reservoirs protection and restoration of forests and shoreline vegetation optimization of the regulation of flow at the local level reduction in water consumption and losses	modernization of irrigation systems diversification and modernization of water supply systems for population centres insurance of risks (including insurance provided with government support)
Reduction in losses from a deterioration in water quality		
improved monitoring and forecasting of flow and information sharing improved monitoring of water quality	improvement of wastewater treatment systems protection and regulation of the use of catchment basins and water protection zones	improvement of water treatment and distribution systems diversification and modernization of water supply systems for population centres
Support for and restoration of aquatic and wetland ecosystems and species		

● analysis of ecosystem services at the basin level ●● improved monitoring of ecosystems and biological resources and transboundary information sharing	●● updating and observance of rules for the operation of the Dniester's system of reservoirs ●● regulation of activities within floodplains and wetlands ●● expansion and strengthening of the network of protected areas and ecological corridors ●● combating poaching and invasive species	●● restoration of shoreline forests, meadows and wetlands ●● restoration of habitats, spawning grounds and fish stocks
General measures for adaptation and development of cooperation in the basin		
● systematic analysis and forecasting of climate change and its impacts in the Dniester basin	● consideration of adaptation needs in long-term Integrated Water Resources Management (IWRM) plans ● providing information about climate change problems in the basin ● inclusion of adaptation needs in socioeconomic development plans for sectors and territories	

Designation of mechanisms for implementation of the proposed adaptation measures:

● **JOINT** actions by countries at the basin level (transboundary cooperation required) – coordination of and direct support for adaptation measures requiring direct cooperation among countries and parts of the basin, including the initiation of and support for measures at the level of individual countries and sections of the basin that are being carried out in the interests of the basin as a whole.

● **COORDINATED** actions by countries in order to do a better job of protecting the interests of the basin as a whole (transboundary cooperation desirable) – coordination, assistance and partial support for the coordinated implementation of adaptation measures at the level of individual countries and sections of the basin that could have an impact on other countries and administrative units within the basin.

● **AUTONOMOUS** harmonized actions in countries and individual sections of the basin (transboundary cooperation useful) – sharing of positive and negative experience at the basin level; initiation of and limited assistance for general measures at the level of individual countries and sections of the basin that are being carried out on a common methodological, organizational and financial basis.

[Figure on page 55]

Classification of adaptation measures by target area, category and approximate cost

Priority measures that are being implemented under the Environment and Security Initiative with the support of Austria, the European Union, Finland, Sweden and Switzerland are shown in italics (see box and map).

The figure illustrates the same groups of adaptation measures analysed from the standpoint of possible mechanisms for their implementation. This analysis takes into account the fact that many of the measures have been developed and should be implemented within the context of national, regional and sector-based programmes (see Chapters 5 and 7). Some of these programmes are intended for the development of the relevant sectors and target areas at the country level (environmental protection, water resources management, emergency response) or at the level of sections of the basin (for example, flood protection plans and systems and plans for the operation of water management installations). Consequently, these programmes ordinarily do not devote sufficient attention to transboundary interests of the basin as a whole, or to existing and future climate trends. Likewise, national and sector-based climate change adaptation plans and programmes are not able to take into account the interests of the basin as a transboundary system.

Thus, an important task for adaptation at the basin level is to promote the consideration of basin-wide interests related to climate change risk reduction within the context of existing mechanisms and processes whose own objectives are distinct from adaptation of the Dniester basin as a whole. Another important task is to identify and encourage a range of actions, the implementation of which will directly help to improve the basin's resilience and adaptation to climate change. Actions that can be carried out using existing and prospective mechanisms for basin-wide coordination and cooperation have a special role to play in both of these cases.

[Map on page 56]

Source: ENVSEC Initiative project materials.

