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

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Expert group:

V. N. Korneev, A. A. Volchak, L. N. Hertman, I .P. Usava, V. N. Anufriev, A. V. Pakhomau, I. E. Rusaya, I. A. Bulak, E. P. Bahadziazh, S. A. Dubenok, S. V. Zavyalov, A. N. Rachevsky (Republic of Belarus); E. Rimkus, E. Stonevičius, A. Šepikas (Republic of Lithuania); P. Buijs (independent expert); G. Crema (independent expert), N. B. Denisov, (Zoï Environment Network), S. Koeppel (UNECE).

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Acknowledgments

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This document has been developed based on the outcomes of the above Project[1], in whose implementation a team consisting of the following experts was involved: V. N. Korneev, A. A. Volchak, L. N. Hertman, I. P. Usava, V. N. Anufriev, A. V. Pakhomau, I. E. Rusaya, I. A. Bulak, E. P. Bahadziazh, S. A. Dubenok (Republic of Belarus), Egidijus Rimkus, Edvinas Stonevičius, Audrius Šepikas (Republic of Lithuania), Paul Buijs (the Netherlands) and Givanni Crema (Italy).

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1 The Project’s outcomes are presented on the UNECE website, in the section entitled “Transboundary Pilot Projects on Climate Change Adaptation”, at:
https://www2.unece.org/ehlm/platform/display/ClimateChange/Neman+project+workshop+and+expert+meeting+19-20+March+2013

Forewords

The Republic of Belarus was one of the first countries to sign the United Nations Framework Convention on Climate Change on 11 June 1992. The Republic of Belarus ratified this Convention by Decree of the President of the Republic of Belarus No. 177, dated 10 April 2000. The convention entered into force for the Republic of Belarus on 9 August 2000. Since 2005, the Republic of Belarus has been a Party to the Kyoto Protocol to the UN Framework Convention on Climate Change.

Activities to mitigate the impact of climate change and allow swifter adaptation, including studies on climate change, are prioritized in a number of documents at various legal levels that are important for Belarus's development.

The National Strategy of Sustainable Socio-Economic Development in the Republic of Belarus until 2020 is the most significant and comprehensive policy document for the Republic of Belarus. Increasing the efficiency of water utilization and improving the quality of water resources, in balance with the public's needs and projected climate change, are strategic goals in the sphere of conservation of the country's water resources. Issues related to the climate change challenge were fixed in the Water Strategy of the Republic of Belarus until 2020 and the State Program of Climate Change Mitigation Measures until 2013-2020.

According to the Water Strategy "… the issues of estimation and use of transboundary watercourses in the river basins with account of European approaches and in the context of the climate change adaptation have not been adequately addressed". The State Program of measures stipulates that the main climate change adaptation activities in the sphere of water resources should include: an assessment of the vulnerability of specific regions to the climate change; development of sectoral climate change adaptation strategies by national bodies of state administration; implementation of these strategies; and mitigation of the impact of climate change-related dangerous hydrometeorological phenomena, including through the elaboration of methods for estimating risks and damage and also scenarios for adaptation to such phenomena.

Given the transboundary character of all large rivers in Belarus, the problems related to the impact of climate change on water resources need to be addressed jointly with other states located in these basins.

The "Strategic Framework for Adaptation to Climate Change in the Neman River Basin" was developed within the framework of the International Technical Assistance Project "River Basin Management and Climate Change Adaptation in the Neman River Basin". It is the first document aimed at improving the management of integrated water resources in the context of the climate change, using the basin approach at the international level.

Igar Kachanovsky
Deputy Minister,
Ministry of Natural Resources and Environmental Protection of the Republic of Belarus

The increasing impact of a changing climate is leading to growing international concern. This effect is very diverse and includes both natural systems and the social sphere. Water resources are also affected by climate change, while their quantitative and qualitative parameters are good indicators of the changes in the climate system. There are no doubts that against the background of this growing threat, it is necessary to take additional measures in the conservation and protection of water resources.

The European Union pays great attention to climate change mitigation and displays political leadership in the development of climate change adaptation plans. Two important programmatic documents on adaptation to climate change have been adopted by the European Commission, namely the Green Paper «Adapting to Climate Change in Europe – Options for EU action» (2007) and the White Paper «Adapting to Climate Change. European Framework for Action» (2010).

The Republic of Lithuania adopted a *"National Strategy for Climate Change Management Policy"* in 2012. The strategy consists of sections on climate change mitigation and adaptation. The purpose of the strategy is to develop and implement a climate change management policy as well as to identify short, medium and long-term goals and objectives of climate change mitigation and adaptation. In 2013, the Government of Lithuania approved an action plan for the period 2013–2020, which also includes a number of measures for water resources.

Problems related to climate change cannot be solved by the efforts of individual countries. Cooperation is necessary among the whole international community. The project "River Basin Management and Climate Change Adaptation in the Neman River Basin" which resulted in the present Strategic Framework, is an excellent example of transboundary cooperation in tackling problems related to water resources and water quality at the basin level. Without any doubt, the results of the project are important at the national level and promote further cooperation on climate change issues in the Neman basin.

Algirdas Genevicius
Vice Minister,
Ministry of Environment of the Republic of Lithuania

Preface

Sustainable development of industry in the Neman River Basin (NRB) that also ensures the ecological functioning of water bodies can be achieved through an efficient and integrated NRB water resources management strategy, which should rely on medium- and long-term regional climate change forecasts and timely adoption of relevant preventive adaptation measures. These measures should account for and capitalize on the benefits of projected changes as efficiently as possible, and also mitigate the potential adverse effects of climate change, based on climate risk assessment.

It is forecast that the climatic changes that have been observed in recent decades in the NRB will persist into the mid-21st century. It is also forecast that the average yearly temperature will increase, the period with seasonal snow cover will be reduced, and annual precipitation will increase, with the increase being more substantial in the first half-year and variations being insignificant in the summer and autumn period.

This will entail changes in the river flow, resulting in redistribution of the intra-annual change of flow due to increased risks of dangerous hydrometeorological phenomena, including rain floods and droughts. A slight increase in the average annual flow across the NRB is projected, which will result in an increase of the runoff to the maximum in winter seasons and earlier onset of spring floods, the intensity of which is likely to decrease due to snow cover instability. The surface flow is likely to decrease across a larger part of Belarus and to increase on the territory of Lithuania and in Kaliningrad Oblast (Russian Federation).

The observed and projected climatic changes will yield both positive and negative consequences for water resources, the population and economy.

The NRB territory is characterized by a large population, a high concentration of industrial enterprises and other facilities (including oil/product/gas pipelines), brisk growth of hydropower engineering and agricultural sectors, and active use of water resources. Given an upsurge of interest among the international community in this region due to its favorable location as a transit route, the region's role and importance are likely to increase.

The Strategic Framework for Adaptation to Climate Change in the Neman River Basin has been developed in the course of implementation of the International Project "River Basin Management and Climate Change Adaptation in the Neman River Basin". The main goal of the Project is to improve the integrated management of water resources using the basin approach in the climate change context, on the example of the Neman River. The Project has facilitated the development of transboundary cooperation between the NRB countries. It was a part of the UNECE Program of pilot projects and used existing platforms for sharing experience between projects and other similar initiatives aimed at developing cooperation for climate change adaptation in transboundary basins. In addition, the Project was implemented with assistance from ENVSEC and UNDP in the Republic of Belarus.

The following principal results were obtained in the course of the Project's implementation:

- the current state of the water resources of the Neman River Basin (quantitative aspects) was assessed, based on an analysis of the impact of economic activities on these resources;

- changes in existing climatic characteristics and runoff over the past 50 years were analyzed;
- climate change scenarios were elaborated and climate change/runoff forecasts were made up to 2050
- an overall assessment of the current water quality of surface waters in the NRB was made, based on the agreed assessment system (Belarus – Lithuania);
- estimations and forecasts of the impact of future climate change on the surface water quality were made at the highest level of generalization;
- hydrometeorological and hydrochemical monitoring systems were analyzed and proposals were developed to optimize these systems for climate change monitoring;
- a common information platform (online database) was developed, containing data on water resources management and adaptation to climate change for the NRB countries;
- consultations were held to discuss the Project's outcomes and strategies for the NRB countries (Belarus, Lithuania, Kaliningrad Oblast of the Russian Federation), with the involvement of representatives of the UNECE, environmental management bodies, international and national experts, water users concerned, and also mass media and the public.

The Strategic Framework also includes a list of main potential measures developed, based on an assessment of the possible impacts of climate change on various types of natural resources and industries within the context of their relation to the severity of the impact on water resources. The damage and risks associated with adverse events of climatic variability may not only be reduced, but also specific economic benefits may be derived from the positive effects of this variability, provided that these measures are competently developed and implemented in a timely manner through specific activities and projects.

The impacts of climate change are not limited to the administrative boundaries of regions and states. Therefore, developing and implementing adaptation measures requires cooperation and integration between regions, states and industries at all levels. Stakeholders should realize the benefits of mutual cooperation aimed at achieving positive long-term effects, rather than take decisions focused exclusively on short-term benefits. "Cooperation" and "dialogue" are key concepts in the process of studying climate variability and managing climate risks.

To achieve efficient results, there is a need to implement basin-based principles of integrated water resources management, which implies active international cooperation, information sharing and effective coordination of actions between decision-makers, representatives of the business and academic communities, civil society and the general public at different levels, including local, regional and international. Within this context, it is reasonable to capitalize on the experience and potential of such international organizations as the UNECE, UNDP, UNEP, WMO, ENVSEC, the World Bank and others.

Financing mechanisms need to be created for specific facilities, sectors and areas of activity to adapt to and mitigate the impacts of climate change, including through the development of a climate change-related risks insurance scheme.

Chapter 1. Background

The data provided in the Fourth and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) [2,3] indicate that climate change is unequivocal. This is currently evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and the rising global sea level. It is stated that the Earth's average surface atmosphere layer temperature has risen by about 0.8 °C over the last one hundred years, while the snow-covered area in the Northern Hemisphere has decreased by 8 % and the global mean sea level has risen by 17 centimeters. It is noteworthy that warming is proceeding at a somewhat higher rate in the NRB. Over this period, average air temperature increased by 1.1 °C throughout the basin, which is characteristic of countries located in the mid latitudes. According to the IPCC's estimates and hydrometeorological observation data, climate change will, in particular, drastically affect the water environment, thereby being responsible for serious vulnerability of water resources to climate change. This may result in widespread consequences for human society and ecosystems.

Moreover, major regularities and projections earlier identified by the IPCC's Fifth Assessment Report and by the Summary of Climate Change and its potential impact on natural resources and mankind have been in principle proved and still further substantiated.

It should be noted that dangerous hydrometeorological phenomena resulting in both natural calamities and technogenic accidents are becoming increasingly significant. The probability of the onset of these phenomena is increasing significantly, in relation both to substantial warming across the larger part of the planet and to cooling in specific regions; the adverse effects of the former and the latter are also increasing. It is noteworthy that recent IPCC study findings [4,5] for the Fifth Assessment Report principally agree with the content of the earlier Fourth Assessment Report, whose methodological framework and scenarios served as a basis for making the majority of regional projections and assessments of future climatic changes.

Therefore, measures are required to improve water resources management in the context of adaptation to climate change, using the basin approach and a strategic framework common for all NRB countries.

To develop the Strategic Framework, regulatory acts and other ecological policy tools of the NRB states (Republic of Belarus, Republic of Lithuania and Russian Federation) and the European Union relating to the management of water resources and adaptation to climate change have been used (see List in Annex A).

The Strategic Framework identifies basic approaches, principal areas of activity and a list of measures aimed at improving water resources management in the NRB in relation to adaptation to climate change. These approaches and activities are based on the results of analysis and forecasting of the changes in climate and flows in the basin between 1961 and 2010 and until 2050, as well as on an assessment of the vulnerability to climate change of water resources and other related natural resources and industries. To this end, climate change scenarios common for the entire basin have been used.

The main goal of the document is to mitigate the adverse effects of climate change on water resources and related natural resources, industries and conditions of vital activity.

Chapter 2. General Characteristics of the Neman River Basin

2.1. Geographical Location and Hydrographic Characteristics

The Neman River Basin is located at 56°15′-52°45′ north latitude and 22°40′-28°10′ east longitude on the territory of Belarus, Lithuania, the Russian Federation (Kaliningrad Oblast), Poland and Latvia (Table 2.1, Figures 2.1-2.4). The total river length is 914 km [7] and the basin area is 98,200 km². Only the upper courses of some tributary streams are located in Poland and Latvia.

Table 2.1
Countries on the Territory of which the River Basin is Located

Total river basin area, km²	Country	Catchment area, km²	Catchment area, %
98 200	Lithuania	46 795	47,7
	Belarus	45 600	46,4
	Russian Federation	3 132	3,2
	Poland	2 554	2,6
	Latvia	98	0,1

Figure 2.1
Map of the NRB's location[2]

2 This map was developed using the information resource http://planetolog.ru/map-continent-big.php?id=EUR&scheme=3;

Figure 2.2
Geographical map of the NRB[3]

3 This map was developed by Zoi Environmental Network, Geneva, Switzerland, in April 2013

Figure 2.3
The Neman River near Grodno (Belarus)[4]

4 Photo: L.N. Gertman.

The Neman's largest tributaries (in terms of length and basin area) are the following rivers (in order of distance of confluence from the estuary): Berezina, Shchara, Zelvyanka, Kotra, Svisloch, Myarkis, Viliya (Neris), Nevezhis, Dubisa, Sheshupe, Yura and Miniya. The Neman river is nominally divided into three reaches: upper (to the confluence of the Kotra river); middle (from the confluence of the Kotra river to the confluence of the Viliya (Neris) river); and lower (past the confluence of the Viliya (Neris) river). The river's width upstream is 30-100 m, midstream it is 80-150 m, and downstream it reaches up to 500 m. The average slope of the river bed upstream is 0.16 ‰, while midstream it is 0.23 ‰ and downstream 0.10 ‰

Figure 2.4
The Neman River near the settlement of Merkine (Lithuania)[5]

5 Photo: Paul Buijs

2.2. Water Resources

The NRB's water resources are mainly formed on the territory of three countries: Belarus, Lithuania and Russia. The tributaries, the headwaters of which are located in Poland and Latvia, contribute an insignificant quantity of runoff (about 0.3 %). In the average water year, Belarus accounts for 43.5 % of the total Neman River runoff, Lithuania 50.0 % and Russia 6.2 %

2.3. Climate

The climate in the NRB is moderately continental. The Atlantic Ocean is the major factor that affects the climate. Atlantic air masses coming from the west are responsible for cloudy and rainy weather in the summer season and significant warming and thawing in the winter season. Amplification of the continental effect in specific periods increases temperature contrasts: in the summer season it contributes to hot weather, in the winter season to deep freeze, and in spring and autumn it leads to frosts. Flows of Atlantic humid air prevail for most of the year and then gradually transform into continental air, specifically in the western and south-western parts.

