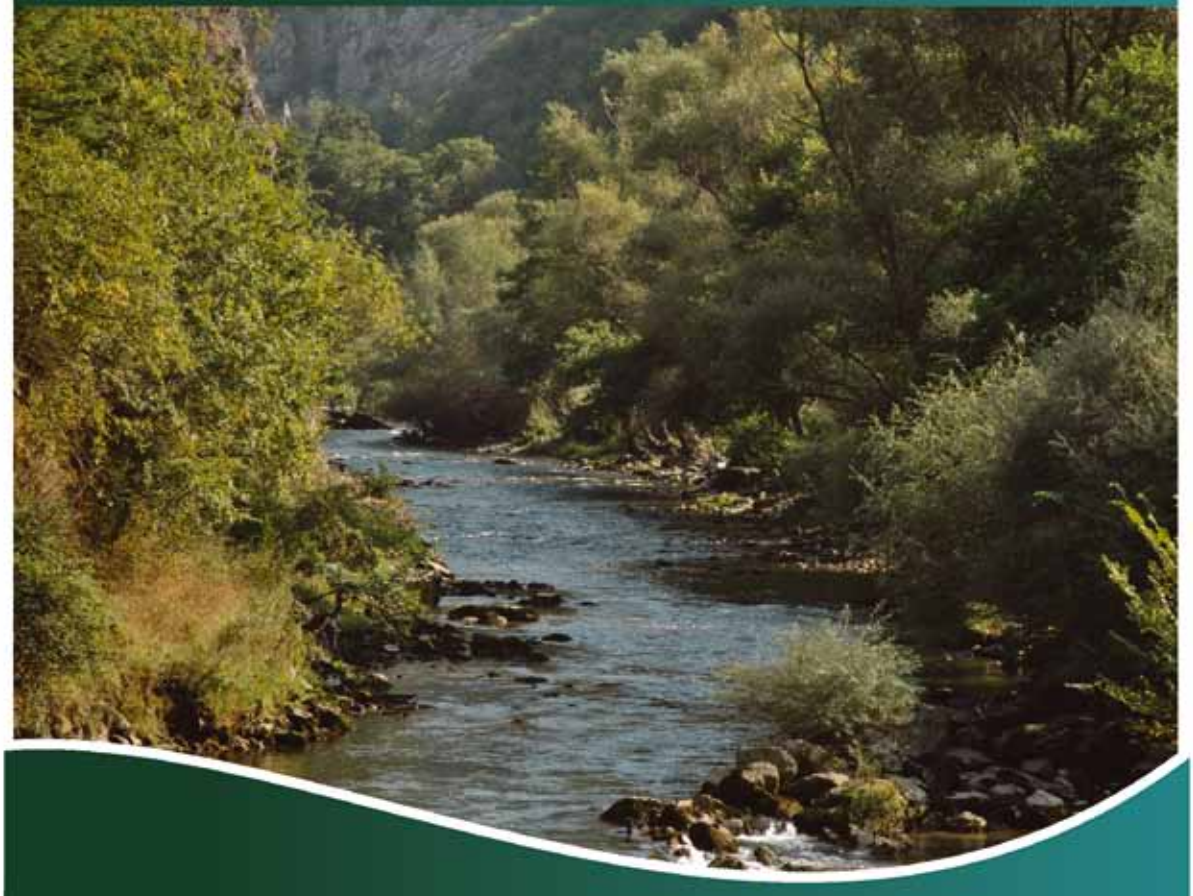
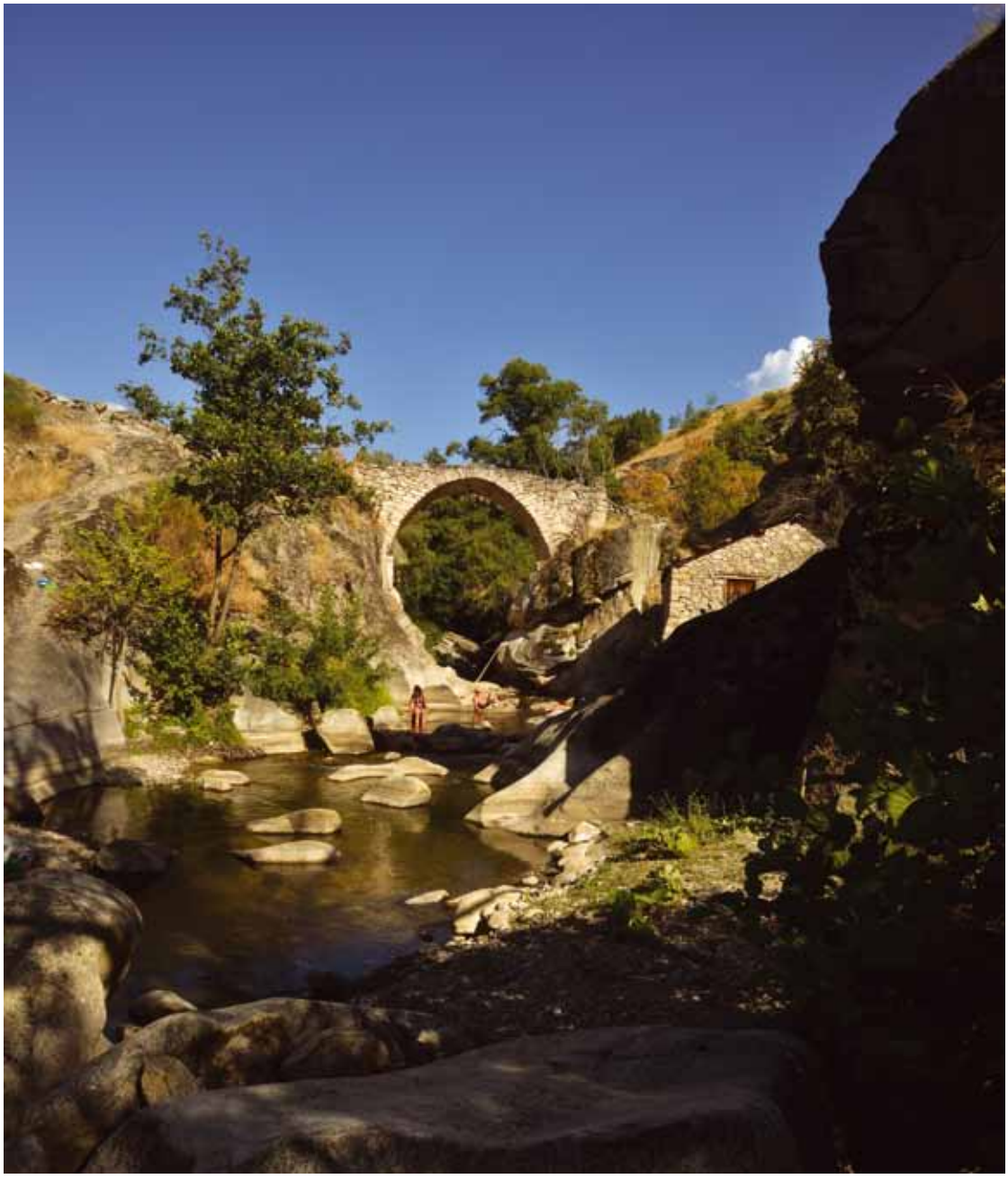
GOVERNMENT OF THE
REPUBLIC OF MACEDONIA
MINISTRY OF ENVIRONMENT
AND PHYSICAL PLANNING

THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE



WATER RESOURCES AND CLIMATE CHANGE

VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES



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WATER RESOURCES AND THE CHALLENGE OF CLIMATE CHANGE

This publication summarizes the key findings of an assessment of the vulnerability of the Republic of Macedonia's water resources to climate change and possible adaptation strategies and measures.

The assessment was conducted as part of the country's Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change by the Ministry of Environment and Physical Planning with support from the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF).

The full report is available at:
www.klimatskipromeni.mk

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"Water is not a commercial product like any other but a heritage which must be protected ..."

(EU Water Framework Directive)

As a vital element in all ecosystems and a crucial part of agricultural production and industrial processes, the availability of water resources is essential for human survival and development.

Water scarcity is already a major problem for many populations - a problem brought about both by a complex combination of natural and anthropogenic (human) causes. And with the onset of climate change, ensuring the future availability of water resources is now a challenge that must be tackled urgently by every state.

Climate change will have a potentially devastating impact on water resources throughout the world. Increasing atmospheric temperatures will intensify evaporation. Major disruptions are set to occur in the hydrological cycle, including changes in the timing and intensity of rainfalls and the flow of water in watersheds. Snowmelt and mountain runoff - a major source of water - will be drastically reduced, leading to serious shortages. The quality of aquatic and marine environments will deteriorate.

The consequences of climate change on water resources, while differing greatly in their impact in different environmental, socio-economic and political contexts, will be both physical and economic. Reduced water supplies, for example - due to reduced snowmelt, increased rates of evaporation and other changes in climate - will bring about an increase in the price of water and will have an especially severe effect on the agricultural sector and food security. Changes in snow pack and runoff will affect hydropower, irrigation, urban water supply, flood protection and commercial and recreational fishing. The political consequences of water scarcity will include increasing competition for water resources, with the allocation of these resources becoming increasingly sensitive.

