

**ENVSEC Project “Reducing vulnerability to extreme floods and climate change in the Dniester river basin”  
(Dniester III floods & climate)**

**Summary of the baseline studies for Ukraine (prepared by Mr. Nabyvanets)  
and the Republic of Moldova (prepared by Ms. Serenco)**

**Summary prepared by Ms. Lesya Nikolayeva, Zoi**

Since the beginning of the century floods have affected the lives of many people. In recent years, the number of frequent catastrophic floods has increased; their economic, social and environmental impacts have worsened leading to the increased casualties. In this very serious situation, the expansion of climate variability and expected climatic changes may result in more frequent and severe flooding. Floods do not respect borders between countries, regions or organizations, so there is need for risk management of transboundary floods, involving governments, since the borders and the population of the respective countries are concerned.

However, it is quite difficult to implement risk management, since it requires joint monitoring, forecasting, early warning system, coordinated risk assessment and joint planning. The main advantages of transboundary cooperation are expanded information and knowledge base, increased set of available strategies and ensuring better and cost-effective solutions. In addition, expanding the territory in question during the basin planning allows taking actions in the places where their effect would be much-needed.

The Dniester is a river in Eastern Europe, one of the largest rivers of the Carpathians. The Dniester flows from northwest to southeast on the territory of Ukraine, Moldova and Transdnistria. The length of the Dniester is 1352 km with basin area of 72100 km. The river starts in the Carpathian Mountains at an altitude of 900 m above the sea level and flows into the Dniester estuary, which is connected to the Black Sea. The average water downstream flow is 310 m/sec. Annual runoff is 10 billion cubic meters. The length of the Dniester within Moldova is 660 km, in Ukraine - 692 km. The basin area within Moldova is 19,070 km that is 57% of its territory, in Ukraine it is 53,030 km. The Dniester is a part of the state border between Ukraine and Moldova, as well as 398-km border between Transdnistria and Moldova.

In its upper reaches the Dniester flows in a deep narrow valley and is a fast mountain river. The flow speed is 2-2.5 m/sec. Right-hand side mountainous tributaries mainly fall into the river here; the largest of them is the Stry river. In its middle reaches the Dniester flows in a narrow and deep canyon-like valley with high, steep and rocky banks, there are only left-hand side tributaries. These are the Zolota Lypa, Strypa, Seret, Zbruch, Smotrych, Murafa. In its lower reaches the Dniester river valley expands and its flow becomes less sweeping. Here, there are right-hand side tributaries, such as the Reut, Byk, Botna. The Dniester's inflow is provided by snow and rain. The river often experiences sudden rise of water level, in particular due to summer heavy rains which often cause flooding.

The Dniester flows into the Dniester estuary, its length being 40 km. The Dniester Delta is a home to a large number of birds nesting in its territory and many rare plant species. The lower reaches of the Dniester, in particular, the area where the Dniester runs into the Turunchuk have been put into an international list of the Ramsar Convention on Protection of Wetlands. On the territory of the Odessa region the natural reserve “Dnestrovsksi Plavni” has been created in the marsh area.

The region of the Dniester River basin can be divided into the following natural units:

- the Carpathians – precipitation of 800-1200 mm/year, the highest peak - 1818 m above the sea level. The rivers are mountainous with a large slope and high flow, highly forested area, elements of Western European flora and fauna, geological structure being flysch; low population density;

- the Carpathian plain - precipitation of 600-700 mm / year, height is 200-500 m above the sea level, shallow valley with wooded areas, dried swamps (at the beginning of this century swamps occupied most of this territory), numerous gravel and sand banks, oxbow lakes, the region is an important industrial center of Ukraine with high population density.
- the Podillia Upland - precipitation of 500-600 mm / year, canyon-like banks of up to 200 meters, developed agriculture, the Dniester HPP and HAPP dams that have formed the reservoir up to 150 km.
- The Black Sea Lowland - precipitation of 300-400 mm / year, height 100-200 m above the sea level, dry steppe area, west of Chisinau there are low, wooded mountains of Kodry.

