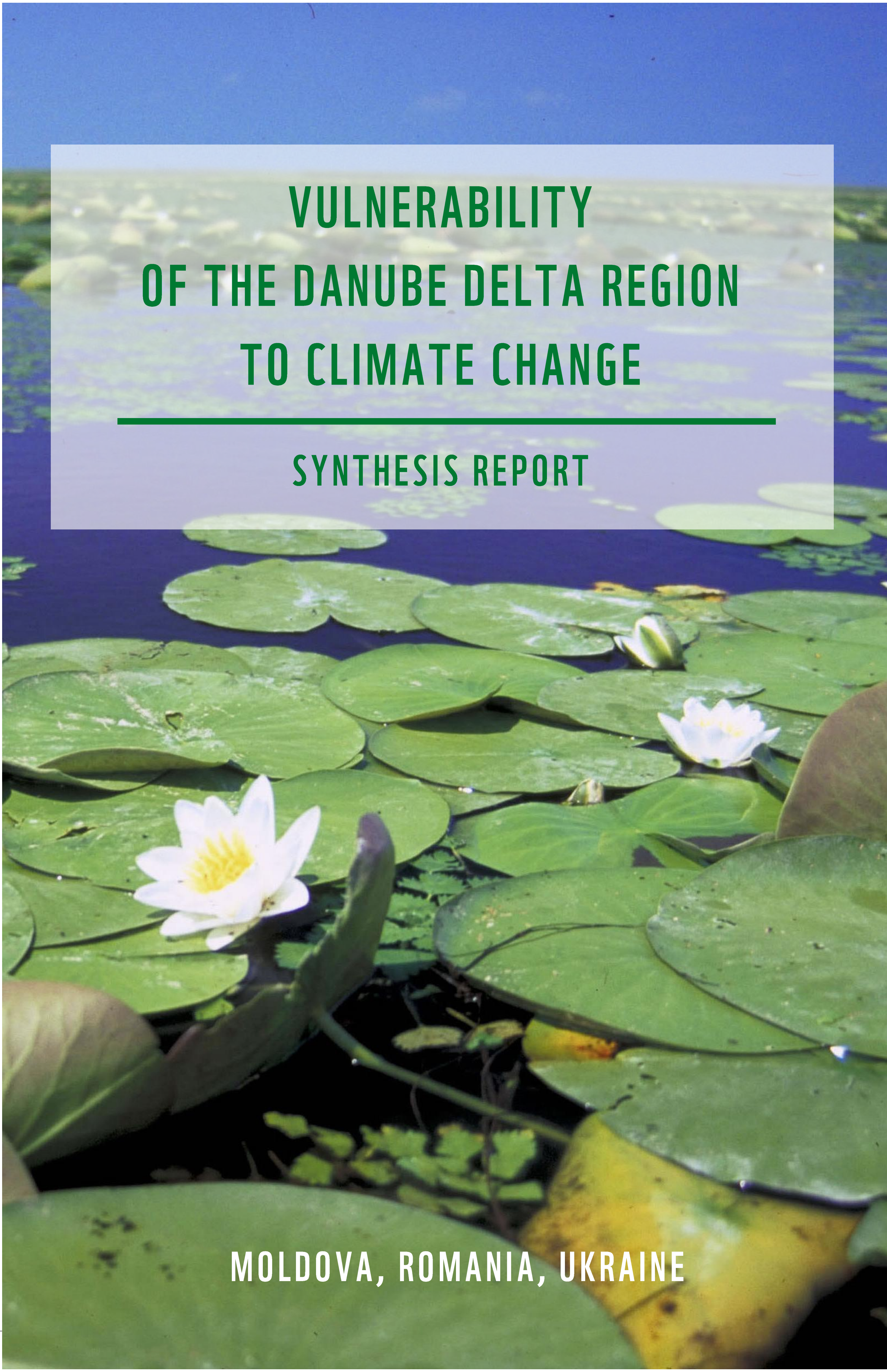

VULNERABILITY OF THE DANUBE DELTA REGION TO CLIMATE CHANGE

SYNTHESIS REPORT

MOLDOVA, ROMANIA, UKRAINE

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List of acronyms used in this document

DDR – Danube Delta Region

DBR – Danube Biosphere Reserve

ICPDR – International Commission for the Protection of the Danube River

TDS – Total Dissolved Solids

WWT – Waste Water Treatment

INTRODUCTION

The United Nations recognise climate change as a major challenge of the XXI century. Some parts of the world will be exposed to more dramatic consequences, some less. Communities in the Danube Delta are already noticing ‘fingerprints’ of climate change – ice events on the rivers are rarer, spawning of the Danube herring occurs earlier as does spring bloom.

This report looks at what has already changed in the region and which impacts of climate change on the ecosystems and communities can be expected in the future. The vulnerability assessment identifies types of ecosystems, economic sectors as well as communities in the Danube Delta that are most exposed to the risks and impacts of climate change.

The findings of this study will be the basis for the development of a transboundary climate change adaptation strategy tailored to the nature and water managers and main economic sectors in the delta. The adaptation strategy will provide recommendations and guidelines to minimise the risks and capitalise on the opportunities presented by climate change, becoming a basis for actions to increase resilience of the Danube Delta ecosystems, contribute to biodiversity conservation and improve local livelihoods of the communities.

This work would not be possible without valuable input and participation of our partner organizations and experts who have long-term history and experience in management of the Danube Delta ecosystems and local economy. Forecasts of future climate parameters and their main consequences for the Danube Delta Region (DDR) are based on the climate change scenario A1B, the regional climate model MPI-M-REMO, the global climate model – ECHAM5-r3, as the most reliable for the period up to 2050. Identification of current trends and tendencies in changes of climatic parameters as well as refining the modelling data were based on the long term observations of the Danube Hydrometeorological Observatory.

This report is produced in the framework of the project «Climate proofing the Danube Delta through integrated land and water management» (Ukraine, Romania and Moldova). The project aims to increase resilience of the Danube Delta ecosystems, contribute to biodiversity conservation and improve local livelihoods for communities by mainstreaming climate change adaptation in local and regional policies and plans.

DEFINITION OF THE DANUBE DELTA REGION AND ITS MAIN CHARACTERISTICS

This study aims to assess the vulnerability of the Danube Delta Region, which includes the Danube Delta sub-basin and the Moldavian Part of the Lower Prut River Basin and occupies 24 686 km^2 with a total population of more than 1,1 million people. The Bilateral Romanian-Ukrainian Danube Delta Biosphere Reserve, the 4 Danube districts of the Odessa region of Ukraine, the Cahul and Yalpug river basins located on the territory of Moldova and the Moldovan part of the Lower Prut river basin (4 rayons and a Territorial Unit – Gagauzia) were looked at more thoroughly.

The Ukrainian town of Vilkovo was chosen as a pilot settlement. It is located directly in the Kilia Branch of the Danube, is the nearest settlement to the sea and therefore, at the greatest extent affected by climate change.

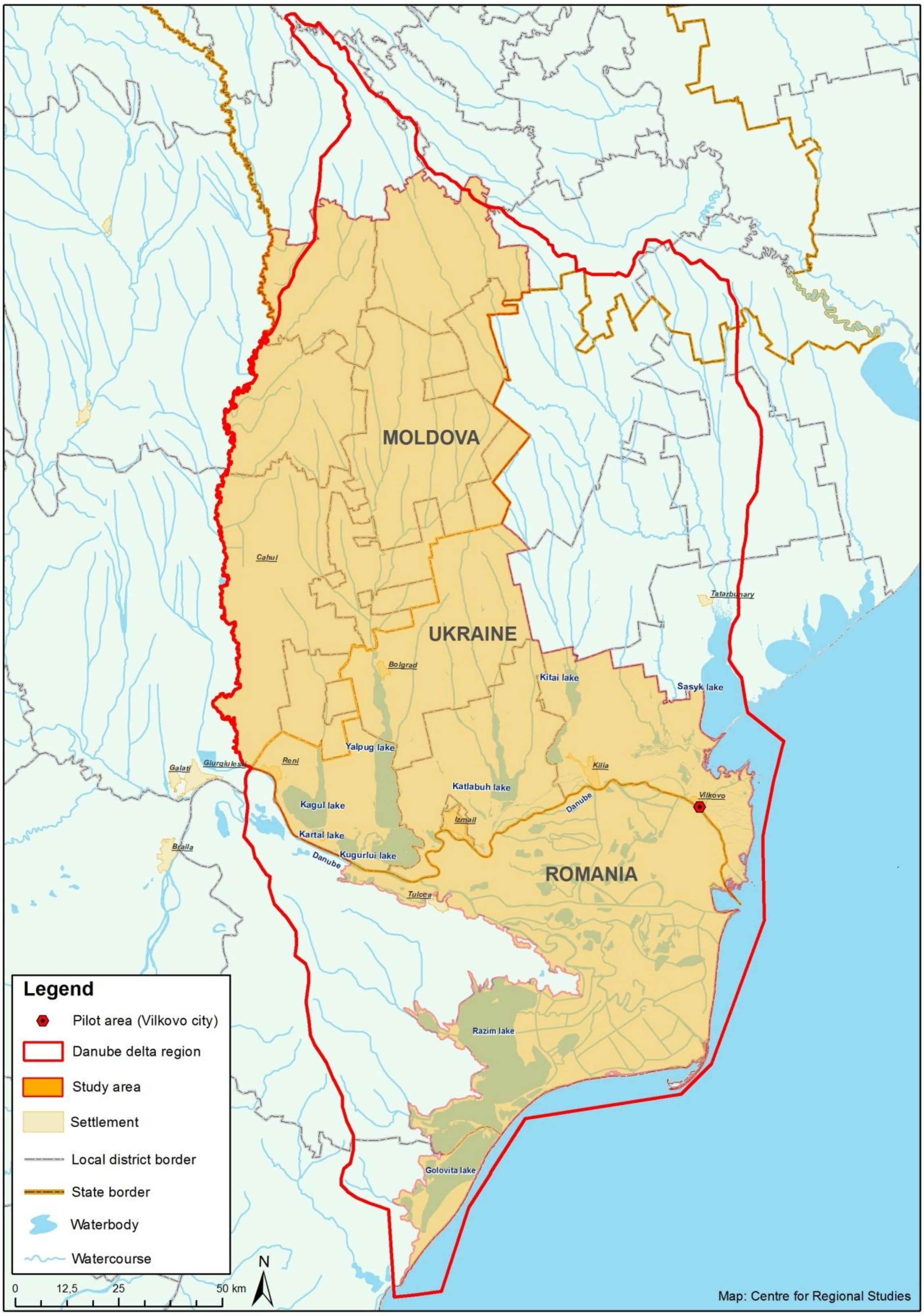
ONE OF THE MAIN COMMON CHARACTERISTICS OF THE DANUBE DELTA REGION IN MOLDOVA, ROMANIA AND UKRAINE IS THE DEPENDENCY OF LOCAL ECONOMY ON LIMITED NATURAL RESOURCES

The region is situated on the periphery of three countries, a fact that determines a number of common issues and specific characteristics. The area is less economically developed than the rest of the countries: there is a number of ports with potentially hazardous objects, poor water supply and waste management and a lack of waste water treatment.