The mean annual air temperature was 6.8 °C in the NRB area over the period between 1981 and 2010. The frost-free period's duration is over 150 days. On average, frosts begin to appear in early October. The transition of the mean daily air temperature to under 5 °C takes place on average in mid-October and to below 0 °C in late November. Mean daily air temperatures go above 0 °C in early March. On average, seasonal snow cover appears in middle December. The average dates of the melting of seasonal snow cover fall in mid-March. As a rule, maximum snow cover depth is 15-20 cm. The prevailing mean monthly air temperature in the winter season is -2 to -6 °C. During cold winters, the minimum temperature may go below -30 °C. The prevailing mean monthly air temperature in the summer season is 16-18 °C. The absolute maximum exceeds 35 °C. On average, the mean annual precipitation across the basin is 672 mm, with the maximum value being observed in the summer season.

2.4. Population

According to data valid as of 1 January 2009, about 2,242.6 thousand people resided in the Belarusian part of the Neman River Basin. Of them, 1,439.0 thousand (64 %) lived in urban areas and 803.6 thousand (36 %) in rural areas. The population residing in the Lithuanian part of the NRB numbers 2,710.8 thousand people. Of them, 1,897.56 thousand (70 %) reside in urban areas and 813.24 thousand (30 %) in rural areas. About 120 thousand people reside in the NRB area in Kaliningrad Oblast (Russian Federation), of whom 70 thousand (58.3 %) reside in urban areas and 50 thousand (41.7 %) in rural areas.

2.5. Industry

The NRB is characterized by active water use, due to the availability of a large number of industrial and agricultural enterprises as well as oil and product pipelines which are potential sources of water resource pollution.

The food, chemical and petrochemical, machine-building and metalworking, forest, wood-working and pulp-and-paper industries, construction materials and consumer goods industries are dominant in the sphere of industrial production in the NRB in Belarus. 10 small hydroelectric power plants (hereinafter “HPP”) operate in the NRB in Belarus. Grodnenskaya HPP was commissioned upstream from Grodno, and there are plans to build Nemnovskaya HPP downstream from Grodno at the settlement of Nemnovo. A part of the runoff from the Neman River Basin (the Viliya river) is diverted to the Dnieper River Basin via the Vileisk-Minsk water system – about 26.89 mln m^3/year. The main consumers are housing and public utilities and amenities, which together account for 65 % of the surface water and groundwater resources. Industry and energy account for about 20 % of the water use. Total water use in the basin makes up 2.75 % of the available water resources. The industries use 2.2 % of the surface flow formed in the basin from the surface water sources. Groundwater use accounts for 3.71 % of the natural ground water resources [8].

The food, wood-working, textile, chemical, metal-working, machine-building, instrument-making and furniture industries are dominant in the Neman River Basin in Lithuania. 32 hydroelectric power plants operate in the NRB in Lithuania, the largest of which is Kaunas HPP.

Industry is less developed in the Russian part of the Neman River Basin. Effluents from two large pulp and paper mills located in the towns of Sovetsk and Neman and from facilities in the towns of Kransnoznamensk, Neman, Sovetsk and Nesterov mainly contribute to the anthropogenic impact. These industries use about 5 % of the surface flow formed in Kaliningrad Oblast from the surface water sources and 0.6 % of the total surface flow. The groundwater use makes up 32 % of the useful groundwater resources.

2.6. Ecological Status of Water Bodies

An *Assessment of the ecological status of surface waters in the Neman River Basin* that was performed within the framework of the Project[6] helped draw the following main conclusions [9]:

- an increased ammonium nitrogen content is generally characteristic of Belarus. As

6 The ecological status assessment was performed using criteria that were agreed upon within the framework of the international Project (Belarus-Lithuania), taking into account Lithuania’s experience in the sphere of classification of water bodies by type (based on common morphometric characteristics) and by the quality of surface water (divided into 5 classes of ecological status).

regards this parameter, water bodies are classified as being of the 3rd quality class (satisfactory quality). Meanwhile, it is not characteristic of Lithuania, since nitrate nitrogen is more often evaluated as being of the 3rd class (or 4th class – unsatisfactory quality) in this group of substances;

- in Belarus, the waters of some water bodies (Neman, Viliya, Zelvyanka, Usha, Servech) are classified in terms of their organic and oxidizable matter as 3rd class in specific years (predominantly by dichromate oxidizability or by biological oxygen demand, BOD);
- in Lithuania, high biological oxygen demand concentrations are common in some water bodies, which are classified as being of the 3rd or 4th quality class;
- in Lithuania, high total phosphorus and phosphate phosphorus content is characteristic of some water bodies. Therefore, water bodies are classified under these parameters as 3rd, 4th or even 5th class (poor quality), while in Belarus only isolated water bodies are classified as 3rd class by this parameter.

Therefore, different parameters may define the dominant pollutants in the group of biogenic elements in Belarus and Lithuania. This may be due to specific features of the sources of pollutants that enter the water bodies, including effluent discharge, export of pollutants from the catchment area, etc. For the same reasons, the 3rd quality class (and in some cases the 4th quality class in Lithuania) in terms of organic and oxidizable matter is characteristic of water bodies both in Belarus and in Lithuania.

The following rivers were assessed as undamaged by anthropogenic activity: Chernaya Gancha (transboundary), Svisloch (transboundary), Myarkis, Ula-Pelesa, Veivirzhas, Yura, Miniya, Salanta, Akmena, Shventoyi and Zheizhmyana. The state of water of the Gozhka and Neman rivers (upstream from Grodno) may also be characterized as “good”, except in the years of 2006 and 2010.

2.7. Environmental Problems

The main environmental problems in the Neman River Basin are due to the flow of pollutants into water bodies from point and non-point sources of pollution.

According to the 2012 State Water Cadastre, 84 enterprises discharging effluents into surface water bodies are located in the NRB in Belarus. 157 effluent discharge outlets to water bodies, including 52 surface wastewater outlets, were on their balance. In 2012, 124,042.0 thousand m^3 of effluents containing pollutants were discharged into surface water bodies in total, including 12,650.4 thousand m^3 of surface wastewater discharged into water bodies via municipal and industrial rain sewerage systems. Of the total effluents discharged into surface water bodies, 108,700 thousand m^3 (87.6 %) were effluents treated to standard quality and 2,140 thousand m^3 (1.7 %) were not treated to sufficient standard; 13,202 thousand m^3 (10.7 %) did not require treatment (given their quality, discharge of these effluents does not adversely affect the receiving water bodies). In 2012, the following quantities of pollutants entered water bodies together with the discharged effluents: BOD_5 – 1,737.5 tons; oil and petroleum products – 11.5 tons; suspended matter – 1,650.9 tons; total phosphorus – 199,057.6 tons; chloride ion – 11,266.8 tons; ammonium ion (in terms of N) – 992.6 tons; nitrate ion (in terms of N) – 332.9 tons; nitrite ion (in terms of N) – 31.9 tons; synthetic surfactants – 21,103 kg; total iron – 52,104.1 kg; copper – 317.9 kg; zinc – 1,743 kg; nickel – 666.4 kg;

total chrome – 506.4 kg; lead – 66.1 kg; and phenols – 264 kg.

In Belarus, the 15 largest enterprises in the Neman River Basin (of 84 enterprises located within the basin limits) account for about 86 % of the total household and industrial wastewater discharge within the basin boundaries (according to the 2008–2012 data). Out of these 15 enterprises, 10 enterprises are housing and public utility enterprises (Municipal Enterprises of Water Supply and Waste Water Treatment) operating treatment facilities; three are fish farms; one is an industrial enterprise; and one is an enterprise whose main line of business that requires water use is pond-based fish farming ("Narochansky" National Park). Analysis of sanitation shows that slightly more than 70 % of the total mass of pollutants in the composition of wastewater discharged by these 13 enterprises enters water bodies with effluents from 6 municipal treatment facilities of housing and public utility enterprises in Grodno, Baranovichy, Lida, Molodechno, Slonim, Volkovysk and also from the treatment facility of the industrial enterprise "Grodno Azot" OJSC. Given that organic matter evaluated by the BOD_5 test, suspended substances and nitrogen and phosphorous compounds make up the bulk of pollutants in the effluents from these enterprises, it is necessary to take action to more efficiently remove them from effluents before discharge into water bodies.

The main load from point pollution sources in the NRB in Belarus that contributes to transboundary pollution is formed within the limits of Grodno (State Unitary Public Utility Production Enterprise "Grodnovodokanal" and "GrodnoAzot" OJSC), and directly enters the Neman river bed downstream of the town. Pollution from the remaining point sources mainly enters small rivers (measuring from 5 to 200 km in length) that are the first- or second-order tributaries of the medium-sized Viliya and Shchara rivers, and also of the Neman. The average annual flow in the estuaries of these rivers ranges from 1.2 $m^3/_s$ to 8.2 $m^3/_s$, which is significantly lower than the water flow in the Neman and Viliya rivers. However, given the predicted climatic changes and possible runoff reduction during specific seasons of the year, low average annual flows may render small rivers extremely vulnerable to climate change due to a considerable anthropogenic impact related to the discharge of effluents and their low degree of mixing with river water. It should be noted that the Usha river, downstream of Molodechno, the Myshanka river, downstream of Baranovichy and the Ditva river, downstream of Lida, are likely to be most vulnerable to climate change. One of the acute problems is inadequate treatment of the surface wastewater discharged into surface water bodies, due to the low performance of treatment facilities as well as the unavailability of such facilities in many settlements (primarily in urban-type settlements).

The impact of non-point pollution sources on water quality across the entire territory of the NRB may be dominant in comparison with pollution from point sources. In this case, pollution from non-point sources may be estimated to be between 40 % and 90 % of the total pollution index. It is noteworthy that surface discharge from the territories of these settlements is a sizeable source of pollution in the water bodies.

A major problem of the ecological status of the Couronian Lagoon is encountered in the Neman River estuary – the Neman River's runoff to the lagoon is over 80 % of the total runoff of rivers discharging into it, which also influences the lagoon's water quality. Hyperblooming of potentially toxic blue-green algae is observed in the lagoon, resulting in a deficit of oxygen due to algae accumulation and decomposition and in the adverse effects on the ecosystem [10]. A specific feature of watercourses in the NRB in Kaliningrad Oblast is that their profile and regimes have been changed by human activity: many of them have been straightened and serve as water receivers of multiple irrigation systems and some of them are connected with canals. Climatic conditions in the Oblast are characterized by high dynamics and they significantly influence the river's inflow. Public utility enterprises significantly contribute to pollution of surface waters in a number of the Oblast's districts and in the city of Kaliningrad. In general, the level of deterioration of water supply networks across Kaliningrad Oblast is 70.0 %. The deterioration of sanitation networks is 70.8 %, that of treatment facilities for the water supply system is 61.2 %, and the deterioration of treatment facilities of the sanitation system is rated at 78.0 %. The majority of existing water supply and sanitation networks were built before the Second World War. The systems are characterized by a high depreciation rate and require refurbishment and retrofitting. The available capacities of the water supply systems are significantly overloaded and are not adequate for uninterrupted water supply in many towns and settlements. The unavailability of treatment facilities in a number of the Oblast's towns results in a high content of biogenic elements in watercourses being wastewater receivers [10].

2.8. Basin Cooperation

Bilateral agreements between the governments, ministries and other organizations of the NRB states serve as the basis for basin-wide cooperation. National regulatory and legal acts and other ecological policy tools (strategies, management plans, etc.) in the NRB states stipulate an integrated approach to the utilization and protection of waters and are aimed at fulfilling the provisions of the UNECE Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes. In addition, amendments and addenda are regularly incorporated into the legislation to harmonize national legislations with the assumed international obligations.

International projects, including regional cooperation projects, are among the most significant and efficient tools for basin cooperation.

2.9. Tendencies and Prospects

As regards geopolitics at the level of the NRB, it is reasonable to implement the basin principle of water resources management in a stage-wise manner. Given the current situation, it is logical to initially establish an International Basin Council (Commission) as a body to include representatives from the departments and organizations involved in managing water resources, large water users, and academic and non-governmental organizations.

Signing an international agreement on the NRB and setting up an International Commission for the Neman River Basin will contribute to the increased efficiency of international cooperation and water resources management in the Neman River Basin.

Chapter 3
Observable Changes in Climate and Runoff in the Neman River Basin

3.1. Observable Climate Change

Analysis and forecasting of the changes in climatic characteristics and runoff in the Neman River Basin were made using data obtained from 23 meteorological stations (8 in Belarus and 15 in Lithuania) and from 25 hydrological regime observation stations (12 in Belarus and 13 in Lithuania) between 1961 and 2010 (Figure 3.1).

Figure 3.1
Network of meteorological stations and hydrological regime stations

The following climate change tendencies were found over the period from 1961 to 2011:

- the annual average air temperature rose by 0.9 °C across the Neman River Basin with a maximum increase of 2.5 °C in the winter season (in January) and of 1.4 °C in the summer season (in July) (Figure 3.2);
- there was a slight increase in average annual precipitation (by 7 %), with the largest increase being observed in the winter season (by nearly 40 % in February), while in the summer season the change in precipitation was assessed as insignificant within the limits of statistical significance of assessments (Figure 3.3).