385 tributaries flow into the Dniester, of which 177 are right-hand side and 208 – left-hand side. The area ratio is as follows: right-bank part of the basin -31034.6 sq.km; left bank - 41,065.4 sq.km.

## **Baseline Study for the Republic of Moldova**

Since 1954, after commissioning of the Dubossary reservoir and the Dniesterian reservoir in 1982 there have occurred some changes in the hydrological regime. The **Dniesterian Reservoir** is one of the most important and designed for the annual runoff regulation. The water-shed area is 40,500 sq.km. The length of the Reservoir on the fairway of the river is 204 km. Coastline is 528 km. The average width of the Reservoir is 0.8 km, max – 2.5 km. The surface elevation at the NBH (normal booster horizon) of 123 meters is 150 square kilometers, the reservoir capacity is 3,300 million cubic meters The **Dubossary Reservoir** provides daily water management and holds a partial cut-off peaks in spring and during rain floods. The length of the reservoir is 128 km. Total capacity of the Dubossary Reservoir: designed - 485 million cubic meters, according to surveys held in 1969 - 372 million cubic meters, still usable capacity is only 209 million cubic meters, and currently available capacity is much smaller.

### **Distribution of flow of the Dniester based on the operation of the Dniesterian hydro allocation system:**

<b>Title</b>	<b>Capacity of 75% million cubic meters per year</b>	<b>Per cent share (%)</b>
Annual runoff volume	8157.2	100
Sanitary discharges	2520	30.89
Additional discharges into the sea except for sanitary discharges	1644.8	20.16
Filling of reservoirs and losses	506.4	6.21
Total water consumption in Ukraine	1743	21.37
Total water consumption in the Republic of Moldova	1743	21.37

*Source: Institute "Aquaproject"*

### **Level regime**

The level regime of the Dniester in Moldova has been substantially influenced by the Dniester hydro allocation system: redistribution in spring tide and storm flooding from truncation of the maximum levels. The highest annual rate in the upper reaches, as a rule, are the levels of rain flood, but in some years, the highest annual levels may also be spring tide levels, fall and even winter floods. In the middle and lower reaches maximum levels of spring floods are usually more summer maxims (1990, 1995, 1999, 2000, 2003, 2005, 2006, 2009). The average rate of rise is 10 to 150 cm / day, maximum of 1-2 m / day, in some years up to 3.5-5.5 m / day. Low levels can usually be seen in the interval between two successive floods. Low levels can be found any month.

### **Hydrological monitoring**

State Hydrological Service of the Republic of Moldova provides the state hydrological monitoring in the Dniester basin at the national level, and has 27 hydrological posts, 9 of which are on the river itself. This service is the only one in Moldova, dealing with hydrological monitoring and forecasting, through various forms of bringing water-related information to consumers (hydrological bulletins, information about start dates and the volume of spring flood, urgent warnings about threat for flooding national economic

facilities, human settlements and human life, posting information on the Hydrometeorological site ([www.meteo.md](http://www.meteo.md)) and in the media). Annually the reports on extreme weather events are being prepared on the basis of data from the Department of Civil Defense and Emergencies, forecasting techniques are being developed and updated with the help of colleagues from the neighboring states.

In the framework of the World Bank project the acquisition and commissioning of 10 automatic hydrological stations on the Dniester River, including upstream and downstream from Moldova, are planned in 2010-2013.

In 2010 Moldavian Agency "Apele Moldova" developed an action plan for flood management and improving water resources management and flood protection (three stages: short-term activities, mid-term and long-term actions for the next decade).

### **Assessment of climatic resources**

This study concentrated on the period from 1945 to 2009 and used the data from meteorological observations of the State Hydrometeorological Service of the Republic of Moldova.

**Solar radiation:** in recent decades in the Dniester River basin an increase of *direct solar radiation* has been detected - in autumn and winter, an increase was 1.0 and 2.5 MJ / m, respectively, and spring and summer - 7.6 and 14.0 MJ / m. The values of *total radiation*, except for autumn months, have also changed towards an increase. *Scattered radiation* has diminished. There was a decrease in the *reflected radiation* in spring and winter months: 0.21 MJ / m and 0.26 MJ / m, respectively. In summer and autumn there was a growth, which amounted to 0.84 MJ / m and 0.48 MJ / m. According to calculations, the area in question has a tendency for decreasing values of the *radiation balance*.