From small channels and poplars to a dialogue between generations and capitals: practical support for adaptation in the Dniester basin[64]

While some problems involving adaptation to climate change cannot be resolved without the use and improvement of government mechanisms, frequently all that is lacking for the resolution of others is imagination and a willingness to take charge. In the final analysis, successful adaptation requires a combination of actions at a number of different levels: from an individual tree, marsh or village to government policy and interstate relations. Work under the Environment and Security Initiative on climate change problems in the Dniester basin has contributed not only to the preparation of the Strategic Framework for Adaptation, but also, within the limits of its fairly modest means, to the identification and implementation of concrete actions, which the participants in the process – experts and organizations from Moldova and Ukraine – had classified as top priorities.

Adaptation "sore spots": poplars, small channels, people

The basin begins with a stream and ends in an estuary. Between these two points, there are countless tributaries and branches, marshes and oxbows, villages and towns, some of which are feeling the impacts of climate change more strongly than others. This group includes the ecosystems of the Dniester delta, which received the first targeted assistance. In order to increase the resilience of floodplain meadows in the delta to adverse conditions, the exchange of water between them and the main course of the Dniester needs to be ensured through numerous small connecting channels, which have become overgrown with reeds and are constantly clogged with silt during the “high water” season. The clearing out of these channels is one of the outcomes of the project.

Floodplain forests are suffering from more frequent and more severe droughts, and project funding has been used for the planting of forests on Turunchuk Island and in the Kuchurhan River valley (young people participated in the latter effort, while at the same time learning to care about preserving the natural wealth of the Dniester).

Heavier flooding in the future will have the greatest impact on the property, health and lives of the basin’s human inhabitants. Emergency services agencies have helped to prepare vitally important information about how to prevent and reduce damage from floods, and to provide this information in various languages to towns, villages and residents in the basin. For certain parts of the basin that are particularly vulnerable to floods (from Mohyliv-Podilskyi to Otachi, towns and villages along the section between the Dubasari reservoir and Palanca, and the Dniester delta), flood zone maps have been prepared for the first time and an estimate of the expansion of these zones as a result of climate change has been performed. Research has been organized in the lower reaches of the Dniester in order to make use of the potential of modern ecosystem approaches to flood control, which entails the lowering of water levels in the river through the flooding of specially designated floodplain sections. At the same time, experts are studying the possibility of creating artificial spawning grounds in the flooded sections.

Shared solutions for the shared basin

Another focus of the priority actions proposed by participants in the ENVSEC projects is to work with the basin as a whole as a single ecological, hydrological and water management system. This involves above all a strengthening of the joint information base. Automation of water flow observations will make it possible not only to collect and store data in modern electronic formats, but also to share these data easily in real time, which is especially important when flooding occurs, for example. ENVSEC projects provide for the automation of seven hydrometeorological observation stations in the Dniester basin, in the upper part of the river in particular. Two stations in Halych and Zalishchyky are already sending continuous data to the Internet. There are also plans to connect data from Moldova and Ukraine in a combined network for shared use and to improve the reliability of forecasts of inflow into the reservoirs of the Dniester hydroelectric complex in the middle part of the basin.

The joint management of the Dniester reservoirs is a powerful tool for adaptation in the basin. In order to facilitate the utilization of its possibilities, the Alliance for Global Water Adaptation, in cooperation with UNECE and OSCE, is completing the development of a simulation model for the Dniester reservoir system. This will provide a more solid foundation for joint decision-making regarding both long-term and real-time management of the Dniester’s water resources. Compilation of the basin’s current water balance will serve these same objectives.

Finally, the future of the basin also represents the shared future of its children. One outcome of the support provided under ENVSEC is a creative competition called Colours of the Dniester, which has already become a traditional event. Every year it inspires schoolchildren in Moldova and Ukraine to give some real thought to the life of the river. Poetry and prose, painting and photography are helping to bring together countries and cities and to strengthen the climate of cooperation in the basin, while the global climate is creating new problems. Scientific and educational expeditions for youth organized by the Eco-TIRAS international association and supported by ENVSEC are also making a contribution to this process.