One of the main common characteristics of all three cross-border areas is the dependency of local economy on a limited number of natural resources.

The percentage of land transformed or fragmented is relatively high in the whole study area as a result of agricultural activities and fishery. The highest level of land conversion is in the Moldavian part (up to 80%), and the lowest (up to 42%) – in the Romanian part due to the existence of the vast protected area.

Danube Delta Region and Study Area



General characteristics of the study area

Moldova	Romania	Ukraine

Population and Administrative Structure

Moldova	Romania	Ukraine
The study area spreads over 4500 km^2, and is inhabited by a rural population of 240 000 people and 130 000 people residing in urban settlements. Administrative governance: 4 rayons (Cahul, Leova, Cantemir, Vulcanesti) and a Territorial Unit – Gagauzia.	Structured in 8 administrative areas and local councils (Maliuc, Crișan, Clilia Veche, Sfântu Gheorghe, Ceatalchioi, C.A. Rosetti, Sulina and Pardina) within the Tulcea County, the study area comprises 5800 km^2. It is inhabited by 9700 people living in rural settlements and 4600 in urban ones.	The study area has a size of 4832 km^2 and is inhabited by 123 100 people living in rural areas, and 166 300 people in urban settlements. It is structured in 4 administrative districts (Bolgradskiy, Reniyskiy, Izmailskiy, Kiliyskiy) and the town of Izmail.

Land Use

Moldova	Romania	Ukraine
The land transformation rate is the highest in the region. 75% of the territory (3400 km^2) is used for agricultural activities (70% – perennial crops, 30% – orchards and grapes), 8% for human settlements (around 50000 households) and the rest of the territory for roads, forests, etc. (around 4%).	The current rate of land transformation is 41.8 %. The land is mainly used for fish polders, agricultural polders, forest plantations and pastures. The total area of arable land is 457,7 km^2 and the forest coverage is less that 1% (the total area of natural forest being 52,6 km^2).	The land transformation rate is 72.2% (68.7% – agricultural lands, 3.5% – settlements). Arable lands make up for 54.5% of the total area or 79.3% of agricultural lands. 3,7% is covered by forest.

Protected Areas

Moldova	Romania	Ukraine
Protected area coverage: "Prutul de Jos" – 1671 ha, Cahul district, Lower Prut lake Beleu.	There are 20 strictly protected areas representing 9.36% of the total area of DDBR.	The protected area coverage is 11.2%. Total area – 54.03 km^2, including the Danube Biosphere Reserve (50.25 km^2). The land is mainly used for agriculture.

Pollution

In Cahul, Comrat, Vulcanesti, Leova two-stage waste water treatment is available. Septic tanks are widely used in the rural areas for WW collection as there are no WWT facilities.

Waste is disposed in open landfills (total area app. 300 ha) without selective waste collection and processing. According to estimations, the average solid waste production is 300 kg/person/year.

A potentially dangerous area is the pesticide dump in Vulcanesti village (around 5000 tons).

There are no centralised sewage and waste water treatment systems available in the settlements. Moreover, there is no official waste management.

Some potentially dangerous areas are ports, oil storages, storages of unutilised pesticides and animal husbandry farms.

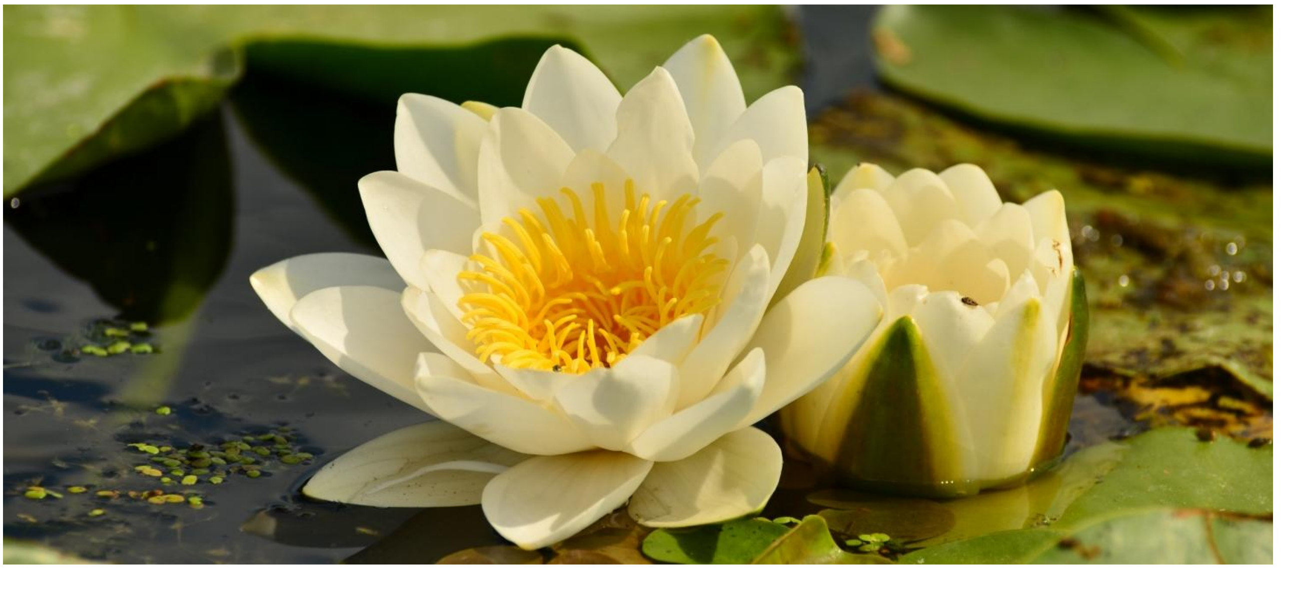
Centralised sewage and waste water treatment is fully functional only in Izmail. There are sewage systems (without treatment) in Reni and Kiliya. In rural settlements waste water is neither collected nor treated. There is also no organised system of solid household waste collection and recycling. Waste (including hazardous kinds) is disposed on landfills or illegal dumping sites. The estimated area of landfills is above 250 ha.

Economic Sectors

The main economic sectors in Moldova are: agriculture and food processing; tourism and fishing from ponds are both poorly developed.

The main economic sectors in the Romanian study area are: agriculture, fishing, wood processing, tourism and navigation.

The main economic sectors are: agriculture (cultivation of crops, vegetables, grapes, sheep, cattle, geese breeding), transport (marine and motor), fishing, fish-farming and tourism.



EXECUTIVE SUMMARY

Based on the analysis of climate change and forecasted impacts on ecosystems and socio-economic development and infrastructure, we divided the region into four sub-regions – Coastal, Delta-Lakes, Budjak Steppe and Dobrogea Upland (outside the study area).

1. **COASTAL SUB-REGION:** characterized by higher air temperature with less precipitation. The main impacts of climate change in the sub-region will be caused by the Black Sea level rise.
2. **DELTA - LAKES SUB-REGION:** huge amount of fresh water resources of the Danube River and Danube Lakes.
3. **BUDJAK STEPPE:** the most arid area that suffers from the deficit of surface and ground water resources.
4. **DOBROGEA UPLAND SUB-REGION:** an area with hilly landscapes with height more than 400 m above sea level. This sub-region is outside the study area.

Climate change: trends, hazards, risks

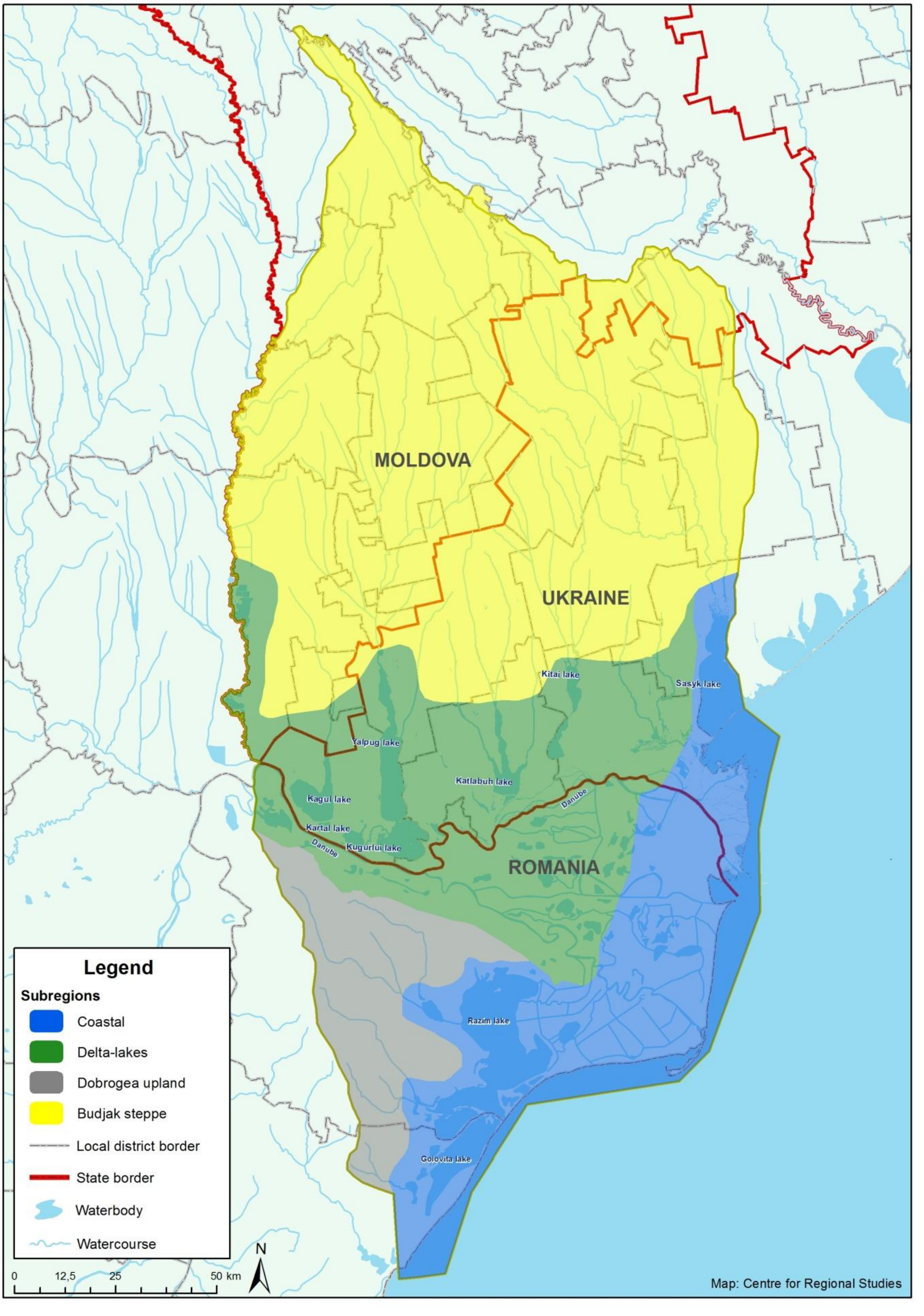
Main drivers of change in the region are e increase in average annual temperature and change in seasonal distribution of precipitation in the Danube Delta sub-basin and in the entire Danube basin. Other changes, in terms of hydrometeorological parameters, will be a consequence of their complex interaction, and the impact of the Black Sea level rise.