**Air temperature:** According to multiyear data collected for the territory of the Dniester River basin, average annual temperature is 8-10°C. Over the past 60 years there has been a change in air temperature. Thus, the average temperature of three winter months by 2009 had increased by 0.7-0.9 °C, compared to that in the 50-ies of the last century. Annual increase in air temperature in winter has been 0.02 – 0.03 °C, in summer a small increase in air temperature – 0.002-0.003 °C per year.

**Precipitation:** Amount of precipitation varies from 490 mm in the south to 550 mm in the north. In spring, summer (except for stations in Chisinau), autumn in the Dniester River basin there has been an increase in precipitation. In winter, the widespread decrease in precipitation has been registered.

**Change of the agroclimatic resources:** Start and end dates of spring and summer periods (transition temperature after 10 and 15 °C, respectively) have changed by 2-5 days. Duration of spring period and the period of the active growing season has increased by 4-12 days. The duration of winter and summer periods in area under investigation has increased by 3-10 days.

**Change of aridity:** over the last decades a large number of years have been dry - every 4-5 years. Droughts have been especially frequent in the last decade (every 2-3 years), and losses caused by them have increased, sometimes they are catastrophic. This phenomenon can be attributed to extremely uneven rainfall during the year.

### **Assessment of the expected climate change**

The prediction is based on the projections obtained by the regionalization of global experiments of three general atmosphere circulation models (HadCM3, CGCM2, CSIROmk2) for two regionally-oriented scenarios - a "passive" (SRES A2) and environmentally oriented (SRES B2). The average annual temperature in the Dniester river basin will continue to rise and by the end of the century this increase can be from 3.4 to 4.7 °C. In the seasonal aspect, the maximum relative warming is expected during winter months (1.1-1.4 times more - by mid-century, 1.5-2.2 times more - by 80th). Minimum relative warming is expected in summer months: by 10-12% at the beginning of the century and up to 20-30% - in the end. The total annual precipitation will gradually decrease in both scenarios of emissions within 10%, mainly in the summertime, and by mid-century, they may decrease by 17-20%. Thus, the territory of the Dniester river basin, as well as Moldova in general, awaits warmer and wetter winters with hot, dry summers. This can lead to a shift in geographical areas, significant changes in the values of evapotranspiration, in the water regime of the river and, consequently, the conditions for the existence of natural ecosystems in the region.

### **Scenarios for water resources of the expected climate change**

Under different scenarios of future climate change, complex changes in average annual water resources of rivers are expected: an increase by 22-50%, or decrease by 2-21%. Future climate change will affect the variability of annual runoff. It is predicted that the coefficient of variation of annual river flow reduces by 13-18%, or, conversely, may increase by 12-14%, depending on the scenario. The forthcoming climate change transforms subannual flow distribution. There will be two hydrological seasons - winter and summer. During the summer season (May-October) fairly stable low water will take place, during which the river's inflow is mainly due to groundwater. Winter season (November-April) is characterized by high and very long snow-rain runoff.

The current water management policy, implemented through regulation of river flow by reservoirs, can somewhat reduce the deficit of water resources in the climate change conditions. Moldova has not fully implemented either Water Framework Convention of the EU (2000), which is the basis for resolving all major issues related to water policy in the countries, or the EU Directive on the assessment and management of flood risks (2007).

### **Vulnerability of water resources due to climate change**

Water resources in Moldova are sensitive to climate change with respect to their quantity and quality. Available surface water resources will decrease by 16 - 20% in 2020. Thus, according to climate projections, there is a threat to the economic development associated with water use, already in 2020's. The increase in air temperature will lead to the growth of surface water temperature and reduction in dissolved oxygen. Already by 2020, water temperature in the Dniester River in spring may increase by 65%. During the summer months (particularly in August) changes in the level of dissolved oxygen in water are the most vulnerable. The expected decrease can be as low as 10% by 2020-s. Such a change in these indicators will lead to a change in the ecosystem, degradation of water resources used by population, and will require additional water treatment in order for people be able to use drinking water.