International context: adaptation and the basin treaty

The signing of the Treaty on Cooperation on the Conservation and Sustainable Development of the Dniester River Basin by the Government of the Republic of Moldova and the Cabinet of Ministers of Ukraine in Rome in 2012 is to a large extent the result of work with the countries by the Environment and Security Initiative partners UNECE, OSCE and UNEP. Ratification of the treaty and its entry into force are among the principal conditions for achieving stability in cooperation in the basin and specifically for its systematic adaptation to climate change in the future. In turn, joint efforts by the countries in the area of climate change adaptation will help to develop mechanisms and to gain experience with dialogue and cooperation in the basin as a whole. Further assistance for ratification of the treaty and the establishment of interstate institutions for basin-wide cooperation remains an unconditional strategic priority for ENVSEC partner organizations.

Source: ENVSEC Initiative project materials.

Economic aspects of adaptation in the basin

The figure showing the classification of adaptation measures in the previous section contains a rough estimate of the cost of implementing the measures in question (as determined by experts). When the estimates for individual measures are combined (not including current expenses and measures for which there is insufficient information to determine cost), the total cost of adaptation in the Dniester basin varies by orders of magnitude – from several million euros to tens of millions and even hundreds of millions of euros.

The range of estimates is tied not only to the difficulty of arriving at precise figures, but also to the uncertainty regarding the level of risk, which these measures are intended to prevent or reduce. The higher the level of expected risk, the more expensive the implementation, especially with regard to measures involving infrastructure. The estimates do not take into account the possibility of and need for a radical restructuring of the measures – a fundamental shift in adaptation methods and, accordingly, in the structure of expenditures depending on the extent of climate change and the increasing uncertainty associated with it (for example, the transition to ecosystem adaptation as an alternative to engineering solutions to flood protection – see box).

The figures cited here will certainly require further substantiation and revision based on more in-depth research, although in any case their accuracy will be limited in principle by the uncertainty surrounding the projections of future climate and the limited possibilities of existing models and methods used for economic calculations[65].

Generally speaking though, in spite of the wide range and uncertainty of the economic estimates, it is clear that the implementation of even a limited set of high-priority measures would allow for the fulfilment of a number of tasks associated with increasing the basin's resilience to future changes. The final determination of the measures is the prerogative of the countries in the basin and will depend, among other things, on the possibilities offered by concrete mechanisms for their implementation, which are discussed in the following chapter.

Adaptation and flood protection

Even for one of the most extensively studied and obvious problems – extreme floods – the range of estimates is quite broad. At the same time, it is clear that even if the present features of the hydrological regime remain unchanged, the cost of the state flood protection programmes now being considered is comparable to the amount of maximum and even average damage (not including damage that is difficult to express in economic terms, such as loss of human life, for example).

Some parameters of flood damage and protection in the Dniester basin (based on multiple years of data)

	Ukraine	Moldova
Economic damage		
Damage from floods, one-time maximum (euros)	500 million**	15 million–150 million*
Damage from floods, average per year (euros)	100 million**	4 million–7 million*
Damage to life and health		
Population in hazard zones subject to flooding (number of people)		100,000*
Average mortality from catastrophic floods (number of people)	30–50**	2*
Flood protection measures		
Cost of current flood protection programmes (euros)	500 million–3 billion***	5 million–15 million*

* For the entire territory of Moldova
** For the western oblasts of Ukraine, including Transcarpathia (Tisza basin)
*** The Ukrainian part of the Dniester (upper reaches), Prut and Siret river basins.

Data sources: Apele Moldovei 2010, Supreme Council of Ukraine 2013, Corobov et al. 2013, Government of the Republic of Moldova 2011, Government of Moldova, World Bank 2007.

In the event that the situation worsens with climate change, the economic advisability of flood protection will only increase[66]. As the relevant climate trends become more pronounced, however, the investment advisability ratio of various protection methods will change.