Figure 3.2
Assessment of air temperature change (°C) in the NRB in 1961-2010 (statistically significant changes are marked by arrows)

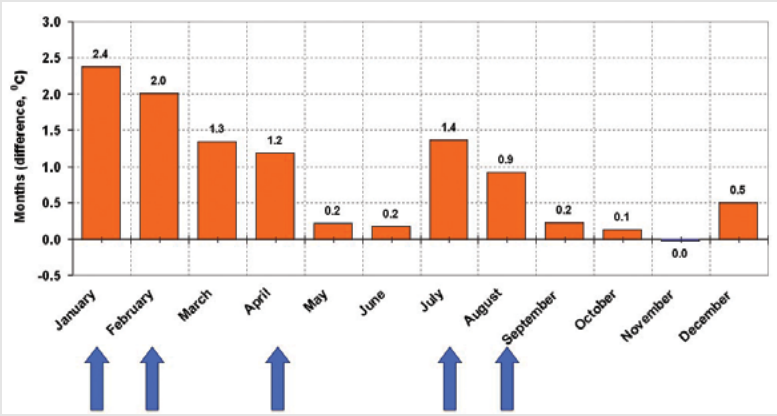
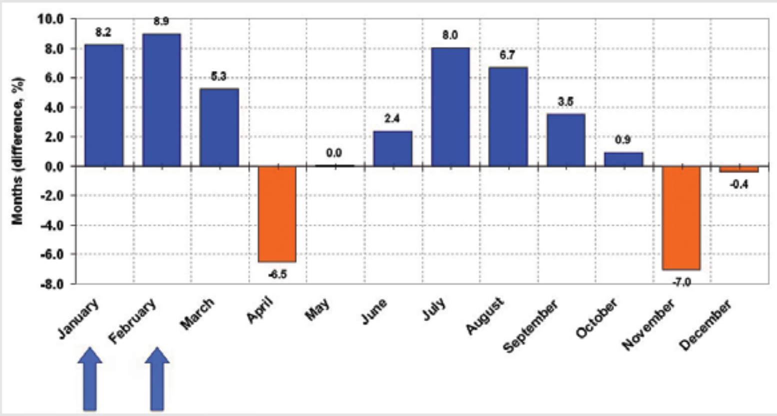


Figure 3.3
Assessment of precipitation change (%) in the NRB in 1961-2010 (statistically significant changes are marked by arrows)



3.2. Observable Changes of Runoff

By nature of intra-annual water availability distribution, the Neman River falls into the category of rivers with a significant spring flood during the period of intensive snow-melting and low runoff during the rest of the year. Due to its climatic characteristics, drought phenomena, spring floods and summer and autumn rain floods that result in flooding are most relevant to the Neman River Basin.

The following tendencies in runoff change were observed in the period 1961-2009:

- a slight increase in the average annual runoff – on average by 2.7 % across the basin (Figure 3.4);
- a reduction in runoff and earlier onset of the spring flood peak;
- an increase in winter runoff across a larger part of the NRB area (Figure 3.5);
- a slight reduction in summer runoff in Belarus and an increase in runoff in the north-western part of Lithuania and in Kaliningrad Oblast (Russian Federation) (Figure 3.6).

Figure 3.4
Change in the average annual runoff (%) in the NRB in 1961–2009

Figure 3.5
Winter runoff change (%) in the NRB in 1961-2009

Figure 3.6
Summer runoff change (%) in the NRB in 1961–2009

Chapter 4
Forecasting Climate Change for the Neman River Basin

4.1. Climate Change Scenarios

Long-term climate change forecasts for the Neman River Basin for a period of 35–50 years (2021–2050) were elaborated, based on CCLM regional climate model calculations and using output data from the ECHAM5 global climate model.

To forecast climate change, two emission scenarios are used:

- *A1B (relatively high-emission scenario)* – a "tougher" scenario implying relatively high greenhouse gas emissions due to rapid economic and demographic growth up to the mid-21st century, followed by population growth deceleration, rapid introduction of state-of-the-art technologies and balanced utilization of energy resources.
- *B1 (low-emission scenario)* – a "softer" scenario implying low greenhouse gas emissions, highly probable abrupt globalization, and a change in the population size similar to that as planned in A1 scenario. However, a rather rapid conversion of the economic system into an information-based system, a model of society that becomes less consumption-oriented, and intensive introduction of novel clean technologies.

4.2. Climate Change Forecasts

Generalization of climate change forecasting, subject to two scenarios, has enabled the conclusions provided below to be made. These conclusions may in principle be adjusted and revised by using other scenarios, without any significant change in the tendencies detected prior to 2050.

The tendency for the air temperature to rise will also persist in the future (until 2050). The annual average air temperature is likely to increase by 1.4 °C – 1.7 °C in accordance with different climate change scenarios, assuming an increase by 2.0 °C – 2.8 °C in the winter season and by 0.7 °C – 1.1 °C in the summer season.

Annual precipitation is also likely to increase in the Neman River Basin. More significant changes are expected in the first half-year, while in the summer and autumn seasons these changes will not be so significant. Due to the most significant air temperature rise being in the winter season and given the change of the amount and composition of precipitation, the snow cover will be reduced in the near future.

The adjusted climate change forecasts until 2050 for the NRB, elaborated using the results of the CMIP5 multi-model ensemble under the four scenarios provided in the IPCC Fifth Assessment Report in 2013 [3], proved the detected forecast tendencies of an average increase on average in air temperature and precipitation in the basin. In addition to the above, an insignificant change in the distribution of the air temperature rise season-wise was found. It is predicted that the increase in the air temperature in the summer will be more pronounced than that forecast under the A1B and B1 scenarios and less pronounced in winter than that forecast under the above scenarios. The air temperature is also expected to increase to the maximum in winter (Figures 4.1, 4.2). The largest precipitation is forecast in the cold season of the year, while in the second half of summer and also at the beginning of autumn, the precipitation will actually remain unchanged or will even slightly decrease (Figures 4.3, 4.4).

Figure 4.1
Air temperature change forecasts using the CMIP5 multi-model ensemble (according to IPCC – 2014) and A1B and B1 scenarios (according to IPCC – 2007).

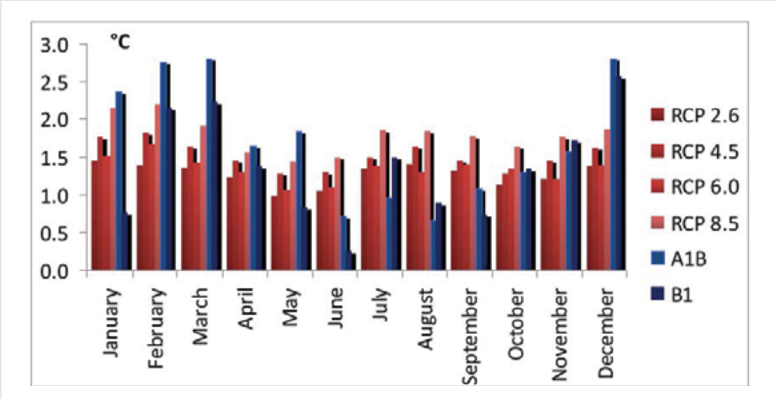


Figure 4.2
Most significant air temperature forecast changes, °C mean for a year (Figure a), mean for winter season (Figure b) and mean for summer season (Figure c)

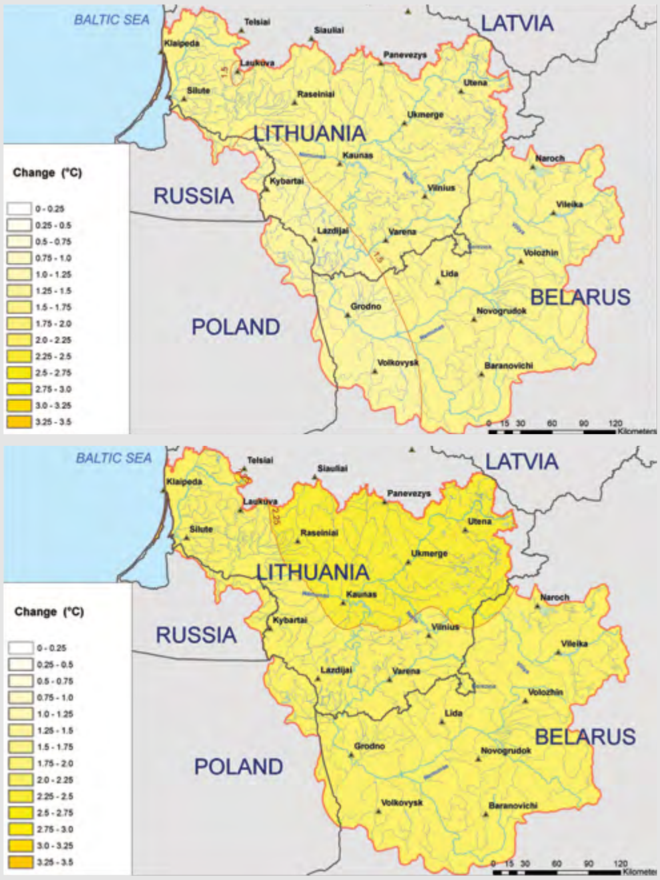


Figure 4.2
Most significant air temperature forecast changes, °C mean for summer season (Figure c)

Figure 4.3
Precipitation change forecasts using the CMIP5 multi-model ensemble (according to IPCC – 2014) and A1B and B1 scenarios (according to IPCC – 2007).

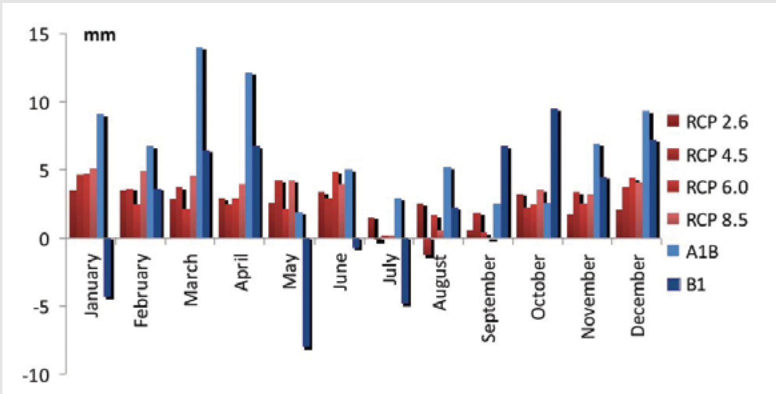
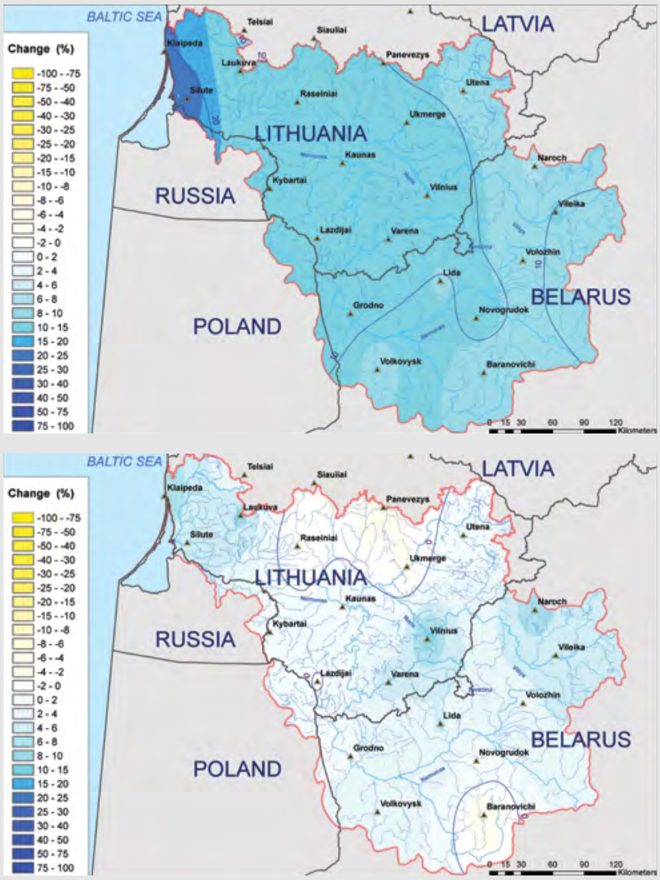


Figure 4.4
Most significant precipitation forecast changes, %: for a year (Figure a)

Figure 4.4

Most significant precipitation forecast changes, %: for winter season (Figure b) and for summer season (Figure c)



Chapter 5
Climate Change Impacts on Water Resources and other Related Natural Resources and Industries in the Neman River Basin

5.1. The Impact of Climate Change Impact on Water Resources

5.1.1. Forecast of Runoff Change

The forecast of the changes to runoff in surface water bodies for the period from 2021 to 2050 was elaborated using two methodologically similar hydrological models:

- the WatBal model with calculations of the evapotranspiration and water balance (WatBal model calculations were made by Lithuanian experts) [11,12,13];
- the Belarusian model of hydrological-climatic calculations based on simultaneous solution of equations of water and heat energy balance (calculations were made by Belarusian experts) [14,15].

According to the runoff change forecasts for the period 2021–2050, the tendencies for a slight increase in the average annual runoff throughout the NRB, spotted in 1961–2009, will persist (Figure 5.1).

The runoff may increase to the maximum in the winter season (up to +40 %), mainly in January and February, due to increases in precipitation and the frequency of thaw periods (Figure 5.2).

The forecast summer surface runoff for 2021–2050 may decrease in the Belarusian part of the NRB (maximum runoff reduction may be nearly -20 %), while in the Lithuanian part of the basin and in Kaliningrad Oblast (Russian Federation), it may increase up to +20 % (Figure 5.3).

Figure 5.1
Generalized multi-model forecast of annual runoff change

Figure 5.2
Generalized multi-model forecast of annual runoff change in winter season

Figure 5.3
Generalized multi-model forecast of annual runoff change in summer season

5.1.2. Extreme Hydrometeorological Phenomena

One of the climate change-induced adverse effects for the Neman River Basin is a possible increase in the frequency and intensity of adverse meteorological and hydrological phenomena: intense rainfall, drought, late frost, flooding due to rain floods and spring floods, specifically in case of a combination of factors such as snow melting and wet-snow and rain precipitation, as well as possible increases in flood duration (Figure 5.4).