The recent analysis of data provided by the long-term hydrometeorological observations in the region demonstrates a trend towards the following changes: the average annual air temperature will increase by 1-1.5°C, summer – by 1.8°C and winter – by 1.3°C until 2050 which entails a shorter frost period, longer warm period and an extended arid period. These will lead to higher evaporation, an increase in number of extremely hot days (heat waves) and a significant decrease of the snow cover period. Faster changes of seasons are very likely.

The long-term forecasts of precipitation are very uncertain. Based on the current trends, the insignificant 6% increase of precipitation (mainly due a higher frequency of rainfalls) can be forecasted. Other forecast scenarios show a decrease in annual average precipitation by 5-15%. Nevertheless, humidity will decrease, and severe droughts will occur more frequently. It has been forecasted that extreme weather events such as torrential rains, waterspouts, storms, thunderstorms, hail, etc. will occur more often, especially in the coastal area.

The average Danube runoff decrease will be insignificant – 5% by 2050 – mainly due to the runoff decrease during the summer. At the same time the average local runoff forecast is of considerable uncertainty. However, a significant reduction (5-25%) of small rivers' runoff is expected in summer. These will lead to higher likeliness of low flow, low availability of water and quality, and water shortages. Further desertification and extreme water stress are expected mostly for the northern, most arid, sub-region, the Budjak steppe.

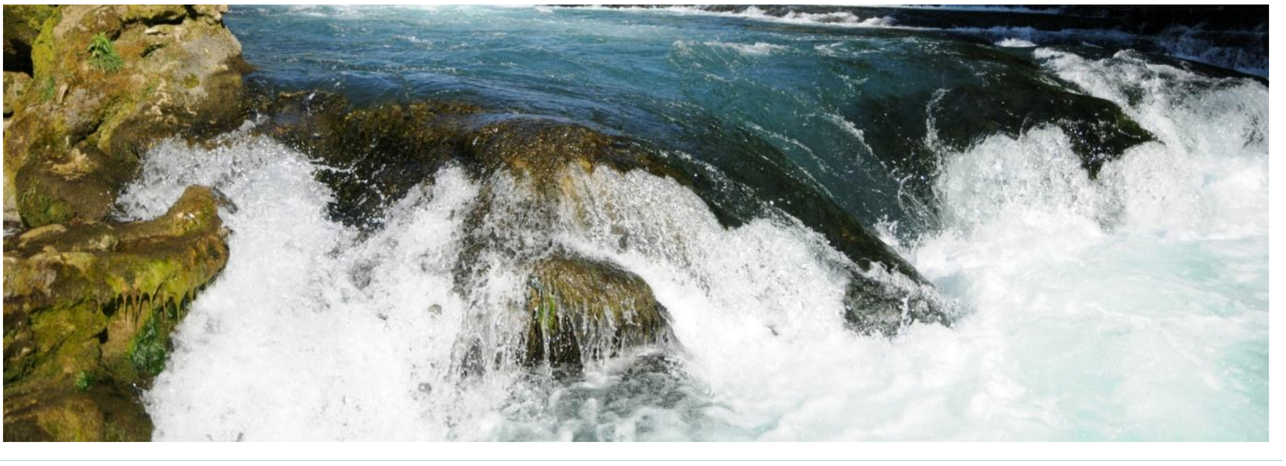
Delineation of the Danube Delta sub-regions



Possible changes of hydrometeorological conditions in the DDR

Parameter/indicator	Period (years)		Comments
	2011-2030	2031-2050	
Average annual air temperature	+0.5- 0,7°C ↑	1.0-1.5°C ↑	Average land layer air temperature will increase.
Maximum annual temperature	+0.8°C ↑	+2.0-2,2°C ↑	Higher absolute temperature maxima.
Minimum annual temperature	+0.6°C ↑	+1.5°C ↑	Minimum temperature will grow in the coastal areas, while in the advanced Delta it may remain at the current level.
Summer months temperature	+0.5°C ↑	+1.3 – 1,5°C ↑	Mainly from July – August.
Winter months temperature	+0.5°C ↑	+1.2°C ↑	Mainly from January – February.
Number of frosty days	10 days ↓	15 days ↓	Less.
Warm period duration	↑	↑	Faster change of seasons is possible.
Number of days with snow cover	↓	↓	Less.
Total annual precipitation	+3% ↑	+6% ↑	General growth of average annual precipitation, but significant redistribution of precipitation within seasons is predicted (5-7% increase during winter time, but 3-5% decrease during summer can be expected).
Extreme precipitation, rainstorms, squalls, thunderstorms, hail	↑	↑	Higher air temperature will be accompanied by higher moisture content in the lower layers of the troposphere. It will lead to less stability of the atmosphere during warm seasons and a higher number and intensity of convective weather events: rainstorms, hail, squalls and thunderstorms.
Moisture deficit (droughts)	↑	↑	Due to general warming and higher absolute temperature maxima. Possibly, due to annual redistribution of temperatures.

Parameter/indicator	Period (years)		Comments
	2011-2030	2031-2050	
Soil heating	⇧	⇧	Due to general warming and higher absolute temperature maxima.
Evaporation, transpiration	⇧	⇧	Increase due to higher temperatures.
Flooding connected with local runoff	⇧	⇧	Increase due to raised frequency and intensity of rainstorms.
Intensity and flooding height in the Danube	⇧	⇧	Calculated hydrological characteristics will change, particularly those of runoff and water level of 1% probability.
Minimum runoff of the Danube	⇩	⇩	Less because of higher temperatures in low-water period.
Sediment runoff in the Danube	⇧	⇧	Stabilization or slight increase due to greater rainfalls in the Middle and Lower Danube. Possible increase of the maximum runoff of sediments.
Sea level rise	⇧	favourable – by 0,15m, unfavourable – 0,5m ⇧	Rise of the level of the Black Sea; possible retreat of inland Danube Delta.
Flooding at the seaside, partial flooding and underflooding of territories	⇧	⇧	Increase due to higher sea level and more frequent wind-caused water level fluctuations because of greater number of squalls and tornadoes.



Parameter/indicator	Period (years)		Comments
	2011-2030	2031-2050	
Water temperature in the delta channels and closed water bodies	+0.7 ⇧	+1.5 ⇧	Increase in all water bodies of the Delta.
Water temperature in lakes in summer	+1.0 ⇧	+2.0 ⇧	Increase substantially in all Danube lakes.
Water quality	⇩	⇩	Deteriorates due to lower dissolved O_2 concentrations. Worse water exchange and eutrophication of the basins. Increasing of TDS for 5-10%.
Ice events	⇩	⇩	Decreased frequency and intensity of ice events.
Repeatability of years with low water level in lakes	⇧	⇧	Due to lower water levels along the Kiliya arm and possible reduction of the minimum runoff.
Water exchange processes in lakes	⇩	⇩	Due to lower water levels along the Kiliya arm and lowering of the minimum levels.

The main threats identified

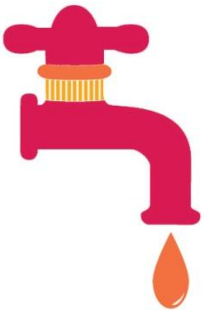
Drought periods and peaks of extremely high temperatures may increase by 10-20% in the period 2020-2025. Longer droughts are the main threat for the whole region and will cause the most significant impact on public health, key sectors of economy (first of all agriculture and fishery), and natural ecosystems.

The main threat to the Danube Delta in the context of climate change is the rise in the sea level and the consequent inundation of coastal areas. The values of the Black sea level rise during 1985-2010 exceeded the rise in the World Ocean level by 1.5-2 times. Under the unfavourable scenario, the sea level rise will be up to 0.5 m until 2050. This will impact the state of the Delta's ecosystem on the whole, and the coastal habitats will be completely transformed or even disappear. Effects on the coastal infrastructure will be significant too. But as the process is slow and gradual, a minimization of harm is possible.

Though forecasts of an increase in frequency and intensity of Danube floods are highly uncertain, extreme floods remain one of the most significant natural disasters in terms of both spatial coverage and severity of damage. Taking into consideration the effect of the sea level rise on the Danube's water level, floods will significantly threaten ports, flood protection constructions, settlements and elements of local infrastructure in the potentially flooded zone. Flash floods in small water bodies will be mostly hazardous to settlements due to increased frequency and intensity of heavy rain storms.

Climate change impact on water and ecosystems

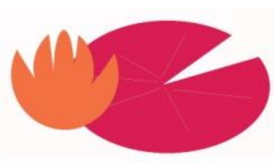
Water Resources



The minimum runoff will diminish as the temperature and evaporation rise. Average water temperature is likely to increase significantly by up to 2°C, in all water bodies, but especially in shallow lakes/reservoirs with regulated water regime and poor water exchange, which would lead to deterioration of the water quality. Ice conditions will become less frequent and shorter. Concentrations of dissolved oxygen will decrease in all bodies of water, especially during the summer months, which may lead to more frequent and intense hypoxia and water blooms (including toxic algae) of coastal waters, lakes and reservoirs. Water exchange processes in the Danube lakes and reservoirs will deteriorate. Small rivers that are now on the verge of disappearance may dry out completely. Low water level in the lakes and the volume of water in combination with high mineralization and temperature will considerably change the ecology of the water basins (e.g. eutrophication, mass mortality).