Based on the expected decrease in water resources, we can identify three regions: the region with traditional water deficit; the vulnerable regions, mainly rural population (southern Transdnistria); Central Moldova (negative impact on rural and urban populations).

Only 23% of the population uses water directly from the Dniester and Prut rivers. In Moldova there is another urgent problem of uneven distribution of available water resources, since the northern part of the country (and the central part, to some extent) is now more or less provided with water, while the southern part is vulnerable because of the natural water deficit.

### **Floods on the Dniester River**

Regular hydrological monitoring has been carried out in Moldova since 1960. However, main historically important floods on the Dniester were registered in 1932 (water discharge was 6280 meters cubic / s), in 1941 (water discharge - 7300 meters cubic / s).

**Flood in 1969:** the amount of 5,500 meters cubic / s, the maximum discharge of 3850 meters cubic / s by the Dubossary Reservoir; rise in water level from 7.5 to 9 m, about 13,930 hectares of floodplain land was flooded, including 8472 - of irrigated land, about 3,920 homes were submerged in water, 703 of which were destroyed; 183 public buildings and 78 businesses.

**Flood in 1970:** minor flooding around 2170 - 2250 meters cubic / s of flow, with a rise of 2 to 4 pm, serious damage was not seen.

**Flood in 1974:** the amount of about 2800 meters cubic / s, discharge by the Dubossary Reservoir was up to 2050 m<sup>3</sup> / s, water level rise was 5 to 6 m.

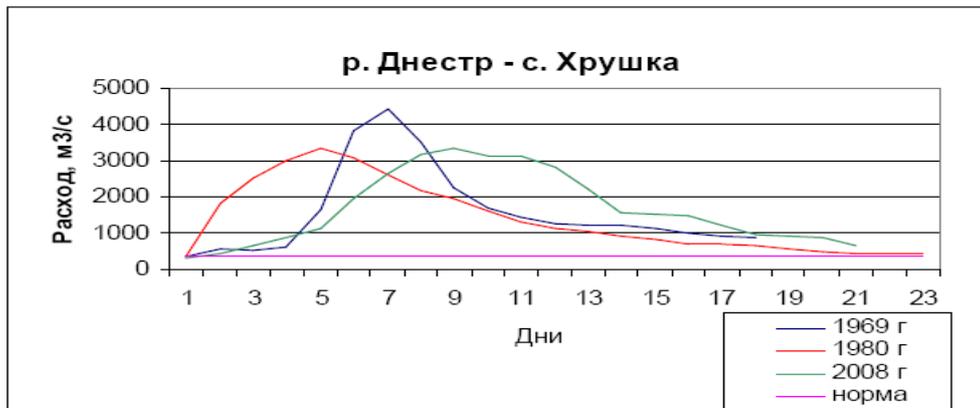
**Flood in 1980:** two waves of rain floods with a maximum flow rate of 2520 meters cubic / s (discharge by the Dubossary Reservoir was 1930 meters cubic / s) and 3600 meters cubic / s (discharge by Dubossary Reservoir was 2630 meters cubic / s). The maximum rise of water level was 6.5 - 7.5 m. About 6000 hectares of agricultural land was flooded.

**Flood 1998:** The amount of 4,000 meters cubic / s, the discharge by the Dniester reservoir was about 2300 meters cubic / s, by Dubossary - 2100 m<sup>3</sup> / s, water level rise - up to 5.5 m.

**Flood 2008:** The maximum flow rate was 5400 meters cubic / s, the discharge by the Dniester reservoir - 3330 meters cubic / s, by Dubossary Reservoir - 3480 meters cubic / s, and water rise was 6-7 m, and in some areas - 8.5 - 9 m. The dam was breached, inundating farmlands and towns.

**Floods of 2010:** water amount was around 2650 meters cubic / s and 3590 meters cubic / s; discharge by the Dubossary Reservoir - 1500 m<sup>3</sup>/sec.