Figure 5.4

A spring flood in the Neman River headwaters near Stolbtsy (2011)[7]

7 Photo: L.N. Gertman

An increase in the irregularity of the intra-annual flow redistribution and increased risks of floods related to sudden thawing in the winter season, earlier onset of spring floods and increased intensity of rain floods (specifically in the Neman headwaters in Belarus and in the western part of Lithuania and in Kaliningrad Oblast of the Russian Federation) will result in increased risks of extreme phenomena. Estimated characteristics of the surface flow of water bodies under extreme hydrological phenomena, including the tendencies of their change over the last 50 years and projections for the period 2020–2050 are provided in Table 5.1.

Table 5.1

Estimated Hydrological Characteristics of the Maximum and Minimum Flow of Main Watercourses of the Neman River Basin, Tendencies of their Change over the Last 50 Years and their Projections for the Period 2020-2050

Neman	Viliya			Viliya	
Exceedance probability (flow probability) P,%	Belarus				
	Stolbtsy	Mosty	Grodno	Vileika	Mikhalishky
Maximum spring flood runoff					
1 %	1,944	2,359	2,317	1,048	1,567
5 %	857	1,456	1,635	582	918
10 %	540	1,144	1,365	424	694
Change of flow in 1961-2009, %	*-53.1*	*-35.5*	*-31.4*	*-35.0*	*-38.6*
Forecast for 2020-2050, %	*-17.1*	*-25.5*	*-25.0*	*-12.2*	*-9.4*

Summer and autumn low-water runoff					
75 %	5.41	66.2	83.7	6.66	29.4
95 %	3.8	59.8	75.8	3.38	26.9
97 %	3.6	58.3	74.1	2.75	26.2
Change of flow in 1961-2009	*-9.6*	*-2.2*	*-4.0*	*-5.2*	*-6.8*
Forecast for 2020-2050, %	*-32.1*	*-17.5*	*-21.8*	*-21.5*	*-21.3*
Lithuania					
	Druskininkai	**Nemanyunai**	**Smalininkai**	**Vilnius**	**Yonava**
Maximum spring flood runoff					
1 %	2,770	2,910	6,140	1,610	2,180
5 %	1,830	2,020	4,680	1,130	1,650
10 %	1,440	1,640	4,030	917	1,410
Change of flow in 1961-2009	*-29.6*	*-28.0*	*-20.6*	*-34.6*	*-23.2*
Forecast for 2020-2050	*-20.0*	*-21.0*	*-15.2*	*-19.6*	*-18.2*
Summer and autumn low-water runoff					
75 %	91.6	119	211	48.9	71.5
95 %	75.2	98.4	180	41.6	60.1
97 %	71.3	93.6	174	40.0	57.8
Change of flow in 1961-2009	*-4.2*	*-3.9*	*+8.2*	*+0.3*	*+2.8*
Forecast for 2020-2050	*-1.1*	*+10.7*	*+7.7*	*+2.1*	*+10.7*

Based on analysis of tendencies/forecasts, the following conclusions may be arrived at:

Spring floods and rain floods

The intensity of spring floods and resulting flood inundations in the NRB has substantially decreased over the last 50 years – on average, the maximum spring flood runoff in the basin decreased by 27.3 % with an earlier onset of the spring flood peak. Therefore, based on the observed tendencies and elaborated forecasts, spring floods are not a priority problem in the NRB, except the Neman headwaters in Belarus, western Lithuania and Kaliningrad Oblast of the Russian Federation. However, despite the fact that the flood problem is not the most urgent as regards the larger part of the NRB, it is relevant since floods cause substantial economic damage, specifically to agricultural production. For example, the river flood plain throughout the larger part of the NRB in Belarus is inundated at least from every 4–10 years. The forecast decrease in the maximum spring flood runoff may be much less substantial compared to the decrease observed over the last 50 years. Flood inundations will, indeed, take place in the future. In this case, inundations of the river flood plain are also forecast, and the damage from these inundations may increase with the increasing intensity of development in the river flood plains. The probability of flash rain floods occurring will also increase, due to the irregularity of the intra-annual flow redistribution. It should be noted that the intensity of these floods, both during the summer and autumn seasons, as well as during other seasons, may be comparable to the flood intensity in cases of such factors as snow melting and intense rains being combined. Therefore, flood-protection hydraulic engineering structures need to be maintained in good working order and repair.

Low-water periods
The problem of low-water periods leading to droughts is relevant for the entire Neman River Basin. Although in general, factors leading to scarcity of water resources are currently nonexistent throughout the NRB and are not likely to emerge in the future, the probability of lengthy low-water periods occurring is increasing.

The summertime runoff slightly decreased over the last 50 years in Belarus (on average by 4.4 %), while it slightly increased in Lithuania (on average by 6.6 %, with a decrease in runoff in southern areas and a slight increase in northern and western areas). In principle, the above conclusion agrees with the results of a study of dry seasons throughout the Neman River sub-basins that used the World Meteorological Organization (WMO)-recommended SDI (streamflow drought index) and SPI (standardized precipitation index) methodologies.

However, the probability of low-water periods occurring will increase in the future. The forecast reduction in the minimum runoff in the summer and autumn seasons in Belarus may be more significant in the future than its reduction over the last 50 years. On average, it will be up to 11 % (maximally up to 20 %). A less significant reduction in the minimum runoff may occur in the future in the southern and eastern parts of Lithuania, with a slight increase even possible in the northern and western parts.

Low-water periods may result in deterioration of the state of the environment and recreational potential of surface water bodies and adjacent areas. They may also lead to a change of the groundwater hydrogeological regime, soil depletion on the flood plain, etc. In addition to the economic damage (mainly to the agricultural sector), the water supply may be put at risk in rural settlements not connected to the centralized water supply system because of a decline in the groundwater level and water shallowing in wells. In addition, the possible increase in the frequency and duration of dry seasons may increase the risk of a substantial reduction in the summer runoff of small rivers, which would result in lower water levels and deterioration of their water quality and recreational potential.

5.1.3. Assessment of the Uncertainties in Forecasting the Impact of Climate Change on Water Resources

The uncertainty in the assessment of the impact of climate change on water resources is associated with many factors, the most significant of which include:

1. Inaccuracies in the identified tendencies of change in meteorological and hydrological characteristics, in light of an assessment of the statistical significance of these tendencies.
2. Uncertainty and ambiguity in the general climate change scenarios and their extremely high level of generalization.
3. Uncertainty of the results of calculations that use hydrological models for runoff forecasting (both Belarusian and Lithuanian), due to errors in the models them-

selves, their verification (validation) and uncertainties in the data and coefficients used (forecast values of air temperature, precipitation, air moisture deficit, soil characteristics, radiation balance components, etc.). In the most general terms, this uncertainty is identified in some discrepancies between the results of forecasts elaborated by Lithuanian and Belarusian experts, with the tendencies identified being generally consistent.

4. Uncertainty in the forecast of socio-economic development and water use in the basin and the forecast of the impact of anthropogenic factors on water resources. However, subject to forecasts, the water utilization by industry in Belarus is likely to increase by 0.5–2.0%/year according to the optimistic scenario of economic development, which would have an insignificant effect on the surface runoff regime.

It has been found that the impact of climate change on the runoff from surface water bodies will be more significant in the NRB in Belarus. Moreover, this change will be related to a greater extent to natural factors than to projected changes in water use: the maximum decrease in surface runoff due to forecast water use may be up to 5 %, while its maximum reduction in the summer and autumn seasons due to climate change-related natural factors may be up to 20 %.

The insufficiency of the economic assessment of climate change in terms of water resources protection and utilization is also responsible for uncertainties in the process of elaborating the long-term runoff forecasts in the context of the changing climate and adaptation measures.

These forecasts may be updated in the future by adjusting the climate change scenarios, refining the global and regional climate models, and also by extending the timeframe of the initial meteorological and hydrological data, supplementing them in subsequent years and taking into account climate change adaptation measures.

5.1.4. Forecasting the Impact of Climate Change on Surface Water Quality

Climate change and the increased air temperature may result in increases in water temperature in surface water bodies. On average, the water temperature is expected to increase by 1 °C throughout the Neman River Basin by the mid-21st century. This may lead to a reduction in the dissolved oxygen in surface waters by an average of 0.25 mg/dm^3 in the summer season throughout the NRB [16, 17]. This is not considered to be a significant reduction in case of high concentrations of dissolved oxygen, but may become significant at low oxygen concentrations. The reduction in the dissolved oxygen content may lead to increased concentrations of biogenic pollutants and also result in the deterioration of hydrobiological indicators of surface water quality. The water temperature rise may increase total mineralization by 3–10 %.

Statistically significant correlations between changes in the possible water temperature due to climate change and the values of the remaining indicators of surface water quality have not been found, since the values of the remaining factors affecting water quality, inclusive of natural conditions of surface water quality formation and anthropogenic impact, are more significant than the climate change-related factors.

5.1.5. Summary of the Assessment of the Impact of Climate Change on Water Resources

Table 5.2
Summary of the Assessment of the Impact of Climate Change on Water Resources

Resource	Impact (risk) features	Adaptation potential
Surface water resources	High probability of exposure to the impacts of climate change and variability. Tendency towards a slight increase in the average annual runoff across the basin (with a decrease in Belarus). Increase in the intra-annual runoff redistribution. Decrease of runoff and earlier onset of spring flooding. Growth of probability of dangerous hydrometeorological phenomena (summer droughts and reduced water levels, summer and autumn rain floods). Increase in risks of damages from floods in the upper reaches of the Neman River on the territory of Belarus, in the western part of Lithuania and Kaliningrad Oblast of the Russian Federation, as well as across the basin in general with increased intensity of reclamation of the river flood plains. Increase in water temperatures and possible reduction of the content of dissolved oxygen, deterioration of the hydrobiological indicators of the state of water ecosystems, change in the regime of surface water levels.	Medium
	Increase in periods of rainfall floods and costs of flood-protection works. Risk of significant reduction of the runoff from small rivers (especially in summer), with lowering of water levels and deterioration of water quality as well as recreational potential. Deterioration of water quality in the Couronian Lagoon. Processes of river bank erosion. Accelerated wash-out of biogenic elements in drainage systems due to deterioration of their condition (mainly in Kaliningrad Oblast).	
Groundwaters	Change of groundwater levels, quantity and quality.	Low

5.2. General Characteristics of the Impact of Climate Change on Natural Resources and Industries in the Context of Their Interrelation with Water Resources

The probable impacts of climate change in the Neman River Basin, taking into account the results of forecasting and consultations held with stakeholders in the states of the NRB, are provided in the most general manner in Figure 5.5 and in Tables 5.3, 5.4.

Figure 5.5

Possible impacts of climate change in the Neman River Basi

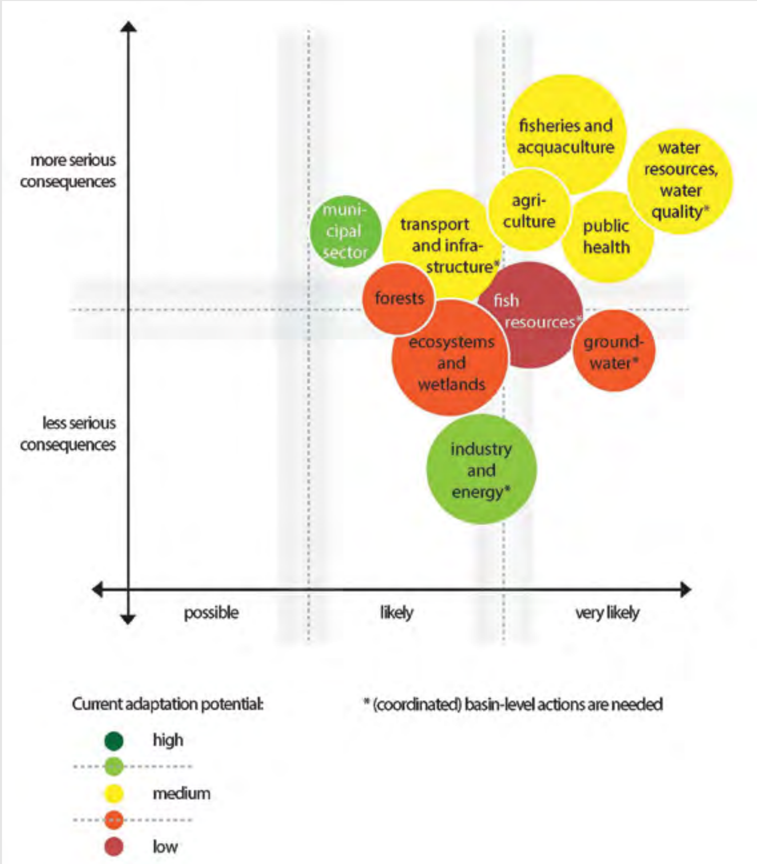


Table 5.3

Summary of the Assessment of the Impact of Climate Change on Natural Resources in the Context of their Interrelation with Water Resources

Resource	Impact (risk) features	Adaptation potential
Forest resources	Changes in the status of forest resources due to climate change in general (structure and composition of forests, infections, parasites) may affect the formation of surface flow. Loss of productivity and quality of timber (scarcity of moisture and the decrease in ground water may provoke drying and reduction of forest cover). Increase in frequency of forest fires. Degradation of woodlands due to increased precipitation, flooding and inundations.	Medium for effective forest management. Lower than medium in Kaliningrad Oblast.
Other ecosystems and wetlands	Likely deterioration of biodiversity characteristics, including a possible reduction of the habitat of indigenous species due to drying out of habitat areas, degradation of water quality along with an increase in temperature, and introduction of alien species. Fires in terrestrial ecosystems (peat lands). Degradation of floodplain meadows through overgrowing by brush woods.	Medium (low for wetlands); at present mainly determined by autonomous adaptation.

	Deterioration of the state of the Couronian Lagoon ecosystems due to hyperblooming of potentially toxic blue-green algae, resulting in dissolved oxygen deficiency.	
Ichthyofauna	Change in species composition, depending on the climate change-related temperature regime of water bodies, and a possible increase in invasive species	Medium-low; at present determined by autonomous adaptation.