Danube Delta Ecosystems

Future sea level rise is expected to accelerate coastal erosion. Sea water will intrude further upstream into the Danube River and wetlands suppressing freshwater fauna and flora. The risk of larger scale damage to biotopes will increase due to more intense flash floods, wildfires, storms, etc. Thereby the habitats most vulnerable to climate change effects are reed beds, lakes, lagoons and salt marshes located along the sea edge of the Delta.



However, the influence of a combination of various climatic factors in individual delta ecosystems remains uncertain, which does not allow forecasting the extent to which real effects of climate change influence various populations. Shift of biotopes (ecological zones) is likely to appear.

It is likely that the general productivity of the Danube Delta water ecosystem will stay as it is due to a stabilizing role of reeds. In the coastal sea waters a slight increase of plankton organisms production is possible (up to 9% more) during the maximum temperature periods.

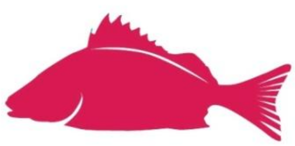
Flora

Higher water level in the Black Sea will enhance long-term underflooding of terrestrial floodplain ecosystems of the secondary delta of the Kiliya Branch. It will lead to changes in the vegetation formation towards salt-loving species, dropout of the fresh-water flora species which have a narrow tolerance to higher water and soil salinity. Fragmentation of biocoenosis, which is observed even now, will become stronger and rare species of flora will be disappearing. Changes of flora resulting in formation of the floristically poor reed communities on vast areas are expected. For some artificially managed wetlands of the Delta like the Stentsovsko-Zhebriyanskie Reedbeds these processes have already occurred. Reeds are sufficiently resistant to slight salting of water and soil, and it will lead to an increase of reed-dominated and salt-loving communities. Besides, the reeds growing in sub-saline habitats ripen quicker and their offshoots are much stronger and viscous which improves their roofing quality.

Significant changes in distribution of both native and adventive species can be expected, while the share of adventive species in tree vegetation (maple) and bushes (salt cedar, silverberry) near the river channel and at rice polders will increase.

Fauna

Wintering conditions for the most of mammal species will improve. However, less days with snow may deteriorate the wintering conditions for rodents and insect-eating mammals. The amphibian species and herpeto fauna will be at an advantage as the number of frosty days in winter reduces and the warm periods prolong. Changes in the life cycle and phenology of birds will result in a shift of migration timing including important commercial game species. Nesting conditions for a number of bird species may deteriorate – impacting species nesting on trees and bushes as well as the aquatic birds.



Fish-growing periods of the main commercial fish species and the number of fishing days will be prolonged which increases pressure on the population of main species. Future climate changes will not trigger a considerable reduction in catches in the Danube, though their qualitative composition may deteriorate. At the same time fish production in the Danube lakes/reservoirs can decrease due to the worsening of water exchange and lower water quality. In summer more fish mortality events can be expected due to algal blooms.

Intrusion and spread of invasive species will put pressure on less adaptable native species. Nowadays, human interventions in wetlands can foster the spreading of alien species. Most of the terrestrial and freshwater alien species are found on disturbed or altered wetlands, or polders. On the other hand, the natural factors of spreading of species in new habitats are not entirely known. In addition to the pressure from the side of invasive species, distribution of fauna as a whole may change significantly due to further change of habitats.

All this will further increase habitat fragmentation in the Delta, the decline of bio-diversity and the vulnerability of Delta ecosystems to changing climate conditions.

Climate change impacts on socioeconomic sectors

Human health

Frequency of cardio-vascular and respiratory diseases may increase. Outbreaks of water- and vector-borne diseases may occur more often, particularly during floods (cholera, hepatitis, leptospirosis, rotovirus infections).

The sectors most vulnerable to the effects of climate change are the two most important in the region – agriculture and water management.

Agricultural activities

Agricultural activities, in particular crops cultivation, are threatened by reduced crop yields and less employment opportunities due to water scarcity, physical damage to crops due to cold spells, flash floods and fires, reduced fertility of soil due to increased intensity of droughts and flash floods, soil erosion. Animal husbandry is at risk of diseases and higher mortality of animals due to extreme temperatures and favourable conditions for spreading viral and infectious diseases.

At the same time, climate change may bring some positive effects to agriculture by offering the possibility of cultivating secondary crops due to prolonged periods of vegetation, as well as cultivating new warm-loving crops. The potential for changes in the structure of the agricultural sector can only be realised if wise measures for adaptation to the changing agro climatic conditions are taken.

Most probable, the system of water management will face increased water demand in the industry sector and for domestic use in the conditions of decreasing water resources. Supply of good quality drinking water may be complicated due to loss of water in the distribution networks and reservoirs, especially in combination with more droughts during summer. Some regions will face further water scarcity.

The second important economic sector based on the use of natural resources is fishery. In the conditions of climate change fishing and fish-farming will be threatened by more frequent drought events, which may lead to more fish mortality. The increasing temperature will result in the decline of fish breeding places, fish mortality caused by overexposure to heat or cold, hard to predict alterations of spawning periods; worsening of spawning conditions due to the salinization of small coastal bodies of water; poor quality and quantity of water in fish ponds and the Danube Lakes.

Activities of local importance such as reed harvesting and forestry will suffer from more frequent occurrences of wild fires, the decrease of quality of roofing reed, and the intensive drying out of artificial forest plantations.

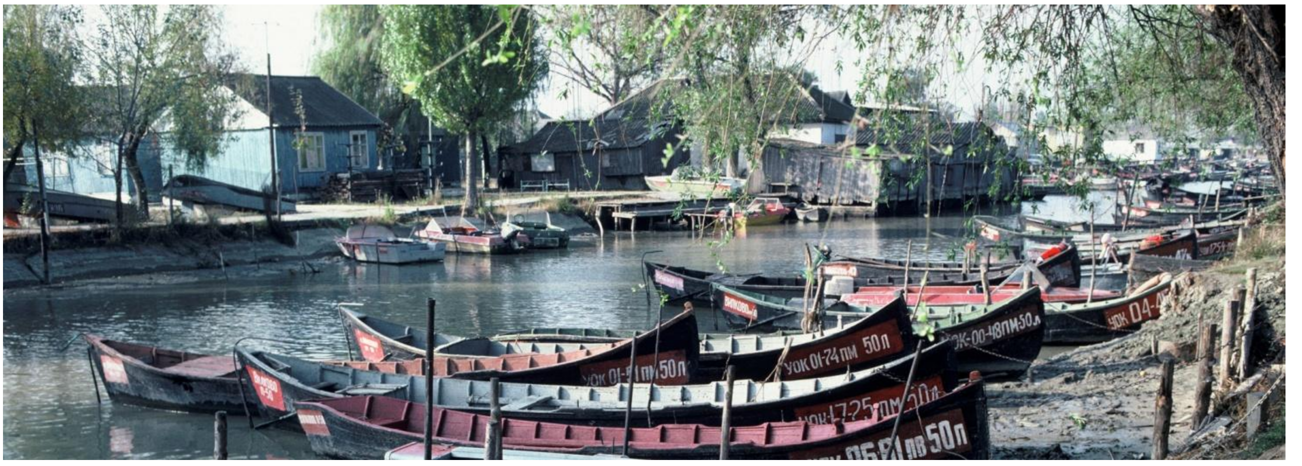
Energy and transport

Energy and transport sectors are exposed to a higher risk of damage of infrastructure (extreme weather events, flooding, etc.). An increase in low flow periods can affect navigation on Lower Danube, and sea level rise can be expected to affect ports and their infrastructure.

In the conditions of adequate adaptations measures the energy sector may also benefit from some of the effects of climate change: a potential decrease of energy consumption for heating due to shorter cold periods, better conditions for wind and solar energy production and a higher potential for biomass use for energy production due to longer vegetation periods.

The effects of water-related aspects of climate change on tourism and recreation could be both, positive and negative. On the one hand current tourist activities can slightly decline due to sea level rise and more extreme weather events affecting both, infrastructure and tourists. Additionally, problems due to higher stress on ecosystems and water reserves during the peak tourism season may arise.

On the other hand new possibilities may open to the tourism sector if wise adaptation is provided: an extended summer season may possibly lead to more tourists, a warmer summer might encourage national tourists to make more frequent trips on the seaside, and the number of job opportunities for local people in tourism sector could increase.



Case Study: Vilkovo

Brief description of the current situation

Of about 20 settlements in Ukrainian Danube Delta Vilkovo is the only town situated «inside» in the Delta, in its most downstream part. The official population is about 7000 people (the actual number of residents is lower). About 2,500-3,000 people are of working age, while the number of full-time jobs currently available in the town is estimated 1700. Further increase of unemployment (especially unofficial) is expected. Main fields of employment for the locals: local industries, fisheries, reed harvesting (seasonal), vegetable and berries cultivation (seasonal), winery and tourism services. There is no infrastructure protecting Vilkovo from Danube floods.

Threats

Vilkovo town is crossed by a dense network of shallow channels (yeriks) connected to the Danube. This makes the town very susceptible to any fluctuations of the river water level. The water level regime in the Danube River near Vilkovo depends on two main natural factors: seasonal changes of water level in the river and spontaneous “rain caused” fluctuations, as well as wind-driven changes fluctuations in the river.

Main water-related threats:

- Accelerated settling down of Vilkovo in soil due to higher average water level in town channels; underflooding;
- Risk of inflow of salty water into the town municipal water supply pipeline due to deep intrusion of sea water caused by strong winds;
- Risk of contamination of drinking water caused by toxic algae blooms.

Main threats to jobs and occupations:

- Decrease of reed yields and decrease of its commercial value;
- Hard-to-predict changes of spawning period along with the increasing water temperature may cause decrease of fish catch;
- The amount of fish resources may decrease due to more frequent and deeper intrusion of sea water.

Vulnerable groups

The most numerous groups vulnerable to the effects of climate change are representatives of the main sectors of local economy – agriculture (both, farming and animal husbandry) and fishery. Farmers will mainly suffer from the damage of crops caused by general change of agro-climatic conditions as well as extreme weather events. Fishermen and fish-farmers are threatened by the change of habitats (e.g. flooding of inner coastal water bodies with sea water) and changes of spawning conditions. Inhabitants and owners of buildings and other property located in potentially flooded area are under risk of flooding both from the river side and from the sea.

Among the groups directly vulnerable to the climate change are elderly and disabled people, who will suffer from increase of cardio-vascular and respiratory diseases. Residents of settlements, facing reduction of quantity and quality of drinking water will be forced to find other sources.