**Floods on the Dniester river near the village of Hrushka in 1969, 1980, 2008:**



#### **List of projects on research and management of the Dniester**

1. The project "Transboundary Diagnostic Study of the Dniester River (Dniester-I, 2004-2006)
2. The project "Transboundary Diagnostic Study of the Dniester River (Dniester-II, 2006-2007)
3. The project "International Risk Management in the Dniester River Basin" (2006-2009)
4. The project "Information Management System for Transboundary Dniester River Basin" (2007-2010)
5. The project "Real-time monitoring and decision support systems for international rivers: the use for the rivers Dniester and Prut" (2001-2002)
6. Project "Democratization of management of the river Dniester" (2008-2010)
7. The regional project "Cooperation for the Protection of the Black Sea" (2007-2009)
8. The project "Strengthening of climate change adaptation of transboundary Lower Dniester region water resources"(2011)
9. The project "Regional aspects of climate change adaptation: the international experience for Transnistria"(2010-2011)
10. The project "Moldova Disaster and Climate Risk Reduction Project" (2010-2012)
11. The project "Supporting the Development of the National Climate Change Adaptation Strategy for the Republic of Moldova"
12. The project "Climate change adaptation policies and sustainable environmental management: Moldova case" (2010)

#### **Projects implemented under the UN Convention on Climate Change**

13. The project "Republic of Moldova: Enabling Activities for the Preparation of the First National Communication under the United Nations Framework Climate Change Convention (UNFCCC, 1998-2000)".
14. The project "Climate Change: Enabling Activities (Phase II, 2000-2002)
15. The project "Moldova: National Capacity Needs Self Assessment for Global Environmental Management" (2003-2005)
16. The project is "Republic of Moldova: Enabling Activities for the Preparation of the Second National Communication under the United Nations Framework Climate Change Convention (UNFCCC, 2005-2009)".
17. The draft "National Human Development Reports" (2005-2009)

#### **Programs and strategies:**

1. Action Plan Republic of Moldova - European Union (as of 2005)
2. National Program for Environmental Safety for 2007-2015.
3. The Energy Strategy of the Republic of Moldova until 2020
4. The concept of national policies on water resources for the period of 2003-2010
5. The program of water supply and sanitation facilities for settlements in the Republic of Moldova until 2006 (2002).
6. Program for land expansion and soil fertility improving for 2003-2010
7. The concept of sustainable development of the settlements in the Republic of Moldova (2001)
8. The investment strategy of the Republic of Moldova (2002).

### ***Programs and plans for monitoring and management of water resources in Transdnistria:***

1. The program "Sanitary and hygienic monitoring of water quality of the Dniester River" (2008)
2. The program of "Reconstruction works on the Dniester River dams that require enhancement" for 2009
3. The program of "Reconstruction works of the Dniester River dams that require enhancement" for 2010
4. Program for 2009-2010 to minimize the impact of the global economic crisis of 2008-2009 on the economy of Transdnistria

### **The practice of flood risk management**

Floods do not respect borders between countries, regions or organizations. Therefore, management of water resources should be transboundary, include the expansion of databases and information, and increase the number of available strategies. In 2007 a new Directive on flood risk management was adopted. Mapping of flood risk and territories in terms of flood risk will be carried out from 2011 to 2015, including the use of scenarios of flooding. Water Directive requires the implementation of a preliminary assessment of flood risk for each river basin district or administrative unit, or portion of an international river basin within the territory. Such work should be done during 2011. An intergovernmental agreement between Moldova and Ukraine on border waters was signed in 1994, applicable in the Dniester River Basin. In 1998 an intergovernmental agreement between two countries was signed to prevent industrial accidents and natural disasters. In 2006, a protocol on anti-flood measures to the 1994 agreement on border waters was signed. There is willingness for cooperation and understanding of the need for cooperation in river basins across borders, but the relevant experience is lacking.

## **Baseline study Study for Ukraine**

### ***Climate studies in Ukraine***

Unfortunately, studies related to the influence of global climate change on regional characteristics of the climate system of Ukraine are not systemic and quite fragmented. The Climate Program in Ukraine was being carried out in 1998-2002. As a part of this program, the major factors contributing to regional climate change in Ukraine were analyzed, the scientific basis for evaluating the possible consequences of the main effects of regional climate change on natural resources, development of certain sectors of the economy and the environment was established. However, a number of program tasks were not implemented due to the lack of required funding.