The Republic of Macedonia's water resources are highly vulnerable to the impacts of climate change. Without adequate preparation, including intersectoral cooperation on an integrated approach to securing water resources, the consequences of water scarcity for human health and safety will be severe.

Previous efforts to address the impact of climate change on the country's water resources

The Republic of Macedonia has developed numerous policies, measures and strategic documents to help overcome the challenges of water scarcity. In 1997, the country ratified the United Nations Framework Convention on Climate Change, submitting its First National Communication in 2003 and its Second National Communication in 2008. The preparation of these documents contributed to developing the country's capacities for assessing its water resources and raising awareness of the impacts of climate change on water security and the need for adaptation. The State Statistical Office set out the country's strategy in a publication of 2010 called *Sustainable Development*, including:

- conserving and managing natural resources
- promoting sustainable consumption and preventing the environmentally harmful effects of economic growth
- using cleaner energy to mitigate climate change

In 2005, the country became a party to the Kyoto Protocol. Since then, the country has also been implementing a National Programme for the adoption of the EU acquis, involving several measures to ensure more efficient and sustainable use of natural resources.

As a candidate and associate member of the EU, the Republic of Macedonia is pledged to implementing key measures of the EU Water Framework Directive. This Directive is intended to protect all surface and ground waters throughout Europe, obliging all signatories to establish a common framework for monitoring water bodies and to apply measures for protecting their ecological integrity. The overarching objective of the Water Framework Directive is to restore all water bodies to ecological health by 2015. The Directive outlines the steps countries need to take to achieve this objective, including a survey and analysis of their main river basins and the impact of human activities on their water resources.

Amongst other relevant EU directives related to water resources, the Directive on Floods of 2007 is of especial importance, aiming to assess, manage and reduce the risk of floods and the impacts of flooding on human health and the environment, cultural heritage and economic activity. The 2007 Directive requires all signatories to develop and implement a comprehensive management plan for each river basin to reduce the risk of floods and their impacts. These plans must include measures to improve the management of water, soil and spatial planning.

The Ministry of Environment and Physical Planning produced its National Communications to the UN Framework Convention on Climate Change (UNFCCC), with UNDP's support, including assessments of the vulnerability of the country's water resources to the impact of climate change.

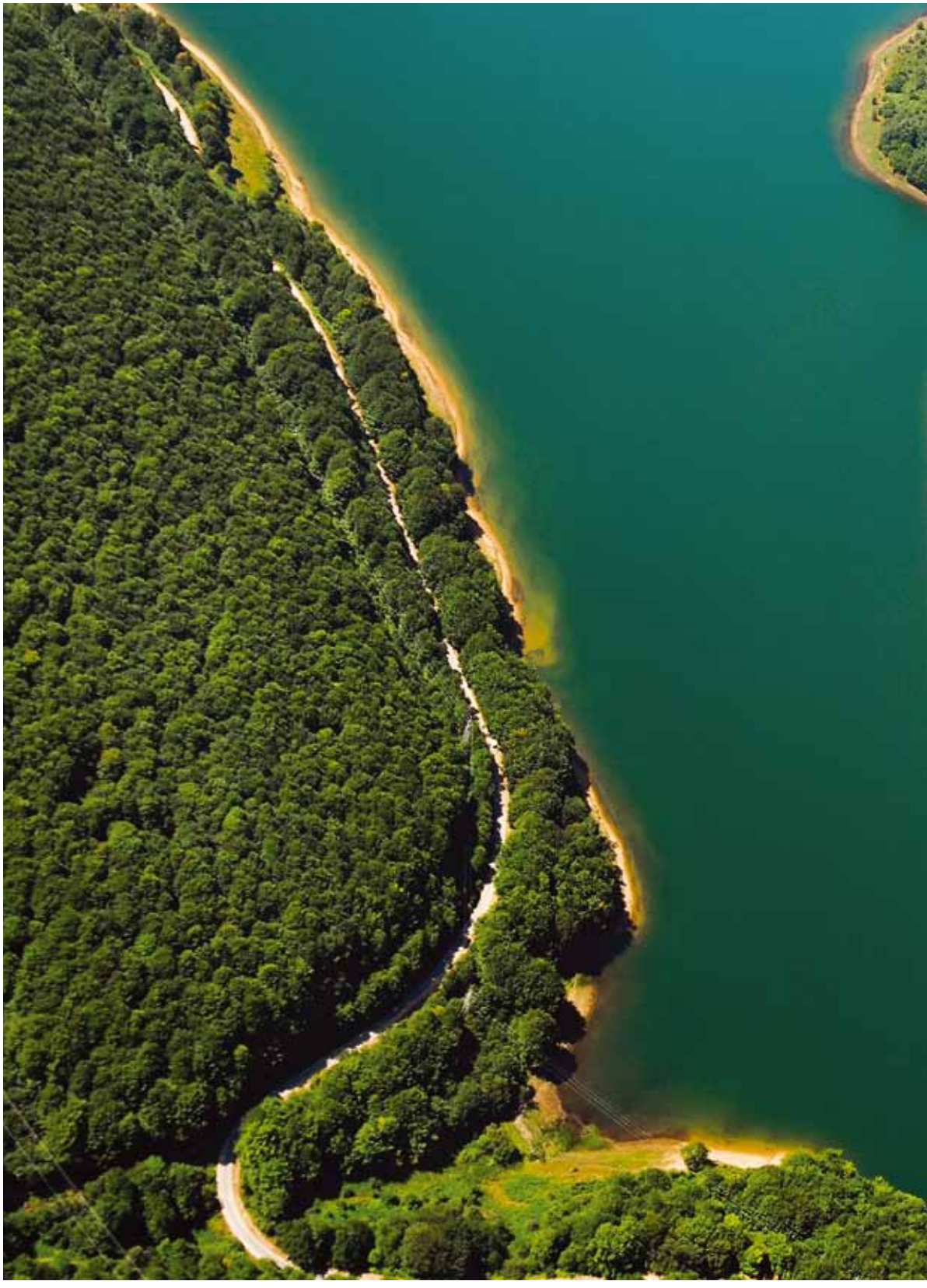
The First and Second National Communications on Climate Change tested a number of scenarios related to water resources. The findings included a projection of a 15% reduction in rainfall by 2050, with a drastic decrease in runoff in all river basins, especially those of the Bregalnica and Strumica rivers in the South-East Planning Region. Other key findings from these vulnerability assessments of water resources include the following projections:

- Overall water availability in the country is expected to decrease by as much as 18% by 2100.
- Dry spells and flash floods will be more frequent and severe.
- The eastern regions of the country will experience the most severe water scarcity.
- By the end of the century, average annual runoffs from the Vardar River will be some 20 % lower than in 2000.
- There will be a continuous decrease of the groundwater recharge for the watershed of the River Vardar.
- The watershed of the River Bregalnica will suffer the greatest impact, with a projected loss of 24% by 2100.

The two previous National Communications also proposed the following priority measures for adaptation to climate change in the water resources sector:

- Modernization of the hydro-meteorological network
- Improvement of data availability and the establishment of data monitoring and processing
- Rehabilitation and reconstruction of existing hydropower and water economy structures and systems
- Development and implementation of effective water management plans

The proposed adaptations comprised intersectoral measures relating both to the supply and demand for water. The Action Plans developed for the first two National Communications included priority measures related to water supply and irrigation systems, flood and drought control, as well as protection strategies for controlling erosion and sedimentation, and measures to ensure water quality through the construction of waste water treatment plants and waste management implementation.



Water Resources in the Third National Communication on Climate Change

As part of its assistance to the Third National Communication, UNDP supported the Ministry of Environment and Physical Planning in development of a further study into water resources and the challenge of climate change, refining an Action Plan with a comprehensive set of measures for adaptation.

The study commenced with a hydrographic survey and a review of all relevant and available data about the country's water resources. This review identified major limitations in the availability of data on key parameters such as air temperature trends in mountainous regions, trends in snow cover and snowmelt, alterations in the volumes of glacial lakes and changes in biodiversity. The study further noted serious deficiencies in the monitoring network of the National Hydrometeorological Service, mostly due to financial incapacity. The Third National Communication thus strongly emphasizes the need to upgrade the monitoring network, to modernize equipment, to improve the processing of data and the implementation of predictive models and to train up experts in modern monitoring and data-processing technology.

Hydrographic survey

The country's terrain ranges from an elevation of 50 m above sea level in the alluvial lowland of the River Vardar in the south, to some 2,700 m in the mountainous north-west. Over eighty per cent of the country is hilly, intersected with valleys and plains, which account for some 19% of the territory. The largest plain is the Pelagonija Plain in the south-west, covering an area of 4,000 km^2 at an average altitude of 600 m. The main valleys are those that extend along the River Vardar, including the Skopje Valley, covering 1,840 km^2.