Table 5.4

Summary of the Assessment of the Impact of Climate Change on Industries and Conditions of Human Vital Activity

Sector of economy	Impact (risk) features	Adaptation potential
Industry	Additional reduction in runoff due to water use may reach up to 5 % in the future; the maximum reduction in runoff may constitute up to 20 % in summer seasons due to climate change. Water scarcity for industry in total is unlikely to occur because of good availability of ground water, but is possible for enterprises using water from the low-water surface sources. Increased contamination of surface waters may occur due to decreased runoff in the summer period.	Medium in Belarus and in Kaliningrad Oblast for improvement of water use and economic mechanisms,
	The reduction of runoff in summer periods will not have a significant impact on the development of industry, but may negatively influence water quality in receiving water bodies, considering that water scarcity for dilution of wastewaters will result in deterioration of water quality.	introduction of water conservation and recovery activities. High in Lithuania, mainly due to the use of groundwater by the industry.
Energy	The risk of water scarcity for power industry facilities is insignificant, except for hydroelectric facilities, due to a possible reduction of water levels in waterways with hydroelectric power stations in dry periods. Risk of interruption of the normal operation of HPPs, with an increased probability of dangerous hydrometeorological phenomena (dry seasons, floods). Risk of increasing the possible impact of nuclear power plants on temperature regime of water bodies.	Medium in Belarus for improvement of water resources management at HPPs, including the effective use of their accumulating reservoirs. Above medium in Lithuania in case of projected minor changes of runoff.
Housing and public utilities	Municipal water supply to settlements in the basin is completely based on groundwater use; the risk of water scarcity due to climate change is low, but water quality may be affected. Deterioration of water supply is possible in settlements without centralized water supply, due to lowering of levels of the first groundwater aquifer and drying up of wells.	High, due to water supply from groundwater sources, improvement of economic mechanisms, systems of water supply and sanitation (also due to centralized water supply in rural areas).

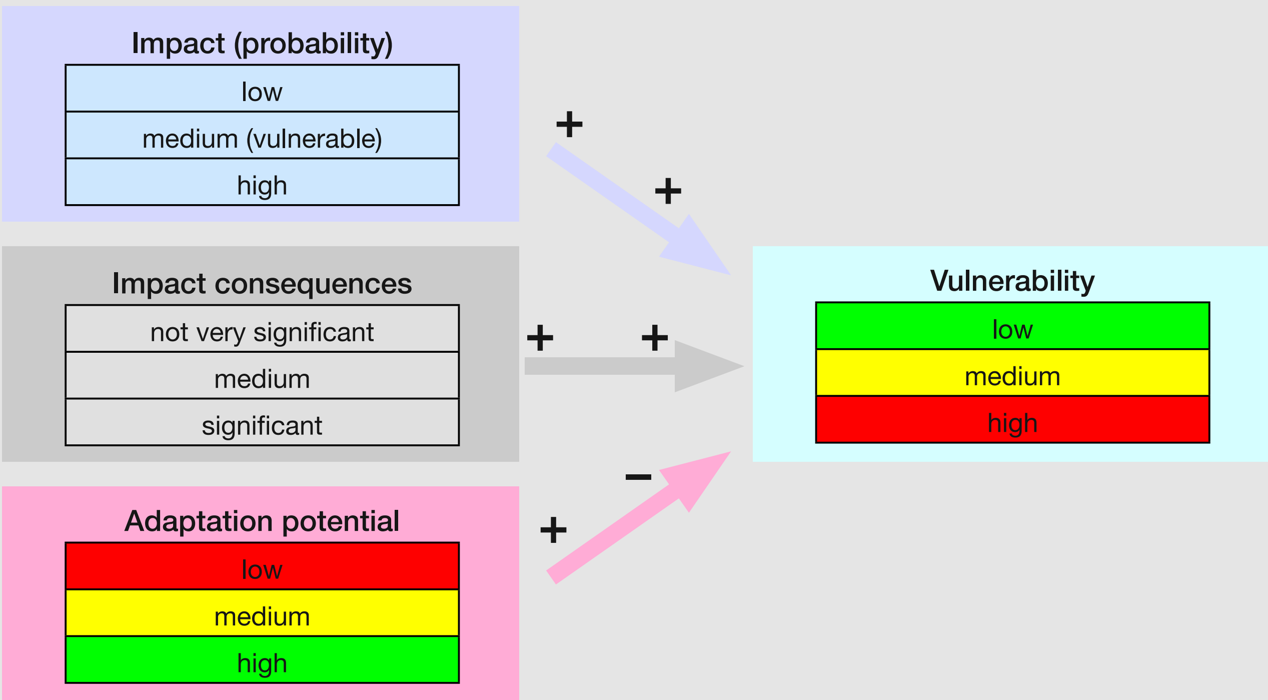
	Risk of interruptions to the water supply from surface water sources during dry seasons (mainly for Kaliningrad Oblast). Additional costs for the development of water supply and sanitation systems, rain sewerage and local water treatment to provide water supply and sanitation services. Increase in water use for household water supply to the population during warm seasons of the year. Deterioration of sanitary-and-epidemiologic situation because of air temperature rises in areas where solid household waste is collected and stored.	
Agriculture	Change in productivity and optimal habitats of agricultural crops, due to possible water scarcity and excess water in soil. Risk of water scarcity for agricultural production is low, except for water users diverting 2-4 million m^3/year of surface waters in certain dry periods of low-water years. The impact of climate change may increase the pollution of soil and water resources (for example, increases in irrigation agriculture and expansion of irrigated areas will lead to a more intensive migration of nitrogen compounds into groundwaters). Propagation of soil erosion and deterioration of water quality due to sharp increases in the frequency of intense floods. Occurrence of new illnesses among agricultural crops, invasive species of plants and rodents is possible.	Medium in case of application of efficient technologies in agriculture.
Fish industry and fish breeding	Possible deficit of water resources in the Neman River's upper and middle reaches for enterprises of the fish industry due to reduction inrunoff and lower levels of surface waters, as well as redistribution among other sectors of the economy. Likely changes may occur in fish fauna; the disappearance or reduction of spawning grounds may provoke a decrease in fish biodiversity. The changing environmental conditions (water temperature, dissolved oxygen, ice regime) will lead to changes in fish production and species composition (including possibilities of new fish species breeding). Deterioration of fisheries and hydrobiological characteristics of the Couronian Lagoon due to the reduction of the Neman River runoff and their improvement with the increase of runoff.	Medium
Legal and institutional aspects of water resources management	Insufficiency of the legal and institutional framework of water resources management (an administrative, but not a basin principle of the water management is used in Belarus; an international agreement on the Neman River Basin does not exist).	High in case of signing and implementing the Neman River Basin Agreement and stagewise implementation of the basin principles of management.

Transport infrastructure, including water transport	A possible deterioration of transport infrastructure as a result of intensification of dangerous hydrological phenomena (dry periods, spring floods and summer/autumn rain floods). Changes in the amount of precipitation may render slopes unstable and lead to road soil component failure; extreme heat may reduce road quality due to the melting of asphalt pavements. Deterioration of conditions for water transport in Belarus due to decreased water levels and accelerated accumulation of sediment in water bodies.	Medium in case of insufficient funding.
Health of population	Reduction of drinking water quality and limited access to water in settlements without a centralized water supply. Increase in water consumption in dry periods. A growing frequency hot and cold periods and increase in the risk of diseases affecting the blood circulation system. Possible deterioration of sanitary-and-epidemiologic situation, occurrence of new illnesses, development of chronic diseases, formation of psychological discomfort in cases of dangerous hydrometeorological phenomena. Risk of outbreak of infectious diseases as a result of water flooding and water logging during floods. Risk of deterioration of water quality and emergence of diseases in people and animals in case of growth of the habitat of toxic algae.	Medium
Recreation	Possible deterioration of water quality in areas of recreation (bathing). Change of conditions for tourism and recreation, including a reduction in the recreation potential for kayaking in cases of lowering water levels in water bodies.	Medium

Chapter 6
Assessment of the Vulnerability of Water Resources and Related Natural Resources and Industries to Climate Change in the Neman River Basin

The vulnerability assessment is based on a determination of the extent to which a system (natural resource or industry) is exposed to climate change-induced adverse effects and is unable to withstand climate change-related adverse impacts, including climate variability and extreme climate phenomena. Vulnerability depends on the character, order of magnitude and rate of climate change, on those changes that affect the system, and on the system's sensitivity and adaptation capacity. In this case, sensitivity is defined as the degree of the system's response to the estimated climate change that is directly related to the system's adaptation potential (Figure 6.1).

Figure 6.1
Vulnerability assessment diagram



Currently, there are no generally accepted unified approaches to the quantitative assessment of vulnerability of both natural resources and industries to climate change. Many countries worldwide have adopted formal procedures, only outlining the climate change adaptation strategy. Scoring approaches, based on a determination of the degree of vulnerability subject to the impact of climate change, are most frequently used. The Neman River Basin's vulnerability is assessed by assigning scores from one to three depending on the impact of factors as they increase.

Vulnerability is assessed in more detail in terms of administrative districts in the NRB

Basin, based on the degree of runoff change for a combination of two climate change scenarios, the general tendencies of which have common features, taking in to account the area of farmland, forests, wetlands, population size (including the rural population), the main industrial sectors and products manufactured, availability of HPPs/CPPs and their capacities, water intake from the surface water bodies, and discharge into the surface water bodies (including water diversion for the fish industry).

The degree of vulnerability was assessed in each administrative unit (district), based on the following criteria: degree of runoff change; adaptation potential assessed for various types of natural resources and industries related to water resources; and climate change impacts. The assessment accounted for the outcomes of consultations held in the NRB states.

In general, the scale used for the assessment of the vulnerability of industries and natural resources is as follows.

Impact probability: low – 1; medium – 2; high – 3.

The impact probability is characterized by the extent of utilization of some or other resource in the economy, for example the forested land area or a portion of the reclaimed land in a district.

This assessment is limited to physical aspects of vulnerability.

Impact consequences: not very significant – 1; medium – 2; significant – 3.

Impact consequences are defined by the degree of dependence of the resource used on the runoff change as an element of physical aspects of the vulnerability assessment. The impact consequences may be lower for Belarus, located in the upper part of the basin, than for Lithuania and Kaliningrad Oblast, due to the capacity to control quantitative and qualitative characteristics of the runoff within the country. The downstream regions are dependent to some extent on economic activity upstream.

The assessment of impact consequences also includes an analysis of social aspects that involve the possibility of compensation for losses and the availability of reserve funds to protect people's lives and effectively restore infrastructure facilities. Lithuania, as a member of the EU, has more possibilities to reduce impacts of climate change than Belarus.

Adaptation potential: low – 3; medium – 2; and high – 1.

The adaptation potential is determined based on the results of consultations and in the generalized form provided in Figure 5.5.

The adaptation potential is higher, with less significant impact consequences, for Lithuania, as an EU member-state, than for Belarus and Kaliningrad Oblast of the Russian Federation.

The *vulnerability* is rated depending on the total score based on the impact probablity, impact consequences and adaptation potential: low – 1; medium – 2; high – 3.

The probable changes in runoff volume and seasonal distribution are considered to be among the critical consequences of climate change in the Neman River Basin. Therefore, the vulnerability was determined based on an assessment of the impact of the surface runoff variation over the limiting period (a respective most significant and characteristic period) as the major criterion (Table 6c.1). The proposed scoring system from one to three was used, in light of consultations. A number of additional criteria, with consideration being given to the impact probability, impact consequences and adaptation potential (Table 6.2) was also used. The assessment was conducted in the administrative districts of Belarus, Lithuania and Kaliningrad Oblast of the Russian Federation using published statistical data [8,18]. Patterns of vulnerability are shown in Figures 6.2, 6.3.

Table 6.1.

Assessment of the Impact of Runoff Changes in the Neman River Basin on Industries and Natural Resources*

Types of impact / Industries and natural resources	1. Maximum flood runoff - more water	2. Minimum runoff (droughts resulting in substantial water level reduction) - less water	3. Water quality change (related to 1 and 2)	4. Impacts not related to water resources
Agriculture	2	3	1	3
Forestry	1	2	1	3
Natural resources (natural ecosystems)	1	3	1	3
Industry and energy	1	2	1	2
Population	2	2	2	2

* Groups of problems directly related to the changes in the regime and state of water resources are highlighted

Table 6.2

Additional Criteria for Assessment of Vulnerability to Climate Change

Industry / natural resources	Additional assessment indicators		Adaptation potential
	Impact probability	Impact consequences *(combination of the specified impact probability indicator with the runoff change value)*	
Agriculture	The proportion of farmland in the total structure of land in the area: this conditions the farming intensity as well as pollution supply due to fertilizer application	The proportion of farmland / August runoff; The proportion of farmland / February runoff when biogenes are washed out from farmland	Medium
	Cadastral valuation of lands the farmland bonitet was taken into consideration – the higher the bonitet, the lower the probability of impact of runoff changes	Soil bonitet / August runoff	

	The proportion of reclaimed land: for changing conditions of spring runoff, availability of an amelioration drainage network is a positive factor reducing the probability of inundation and flooding; during reduced summer runoff periods, drainage amelioration is a negative factor: the probability of fires and droughts increases	The proportion of reclaimed land / March runoff; The proportion of reclaimed land / August runoff	
	Availability of an irrigation network as an element that reduces water scarcity at a time of minimum runoff	The proportion of irrigated land/ August runoff	
Forestry	The proportion of forested areas in the total land structure of the area	The proportion of forested areas / August runoff	Medium
	The proportion of wetlands that may be transformed into forested land under conditions of decreased runoff	The proportion of wetlands / August runoff	
	The proportion of reclaimed non-agricultural land where the probability of fires occurring during a significant reduction of runoff is high	The proportion of reclaimed non-agricultural land / August runoff	
Natural resources (natural ecosystems)	The proportion of forested areas in the total land structure of the area	The proportion of forested areas / August runoff	Medium
	The proportion of wetlands in the total land structure of the area	The proportion of wetlands / August runoff	
Natural resources (natural ecosystems)	The proportion of specially protected natural areas in the land structure of the area	The proportion of specially protected natural areas / August runoff	Medium
Industry and energy	Structure of industry in the total output – this reflects the dependence of industries on the availability of water resources	Dependence of leading industries on the August runoff	High
	Effluents discharged into water bodies – reducing river runoff may increase pollutant concentration due to the reduced diluting capacity of receiving water bodies	Discharged effluents / August runoff	
	Availability of HPPs and CPPs and their capacities – possibility of producing sufficient electricity during reduced or increased runoff	Availability of HPPs / August runoff Availability of CPPs / August runoff	
Population	Urban and rural population ratio – determines the degree of access to various social and economic benefits (drinking water, healthcare, education, etc.)	Share of the rural population / August runoff	Medium