As the intensity and frequency of catastrophic floods increase, at some point a threshold will be reached at which the regulating capacities of the reservoirs will no longer be sufficient. Similarly, as current experience shows, as the effects of climate change grow and the degree of their uncertainty rises, there will be a decline in the relative effectiveness of “hard” engineering measures compared to “green adaptation”, which uses the natural capacity of restored floodplains and river channels to contain and dissipate the energy of a flood wave[67].

Possible relative importance of various flood protection measures depending on the extent of climate change

	Expected increase in the intensity of catastrophic floods:			
	0%	+15%	+30%	+50%
Updating and coordination of flood protection plans				
Updating and tightening of rules for the operation of reservoirs				
Restoration and optimization of flood protection structures				
Restoration of natural floodplains and riverbeds				
Monitoring, forecasting of flow and real-time information sharing				
Emergency response plans				

The size of the symbols indicates the relative importance of the measure.

In terms of long-range planning and funding of flood protection, it is important to identify the point at which further investments in "hard" hydraulic engineering infrastructure will begin to give way to ecosystem measures that are more effective under the new conditions. This will require a shift in strategy towards a fundamentally new approach with a different capital investment structure. Of course, serious research and sophisticated mechanisms for the analysis and monitoring of the effectiveness of investments will be needed to achieve this.

07. WHERE TO BEGIN

Institutional mechanisms

Implementation of the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin should be based on institutional mechanisms that are already in place. There are essentially three sources for mechanisms of this kind (see Chapters 5 and 6):

- Plans, programmes and legislation at the national level and at the level of regions in Moldova and Ukraine located within the Dniester basin, which are aimed at the development of sectors and activities related to climate change adaptation. This also includes plans and programmes targeted directly at adaptation to climate change;

- Plans, programmes and mechanisms related to the fulfilment by Moldova and Ukraine of international and bilateral commitments concerning problems and interests of the Dniester basin and problems related to climate change;

- Mechanisms for direct cooperation within the basin.

With regard to the countries' national and regional programmes, plans and legislation, it is necessary to define what the specific objectives are and how the needs related to adaptation in the Dniester basin can and should be taken into account in the planning and implementation of these measures. This will require analytical work at the basin level in close cooperation with agencies and organizations in Moldova and Ukraine that are responsible for the implementation of the plans and programmes. Their optimization, taking into consideration the interests of the basin, will require the relevant decisions by the government of each country. At the same time, and in conjunction with the responsible and interested agencies, sources of funding for the optimization process will need to be identified as well (including additional actions and measures to take into account the specific interests of the basin and climate change in the basin). In addition to the central government bodies, it is extremely important to engage in a dialogue with regional authorities, especially those representing the most vulnerable regions in the middle and lower parts of the basin (including Odesa Oblast in Ukraine and the Transdniestrian region of Moldova).

International cooperation mechanisms that provide for cooperative activities among specially authorized agencies on matters that fall within their jurisdiction may be used directly for the optimization of plans and programmes to meet the international (including bilateral) obligations of Moldova and Ukraine. For example, hydrometeorological services can share information and forecasts; water resources management authorities can cooperate in the management of water resources, flood protection and the operation of hydraulic engineering structures; environmental protection agencies can work to develop a network of protected areas and on transboundary cooperation to promote environmental protection, among other things.

The plans for specific measures aimed at the fulfilment of international and bilateral obligations and the implementation of cooperation programmes based on the needs and interests of the Dniester basin can be optimized in accordance with input from the relevant agencies or bodies responsible for management of the basin, accompanied by a corresponding study of the specific adaptation needs in the basin, the nature of concrete actions and funding sources for the implementation of additional measures. In the context of the association with the European Union, mechanisms for implementation of the relevant EU directives also need to be utilized.