Of the country's four river basins - the Vardar, Strumica, Crn Drim and Juzna Morava basins - the River Vardar basin is the largest, at 20,546 km^2, gravitating towards the Aegean Sea. The basin of the River Strumica, a tributary of the River Struma in neighbouring Bulgaria, extends 1,520 km^2 in the south-east and also gravitates towards the Aegean Sea. The Crn Drim flows out of Lake Ohrid in the west and extends 3.355 km^2, gravitating towards the Adriatic Sea. The smallest river basin, the Juzna Morava in the north, extends 44 km^2 and gravitates towards the Black Sea.

The water potential of these river basins depends on precipitation. The average sum of annual precipitation in the River Vardar basin is 700 mm, while the average for the River Strumica basin is 790 mm and the sum for the Crn Drim basin is 980 mm. The maximum sum of precipitation - 1,400 mm - has been recorded in the west, while the minimum sum - 380 mm - has been registered in the east.

The country has constructed 21 large dams and 120 small dams and reservoirs to harness the potential of these rivers.

There are 4,414 springs in the country, yielding a total of 991,9 million cubic metres per year, of which 58 springs have a capacity of over 100 litres per second. Over 1,600 of these springs are tapped and used for micro-scale water supply, while over 280 are 'captured' for large-scale water supply to villages and towns. Their total yield is over 195 million cubic metres per year.

The country's surface waters - its lakes, rivers, streams and wetlands - constitute highly important ecosystems. The quantity of these surface waters mainly depends on precipitation and snowmelt, with most surface runoff flowing into the surface waters except in areas of karst (limestone) where the water remains in the ground for longer.

Of the country's three largest natural lakes - Ohrid, Prespa and Dojran - the largest is Lake Ohrid, situated at 695m above sea level and with a total surface area of 358 km^2 and a maximum depth of 285 m. Lake Prespa, situated at 853m above sea level, is the second largest with a total surface area of 43km^2 and a maximum depth of 54 m. The lakes of Ohrid and Prespa are located in the south-west and are connected by underground channels of karst and their waters flow through the basin of the Crn Drim River. The smallest lake - Lake Dojran - is situated in the south-east at an elevation of 148 m and has a total surface area of 43 km^2. All three lakes are transboundary, with some 15 km^2 of Lake Dojran's surface area lying over the border with Greece, while some 130 km^2 of Lake Ohrid lies within Albania's borders. Lake Prespa spreads across the borders of both Albania and Greece.

An important role in the protection of these lakes is played by the country's three national parks: Mavrovo, Galicica and Pelister.

Mavrovo National Park was established as a National Protected Area in 1948 and covers an area of 731km^2 in the north-west of the country. The park encompasses numerous rivers, including the River Radika, and the artificial Lake Mavrovo.

Pelister National Park was also established in 1948 and includes two glacial lakes, known locally as the mountain's 'eyes'. The 'Big Lake' is situated at an altitude of 2,218 and 2,180 m above sea level and has a total surface area of 4.2 ha and a maximum depth of 14.5 m. The Small Lake is situated at an altitude of 2,180 m above sea level and, although it has a similar water surface to the Big Lake, its maximum depth is only 2.6 m.

Galicica National Park was established in 1958 and is shared with Albania. Lake Ohrid and Lake Prespa are included within this protected area.

Assessment of the impact of climate change on water resources

Water resources in many regions and countries are vulnerable due to increasing demand for water, the prevalence and sensitivity of many simple water management systems to fluctuations in precipitation and runoff, and the considerable time and expenses required to implement many adaptation measures.

Water resources in this country are vulnerable to the impacts of climate change in terms of both water quantity and water quality.

In any country or locality, the impacts of climate change on water resources will greatly depend on the baseline condition of the water supply system and the ability of managers of water resources to respond not only to climate change but also to population growth and changes in demands, technology, and economic, social and legislative conditions. For this reason, the Third National Communication project included an in-depth assessment of the Strumica River basin in the South-East Planning Region.

Methodology

Limitations: The assessment of regional vulnerability is necessarily qualitative due to uncertainties regarding the sensitivities and adaptability of natural and social systems.

A Water Balance Model was developed for the basin of the River Strumica in two basic scenarios: (i) current/reference condition, and (ii) projected condition up to 2025.

Findings

Statistical trends in the country's water resources

The analysis of statistical trends in data related to water quantity and quality is a critical aspect of water management. The analysis conducted within the Third National Communication project identified trends in time-series data such as rainfall, temperature, streamflow, stream water level, spring discharge and, groundwater level.

The input and analysis of this new data identified the following trends:

- On the basis of this combined data, the study revised its projection of temperatures for 2050 in this region upwards to 15.74 °C. The data obtained from the Nov Dojran and Strumica meteorological stations both showed a trend of significant temperature increase.
- The combined data showed the long-term average sum of annual precipitation in the Strumica region to be 583.1 mm. Based on this data, the study projects that by 2050 the sum of annual precipitation will have decreased by approximately 7% of the revised long-term average.