In 2010, the National Academy of Sciences of Ukraine (NASU) with the participation of the Ukrainian Research Hydrometeorological Institute with the Ministry of Emergency and National Academy of Sciences (UkrRHI) and the State Hydrometeorological Service with the Ministry of Emergency of Ukraine worked out a new Climate Program.

The studies of the global climate change effects on the climate system of Ukraine are gathered within the NAS of Ukraine. Currently, the NASU scientists are conducting a study to develop detailed forecasts of regional climate change in Ukraine using regional climate models. Fundamental climate research is also being carried out by the Ukrainian Research Hydrometeorological Institute with Emergency Ministry and the NAS of Ukraine (UkrRHI). In 2003 the Institute published monograph "Climate of Ukraine". The Institute is planning to complete two research topics:

- «The study of regional climate changes in Ukraine in the midst of global warming processes»;
- «The numerical prediction of regional climate in Ukraine on the basis of the possible scenarios of global climate change in the XXI century».

In 2009, the document "Dynamics of climatic characteristics in Ukraine, the preliminary forecasts of climate change and its possible impact on the sectors of the economy" was drafted.

In 2009 UkrRHI developed a document entitled "The third, fourth and fifth national communications of Ukraine on climate change."

Also starting from 2009, two research projects: "Development of National Strategy of Ukraine on questions of climate change for the post-Kyoto period" and "Investigation of the vulnerability of economic sectors to climate change and identification of adaptation measures" have been carried out.

In 2009 within the framework of "Cooperative Grant Program Climate Change & Energy Competition for Joint US-Ukrainian Research Teams", the project "Formulation and evaluation of activities on adaptation of water resources to uncertainties in the climate change in the Carpathian region" was selected. The main idea of the project is to combine the experience of Ukrainian specialists in the development and application of meteorological and hydrological models and US experts on water management adaptation to climate change.

UkrRHI has joined the consortium of national hydro-meteorological services and research institutes of East European States to implement the project "The climate of the Carpathian region". One result of this project will be a digital climatological atlas.

In 2004-2005 the project "Improving the opportunities for sustainable management of wetlands of the Azov-Black Sea region in Ukraine and the prevention of adverse climate change" was implemented.

### ***Brief description of climatic resources and their changes***

Climate studies in Ukraine were conducted on a national scale of either physiographic zones or on the basis of another zoning (e.g. landscape-hydrological), but not in the context of river basins.

Over the last twenty years the average annual temperature within the flat part of the territory of Ukraine has grown by 0.8 °C. Mountain regions of Ukraine are characterized by somewhat smaller rate of increase in annual mean air temperature. For the Ukrainian Carpathians, this value is 0.7 °C. The largest contribution to the change in annual temperatures has been made by winter (January) and spring (March) seasons.

Within the flat part of Ukraine the amount of precipitation during 1989-2008 years increased in all seasons (except winter), but most significantly - in spring and autumn (by 9 and 18% respectively). Significant increases in precipitation of the fall season are due to September and October (by 35 and 21% respectively).

In Ukraine the problems with water supply in the south and south-eastern regions could be exacerbated; these regions are already suffering from droughts during summer low water periods, and where the population is poorly provided with drinking water of good quality, there is also an intensification of waterlogging and flooding in Polesie, Carpathian and Transcarpathia.

The climate change could lead to the alterations of hydrological regime of rivers, and as a consequence – potential reduction of fresh water.

### ***Vulnerability of water resources to climate change***

Fluctuation in precipitation determines the respective changes of runoff. Since 1970-1980 water availability in the basins of the Tisa, Dniester and Prut has decreased mainly by 2-5% compared to the previous period (1950-1980). In some basins of the Carpathian region the water availability for the same periods has reduced up to 10-12%. It should be noted that the decrease in water content has occurred here mainly due the cold period flow. Concerning water availability in Ukraine, there are significant irregularities of a range of year-to-year fluctuations of water flow both for hydrological years, and for some seasons (cold and warm periods).