Connection between climate change adaptation in the Dniester basin and certain public policy mechanisms in Moldova and Ukraine and interstate and international cooperation

Moldova	F	S	Q	E	G
Environmental strategy		●	●	●	●
Climate change adaptation strategy	●	●	●	●	●
Strategy for adaptation of water supply and wastewater systems to climate change	●	●	●		
Management plan for the Dniester basin district	●	●	●	●	●
Programme to develop water resources management and water conservation	●	●	●		
Programmes to provide water supply and sewage systems in population centres		●	●		
Plan to protect population centres from flooding	●				
Emergency civil defence plan	●				
Programme to create a national environmental network				●	●
Ukraine					
State environmental policy strategy			●	●	●
National action plan for environmental protection			●	●	●
National, sector and oblast action plans for climate change adaptation (under development)	●	●	●	●	●
State Targeted Programme for the Development of Water Resources Management and Environmental Restoration of the Dnieper River	●				
State Targeted Programme to Protect the Population and Territories against Industrial and Natural Disasters	●	●	●		
State Emergency Response Plan	●				
Forests of Ukraine State Targeted Programme for 2010–2015		●		●	
State Programme for the Formation of a National Environmental Network				●	●
Bilateral cooperation					
Treaty on Cooperation on the Conservation and Sustainable Development of the Dniester Basin (not ratified)	●	●	●	●	●

Agreement on the Joint Use and Protection of Boundary Waters	●		●	●	●
Agreement on the Prevention of Industrial Accidents, Natural Disasters and the Elimination of their Consequences	●				
Agreement on Scientific and Technical Cooperation between Hydrometeorological Services	●	●			
Agreement on Cooperation between Administrative-Territorial Units of Moldova and Border Oblasts of Ukraine					●
Multilateral cooperation					
Global conventions of the United Nations (on climate change, biological diversity, persistent organic pollutants)			●	●	●
UNECE conventions and protocols (Helsinki, Espoo, Aarhus, on the transboundary effects of industrial accidents)	●		●	●	●
Other regional conventions on the protection of natural complexes and biodiversity (Ramsar, Bern, Bonn)				●	
Cooperation with the EU (Association Agreements, European Neighbourhood Policy, Eastern Partnership)	●	●	●	●	●
Cooperation with international organizations (UN, OSCE, NGOs) and financial institutions (World Bank, European Bank for Reconstruction and Development, European Investment Bank)	●	●	●	●	●
Bilateral cooperation and technical assistance programmes	●	●	●	●	

Some of the names have been abbreviated in the table.
Target areas for adaptation activities: F – floods, S – water scarcity, Q – water quality, E – ecosystems, G – general measures

Within the context of the implementation of the EU Water Framework Directive, for example, Moldova has already begun work on the development of a management plan for the Moldovan part of the Dniester basin. The creation of a future management plan for the Ukrainian part of the basin and its coordination with the Moldovan plan, as well as the consideration of basin-wide and climate-related aspects in both of the plans, could become effective mechanisms for the introduction of a concrete adaptation framework and related measures.

Among the bilateral cooperation mechanisms, plenipotentiaries of the Moldovan and Ukrainian governments responsible for implementation of the 1994 boundary water cooperation agreement and bilateral working groups operating under the auspices of the agreement (see Chapter 5) could play a special role. Although this mechanism is not intended for the systematic review and resolution of strategic issues involving the basin's development, problems related to the Dniester are regularly discussed at meetings of the plenipotentiaries and working groups. In the absence of mechanisms for integrated basin-wide cooperation at this time, these groups could take on a coordinating role with regard to adaptation in the Dniester basin, and then turn this role over to the Dniester Commission at some point in the future (see below).

Some aspects of climate change adaptation can be addressed by other basin-focused agencies that already exist in Ukraine and Moldova and by the Interagency Commission on

Establishment of the Operating Regimes of Dnieper and Dniester Reservoirs under the State Water Resources Agency of Ukraine (see Chapter 5). And finally, in the event of the entry into force of the Treaty on Cooperation on the Conservation and Sustainable Development of the Dniester River Basin, which was signed by the Government of the Republic of Moldova and the Cabinet of Ministers of Ukraine (see Chapter 5), its principal body, the Commission on Sustainable Use and Protection of the Dniester River Basin, will be responsible for the coordination of water resources management and conservation activities throughout the entire basin. The Commission will be the mechanism that is best suited for the full-scale development, coordination and implementation of basin-wide measures for adaptation to climate change. Further steps towards the preparation and implementation of the Strategic Framework for Adaptation in the basin will depend directly on the fate of the treaty and its institutions.