Key Findings

Analysis of these trends show the Strumica region is vulnerable to the impact of climate change on water resources in numerous respects, especially the agriculture sector, which is expected to suffer from severe water shortages during summer. The assessment identified the following key problems:

1. Inefficient irrigation systems in poor condition that lose water and have little capacity for adaptation to new crop pattern. The causes behind this inefficiency include lack of maintenance and the limited resources of smallholders to upgrade their irrigation equipment, but also ineffective implementation of legislation related to the protection of water resources and the difficult financial situation of the region's water management organizations.
2. Unregulated use of surface and ground waters. This problem applies both in the Strumica region and at national level and is due to farmers using groundwaters for irrigation. (This in turn is due to the unsuitability of most of the country's irrigation systems for micro-level irrigation.) There is an urgent need to map and inventories all existing irrigation wells in the Strumica watershed.
3. There is no reliable data on consumed water for irrigation. Most of the irrigation schemes do not have measuring devices on irrigation intakes, river diversions or canal outlets. The price for irrigation water is defined per 1 ha of irrigated area, not in cubic metres of consumed water. The amount of cost revenue collected varies from 30–85%. This shortcoming in revenue collection is a key cause of the constrained financial capacity of the World Meteorological Association. The price of water per crop varies in different irrigation schemes and depends on the type of system (gravity or pumping), climate and soil conditions.
4. Since 2002 storms and flash floods have become more frequent in the region and are causing significant damage. Although the long-term projection is for increased temperatures and a decrease in sums of precipitation, the past period studied shows significant climate variability, with increased precipitation.
5. The proportion of winter precipitation received as rain instead of snow is increasing. Such shifts in the form and timing of precipitation and runoff are of concern to water managers in relation to irrigated agriculture, urban water supply, and flood protection. Cropping practices will need to shift towards reduced or no tilling technologies, which enhance water infiltration and conserve soil moisture, and towards more efficient irrigation technologies.

ADAPTATION STRATEGIES AND MEASURES

The analyses conducted within the Third National Communication project identified various strategies and adaptation measures to reduce the vulnerability of water systems to climate change. These options include pricing systems, water efficiency initiatives, engineering and structural improvements to water supply and irrigation infrastructure, agricultural policies, and urban planning/management.

At national and regional level, priorities for reducing vulnerability include placing greater emphasis on integrated, intersectoral management of water resources, using river basins as management units.

To increase the resilience of the River Strumica basin, adaptation must include both technical and management measures and practices. Technical measures include the rehabilitation of existing water supply systems as well as the construction of reservoirs for runoff regulation. Better water management requires policy shifts and significant investments guided by the following principles:

1. Adaptation measures should be mainstreamed within the broader development context.
2. The governance and management of water resources should be improved and land and water management should be integrated.
3. Knowledge and information on climate, water and adaptation measures should be shared more widely and improved. Investments are needed in the development of comprehensive and sustainable data-collection and monitoring systems.
4. Stronger institutions and water infrastructure are needed to build long-term resilience and to achieve healthy ecosystems;
5. Investments are needed in cost-effective adaptive water management and technology transfer.
6. National budgetary allocations for water need to be increased and innovative funding mechanisms are needed for adaptation through improved water management.

Sector-specific measures to mitigate the impact of climate change on water should also be adopted. Water management polices and measures can reduce the greenhouse gas emissions associated with different sectors. The 2008 Report of the International Panel on Climate Change, 'Climate Change and Water' outline a number of sector-specific measure for mitigation. In its Fifth Assessment report, the IPCC states that 'adaptive water management techniques, including scenario planning, learning-based approaches, and flexible and low-regret solutions, can help create resilience to uncertain hydrological changes and impacts due to climate change.

Given the uncertainty associated with climate change, win-win, no regret and low regret measures should be chosen as a priority. Based on the results of the water balance modelling and the vulnerability assessment of the Strumica River performed as part of the Third National Communication, the following adaptation measures are proposed to avoid water shortages projected without adaptation by 2025. These measures are in accordance with the principle of undertaking win-win and no- or low-regret actions that will benefit the water sector even in the most moderate projections of climate change.