Adaptive capacity

The region has relatively high natural adaptive capacity due to the high rate of natural areas within the protected areas. In addition to this, the huge potential for wetland restoration is the resource for the region to increase its adaptative capacity to the effects of climate change.

From the point of view of social and economic systems the Danube Delta Region has poor possibilities for adaptation to the effects of climate change due to high latent unemployment rate, high share of socially disadvantaged people, low average income, and deteriorated infrastructure as well as an economy focused mainly on the agricultural sector.

But there are positive institutional conditions for successful adaptation to both, negative and positive effects of climate change: the existence of the bilateral Romanian-Ukrainian Danube Delta Biosphere Reserve and the operation of basin-wide platforms bringing together key stakeholders and users of natural resources (Danube River Basin Council in Ukraine and Dobrogea-Littoral Basin Committee in Romania).

OBSERVED AND PROJECTED CLIMATE CHANGE IMPACTS ON ENVIRONMENTAL AND SOCIO-ECONOMIC SYSTEMS AND HUMAN HEALTH

Climate, hydrological conditions and extreme weather events

The Danube Delta region is situated in the moderate continental climate zone with hot dry summers and cold winters. The values of the average annual air ***temperature*** are 10-12˚C; the maximum values reach 12.2-12.6˚C and the minimum – 9.1-9.6˚C. The influence of cyclones from the Mediterranean tends to result in sudden changes in weather and intensive rainfall, especially in summer. In winter temperatures can go below – 27˚C, though proximity to the Black Sea reduces the chill factor.

The Danube Delta territory receives ***precipitation*** rather evenly with the annual sum about 400-460 mm. The amount of precipitation reduces towards the sea. Precipitation is characterized by high interannual and seasonal variability. Precipitation occurs more frequently during the winter: in December-February there are 12 to 14 precipitation days in each month. The minimum number of precipitation days in the Danube Delta falls on August-September (about 7 days), so the average precipitation intensity in summer is half of winter.

Wind velocity of 3,5-7 m/s is the most common in the Delta. Prevailing directions of storm winds ((≥15 m/s) are north-western, northern and north-eastern. The number of stormy wind days in the Danube Delta increases towards the seashore of the Delta. Average ***humidity*** varies from 80% till 86% increasing towards the sea.

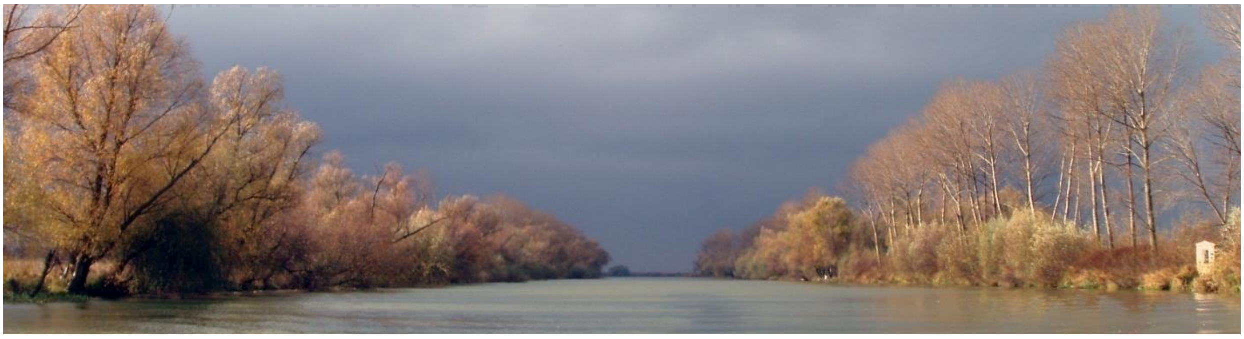
In the last 35 years the shoreline in Romania has retreated inland between 180 to 300 meters, 80 ha/year of the beach area has been lost there, while the Ukrainian side of the Delta is actively growing.

The tables below summarize the observed impacts and changes in the Delta directly or indirectly caused by climate change as well as forecasts of future vulnerability on the basis of climate change models and scenarios. The tables are based at findings and results of national assessments from Republic of Moldova, Romania and Ukraine as well as results of the Danube Climate Adaptation Study, Munich University for ICPDR.

MD: Data from Moldavian report	**UA:** Data from Ukrainian report
RO: Data from Romanian report	**DCA:** Data from Danube Climate Adaptation Study, Munich University for ICPDR

Key climate variables	What is happening now	What could happen
Global temperature (C)	Three independent long records of global average (land and ocean) annual temperature show that the decade between 2002 and 2011 was 0.77°C to 0.80°C warmer than the preindustrial average (end of 19th century). The Arctic has warmed significantly more than the globe as a whole.	The further rise in global average temperature is projected to be between 1.1-6.4°C by 2100 taking climate model uncertainties into account. The EU target of limiting global average temperature increase to 2°C above pre-industrial levels is projected to be exceeded during the second half of this century and likely around 2050 for scenarios that assume no global mitigation policy. The Arctic is projected to warm more than the globe.
European temperature (C)	The average temperature for the European land area for the last decade (2002-2011) is 1.3°C above the preindustrial level, which makes it the warmest decade on record. Heat waves have increased in frequency and length.	Land temperature in Europe is projected to increase between 2.5°C and 4.0°C by 2071-2100. The largest temperature increases during the 21st century are projected over eastern and northern Europe in winter and over southern Europe in summer. Heat waves are projected to become more frequent and last longer across Europe over the 21st century.

Key climate variables	What is happening now	What could happen
Regional temperature (C)	**MD:** The largest temperature increase is observed in the last 10-12 years (0,5°C). Max annual temperature in this period also increased by 0,9°C in comparison with the precedent period; warming in winter is less significant than in summer.	**MD:** Increase in temperatures for the coming period of 20 years for 2-2,5 or 1 degree (according to different data sets) during summer and 0,7-0,8 in winter.
	RO: The average annual air temperature increased by 0.5°C in Tulcea and by 0.8°C in Sfântu Gheorghe. The amplitude increased by 0.9°C in the last 30 years.	**RO:** For the 2021-50 periods the prediction scenarios shows an increase of air temperature by 1.1°C average. The amplitude and abrupt changes in seasonal temperatures are predicted with an increase of 1.1°C.
	UA: Minimum air temperature increased by 0.5°C in Izmail and by 1.3°C in Vilkovo. The trend is more prominent in maximum air temperature: up by 0.9°C in Izmail and 1.7°C in Vilkovo.	**UA:** Between 2021-50 the average annual temperature will increase by 1.0-1.5°C, summer – by 1.3°C, winter – by 1.3°C.
		DCA: 2021-50, summer temperature by 1.8-2.1°C, winter Temp by 1.4-1.5°C. 2071-2100: an increase of 3°C for all seasons and especially for summer an increase of about 4.1-4.5°C is possible.



Precipitation (C)	**MD:** Winter precipitation in the region has been declining by 1.1831 mm/year for the last 100 years; summer precipitation is also decreasing by 0,1738 mm/annualy. More torrential precipitation.	**RO:** In the 2021-50 period a decrease of annual average precipitation by 5-10% can be expected.
	RO: The average annual precipitation slightly decreased in the last 30 years. Moreover, the rainfall abundance (water quantity) increased.	**UA:** 2021-2050: 6% increase in annual precipitation.
	UA: Seasonal distribution of precipitation has not changed during 1945-2010, while annual precipitation sum has shown slight increase.	**DCA:** 2021-2050: 5-15% decrease in annual precipitation, less summer rainfall and unchanged or slightly increased winter precipitation is expected.

Key climate variables	What is happening now	What could happen
Evaporation	**UA:** Slight increase has been observed during the summer due to increase in air and water temperatures.	**MD:** Increase in potential evaporation (20-30% more in comparison with a period 1970-1980).
		UA: Further increase, especially in summer.
		DCA: Potential evaporation will increase, especially in summer. In regions with high water availability the mean annual evapo-transpiration will increase; in regions with low water availability – decrease.
Storms (C)	**MD:** More storms.	Available climate change projections show no clear consensus in either the direction of movement or the intensity of storm activity.
	RO: An increase in intensity and frequency of the storms, especially in the coastal area, has been recorded between 1990 and 2011.	**RO:** The predictions on storms frequencies and intensities are unclear because of a lack of sufficient data.
	UA: Intensity of convective precipitation (rainstorms) has slightly increased.	**UA:** The share of convective precipitation (rainstorms) will be more significant in the annual precipitation sum.

Key climate variables	What is happening now	What could happen
Snow cover (C)	**MD:** 20-25% decrease in snow precipitation from normal distribution for the last 10 years.	Model simulations project widespread reductions in the extent and duration of snow cover in Europe over the 21st century. Snowmelt conditions occurring earlier; slower/later build up of snow coverage and faster/earlier melting.
	RO: In the last decade the snow cover slightly decreased in frequency, duration and quantity.	**RO:** Reduction of the frequency, duration and amount of snow cover.
		UA: Significant decrease of number of days with snow cover.

Key climate variables	What is happening now	What could happen
Danube Runoff	Discharge during summer months decreased to a certain degree (from 26.9 to 25.6% of annual discharge), while the total water runoff of the river increased. **UA**: In the last decades periods of maximum average monthly discharge shifted from May-June to April-May	**MD:** Decrease by 5-20% until 2020-2025.
		RO: Decrease by 5-15% in the next 30 years.
		UA: Decrease of minimum runoff during mean water, while average runoff will change insignificantly.
	RO: A slight decrease during the summer period has been observed.	**DCA:** Decrease of 5 to 20% until 2020 and 6 to 36% until 2070

Key climate variables	What is happening now	What could happen
Water temperature	**MD:** During summer time it is around 30 degrees, but during hot periods it is up to 31-32 degrees.	**RO:** Considerable increase of the average annual water temperature mainly in the small lakes with insufficient water circulation.
	RO: In the last 30 years the average annual water temperature increased by 1.2°C in the inner Delta and by 1.5°C in the coastal area.	**UA:** Water temperature will significantly increase in all water bodies, but especially in the Danube lakes with regulated water regime and poor water exchange processes.
	UA: Average annual temperature of water in the Delta branches during 1961-2010 increased by 1°C, and max annual temperature by 1,9°C; in the Black Sea northwards of 400 N, water Temp increased by 1.50°C and even more in coastal shallows, bays, gulfs, deltas, especially in summer time.	**DCA:** Increase in water temperature of all aquatic systems (rivers, lakes, groundwater bodies); less freezing periods in winter and less ice cover on lakes and rivers.
Water flow	**RO:** In the last decade water shortages have been observed.	**UA:** Irretrievable water consumption will become greater due to higher irrigation needs.
		MD: Increase in low flow periods as a result of more intense summer droughts (12-15 m^3/sec in Lower Prut area, while average is around 70 m^3/s). Water in the Yalpugh and Cahul rivers may disappear for 3-4 months in summer and autumn.
		RO: Model predictions show an average annual low water table in the channels and very low water level or no water in medium or small lakes.
Drought	**RO:** In the driest area of Romania (Dobrogea-Danube Delta) slightly longer drought periods were recorded. Romania has been affected by drought annually and by extreme drought every four to six years with significant environmental and social implications.	**MD:** Occurrence of droughts, water scarcity, heat waves and dry periods may increase by 10-20% in the period 2020-2025.
		RO: Increase of drought periods by 10% in the next 30 years.
	UA: Duration of dry periods increased.	**UA:** Longer and more intense droughts.