Concrete steps

A number of steps need to be taken in order to launch the implementation of measures provided for under the Strategic Framework for Adaptation to Climate Change in the Dniester River Basin:

- Within the context of the drafting of this document, agree upon the Strategic Framework for Adaptation and the principal groups of measures related to it, at the basin level and/or on a bilateral basis (see Chapter 6);

- For each target area, perform an approximate analysis of the effectiveness, compatibility and cost of individual measures, taking into account climate trends and uncertainty, and determine the sequence in which the measures should be implemented;

- For each of the measures selected (or, at the initial stage, for a limited number of measures), perform a detailed analysis of the sequence and the instruments needed for their implementation (informational, legal, institutional, financial) and possible funding sources;

- Begin the implementation of adaptation measures taking into account the selected sequence and mechanisms, in cooperation with authorized bodies and interested agencies and organizations of the countries, regions and basin.

Taking into consideration further analysis and consultations, a plan for the implementation of concrete adaptation measures and for mobilization of the necessary resources will be developed as a Strategic Framework Implementation Plan, which will become an integral and essential part of the methodological foundation for the Dniester basin's adaptation to climate change.

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NOTES

[1] UNECE and OSCE 2005; Ukrainian Scientific Research Institute of Water Management and Environmental Issues (UNIIVEP) 2011.

[2] GRID-Arendal/Zoï 2012; Corobov 2013, 2014; Environment and Security Initiative, UNECE, OSCE, UNEP, 2013.

[3] UNIIVEP 2011.

[4] Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention): www.ramsar.org/sites-countries/the-ramsar-sites.

[5] Lisichenko and Bukharev 2006, cited in Lukarzhevska 2012.

[6] See, for example, the report by the European Commission-United Nations technical scoping mission (EC/UNEP/OCHA 2010). According to press reports and experts, by the middle of 2013 the situation in Kalush had become critical once again, and there was a real possibility that industrial waste from potash production would enter groundwater that was hydraulically connected to the Dniester.

[7] IPCC 2013.

[8] See, for example, the description of the IPCC Fourth Assessment Report scenarios in UNEP/GRID-Arendal 2012. The A1 scenario, which is cited most frequently here, is distinguished by high rates of economic growth, achievement of the maximum population on the planet by the middle of the century, followed by a population decline, as well as rapid introduction of new and efficient technologies. The differences among the regions are gradually eroded as a result of intensive cultural interaction, and differences among the regions in terms of per capita income also shrink significantly. There are three versions of scenario A1, which describe the various versions of energy development: intensive use of fossil fuels – A1F1, the use of non-fossil fuels or a combination thereof – A1B.

[9] See, for example, Corobov 2004.

[10] Ukrainian Hydrometeorological Scientific Research Institute (UHMSRI) 2012; A detailed analysis of climate change trends in the Dniester basin in the past and up to 2050 is also provided in Corobov et al. 2013.

[11] UHMSRI 2012, UHMI 2014.

[12] Corobov et al. 2014.

[13] UNDP 2009, Serenko 2011, UHMSRI 2012, Corobov et al. 2013, OECD 2013.

[14] UNECE, OSCE, UNEP 2013.

[15] See, for example, OECD 2013a, OECD 2013b.

[16] A flood with a water volume that is exceeded on average once every 100 years (that is, with a statistical probability of 1 per cent).

[17] Kolomiets et al. 2012, Zheleznyak et al. 2015.

[18] Corobov et al. 2013.

[19] UHMSRI 2012.