Figure 6.2

Generalized map of vulnerability to climate change in the Neman River Basin with account of industries and natural resources

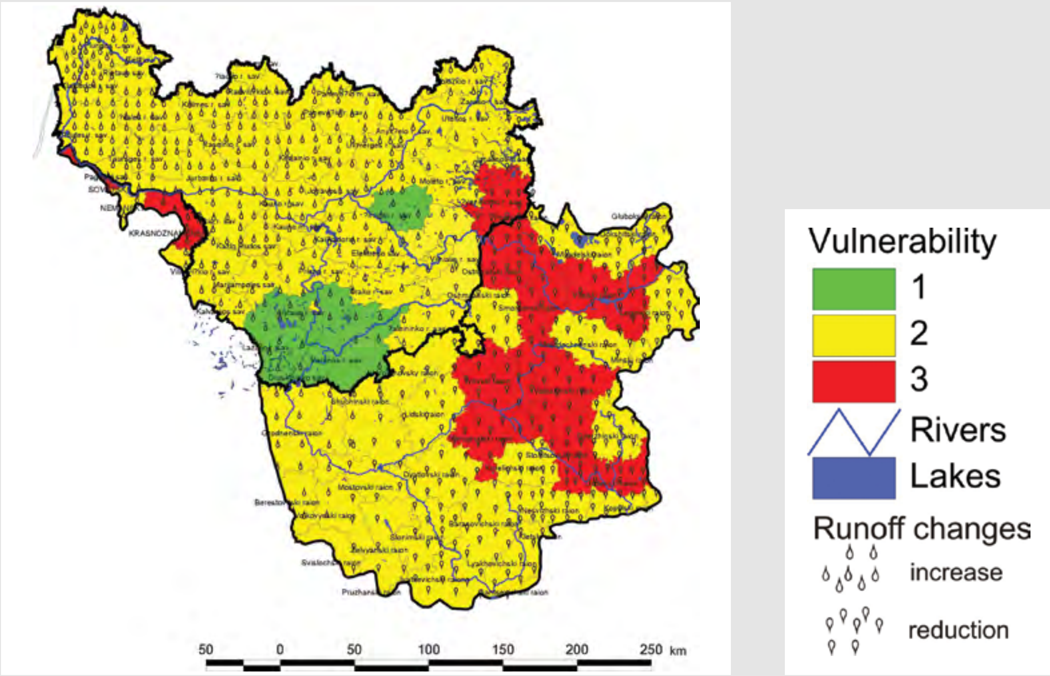


Figure 6.3

Maps of vulnerability to climate change in the Neman River Basin:
a - agriculture; b – forestry

a b

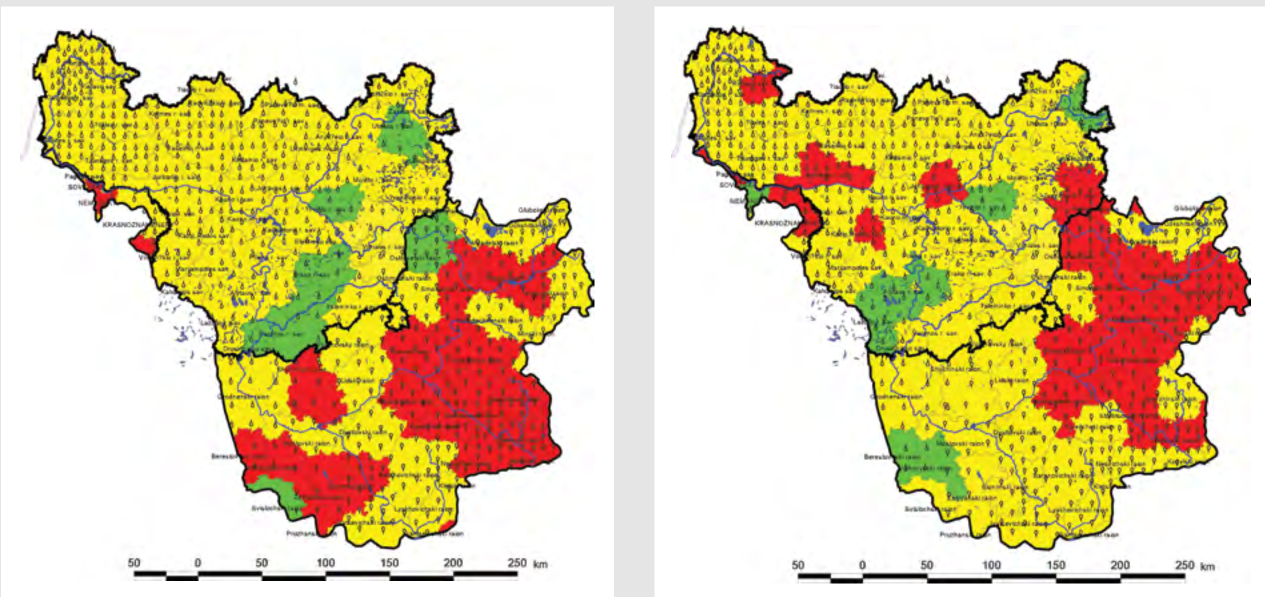
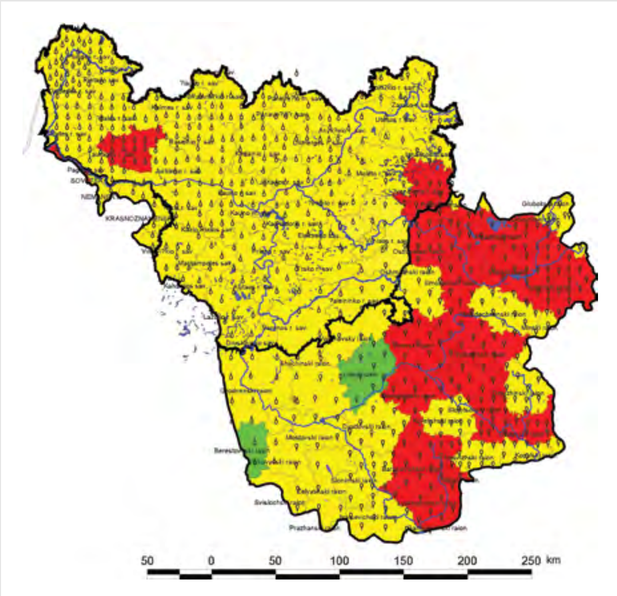
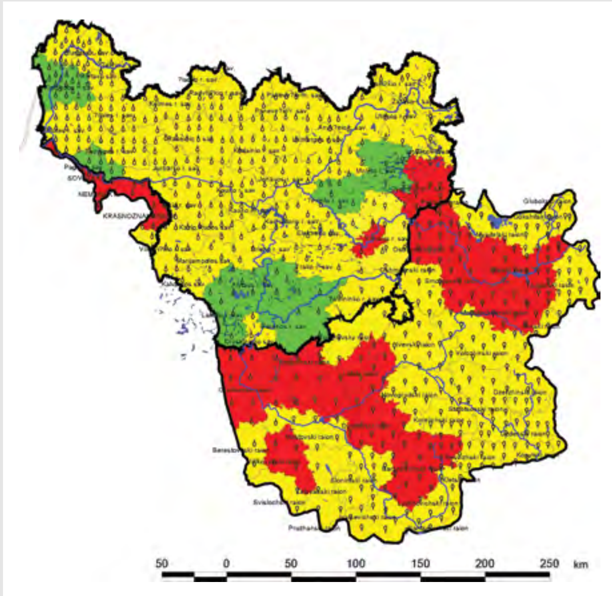


Figure 6.3
Maps of vulnerability to climate change in the Neman River Basin:
c – industry; d - natural resources (natural ecosystems)

c



d



An integral assessment of areas by degree of vulnerability generally differentiates the basin territory into 3 sections:

- an upper reach, where a significant downward trend in the runoff is forecast;
- a middle reach, where areas with an average degree of vulnerability and or a low degree of vulnerability (in Lithuania) prevail;
- a lower reach, where areas with a high degree of vulnerability are located.

The integral vulnerability assessment, which combined an assessment of the vulnerability of the main industries and natural resources, indicated a certain azonality and proximity of areas with high and low vulnerability. However, according to the assessment, the areas in which a significant reduction of runoff during the summer is forecast are most vulnerable. This factor is most critical for the development of industries and natural resources, primarily due to significant deviations from the current indicators. Areas with a low degree of vulnerability are located in te zone with minimum estimated runoff changes. However, analyzing in detail the contribution of each component to the integral assessment allows the identification of additional criteria that greatly contribute to the overall picture of the vulnerability of areas to changes in runoff.

As for the Belarusian *forestry industry*, a combination of the reduced runoff and a large wetland area in the Shchara river basin may yield a positive effect, manifesting itself in a possible increase in the forested area and enhanced adaptability of this industry to the changes that are likely to occur [20, 21]. Alternatively, with increasing runoff, the probability of the forested land being transformed into waterlogged areas or wetlands increases the vulnerability of the forestry industry and identifies vulnerable areas in Lithuania. The eastern parts of Belarus, where a significant reduction of summer runoff is forecast and a well-developed drainage amelioration network is available, are prone to increased occurrence of fires on the drained land, thereby increasing the vulnerability of areas even to a relatively slight reduction in the runoff. In Kaliningrad Oblast, where forested land makes up less than 10 %, the runoff change-related vulnerability of the forestry industry sharply decreases [22].

To assess the vulnerability of *industry*, the volume of discharged wastewater proved to be a critical factor that contributed to a significant increase in the vulnerability of Belarusian areas to the change in runoff, specifically in the context of the estimated changes in runoff in the summer and autumn. Therefore, industry is rendered highly vulnerable in more than half of the Belarusian areas as its operation is dependent on surface runoff. This necessitates the introduction of advanced water-use technologies in these areas, primarily to increase the efficiency of water recirculation and reuse systems at enterprises.

As regards the Lithuanian areas with a low degree of vulnerability for industry in the context of the estimated runoff increase, the development of the hydropower industry is a positive factor due to the possibility of reducing flood peaks and also accumulating surface runoff during high-water periods for use during low-water periods in the future.

The combination of wetlands and a slight reduction in the runoff helped in the identification of specific low vulnerability areas in Belarus for *natural* ecosystems. The high vulnerability of other areas in the upper part of the Neman River Basin is related to a high degree of transformation of wetlands into forested land under reduced runoff conditions, while in the middle and lower parts of the basin there exists the risk of forested land being transformed into waterlogged areas under the increased runoff conditions.

As for the *agricultural sector*, apart from a substantial area of farmland, a critical factor is an estimated increase in runoff in specific periods of the year which, all other things being equal, may result in increased vulnerability of the areas in the middle reaches of the Neman River in Belarus. The reduction in the August runoff is a dominant factor for areas in the upper part of the basin in Belarus. As a rule, in areas with a high cadastral valuation of lands, the ratio of ploughed land is over 60 %, which offsets the advantage of high soil bonitet when assessing vulnerability. For Lithuania, where the ratio of ploughed land is significantly smaller compared to that of Belarus, this helps to identify areas of low vulnerability under conditions of a slight change in runoff.

Chapter 7
Strategic Framework for Adaptation to Climate Change

7.1. General Principles of Adaptation and Existing Tools in the Sphere of Water Resources Management and Climate Change Adaptation

Adaptation to climate change is an essential prerequisite for managing water resources. This requires the formulation and implementation of effective strategies.

The basic and most relevant approaches to the identification of strategies for adapting the international Neman River Basin to climate change govern that: "the policy of adaptation should be formulated in the context of the integrated water resources management concept, which requires planning at the river basin level, close intersectoral cooperation, involvement of the public and water use optimization"; and also that "adaptation is not a one-off measure, but rather an on-going and long-term process integrated into all planning levels" [5].

Therefore, the basis for the adaptation of the NRB to climate change resides in the use of a basin approach, subject to which the problems and needs of the basin as a whole are the focus of attention irrespective of their spatial distribution and regardless of which department and territory they are specific to. In addition, basin cooperation mechanisms are proposed to identify and resolve those problems. This provides a broader view of the sources of risk and methods for solving problems in the context of common interests.

The principles of climate change adaptation mainly imply that countries, territories and sectors should implement most basin adaptation measures within the framework of their own development and climate change adaptation strategies, also using other national ecological policy tools.

For example, the importance of studying climate change is stipulated in the National Strategy of Sustainable Socio-Economic Development in the Republic of Belarus until 2020. According to this document: "the strategic goal in the field of conservation of the country's water resources consists in enhancing the efficiency of utilization of water resources and improving their quality, whilst maintaining a balance with public needs and possible climate change". Climate change issues are also dealt with in the Water Strategy of the Republic of Belarus until 2020. According to the Water Strategy: "…issues pertaining to the assessment and use of transboundary watercourses within the river basin with consideration for the European approaches and in the context of the climate change adaptation are not fully settled".

The National Strategy of Lithuania on Adaptation to Climate Change until 2050 defines basic principles and adaptation goals, including short-term (until 2020), medium-term (until 2030) and long-term (until 2050) goals.

The main federal-level ecological policy tools of the Russian Federation in the field of climate change adaptation include the Water Strategy of the Russian Federation until 2020 and the Climate Doctrine of the Russian Federation and Comprehensive Plan for Its Implementation until 2020. The principal provisions of the Regional Climate Strategy for Kaliningrad Oblast – a strategy for adaptation to climate change – were formulated in 2014.