In most river basins year-to-year variations in water content have decreased by 20-40% over the last period. It should be noted that the expected climate warming will lead to instability of the snowpack and decrease of the flow of rivers by melt water. In the worst-case scenario, warming would lead to shallowing

of many small rivers in mountainous and foothill areas of the country, and small rivers may cease to exist. Most resistant to climate change will be the rivers that use mostly underground water.

All models predict a significant decrease of water resources in the Dniester basin. Also it was noted that shortage of water availability is characteristic of much of the Dniester basin in its downstream (lower tributaries of the Dniester in Moldova), some parts of the tributaries in the Vinnitsa region, and all the tributaries in the Odessa region.

Both extreme floods and an acute shortage of water are typical for the lower part of the Dniester river. In 2009 Odessa Oblast Department for Water Management made inventory of availability and technical condition of hydraulic structures on water bodies of Odessa region. As a result, the inventory found that out of 1190 reservoirs and ponds in 26 districts of the region 344 ponds in 24 districts completely dried up, which amounts to 29%. 52 small rivers, 6 rivers of which (Gonorivka, Sukhoi Molokish, Kuchurgan, Rybnitsa, Soshka and Devka washes), being dried and partially dried, are tributaries of the Dniester.

#### ***Model calculations of climate change in Ukraine***

According to the fourth IPCC report, Ukraine is not included in the list of the regions of our planet which are the most vulnerable to global warming. To assess possible changes in regional climate in Ukraine, the simulation European-based results of different models have been used.

All models predict a rise in air temperature for the territory of Ukraine; however, the extent of this increase is different. By the end of XXI century AOGCM predict increase in temperature averaged for the entire territory of Ukraine as compared to 2001-2010 by 2.0 ° C, 3.1 ° C and 3.8 ° C (average, under three different scenarios). The average annual rainfall will change slightly, but changes will be regional and seasonal.

For more detailed analysis of projected climate change on the territory of Ukraine the UkrRHI specialists selected ten global models out of 23 AOGCM. In addition, the simulation results of AOGCM climate research centers of Norway, USA, Canada, Germany, Britain and Japan were analyzed by UkrRHI.

#### ***Characteristics of flood in the basin of the Dniester***

Dniester discharge is characterized by an almost continuous alternation of floods that occur in spring, summer and autumn periods. High floods are caused by sudden melting of snow, rains, and in summer period - heavy rains. Floods of varying intensity repeat themselves 3-8 times per year on the Carpathian rivers.

**Outstanding floods on the Dniester River in the last 120 years:**

<b>Year, month</b>	<b>Maximum water level above post point "0", cm</b>	<b>Maximum discharge, meter cubic / sec</b>
1893, June	950	4440
1900, June	860	3730
1906, June	800	3070
1913, July	895	4120
1927, September	891	4070
1941, September	1251	8040
1948, July	865	3420
1969, June	1078	5970
1980, July	907	3910
2008, July	1014	5400

**Flood of 2001:** A very swift rain flood was formed in the upper of the rivers Dniester and Stryy; precipitation was 100-150 mm in a short period of time; rise in water level was 3.8 m, villages and towns were partially flooded.

**Flood of 2004:** Daily heavy rains resulted in the formation of rain floods on the rivers of the Dniester river basin with a rise of the levels by 1.0-2.8 m in the lower reaches of rivers Stryy, Svecha, Strvyazh, Dniester (in some places up to 4.2 m). Precipitation was 41-275 mm (44-220% of monthly norm).

**Flood of 2007:** High rainfall flood in mid-September for the rivers of the mountainous part of the Dniester basin is a rare phenomenon. The amount of precipitation during two days was 64-180 mm; rise in water level was by 0.8-2.9 m, and in some places - by 3.1-3.9 m; this flood was one of the main reasons for the sharp increase in the flow of water to the Dniester reservoir. Inflow increased to 2480-2530 meter cubic / sec (average daily flow of 318 meter cubic / sec).

In the Lviv region 1951 towns were flooded, three intakes were stopped and complicated, 17 settlements were left without electricity, more than 200 thousand sq.meters of roadway were damaged, two road bridges were destroyed and 8 – damaged. 216 persons were evacuated from 7 towns. In Ivano-Frankivsk region - 250 houses were submerged in water, 240 hectares of farmland were flooded, 46 km of roads, 21 automobile and 24 pedestrian bridges were destroyed, 7.02 km of bank stabilization was destroyed and 14.97 km of bank stabilization and 21.81 km of banks was damaged.