Construction/modification of physical infrastructure

- Installation of canal linings to increase the efficiency of irrigation
- Use of closed conduits instead of open channels
- Integration of separate reservoirs into a single system
- Construction/rehabilitation of reservoirs/hydro-plants/delivery systems
- Raise the height of dams
- Removal of sediment from reservoirs for more storage
- Inter-basin transfer of water

Adaptive management of existing water supply systems

- Upgrade operating rules for reservoirs
- Use conjunctive surface/groundwater supply
- Physically integrate the reservoir operation system
- Coordinate supply and demand
- Indigenous/native options

Policy, conservation, efficiency, and technology

Domestic

- Municipal and in-home re-use of water
- Leak repairs
- Rainwater collection for non-potable uses
- Low-flow appliances
- Dual-supply systems (potable and non-potable)

Agriculture

- Irrigation timing and efficiency
- Drainage re-use, use of wastewater effluent
- High value/low water use crops
- Drip, micro-spray, low-energy, precision application irrigation systems

Industry

- Water re-use and recycling
- Closed cycle and/or air cooling
- More efficient hydropower turbines
- Cooling ponds, wet towers and dry towers

Hydropower

- Reservoir re-operation
- Additional reservoirs and hydropower stations
- Low head run of the river hydropower
- Market/price-driven transfers to other activities
- Using water price to shift water use between sectors

The Third National Communication also proposes the following measures for the prevention of flooding, which is becoming ever more frequent in many areas, including in this country:

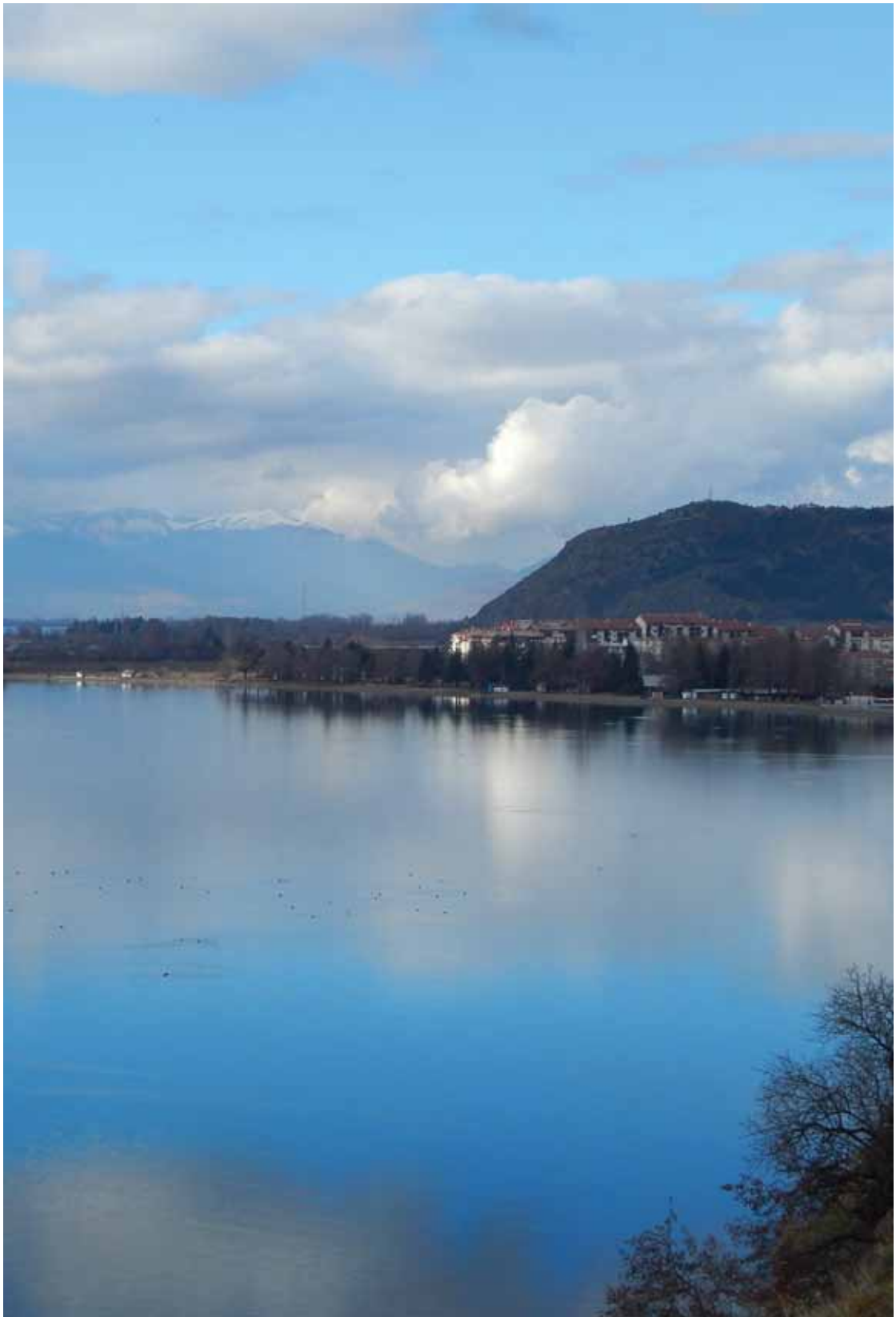
- Restriction of urban development in flood-risk zones
- Measures aimed at maintaining dam safety
- Afforestation and other structural measures to avoid mudflows
- Construction of dikes
- Changing in operation of reservoirs and lakes
- Land use management
- Implementation of retention areas
- Improved drainage possibilities
- Structural measures such as temporary dams, building resilient housing and modifying transport infrastructure
- Migration of people away from high-risk areas