National and regional programs and plans, most of which aim to develop the respective industries at the national level, may be considered as practical mechanisms of climate change adaptation. This includes environmental protection, the housing and public utility sectors, industry, energy, emergency response, and engineer operations to reduce flood-related risks and damage (including by siting new hydraulic engineering structures and retrofitting existing ones) and to develop the monitoring network. To finance their activities, these programs use both the states' own resources and funds from international finance organizations. However, both transboundary basin interests as a whole and existing and future climatic trends are not adequately accounted for in these programs. Therefore, a critical goal of adaptation throughout the NRB consists in accounting for the basin-wide interests associated with changing the degree of risk related to climate change within the frameworks of existing mechanisms and processes pursuing their own goals, although these goals may somewhat differ from those related to the adaptation of the entire NRB.

Another critical goal is to identify and stimulate a range of actions whose implementation would directly contribute to an increase in stability and climate change adaptation in the basin. Actions that may be implemented using existing and future mechanisms of basin coordination and cooperation are of particular importance in both cases. Therefore, to implement them, there have been proposals not only of strategies and measures based exclusively on national strategies and other ecological policy instruments, as well as national and regional programs, but also those which would contribute as far as possible to resolving the problems associated with adaptation at the basin level.

Bilateral agreements between the NRB states that serve as a basis for bilateral cooperation are of great importance in the field of climate change adaptation. These include the following:

- Agreement between the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus and Ministry of Environment of the Republic of Lithuania on Cooperation in the Field of Environmental Protection (signed 14 April 1995);
- Agreement between the Government of the Russian Federation and Government of the Republic of Lithuania on Cooperation in the Field of Environmental Protection (29 June 1999);
- Technical Protocol on Cooperation in the Field of Monitoring and Exchange of Data on Transboundary Surface Waters (signed in 2008 between the Ministry of Environment of the Republic of Lithuania and the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus);
- Agreement between the Lithuanian Geological Service of the Ministry of Environment and Republican Unitary Enterprise "Belarusian Research Geological Exploration Institute" (RUE "BelNIGRI"), 2011.

7.2. General Characteristics of the Strategic Framework

The Strategic Framework has been developed taking into consideration analyses and forecasts of the climatic and hydrological characteristics of the Neman River Basin and the tools in the sphere of water resources management and climate change adaptation that are available with the basin states.

In the course of developing the Strategic Framework (Tables 7.1, 7.2), three rounds of consultations were held within the Project. These involved international workshops and an assessment tour of the NRB with the participation of representatives of the UNECE, environmental management bodies, international and national experts, water users concerned and also the mass media and public. The consultations were held in Belarus (Grodno, October 2012; Minsk, March 2013); in Lithuania (Druskininkai, October 2012; Vilnius, May 2013); and also in Kaliningrad Oblast (Kaliningrad, January 2014).

Figure 7.1
Workshop in Grodno, Belarus, (October, 2012)

Table 7.1
Strategies of Adaptation for Water Resources and Other Related Natural Resources to Climate Change

Natural resources	Adaptation strategies
Surface water resources	Effective management of water resources and optimization of water consumption, including regulation of requirements related to agricultural and urban development activities in the river floodplains, in order to reduce the risk and damage from floods and droughts. Monitoring of the situation in the basin, including improvement of the monitoring system for hydrological, hydrodynamic and hydrochemical regimes as well as automation of the monitoring points. Organization of information exchange between the countries on a regular basis. Development of management plans for water resources and flood risks across the basin and regular mapping of the risk of flooding. Development of action plans for emergency situations, implementation of early warning systems, distribution of information (including across the borders) about the danger of floods, and city planning according to flood risk maps. Reduction of pollution from point and non-point sources. Monitoring and retrofitting of hydraulic installations. Rehabilitation of the irrigation and polder systems. Bank stabilization measures. Awareness-raising among the population. Technical re-equipment of hydrologic networks [23].

Groundwaters	Integrated groundwater monitoring. Evaluation of the status of groundwaters and their vulnerability to climate change. Effective water resources management and optimization of water use, including regulation of requirements related to groundwater intake. Assessment of interaction between surface and groundwaters, efficient management of drainage systems.
Forest resources	Monitoring and analysis of the situation. Implementation of integrated activities for sustainable forestry, including replacement of the most sensitive species by more resistant ones. Transboundary monitoring of infections and parasites. Amelioration and re-waterlogging of forested areas. Forestry engineering actions to protect forests against fires, infections and pests.
Other ecosystems and wetlands	Monitoring and preventing introduced species (invasive species) from propagation. Monitoring of ecosystems and water quality. Control of compliance with the technologies of natural resources management (for example, during the development of peat lands). Preservation and expansion of wetlands, including revegetation. Accounting for basin aspects during implementation of measures aimed at improving biodiversity at the regional level (fragmentation prevention).
Fish fauna	Restoration of fish fauna and habitats, combating invasive species, water protection measures.

Table 7.2

Strategies of Adaptation of Industries to Climate Change in the Context of their Dependence on Water Resources

Sector of economy	Adaptation strategies
Industry	Development of water efficient, water-saving and clean technologies (“green economy”). Reduction of wastewater discharges and their pollutant content. Improvement of economic mechanisms for water supply and sanitation. Awareness-raising among the population.
Energy	Improvement of engineering projects and technologies of HPP construction. Updating the rules of HPP maintenance, taking into consideration the estimated changes in hydrological regime at the basin level. Improvement of the management of releases from reservoirs and wastewater discharges. Increasing use of renewable energy sources and of waste for energy production. Transboundary information exchange.
Housing and public utilities	Development of the water supply and sanitation systems, including in rural settlements. Periodical assessment of groundwater deposits and monitoring (quality and quantity indicators). Introduction and upgrading of wastewater treatment technologies. Reduction of areas of waste disposal through improvement of systems for waste processing. Implementation of measures to reduce water loss; improvement of the rain sewerage system.

Agriculture	Reduction of pollution from point and non-point sources. Introduction of effective technologies, including for small farms; soil erosion control. Replacement of agricultural crops by more productive and resistant varieties (adapted to the new climate conditions).
Fish industry and fish-breeding	Effective supervision and optimization of water use. Fish fauna monitoring and regulation of fisheries; use of possibilities for breeding new species, including through the expansion of the network of artificial reservoirs and aquaculture growing. Additional technological measures in Belarus (aeration, increase in flow, chemical methods).
Legal and institutional aspects of water resources management	Improvement of the legal and institutional framework of basin management. Awareness-raising among the population. Transboundary information exchange.
Transport infrastructure, including water transport	Adaptation of water transportation to the increased frequency and amplitude of water level fluctuations, including by conducting engineering activities to improve the capacity of watercourses. Monitoring and forecasting of dangerous hydrometeorological phenomena. Introduction of systems to prevent and mitigate emergency situations. Improvement of engineering protective measures to mitigate the negative impact of dangerous hydrometeorological phenomena on the road network. Awareness-raising among the population. Designing new roads and buildings in view of ongoing climate change, using construction materials designed for the increased number of cycles of freezing and thawing.
Health of population	Improvement of monitoring and control of the surface and groundwater quality, awareness-raising among the population. Flood forecasting and mitigation of flood damages.
Recreation	Maintenance of the tourist and recreational infrastructure; ecotourism development. Awareness-raising among the population.

Chapter 8
Elaboration and Implementation of Climate Change Adaptation Strategies

Activities stipulated in the Strategic Framework may be implemented via elaboration and implementation of respective measures. These may be general measures or specific projects. It is reasonable to apply the available water resources management tools possessed by the NRB states which, in combination with other factors including natural and anthropogenic factors, define the adaptation potential.

The NRB states possess specific resources for adaptation to climate change [24]. However, according to estimations, the adaptation potential of Belarus, which lacks its own mineral reserves and is not a EU member-state, is lower than that of Lithuania, a EU member-state, and of the Russian Federation, which possesses substantial mineral reserves. In addition, according to the IMF, the GDP per capita in Belarus was lower than in Lithuania and the Russian Federation in 2012–2013 [19], thereby also reducing Belarus's adaptation potential.

Climate change adaptation measures are classified into the following main types [5]:

- *preliminary measures and preventive measures (short-term measures)* aimed at supporting, planning and implementing preliminary measures for sustainable water resources management in the context of the climate change. These include monitoring, conducting surveys for making assessments and forecasts, preparing management plans, creating risk and vulnerability maps; and raising population awareness;
- *stability improvement measures and countermeasures (medium-term measures)* are aimed at mitigating the adverse effects of climate change and climatic variability, and the direct adverse effects of extreme phenomena;
- *recovery measures (long-term measures)* are aimed at securing the recovery of economic, social and natural systems after extreme phenomena.

The classification system for the main climate change adaptation measures, which takes into account their orientation, and a list of measures with their estimated costs are provided in Annex B. Activities for implementing the strategies for adaptation are summarized in Table 8.1.

Climate change adaptation measures, including anticipatory adaptation, are planned, managed and implemented within the framework of the governmental climate policy, which takes into account sectoral, regional and local features as well as the long-term character of these measures and their degree of influence on various aspects of the life of society, the economy and the state.

Climate change adaptation measures are implemented by integrating these measures into the management of the water resources of the Neman River Basin. This integration process is intensified most during the development and implementation of pilot climate change adaptation projects at the regional level, and also during improvement and preparation of the following fundamental documents:

- Schemes for the Complex Use of Water Resources (SCUWR) in the Neman River Basin (in the future – Neman River Basin Management Plan) – territory of the Republic of Belarus;
- Neman River Basin Management Plan (Republic of Lithuania);
- Complex Schemes of Water Body Use and Protection of the Neman River Basin and Baltic Sea River Basin – Kaliningrad Oblast.

Furthermore, it is reasonable to introduce adaptation strategies and measures for implementationwhile forecasts, plans and socio-economic development programs are being elaborated.

The signing of an International Agreement on the Neman River Basin and setting up of an International Commission for the Neman River Basin would provide an important additional practical mechanism for implementing these strategies. This Commission, whose decisions may however not be exclusively prescriptive in nature, would potentially become one of the most important mechanisms for cooperation in the field of nature conservation in the NRB and also for dealing with issues related to climate change adaptation.

Table 8.1

Classification of Measures within the Strategic Framework for Adaptation to Climate Change in the Neman River Basin

Group of measures	Description of measures	Total estimated cost of measures*
Direct actions at the basin level	Signing an international agreement on the Neman River Basin	?
	Setting up and operating an International Commission for the Neman River Basin.	€
	Development of the overall Neman River Basin Management Plan	€
	Evaluation of the status of groundwaters and their vulnerability to climate change	€€
Actions to more fully consider the interests of the basin	Improvement of the meteorological and hydrological monitoring network (setting new automatic stations and computerization of existing ones)	€€
	Improvement of the Schemes for the Complex Use of Water Resources (SCUWR) in the Neman River Basin (Belarus, Kaliningrad Oblast) and Water Resources Management Plan (WRMP) (Lithuania)	€€
	Development of water supply and sanitation systems and improvement of economic mechanisms in this field	€€€€
	Improvement of engineering, construction and operation of HPPs, of information exchange and early warning systems, taking into consideration the estimated changes in hydrological regime at the basin level.	€€€
	Improvement of flood risk management and flood protection works	€€€

Actions at the national and local levels	Implementation of SCUWR and WRMP measures	€€€€
	Development of generating capacities using renewable energy sources	€€€
	Improvement of project engineering and construction technology for roads and transport infrastructure. Improvement of the existing communication network	€€€€
	Improvement of water use and farming technologies in the context of climate change	€€€
	Improvement, development and maintenance of recreational infrastructure	€€€
	Improvement of monitoring and assessment of water resources quality	€€

* Total estimated cost of measures:

€ — up to 100 ths Euro
€€ — up to 1 mln Euro
€€€ — from 1 to 10 mln Euro
€€€€ — over 10 mln Euro

? — the information needs to be additionally analyzed

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ANNEX A
List of main regulatory acts and other ecological policy tools

1. Water Code of the Republic of Belarus, as revised in 2013;
2. National Strategy of Lithuania on Adaptation to Climate Change until 2050 (approved by the Parliament of the Republic of Lithuania on 6 November 2012, Resolution No. XI-2375);
3. Water Strategy of the Republic of Belarus until 2020 (approved by Resolution of the Board of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus No. 72-P on 11.08.2011);
4. The Climate Doctrine of the Russian Federation (approved by Decree of the President of the Russian Federation No.861-rp on 17.12.2009);
5. Comprehensive Plan of Implementing the Russian Federation's Climate Doctrine for the Period until 2020" (approved by Decree of the Government of Russian Federation No. 730-r on 25 April 2011).
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7. Water Code of the Russian Federation (amended as of 7 May 2013);
8. Water Strategy of the Russian Federation for a Period Until 2020 (approved by RF Government Decree No. 1235-r on 27 August 2009, amended as of 28 December 2010);
9. On Approval of Priority Directions of Scientific and Technological Activities in the Republic of Belarus for 2011 – 2015 (Decree of the President of the Republic of Belarus No. 378, 22 July 2010, National Register of Legal Acts of the Republic of Belarus, 2010, No. 183, 1/11797);
10. National Strategy of Sustainable Socio-Economic Development of the Republic of Belarus until 2020 (May 2004);
11. Environmental Protection Strategy of the Republic of Belarus until 2025 (approved by Decision of the Board of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus No. 8-R on 28.01.2011);
12. Law of the Republic of Lithuania on Drinking Water Supply and Waste Water Treatment (No. X-764 of 13 July 2006);
13. Law of the Republic of Lithuania on Water (No. VIII-474 of 21 October 1999, amended as of 5 July 2000 No. VIII – 1807);
14. Nemunas River Basin District Management Plan (approved by Resolution No. 1098 of the Government of the Republic of Lithuania on 21 July 2010);
15. Action Plan on the Implementation of the Goals and Objectives of the Strategy of National Climate Change Management Policy of the Republic of Lithuania for the Period of 2013-2020;
16. Federal Target Program "Development of Water Resources Utilization System of the Russian Federation in 2012 – 2020" (approved by Resolution No. 350 of the Government of Russian Federation 19 April 2012).
17. Draft State Program "Socio-Economic Development of Kaliningrad Oblast until 2020".
18. Target Program of Kaliningrad Oblast "Environmental Improvement of the Territory of Kaliningrad Oblast in 2008-2013.