[20] Compared to the period 1981–2010, the overall trends in the change in the number of days with flooding and the intensity of the floods will continue, although the quantitative estimates may differ since at the beginning of the twenty-first century the highest air

temperatures were observed in the Dniester basin, along with intensive convection, and accordingly, heavy precipitation and flooding. Therefore, the difference between the expected values of the relevant parameters in the middle of the twenty-first century and in 1981–2010 will be smaller than when compared to 1971–2000 (V. Balabukh, personal communication).

[21] OECD 2013.

[22] Sîrodoev and Knight 2007.

[23] The text in the box was prepared with the assistance of N. Babich.

[24] Bejenaru et al. 2014.

[25] O. Melnichuk, personal communication; see also Sîrodoev and Knight 2008.

[26] OECD 2013.

[27] UHMSRI 2012.

[28] UNDP 2009.

[29] Melian 2011.

[30] Sîrodoev and Knight 2007.

[31] Ecospectrum 2012

[32] Corobov et al. 2013, 2014.

[33] An example of this kind of mechanism can be seen in the floodgates for regulating the inundation of the Talmaza overflow lands, recently constructed by the BIOTICA Ecological Society with support from the Austrian Government.

[34] Snigirev 2011.

[35] The decline in the fish catch in the Dniester by a factor of 2-3 compared to the 1990s is linked to a significant shrinking of the area of spawning grounds in drought years and to the death of individuals of phytophilic species given the unstable temperature patterns.

[36] http://ukrstat.gov.ua and http://www.statistica.md.

[37] See the draft strategy – Government of the Republic Moldova 2014. The original, lower estimate of the cost of the strategy's implementation (US$2 million) covered primarily the organization of scientific research work for further detailed development of the provisions of the strategy and laying the institutional groundwork for its implementation (Ministry of the Environment of the Republic of Moldova 2011, Taranu 2013).

[38] OECD 2013.

[39] Trofimova 2013.

[40] Round-table meetings in Kyiv (December 2012) and Chisinau (July 2013); see also Trofimova 2013.

[41] http://necu.org.ua.

[42] Ecospectrum 2012.

[43] Supreme Council of Ukraine 2013, Babich 2011.

[44] Government of the Republic of Moldova 2011b.

[45] UNEP/Zoï 2012.

[46] Corobov et al. 2013, 2014.

[47] Supreme Council of Ukraine 2000, Government of the Republic of Moldova 2011a.

[48] Agreement on Scientific and Technical Cooperation between the Main Hydrometeorology Administration under the Moldovan State Department for Environmental Protection and Natural Resources and the Ukrainian State Committee on Hydrometeorology (1996).
[49] UNEP/Zoï 2012.
[50] Agreement between the Government of the Republic of Moldova and the Government of Ukraine on the Joint Use and Protection of Boundary Waters (1994).
[51] UNEP/GRID-Arendal/Zoï 2010.
[52] Regulation on the Interagency Commission on Establishment of the Operating Regimes of Dnieper and Dniester Reservoirs under the Ukrainian State Water Resources Agency. Approved by a decision of the State Commission on Industrial and Environmental Safety and Emergencies on 21 September 2000.
[53] http://apelemoldovei.gov.md/libview.php?l=ro&idc=127&id=271.
[54] http://dniester.org/wp-content/uploads/2009/06/d0bfd0be d0bbd0bed0b6d0b5d0bdd0bdd18f-d0bfd180d0be-d0b1d0b 0d181d0b5d0b9d0bdd0bed0b2d183-d180d0b0d0b4d183-d0b4d0bdd196d181d182d180d0b0.doc.
[55] Government of the Republic of Moldova 2013, 2014.
[56] The creation of an association of Dniester national parks was discussed at the regional scientific workshop on Wetlands for our Future: Optimization of Resource Utilization and Preservation and Protection of Biological and Landscape Diversity at the Podilskyi-Tovtry National Park (Kamianets-Podilskyi, 6 February 2014).
[57] http://dniester.eu/611.
[58] Agreement on Cooperation between Administrative-Territorial Units of the Republic of Moldova and Border Oblasts of Ukraine (1997).
[59] http://dniester.org/wp-content/uploads/2013/01/rus.pdf. At the time this text was prepared, the Dniester Basin Treaty that was signed in 2012 had still not been ratified by Ukraine.
[60] UNECE 2009.
[61] Almost 37 per cent of the Dniester's flow, based on the volume occurring on average every other year, is regulated by the reservoirs of the Dniester hydroelectric complex (not including the pumped-storage hydroelectric power plant) and the Dubasari Hydroelectric Power Plant (UNIIVEP 2011).
[62] UNECE, OSCE, UNEP 2013.
[63] See, for example, Corobov et al. 2013, Trombitsky and Corobov 2011, and Ecospectrum 2012, as well as descriptions and documents of the relevant targeted government programmes of Moldova and Ukraine.
[64] The text in the box was prepared with the assistance of A. Plotnikova.
[65] OECD 2013a, WMO 2007, EEA 2013.
[66] Examples of estimates of cost-effectiveness ratios for expenditures in countries in the basin: 7 to 1 for providing flood protection (Corobov et al. 2012) and 4 to 1 for protecting the Black Sea shoreline against a rise in sea level (Rubel, O., in Trombitsky and Corobov 2011).