These adaptation measures need to be implemented on different time scales: long-term, medium-term and short-term. In order for these measures to be effective, it is imperative that strategies do not focus solely on short-term and mid-term projections and measures.

Long-term adaptation measures include institutional and legal changes for better management and coordination of water resources, including changes in laws on land use.

Medium-term measures include the introduction of hydrological planning measures such as risk management in drought and flood management plans.

Short-term measures are related to decisions that can be adopted in the current institutional, legal and infrastructural framework, and usually refer to risk assessment, preparedness and vulnerability reduction, including, for example, revised water allocations during periods of drought.



ACTION PLAN

Within the Third National Communication the adaptation measures proposed in the First and Second National Communications were reviewed and a number of limitations and gaps in the water sector were identified. In addition to the major problem of insufficient data collection and availability, the highlighted the low level of investment in research, a lack of well-qualified and trained personnel with the capacity to implement the adaptation measures and other systemic and institutional shortcomings.

The study also highlighted opportunities to overcome the limited financial resources available for implementing the proposed adaptation measures, including active use of the EU Framework Research Programmes and the allocation of funds in the relevant institutions. The Third National Communication highlights the need for the country to continue accumulating experience to cope with droughts and floods and make best use of existing technologies in water supply and irrigation used in the country. To coordinate these measures more effectively, the report recommends steps be taken to enhance the role of the National Climate Change Committee.

The following table is part of the Action Plan from the Third National Communication referring to the water resources sector and sets out actions to conserve water by type, defining responsibilities, timeframes, financial means for implementation, and constraints through identified possible barriers and risks. These actions must be taken by all stakeholders including the Government and the public.

For local government and regional organizations, the Plan helps evaluate and identify practices appropriate for water users. For state-wide associations, organizations, and agencies the Plan helps organize water management efforts to achieve shared goals.

It is essential to remember that the impacts of climate change on water resources will have implications for the whole country - including business, communities, individuals and the environment. These wide-ranging consequences call for a multi-sectoral approach and the integration of water sector concerns within all resource planning and management policies and measures.

Transboundary cooperation will also be needed to increase the resilience of water resources shared with other countries. Such cooperation will further create opportunities for sharing knowledge and experience and will allow for the exploration of more cost-effective measures. Legislative, regulatory and economic measures can all benefit from a joint transboundary approach.

Adaptation actions for water conservation and management are presented in the table below:

Action	Type	Stakeholders	Timeframe	Financing	Constraints	Comments
Modification of existing water supply and irrigation systems to decrease water losses (drip, micro-spray, low-energy, measuring devices)	Capacity building Maintenance Planning	MAWFE Public water management enterprises	Long-term	High budget		Link: Agriculture
Implementation technology for re- use of water (municipal, drainage, waste water)	Policy	MAWFE Public water management enterprises	Medium-term	Medium budget	Finances, Technology aspect	Link: Agriculture Health
Inventory and GIS mapping the existing wells for groundwater use	Capacity building Policy	MAWFE Local municipalities Public water management enterprises	Short-term	Low budget	Low public awareness	Link: Agriculture
Construction system for inter-basin water transfer	Policy Planning	MAWFE MEPP Public water management enterprises	Long-term	High budget	Finances, Access to International funding programs	Link: Agriculture
River basin management plan development including conjunctive surface and groundwater supply	Policy Modelling	MAWFE MEPP Local municipality Public water management enterprises	Short-term	Medium budget		Link: Agriculture
GIS hazard events mapping and risk management (drought and flood)	Policy	MAWFE MEPP Public water management enterprises NGOs	Short-term	Medium budget	Lack of data	Link: Agriculture Forestry Biodiversity Health
Monitoring network improvement (surface water, groundwater, water use, water quality)	Capacity building Policy	MAWFE MEPP HMS Public water management enterprises	Short-term	Medium budget	Finances	Link: Agriculture Forestry Biodiversity Health