Key climate variables	What is happening now	What could happen
Wild fires	In some parts of the Delta fires became common during the last years.	There is a higher risk of ignition of wild fires due to natural reasons as well as increase in the area of man-caused fires due to intensification of droughts.
	MD: Fires in the meadow and wetland areas seem to increase, but better reporting on this is needed.	**RO:** Possible wild fires in if the conditions are appropriate such as high temperature, long drought period, dry flammable vegetation and wind.
	RO: No records of wild fires. Only seasonal, mainly in autumn, man-caused fires on dry reed beds in order to gain large pasture area in the spring time.	

Sea level rise	**RO:** On the entire coast line the average rate of sea level rise is 0,25 cm/year. The correlation is made with erosion and sand deposition processes.	**RO:** Black Sea water level increase rate: 0.25 cm/year (long term).
		UA: 2050: favorable – sea level rise by 0,15m, unfavorable – 0,5m.
	UA: During 1985-2010, the rate of sea level rise was already 6.9 and 9.8 mm/year on two gauge stations. These values exceed 1.5-2 times the level rise for the entire World Ocean.	**DCA:** Increase of the Black sea level; possible retreat of the Danube Delta sea edge.

Key climate variables	What is happening now	What could happen
Flood	In recent decades, due to earlier snowmelt in the Danube basin, the spring-summer flood peak begins 10-15 days (on average) earlier than in previous years[1].	**RO:** Increase in frequency and intensity of floods. There is a high risk that settlements will be flooded.
	MD: Due to the extremes in precipitation, floods can increase in the Lower Prut region in any period of the year.	**UA:** Frequency and intensity of floods, caused by local runoff will increase due to a higher share of rainstorms in the total precipitation amount. Intensity and amplitudes of the Danube floods will increase. The role of liquid precipitation in forming flood conditions will increase. Floods in the coastal area will also increase due to the rise of the sea level as well as due to the increasing frequency and intensity of wind-caused water level fluctuations. There is a risk of failure of dykes along the Danube, as well as dams on the small rivers.
	RO: In the last decade more extreme flood phenomena have been recorded with high water table in all hydrological system of the Danube Delta. Already, in some parts, the dyke system failed.	

[1] Gidrologiya del'ty Dunaya (Hydrology of the Danube Delta), Moscow: GEOS, 2004.

Key climate variables	What is happening now	What could happen
Lake and river ice cover	**RO:** In the last 10 years the frequency of ice cover on the lakes and Danube River decreased.	Frequency and intensity of ice conditions in all water bodies will decrease.
	UA: During 1961-2012 ice events in the Danube Delta arms were observed 10 times only, i.e. the probability of a fixed ice sheet is about 20%, or once in five years. In 1931-1961 the freeze up was recorded in 19 winter seasons out of 30, and the probability of this phenomena equalled 63%. Thus, frequency of ice events is reduced more than 3 times for the last 50 years.	
Hypoxia	Increasing frequency of hypoxia in the bottom layers of the sea caused by sharply pronounced thermo cline.	Frequency of hypoxia in the bottom layers of the sea will further increase. Content of dissolved oxygen will decrease in all water bodies, especially during the summer months. Amplitudes of daily fluctuations of O_2-CO_2 balance will increase.
	MD: Hypoxia at the bottom of artificial lakes (Comrat, Taraclia, Congaz).	**RO:** Decreasing content of dissolved oxygen in most of the lakes with low transparency and no water circulation or connectivity.

Ecosystems

The Danube Delta has an area of about 600,000 ha, and a fifth of it is located in Ukraine. The Ukrainian part of the Delta grows intensively, and every year its total area increases by more than 1 km^2, while Romanian shoreline has retreated inland between 180 to 300 meters and 80 ha of the beach area has been lost per year during the last 35 years.

The Delta features great landscape diversity. There are more than 30 types of ecosystems in the Delta. Here you can find extensive shallows, islands, sand bars, reed beds and picturesque patches of floodplain forest. There are 49 types of natural or partly man-induced habitats (according to Romanian habitats classification). The Delta is part of one of the biggest migration corridors connecting North of Eurasia with Mediterranean coast, Middle East and Africa and a very important nesting and wintering ground for waterfowl bird.

The Danube Delta maintains its enormous biodiversity in a better state than most other deltas in Europe, even in the world. Many of the species that live within the Delta are unique to it, these include plants and animals.

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The ***MAIN FACTORS*** predetermining the condition of natural resources and water ecosystems of the Danube Delta are:

- **HIGH ABUNDANCE OF WATER.** From time to time 80% of the Delta area is flooded. About 700 lakes occupy at least 10% of its territory. The drainage network of the Delta has a waterway density of 1 km/km^2.
- **HIGH CONTENT OF NUTRIENTS.** It is known that nearly 58% of total nitrogen (340,000 t) and 66% of total phosphorus (55,000 t) enter the Black Sea via the Danube Delta.
- **FAVOURABLE TEMPERATURE CONDITIONS.** The average annual temperature in the Delta water basins has grown up by 1°C for the last 30 years and reached 13.0°C, the average annual temperature in the water basins amounted to 12.5°C. Also, the water temperature in the Delta wetlands exceeds >5°C during 265 days in a year.

Peculiarities of the Danube Delta ecosystem:

THE HIGHEST PRIMARY PRODUCT LEVEL. The average value of the gross primary product of the Danube floodplain shallows is 1.8 times greater than in similar areas of the Dnieper delta and reaches 5.62 mg Corg·l-1· day-1. Reed beds *Phragmites australis* in the Danube delta are the largest in the world and occupy 280,000 ha, which is about 50% of the Delta.

›4,000

SPECIES INHABIT DANUBE DELTA REGION

HIGH BIOLOGICAL DIVERSITY OF LAND AND WATER ORGANISMS. The total number of identified species exceeds 4,000, including 1,120 water organisms. As compared to the Dniester and Dnieper deltas, the discovered diversity of species is greater 1,7 and 1,2 times, respectively.

The Danube is the main river of the Black Sea basin which influences considerably its productivity and biodiversity. About 50% of the total freshwater runoff of the Black Sea comes from the rivers of its north-western part, and 36% of this volume comes from the Danube. Out of that, the Danube runoff carries 91% of allochthonous organic matter and 70% of total nitrates coming to the sea with the river waters. Experts say that the annual volume of plankton flowing out from the Danube delta comprises about 1,340,000 t, bacteria equalling 80.8%, phytoplankton – 11.1% and zooplankton – 8.1%.

The existence of many coastal fish species, including those migrating from the sea to the river, e.g., Danube shad and salmons, is possible due to the existence of highly productive ecotone «river-sea» in the Danube Delta front.

The major influence has been a gradual worsening of water quality during the last fifty years. Economic decline of major industries in the former Eastern Bloc States and the closure or reduction in outputs of many factories and industrial plants has reduced the levels of pollution entering the Danube from these countries. Further reductions in river pollution, should enable ecosystems within the Delta to recover.

The creation and dredging of some navigation channels within the Delta, and the blockage of many side channels, has had a significant effect on the movement of water within the Delta. Large areas were made into polders for fish farming and parts of the floodplain were drained for agriculture and forestry. These activities disrupted the normal hydrological cycles and it will take years to reverse the harmful effects. In some areas the build up of salt in the soil has led to the gradual death of cultivated vegetation.

Natural forest cover is declining in the Delta, because the planting of large areas (around 4,650 hectares) of hybrid poplars has brought few economic or ecological benefits.

Fishing continues to be a major source of income for people who live in the Delta, but the declining quantity of fish available is a concern for commercial fishermen. Sport fishing is increasing, but these anglers are less concerned by the numbers and the size of the fish caught.

Potential changes in the Danube Delta and Black Sea coastal zone ecosystems due to climate change

Key impacts	What is happening now	What could happen further
Coastal erosion	As the World Ocean level rises, the threat of sand coast erosion increases, e.g. of Razem and Sinoe limans (a type of lake specific for the Black Sea shore) in Romania. The Delta ecosystems are very susceptible to the higher sea level.	Further rise of the Ocean and the sea levels will increase coastal erosion. Salt sea water will intrude further upstream into the Danube river and wetlands suppressing freshwater fauna and flora. Future climate change, in particular rising sea levels, is expected to accelerate coastal erosion.

Eutrophication	Higher water temperature in summer months is leading to longer periods of algae blooms in lakes and wetlands. Water blooming on the sea surface appeared recently as a phenomenon. **RO:** The loss of breeding areas and eutrophication are two of the factors that have led to a decline in common carp populations. Tench numbers have also increased, but these are a valuable species. A general increase in turbidity has led to a reduction in macrophytes, leading to changes in primary production.	Frequency and intensity of toxic and nontoxic algal blooming will increase because of hypoxia, low water table and high temperature.

Key impacts	What is happening now	What could happen further
Physical damage to habitats	The increased frequency and intensity of extreme weather events led to more damage to vegetation.	The risk of larger scale damage to biotopes will increase due to more intense flash floods, wildfires, storms etc.
Loss of biodiversity and mosaic wetlands	**MD:** The surface of the artificial water bodies has strongly decreased due to sedimentation. One could estimate loss of around 40% of water volume in the ponds and so respectively water surface. Hydrotechnical construction in the Yalpugh river valley led to the disappearance of water in the Yalpugh downstream of the Taraclia artificial lake. An increasing of air temperatures and hydrotechnical activities led to a change of the wetland and meadow vegetation of 80%, the biomass of the wetland areas also decreased by 50-60% for last 30-35 years (beginning of hydrotrech constructions).	In the northern and central part of the seaside of the Delta will grow intensively and fresh-water vegetation will develop here. However, vegetation is forming very fast now and in the future, given the decay rate of the northern channels of the Kiliya branch, the process will be even faster. Overgrowing of water basins will take place leading to a drop out of certain stages of the vegetation formation process. As a result, higher water vegetation and appearance will deteriorate and the share of inferior (algae) and adventive plant species will increase. If no hydro land reclaiming works are started, this process will intensify even more. Degradation of phyto- and biodiversity which commenced in the 80's will be ongoing. The southern coast is subject to strong erosion and the process is expected to intensify in the future, unless protection measures are in place.
	RO: Field observations revealed some changes in vegetation structure and distribution: forest species started to dry (*Alnus glutinosa*), while in aquatic vegetation certain species, more adapted to the new conditions, dominate the lake.	
	UA: Some parts, e.g. Stentsovsko-Zhebrian marsh, witness catastrophic changes in vegetation which has led to a formation of floristically poor reed communities with rootstock occupying the entire water column over vast areas. The water surface area has decreased considerably.	