ANNEX B
Review of measures within the strategic framework for adaptation to climate change in the Neman river basin

Preliminary measures and preventive measures (short-term measures)		
Proposed measures (activities)	Completion date, estimated cost (thousands of Euro)	Remarks (possible funding sources)
International activities		
Preparation and signing of an International Agreement on the Neman River Basin and establishment of an International Commission for the Neman River Basin.	2014–2020 600.0	Budgets of countries concerned; international projects
Belarus		
General activities Improvement of the meteorological and hydrological monitoring network: siting 2 new automatic hydrological stations (at trans-boundary sections of the Neman and Viliya rivers) and computerizing existing hydrological and meteorological stations.	2014–2020 1,027.0	National budget, international projects
Development of flood risk maps and flood risk management plans.	2014–2016 600.0	International projects, National budget; local budgets;
Improvement of the Schemes for the Complex Use of Water Resources (SCUWR) in the Neman River Basin and their conversion into the Water Resources Management Plan, containing a typology of water bodies and an assessment that takes into account the EU Water Framework Directive and experience.	2014–2015 300.0	National budget; international projects
Assessment of the status of groundwaters and their vulnerability to climate change, taking into account the typology of underground water bodies and their assessment, with consideration for the EU Water Framework Directive and experience.	2014–2016 400.0	International projects
Implementation of pilot climate change adaptation projects.	2014–2020 800.0	International projects
Housing and Public Utilities Improvement of tariff policy. Development of strategies to finance investment in the industry. Improvement of the system for managing housing and public utilities enterprises. Improvement of the framework of regulatory and legal acts in the sphere of water supply, sanitation and waste management.	2014–2020 600.0	Innovation Fund of the Ministry of Housing and Public Utilities; credit resources of the International Bank for Reconstruction and Development; Innovation Fund of the Ministry of Construction and Architecture

Agriculture Elaboration of strategies and plans of actions to mitigate damage from climate change and increase resistance in the sphere of plant and livestock breeding. Updating of the regulatory framework concerning livestock and poultry enterprises and waste management systems, including introduction of the best agricultural practices to mitigate the anthropogenic impact on water resources. Improvement of the framework of regulatory and legal acts in the reclamation sphere.	2014–2020 500.0	Scientific/Scientific and Technical Programs; International projects
Fish industry Assessment of the impact of climate change on the industry in terms of specific fishery water bodies in the region. Elaboration of strategies and guidelines on adapting actions and practices to mitigate the adverse effects of climate change.	2014–2020 500.0	State Scientific/Scientific and Technical Programs
Energy Assessment of the impact of climate change on the industry in the region. Elaboration of strategies and guidelines on adapting actions and practices to mitigate adverse effects in the region. Improvement of the framework of regulatory and legal acts concerning the utilization of renewable energy sources and the conservation of water resources in the context of water use for energy needs.	2014–2020 500.0	State Scientific/Scientific and Technical Programs; International projects; Innovation Fund of the Ministry of Energy
Industry Assessment of the impact of climate change on the industry in the region. Elaboration of strategies and guidelines on adapting actions and practices to mitigate adverse effects in the region.	2014–2020 500.0	State Scientific/Scientific and Technical Programs; International projects
Development of water-saving and clean technologies. Reduction of discharge of effluents and the content of pollutants therein. Improvement of the economic mechanism for controlling water use.	2014–2020 1,000,000.0	Resources of enterprises and investors; State Programs; credit resources of the International Bank for Reconstruction and Development and other banks
Transport infrastructure, including waterway transport Assessment of the impact of climate change on the industry in the region. Elaboration of strategies and guidelines on adapting actions and practices to mitigate adverse effects in the region. Improvement of the framework of regulatory and legal acts concerning the development of transport infrastructure and transport operations.	2014–2020 500.0	State Scientific/Scientific and Technical Programs; International projects; Innovation Fund of the Ministry of Transport and Communications

Recreational and health improvement activity Assessment of the climate change impact on the industry in the region. Elaboration of strategies and guidelines on adapting actions and practices to mitigate adverse effects in the region.	2014–2020 200.0	International projects; local budgets; investor funds
Lithuania		
Improvement of the meteorological and hydrological monitoring network: establishing new automatic stations (2 hydrological and 4 meteorological)	2014–2020 134.0	EU funds
Improvement of the Neman River Basin Water Resources Management Plan and Program of Measures, based on assessments and forecasts of the changes in climate and runoff, as well as data on the Belarusian part of the NRB. Assessment of the ecological status of water bodies, including the causes, sources and characteristics of pollution.	2015 300.0	EU funds
Development of flood risk maps and flood risk management plans.	2014–2015 600.0	EU funds
Kaliningrad Oblast of the Russian Federation		
Improvement of the meteorological and hydrological monitoring network: establishing new automatic stations (2 hydrological and 2 meteorological).	2014–2020 94.0	International projects
Studies of the problems concerning formation and assessment of water resources. Studies of the hydrological and hydrochemical regime of the land surface waters in the context of climate change in the Russian Federation.	2012–2020 8,850.0	Federal Target Program "Development of the Water Resources Utilization System of the Russian Federation in 2012–2020"
Rehabilitation of hydraulic engineering structures and water bodies in Kaliningrad Oblast.	2012–2020 2,020.0	
Development of flood risk maps and a flood risk management plan.	2014–2015 150.0	International projects
Implementation of the program of activities of the Complex Schemes for the Use and Protection Water Bodies in the Neman River Basin and rivers of the Baltic Sea Basin – Kaliningrad Oblast.	2011–2030 2,800,000.0	Federal and Regional Programs; International projects
Regional assessment of the vulnerability of the regions' economy and population to climate change	2011–2020	Regional Programs; International projects
Evaluation of the potential for cost-effective utilization of renewable energy sources and measures stimulating their further propagation.	2011–2020	Regional Programs; International projects

Stability improvement measures and countermeasures (medium-term measures)		
Proposed measures (activities)	Completion date, estimated cost, (thousands of Euro)	Remarks (possible funding sources)
International activities		
Preparation and approvals of the Neman River Basin Management Plan in the context of climate change adaptation within the framework of the International Agreement on the Neman River Basin.	2015–2030 800.0	Budgets of countries concerned; International projects
Belarus		
General activities Implementation of activities of the Schemes for the Complex Use of Water Resources (SCUWR) in the Neman River Basin (Water Resources Management Plan) in the context of adaptation to climate change.	2016–2050 2,000.0	National budget, International projects
Implementation of activities of the flood risk management plan.	2016–2050	National budget; local budgets; International projects
Housing and public utilities Introduction of a system of insurance against risks in the sector, including risks associated with climate change. Establishment of regional centers to operate water supply and sanitation systems. Elimination of subsidies and cross financing.	2016–2050 600.0	Local budgets; funds of housing and public utilities enterprises
Development of centralized water supply and sanitation systems in the region, increasing coverage up to 98 % (water supply) and 70 % (sanitation) in urban areas. Reduction of losses and unaccounted consumption of water from the water supply system by 5 %. Reduction of discharge of insufficiently treated effluents into water bodies. Higher coverage by centralized and local household sanitation systems.	2011–2020 16,200.0	State “Clean Water” Program of Water Supply and Sanitation in 2011–2015; credit resources of the International Bank for Reconstruction and Development
Retrofitting large-capacity (over 100,000 PE) municipal treatment facilities in the towns of Grodno, Baranovichy, Lida, and Molodechno by introducing biogenic substances removal systems.	2011–2025 2,121.0	International technical assistance projects; credit resources of banks, including international banks; local budgets; State “Clean Water” Program of Water Supply and Sanitation; Funds of housing and public utilities enterprises

Retrofitting medium-capacity (10–100 ths PE) municipal treatment facilities in the towns of Smorgon, Ivatsevichy, Novogrudok, Vileika, Dzerzhinsk, Shchuchin, Oshmyany, Myadel and others by introducing biogenic substances removal systems.	2011–2025 10,000.0	International technical assistance projects; State “Clean Water” Program of Water Supply and Sanitation; funds of housing and public utilities enterprises
Higher coverage by centralized and local household sanitation systems in small settlements and in rural areas. Upgrading of low-capacity treatment facilities and rehabilitation of absorption fields by implementing projects for improved treatment facilities.	2011–2035 20,000.0	State “Clean Water” Program of Water Supply and Sanitation; local budgets; funds of developers
Improvement of practice for designing rain sewerage systems in the context of climate change. Implementation of activities to minimize surface effluents in built-up areas.	2011–2025 5,000.0	Local budgets; funds of developers
<u>Agriculture</u> Introduction of a system of insurance against risks in the sector, including risks associated with = climate change.	2011–2015 200.0	Funds of farms and insurance companies; local budgets
Construction of dung yards, farm animal waste processing/treatment facilities and engineering systems for the protection of water resources from pollution.	2011–2035 15,000.0	International projects; Program of Reconstruction, Technical Re-Equipment and Construction of Pig-Growing Complexes in 2011–2015; National Program for the Development of the Dairy Industry in 2010–2015; banks’ credit resources;
Soil erosion control. Selection and zonation of thermophilic varieties and hybrids. Improvement of agrotechnology, development of biotechnologies and implementation of soil-protective and moisture-saving technologies. Development of amelioration and silvicultural reclamation.	2011–2045 45,000.0	Funds of farms; regional programs of development; local budgets; banks’ credit resources
<u>Fish industry</u> Improvement of water utilization. Rehabilitation of production capacities through the mechanization and automation of main processes and a reduction of manual labor.	2011–2025 20,000.0	State Program for Fish Industry Development in 2011–2015; Banks’ credit resources
<u>Energy</u> Improvement of project engineering and construction technology at hydropower facilities. Updating of the rules of operation at hydropower plants, taking into consideration projected changes in the hydrological regime at the basin level.	2011–2025 10,000.0	Scientific and Technical Program of Rate Setting and Standardization. National Energy Saving Program in 2011–2015

Wider use of renewable energy sources. Development of generating capacities in the region using renewable energy sources.	2011–2035 8,000,000.0	State Program for the Construction of Hydropower Plants in the Republic of Belarus in 2011–2015. State Program for the Development off the Belarusian Energy System for the Period until 2016; International credits
Transport infrastructure and transport Improvement of project engineering and construction technology for roads and transport infrastructure. Improvement of the existing communication network.	2011–2025 50,000,000.0	State Program of Road Transport Development in the Republic of Belarus in 2011–2015; State Program of Transport Development in the Republic of Belarus in 2011–2015; programs of Inland Waterway and Maritime Transport Development of the Republic of Belarus in 2011–2015
Recreational and health improvement activity Improvement, establishment and maintenance of recreational infrastructure. Implementation of programs for the restoration of water bodies for their recreational use.	2011–2025 1,000,000.0	Local budgets; investor funds; bank credits
Lithuania		
Implementation of activities for achieving the goals and objectives of the National Strategy for Climate Change Management Policy of the Republic of Lithuania.	2013–2020	Action Plan for the Implementation of the National Strategy for Climate Change Management Policy of the Republic of Lithuania for the Period 2013–2020
Implementation of activities of the Neman River Basin Water Resources Management Plan.	2016–2050	EU funds
Implementation of activities of the flood risk management plan.	2015–2030	EU funds
Kaliningrad Oblast of the Russian Federation		
Implementation of the Climate Doctrine of the Russian Federation until 2020.	2012–2020	Comprehensive Plan of Implementing the Russian Federation's Climate Doctrine for the Period until 2020
Rehabilitation of hydraulic engineering structures and restoration of water bodies in Kaliningrad Oblast.	2012–2020	Federal Target Program “Development of the Water Resources Utilization System of the Russian Federation in 2012–2020”

Implementation of the program of activities of the Complex Schemes for the Use and Protection Water Bodies in the Neman River Basin and rivers of the Baltic Sea Basin – Kaliningrad Oblast	2012–2020 17,140.0	Regional programs; International projects
Implementation of activities of the flood risk management plan.	2011–2030 2,800,000.0	Regional programs; International projects

Recovery measures (long-term measures)		
Recovery measures (long-term measures)	Completion date, estimated cost, (thousands of Euro)	Remarks (possible funding sources)
International activities		
Implementation of plans for the management of the NRB, taking climate change adaptation into account and making regularly amendments within the framework of the International Agreement on the Neman River Basin.	2016–2050 1,000.0	Budgets of countries concerned; International projects
Belarus		
Implementation of activities of the Schemes for the Complex Use of Water Resources (SCUWR) in the Neman River Basin (Water Resources Management Plan) in the context of adaptation to climate change.	2016–2050	Nationalbudget; International projects
Implementation of activities of the flood risk management plan.	2016–2050	National budget; local budgets; International projects
Implementation of activities of the State Climate Change Impact Mitigation Program in 2013–2020.	2013–2020 8,620.0	National budget
Implementation of remedial activities to achieve high quality indicators of water bodies, taking climate change adaptation into account.	2020–2050 Over 10,000.0	National budget; local budgets; International projects; funds of enterprises.
Lithuania		
Implementation of activities for achieving the goals and objectives of the National Strategy for Climate Change Management Policy of the Republic of Lithuania	2013–2020	Action Plan for the Implementation of the National Strategy for Climate Change Management Policy of the Republic of Lithuania for the period 2013–2020
Implementation of activities of the Neman River Basin Water Resources Management Plan.	2015–2030	EU funds, national budget
Implementation of activities of the flood risk management plan.	2015–2030	EU funds, national budget

Kaliningrad Oblast of the Russian Federation		
Implementation of Climate Doctrine of the Russian Federation until 2020.	2012–2020	Comprehensive Plan of Implementing the Russian Federation's Climate Doctrine for the Period until 2020
Rehabilitation of hydraulic engineering structures and restoration of water bodies in Kaliningrad Oblast.	2012–2020 17,140.0	Federal Target Program "Development of the Water Resources Utilization System of the Russian Federation in 2012–2020"
Implementation of the program of activities of the Complex Schemes for the Use and Protection Water Bodies in the Neman River Basin and rivers of the Baltic Sea Basin – Kaliningrad Oblast	2011–2030	Federal and regional programs; International projects
Implementation of activities of the flood risk management plan.	2011–2030	International projects; Federal and regional programs