**Flood of 2008:** Catastrophic flooding rain, precipitation in some places reached 200-350 mm. In the Lviv region 4,975 homes, 3,014 basements, 6,141 home gardens in 162 settlements of 8 administrative districts were flooded and 4 regional bridges and 21 highway bridges were destroyed. In Ivano-Frankivsk region 417 settlements, 24905 residential houses, 20,600 hectares of farmland were affected. 602.6 km of banks was washed out, river bank protection: 100.84 km damaged and 25.445 km destroyed, 10.645 km of dykes was destroyed, 347 highway and 416 pedestrian bridges, 664.94 km of roads, 24 water intakes were damaged and flooded. The death toll was 19 persons, including 5 children. 70% of grain crops area was lost. In Chernivtsi region infrastructure was severely damaged in 10 districts and the city of Chernovtsy. 123 small and large bridges were partially damaged and destroyed, 31.8 km of road surface, 60 m of pipeline, 162 residential houses were destroyed. 9,815 homes, 21,319 of home gardens, 10400 hectares of agricultural land, 31,600 m of the roadway were flooded. 2,194 homes were disconnected from gas supply, 1320 m dams were washed out, 7 persons died and 1 person was missing. In Ternopil region 26 settlements were affected, 511 residential and administrative buildings were damaged. 9,025.3 hectares of farmland and over 200 public wells were flooded. 101 km of roads was destroyed and 306.935 km of highways, 10 road and 14 pedestrian bridges were damaged.

#### ***List of projects on research and management of the Dniester River***

1. The project "Transboundary Diagnostic Study of the Dniester River (Dniester-I, 2004-2006): preparation of legal opinion on the state and improvement ways with regard to the international legal framework for transboundary cooperation on conservation and sustainable use of water resources of the Dniester River; conduction of a diagnostic study of the transboundary Dniester river basin; signing of a protocol of intent on cooperation in the field of environmental rehabilitation of the Dniester River (2005).
2. The project "Transboundary Diagnostic Study of the Dniester River (Dniester II, 2006-2007): development of a program of actions to improve transboundary cooperation and sustainable management of the Dniester River basin for the period of 2007-2010, preparation of a draft Regulation on public participation in the activities of the Dniester Commission and decision-making process regarding the state of the river basin, preparation of a draft Regulation on cooperation on sanitary and epidemiological control of water quality in the transboundary Moldovan-Ukrainian section of the Dniester river basin and transboundary rivers in the Black Sea basin, adoption of the Regulations of the Ukrainian-Moldovan cooperation in running of the joint website.
3. The project "Transboundary cooperation and sustainable management in the Dniester basin: Phase III - implementation of the Programme of Actions "(Dniester-III). The project is aimed at further improvement of the joint Moldovan-Ukrainian cooperation in the basin management.
4. The project "Transboundary Risk Management in the Dniester River Basin" (2006-2008). The project, on the one hand, aims at improving the technical conditions of the environmentally hazardous industrial enterprises in order to minimize potential contamination of water resources and, on the other hand, developing and implementing an international plan to prevent emergencies and alert about them in the basin of the Dniester.

5. The project “Technical Assistance for the Lower Dniester River Basin Management Planning”. Three components of the project: improving access to information to ensure effective, from the standpoint of decision-making and financial costs, water management; improvement of the institutional system of water management; supporting the creation of Nizhnednestrovskyy National Park.

***The practices of flood risk management***

***Government programs and projects:***

1. State complex program on flood protection in river basins of Dniester, Prut and Siret (2008).
2. State specific social program for the development of civil protection in 2009 - 2013.
3. The integrated program of protection against the harmful effects of water in rural settlements and agricultural land in Ukraine in 2001-2005 and forecast up to 2010.
4. The project on the rehabilitation of the network of hydrological monitoring of the hydrometeorological service, funded by the World Bank's loan.
5. Flood protection in the Dniester River Basin (run by the State Committee for Water Resources).