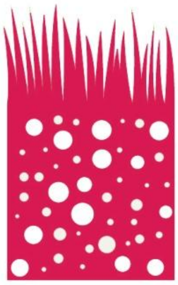
Key impacts	What is happening now	What could happen further
Disappearing rare species on floodplains	**MD:** Steppe and meadow vegetation covers around 10% of the territory and host around 790 species, 30 of which are included in the Red Book.	The reduction of the Danube runoff accompanied by a temperature rise and more contrast weather events will worsen the water exchange and flushing of the floodplains.
	RO: Badgers and European mink are very rare in this area. The red list of DDBR contains a number of 382 species. More than 40% are critically endangered species.	The water ecosystems may suffer secondary pollution with organic debris which will intensify degradation of the floodplain ecosystems. Vegetation will become simpler, communities will fragment so that the share of the higher water vegetation diminishes. The share of air- and water vegetation and proper water vegetation represented by pondgrass and hornweed, as well as charophytes, may decline while the share of inferior plants, mostly filamentous algae, etc. will grow especially in Stentsovsko-Zhebrian marsh.
	UA: Rare species of plants on floodplain ecosystems of the Kiliya branch of the Danube Delta are disappearing: on Zhebrian ridge, only one species – common sawgrass listed in the Red Book of Ukraine – is still present, despite having disappeared in the other parts of the Reserve in Ukraine.	

Key impacts	What is happening now	What could happen further
Change of vegetation on islands	The changes of the inner islands in the Delta may be judged by the example Ermakov island, Ukraine. Taking into account the current considerable anthropogenic load on the island plant communities, the existence of the navigable channel and the forecasted further dredging works near the Ermakov island, as well as a huge number of adventive species and new species being discovered each year, it is possible to predict their further expansion, particularly that of thermophilic species which are well adapted to mineralization both of water and land-based ecosystems.	On Ermakov Island the water-and-marsh type of vegetation will be gradually restored. The share of adventive species in tree vegetation (maple) and bushes (salt cedar, silverberry) near the river channel and at artificial rises which were reclaimed at dredging the navigable channel will increase. Temperature rise and less runoff will cause more frequent arid periods, thus increasing the probability of fires on the islands. The higher Black Sea level will not practically take a toll on the island flora but, should the salt wedge rise above the island level, the mineralization of the flooded meadows will increases, and rare species registered in the Red Book of Ukraine – summer snowflake and other stenobionts – will disappear. The share of plants with a higher capacity of nitrogen fixation (bladderwort) and other kinds of water plants resistant to a considerable eutrophication (meakin and myriad-leaf) will increase. The new adventive species – *Elodea nuttalli* – which has greatly spread in the water basins of Ermakov Island will spread out further.
Declining ground water and plant diversity at sand dunes and ridges	The Zhebrian sand ridge is under pressure from reforestation with Crimean pine and extraction of sand from quarries. Both factors lead to violation of the hydraulic condition in depressions and the ground water level in sand dunes. It brings a decrease of plant diversity, particularly of rare and disappearing psammophyte species. **RO:** In the Danube Delta Biosphere Reserve 128 alien plant species were identified (Doroftei & Covaliov, 2009). Most affected are natural floodplain forest, meadows and beach sand dunes.	Further lowering of the ground water level due to less runoff in the Danube and increase of water temperature will enhance the probability of fires on the ridge. Bessarabian carnations recover extremely bad from fires and may go extinct because it is a narrow endemic. Disturbances of the ground water level in depressions will lead to a disappearance of all orchid species in the Reserve as well as other rare species of the Zhebrian ridge (small cattail, common sawgrass and late leucanthemella).

Reeds

Danube Delta hosts the largest reed bed in the world, spreading over more than 280,000 ha which is about 50% of the delta.

Reed (*Phragmites australis*) is ecologically and economically very important in the Delta. It provides a vital habitat for invertebrates, amphibia, fish, birds and mammals whilst acting as natural water filter.



REEDS IN THE WETLANDS ACT AS NATURAL WATER FILTERS THUS CLEANING THE WATER IN THE RIVER

Reed beds are the main factor mitigating extreme impacts and stabilizing ecological conditions in the Danube Delta. Many wetlands of the Danube Biosphere Reserve have a great reserve of common reeds (*Phragmites australis*). Thus, in Zhebrian wetlands the area covered by reed comprises from 36 to 91% with the average productivity of 10 t of dry mass per ha.

In the Danube Delta there is a centuries-long tradition to harvest reeds, cut the hay as well as burn out old wetland vegetation. It ensured the removal of reed biomass or prompt utilization of dead organic matter, which facilitates the restoration of wetlands. Still, taking into consideration a certain environmental and ecological threat of having fire in the wetlands ecosystem, to maintain the wetlands and support their high nature-protection potential, the ecological management priority should be to harvest reed in winter. Reeds are cut on a commercial basis and then exported.

Harvesting of reed in wetland ecosystems is an important regulatory mechanism which increases wetlands productivity up to five times as compared to unmanaged sites where dead organic matter is not removed. In doing so, the oxygen content in the ecosystem increases while carbon dioxide and various pollutants in water and air decrease, in parallel with many other processes which have not only regional but also Biosphere significance. Cutting wetlands in a mosaic pattern during winter improves washout capacity of wetlands which benefits ecological condition of wetlands and also enhances their biodiversity. Removal of dead organic mass reduces fire threat and makes reproductive capacity of wetlands higher.

Harvest of reed is a way to support the region’s economy and to create a considerable number of jobs – that is particularly vital during an economic crisis, providing alternative to poaching or other illegal activities. Besides, sustainable use of reed resources is in full accord with the international strategies for management of other Biosphere reserves around the world.

Key impacts	What is happening now	What could happen further
Change in dominant communities	The share of reed beds in the Delta is slightly declining especially in natural wetland areas. **RO:** In the Danube River there are low water level conditions, especially in summer time. Due to these "obstacles", some channels and lakes get disconnected from their supply channels and can even become dry. This results in a significant modification of flora and fauna species behaviour, mostly negatively impacted from a biodiversity point of view.	Higher water level will result in diminishing area of reed beds and more favourable conditions for Mace and Bulrash community in the lower parts of the Delta. An increase of the Black Sea level and more frequent wind-induced events will lead to formation of salt marshes and marsh/grassland.
Increase in fire frequencies	Higher frequency of fires stimulates change in vegetation with more of marsh-and-grassland type and a greater share of meadow herbs and lower share of reeds (observed on the islands of Stambulskiy, Kubanu, Kubanskiy, Ochakovskiy, Ankudinov and Prorvin, Ukraine).	This process of meadowing will continue in the future as fires become more frequent. A change of the reed wall structure will be the other negative consequence of fires as the ash elements accumulating in soil will make stems weaker, which reduces commercial quality of reed.
Longer growing season	Reed growth and its development period is changing, particularly its transition to winter stage. During the last 3-4 years, particularly in winter of 2011, leaf fall stage hardly occurred, and the time of starting commercial reed harvesting was delayed.	The temperature increase by 1.5-2.0°C will lead to further changes of the reed development period, especially its transition to winter stage, which will substantially violate the timing of commercial reed mowing for export.
Salt water intrusion	The increasing level of Black Sea that results in deeper penetration of salt water into the Delta fosters development of commercial quality reed beds along the sea front of the delta.	Mineralization of the ecosystem will increase because of the rise in the Black Sea level. Reeds are sufficiently resistant to slight salting of water and soil, and so conditions will lead to an increase of reed-dominated and salt-loving communities of species. Besides, the reeds growing in sub-saline habitats ripen quicker and their offshoots are much stronger and viscous which improves their roofing quality.

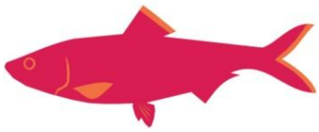
Animals

	What is happening now	What could happen further
Phenology and lifecycle	In 1970 there were 9 species of sandpipers wintering in the delta and now there are 29 species. Other species that have started spending winter in the Delta regularly are: Pelecaniformes – *Pelecanus crispus* Ciconiiformes – *Nycticorax nycticorax* (Night Heron), *Egretta garzetta* (Little Egret). Anatidae – garganey (*Anas querquedula*), common teal *(Anas crecca),* Gadwall *(Anas strepera),* Eurasian Widgeon (*Anas penelope),* Ferruginous Duck (*Aythya nyroca*). *Laridae* - Great Black-headed Gull (*Ichthyaetus ichthyaetus),* Little Gull (*Hydrocoloeus minutus),* Whiskered Tern (*Chlidonias hybridus*). In Ukrainian Delta we can see expansion of the habitat of the dice snake (*Natrix tessellata).*	Changes in the life cycle and phenology of birds and fish will lead to a shift of migration timing including important commercial game species. Cold-blooded species and some mammals will fall into hibernation later and start reproduction earlier. The loss of habitat for Amphibians will lead to decrease in population sizes (*Lissotriton vulgaris, Bufo bufo),* while reptiles will regain the space. Less snow in winter will be favorable for wintering of mammals but complicated for rodents and insectivore mammals etc. Projections of the phenological responses of individual species are scarce and highly uncertain.

Invasive species	**RO:** The number of alien species is growing in terrestrial ecosystems; most of terrestrial and freshwater alien species are found on disturbed or altered wetlands or polders. The presence of a high number of alien species and the expansion of their areal resulted in emergence of both new species and associations, non-specific to deltaic territory so far. The introduction and spread of non-native species has also put pressure on less adaptable fish. Muskrat was introduced from North America in 1954 and it has established itself as one of the Delta's most plentiful mammals.	**RO:** Non-native invasive plants may be better adapted and take advantage of a changing climate (Dukes and Mooney, 1999). Nowadays, human interventions in wetlands can foster the spreading of alien species. On the other hand, the natural factors of spreading in the new habitats are not entirely known. All this will further increase habitat fragmentation in the Delta, the decline of biodiversity and increase vulnerability of Delta ecosystems to changing climate conditions.