[67] The current flood protection strategies are focused to a large extent on restoration and use of the natural properties of river channels and floodplains. See, for example, the overview of experience and examples in WMO 2006, EEA 2013, OECD 2013a.

According to the authors of studies on the vulnerability of the Dniester basin, one of the reasons for the adverse impacts of catastrophic floods is a failure to carry out the necessary operational measures in the Dniester floodplain, in the riverbed itself in particular, and also in the water protection zones and shoreline protection belts. These problems are frequently aggravated by the fragmentary nature of approaches to addressing the prevention of flood damage. For this reason, the pressing task with regard to many mountain rivers is to implement integrated measures aimed at reducing the destructive impact of floodwaters by improving the natural conditions of the river valleys and increasing the reliability of flood control structures (Corobov et al. 2013).

In the opinion of participants who attended the round-table meeting of Ukrainian water resources management and environmental protection agencies in Kyiv in February 2014, "it is necessary to perform landscape planning in the Dniester basin catchment area with the aim of achieving the optimal relationship among forests, meadows and agricultural land. Erosion-control measures, including drainage and trapping canals, hillside water-retaining walls, the grading of ravines and the creation of graduated drops on small rivers (especially in the mountains), will provide for a reduction in the intensity and velocity of hillside flow, thereby increasing the time that it takes for a flood wave to travel and reducing its maximum level" (Yu. Nabivanets, N. Babich, meeting recommendations).

Experts working in the water resources management complex in Moldova believe that "the concept behind the existing flood control dams, which is primarily to protect floodplains from inundation with the aim of increasing agricultural output and only secondarily to protect population centres, given the socioeconomic situation in the country today, is not consistent either with the current requirements or the capacities of the state. In light of this, flood control dams should be used to prevent the flooding of population centres" (Aquaproject/Apele Moldovei 2010). Shifting the emphasis in this direction will at the same time make it possible to free up some of the floodplains for "natural" flood protection. See also Melnichuk and Gudumak 2011.

The adaptation measures proposed for the Transdniestrian region of Moldova include the conversion of arable floodplain land into polders with the regulated inflow and outflow of floodwaters and into regulated meadow spawning grounds (Ecospectrum 2012).

The Ukrainian State Water Resources Agency is also considering the possibility of protecting agricultural land in the Dniester delta and the Odesa-Reni highway by restoring the low-water streamflow system for intensification of the water exchange between the river and inundated areas.

One of the problems with the organized flooding of floodplains to lower the water levels during floods is related to the cost of buying up agricultural land from owners or providing compensation for economic losses in these sections.