Fish

Of the 134 fish species that have been recorded within the Bilateral Danube Delta Biosphere Reserve, 106 fish species of 38 families are registered within the Ukrainian part of the Reserve. All 7 species of fish from the European Red List occur in the Reserve. These are Bastard fringe, Atlantic sturgeon, Black Sea salmon, Danube salmon, European mud minnow, Chop and Little chop. Freshwater fish are most spread in the Danube Delta Biosphere Reserve. The sturgeons are the most primitive type of fish caught in the Delta and three species migrate into the river to spawn. There are 31 species of fish that are able to live in both seawater and freshwater. They come into the rivers and canals to spawn and include the Black Sea herring, Black Sea Salmon shad, and a small clupeid herring. Some of the carp, perch, zander and Danube catfish are able to withstand small dilutions of salt water. There are 44 fish species that live exclusively in the freshwaters of the Delta. These include pike, tench, rudd, orfe, barbel and bream. Many of these fish are very important commercially and they provide the main source of income for people who live in the Delta.



HERRING IS ONE OF THE MAIN SPECIES FOR COMMERCIAL FISHING

Most economically valuable are migrating fish species such as Black Sea herring (*Alosa pontica*) which is a mass caught fish in the Lower Danube. Sea commercial fish common for the Reserve water area are anchovy, sprats, silverside, whitings, spiny dogfish as well as the mullet family species – golden mullet and so-iuy mullet.

There are 11 alien or introduced fish species: silver and spotted silver carps, grass carp, golden carp, so-iuy mullet, red bream, Amur sleeper, Amur stone morocos, silver sea trout, doradoes and goldlines.

The construction of polders in the late 1950s and 60s, to create farm and forest areas, reduced the area of the „Danube meadow" available in the flood season for spawning for carp and other commercially valuable species. In the first half of the 1960's catches in the Lower Danube reduced more than 4 times. Some of the more commercially valuable fish species like common carp have been in part replaced by crucian carp, bream and roach.

Key issues	What is happening now	What could happen further
Fish lifecycle	**UA:** Spawning of the Danube herring, the main commercial fish species in Vilkovo, has shifted to 2-3 weeks earlier during the last 50 years. Crucian carp has expanded its range since 1970 and the impact of the grass carp or silver carp is being monitored.	The increase of water temperature in the river and lakes will result in earlier spawning, faster development of food supply and prolongation of the feeding period. Future climate changes will not trigger a considerable reduction in catches, though their qualitative composition may deteriorate. Fish production in the Danube lakes may reduce due to worsening of water exchange and lower water quality. During the summer higher fish mortality can be expected due to algae blooms.

Climate impacts on socioeconomic system

Modern development of the region was based on sea-related industries and transport clusters. The transport cluster of the region handles and distributes cargo among various kinds of transport.

The industrial structure of the Ukrainian part of the Delta mainly consists of the processing and food enterprises (milk and fish processing factories, meat-processing factories, etc). A considerable part of the industrial enterprises is declining and needs equipment and technology modernisation. Industry provides jobs for 3-8% of population and construction sector for 2-3% more. Local unemployment is on the rise during last years as part of the general trend in the region. Fishing industry employs the major share of population but it has been in decline during the last couple of years.

Agricultural industry constitutes 17% of Odessa region GDP but it is much more important in the Danube Delta region. It specializes in grain production (including rice growing), wine-production, vegetable growing, cattle farming and fish breeding. 34% of population in Reni district and up to 70% in Ismail district is employed in agriculture. Moldova is heavily agricultural, about 60 % of the total area in the country is agricultural land. Agriculture is less important in Romania. Together with forestry and hunting it employs 29.03% of population, then comes fishery with 15.13%, transport and communications 14.7%. Around 40% of rural population lives in poverty. Poverty exists even though agroindustry is well developed and there is a high level of agronomic education. Official unemployment recorded in the region is 1.5-2 times higher than in the Odessa region and the situation is even worse in the Kiliya district.

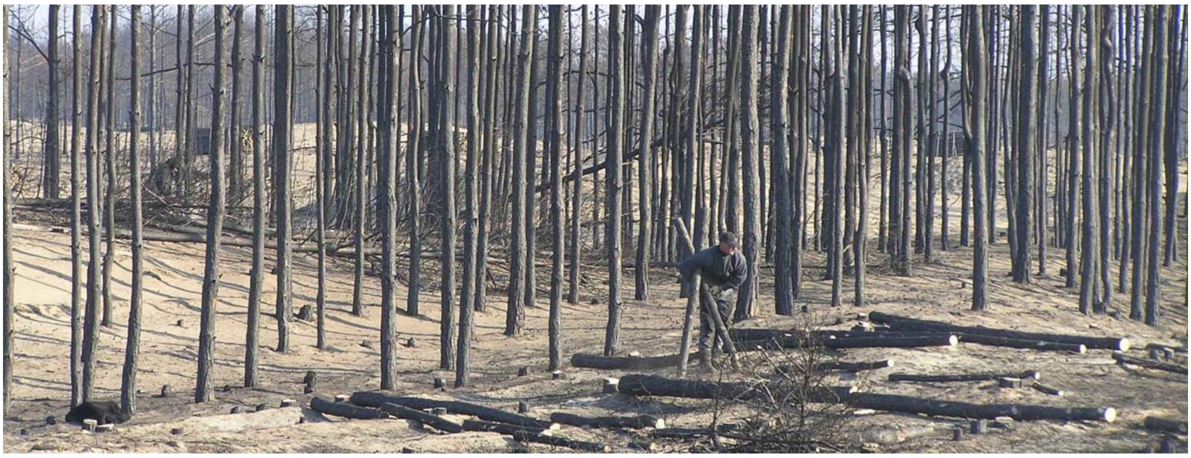
Rural settlements in the Ukrainian Danube Region are mainly big. Three topographic types of rural settlements prevail: valley, gully, lake-adjacent and liman-adjacent types, which means they are highly prone to flooding.

Key sectors	What is happening now	What could happen further
Agriculture	**MD:** Due to deficit of precipitation sunflower, cereals harvest decreased (for 20-30%), while grape production remained at approximately the same level, with better quality. The main problem is erosion, which leads to the loss of humus and nutrients. 70-80% less fertilizers are used now than during last 20 years-. Droughts and torrential precipitations can lead to physical damage to crops.	**UA:** Due to artificial and complete regulation of the rice-growing farms' hydraulic systems in Ukraine, they will be less susceptible to climate change. Longer vegetation period will make it possible to grow rice within optimal period and reduce the harvest losses caused by its late harvesting. There is an increased risk of losing winter crops due to less snow cover, as well as an increased risk of physical damage to crops by extreme temperature contrast, fires, flash floods. Lastly, there is a risk of nutrients being washed-out from arable lands and intense soil erosion due to increased frequency of rainstorms.
	RO: Overgrazing has been common which resulted in general spread of weeds. Grazing is important, however, because it helps to limit the spread of scrub over ecologically valuable grasslands. In the last decade the arable lands surfaces decreased, therefore the production decreased drastically.	
	UA: During the last 10 years, production of such agricultural crops as sunflowers, sugar beetroot and vegetables decreased while the grains and grapes production increased.	

Key sectors	What is happening now	What could happen further
Growing season for agricultural crops	**RO:** Duration of the vegetation period is favourable for seasonal crops but insufficient precipitation limits yields.	Growing season will become longer**:** Some changes in crop species will be needed in order to increase the productivity of some adapted species.
	UA: Agro climatic conditions of winter wheat and spring barley cultivation are sufficiently favourable.	The change of temperature conditions in autumn makes it necessary to revise the optimum periods for seeding of winter crops. Planting should be shifted to 20-25 days later (October 9-16).

Agropheno-logy	**MD:** A prolongation of the vegetation period is expected for 10-12 days. Based on that one could estimate economic losses associated with the agricultural land maintenance (pest application, moisture loss, etc.) for 5-10%.	**UA:** warmer climate would make it possible to cultivate: • second crops after harvesting the primary ones (winter wheat, spring barley). The second crops might be: buckwheat, millet, mid-season varieties of corn, soya, potatoes, tomatoes, Sudan grass; • new crops such as cotton for which an adequate amount of heat is available now and, as it is expected, will be available in future.

Key sectors	What is happening now	What could happen further
Water-limited crop productivity	Agricultural activities became more irrigation dependent.	The role of irrigated agriculture can increase. Drought-resistant crops will be better suited to new conditions.
Irrigation water requirement	**MD:** Water volume used for irrigation could be up to 2000-2500 m^3/ha/year from the Prut river. Water from Yalpugh river has high TDS content (ca. 3 g/l) and cannot be used for irrigation. Underground waters have also high content, but some wells can be used for irrigation.	There can be a lack of water resources for irrigation Irrigation system will not be effective because of the water shortages.



Forestry and forest fires	**RO:** Forestry within the Delta has enjoyed a rather chequered history, mainly due to the use of inappropriate species to create plantations. Natural woodlands do not tend to suffer from the same problems, since they have evolved in balance with nature. Natural forests of willow, oak, ash, white poplar and aspen cover 8,000 ha of the territory. Plantation forests cover 5,400 ha, but this area is set to decline as the trees are cropped and natural forests are encouraged to regenerate for ecological reasons. **UA:** During the severe reed-bed fires in 2010 some parts of floodplain forest were damaged.	**MD:** Fires of the meadow vegetation are more likely to start. There will be changes in forest structure and species composition. More adapted species to climate change pressures will be present.

Key sectors	What is happening now	What could happen further
		
Energy	**MD:** Local vegetation resources are insufficient to cover local heating needs. Artificial planting could satisfy 20-30% of the local houses with heating. **RO:** Some villages (e.g. Gorgova) have no electricity. **UA:** Odessa oblast satisfies only 60% of its energy needs from domestic energy production, the rest is imported from other regions of Ukraine. A lack of the local electric power generating capacities considerably slows down economic development and contributes to social tensions even though the region has high potential to become energy independent using solar and wind technology. Heating in some settlements (including big ones) fully depends on delivered energy sources (coal and firewood) due to absence of centralised gas supply.	There will be a great need for diversification of energy sources and better conditions for wind and solar energy production. Also the energy consumption for air conditioning or heating will increase. Moreover, there is an increased risk of physical damage to energy infrastructure. 

Key sectors	What is happening now	What could happen further
Tourism	In the Romanian part of the Delta the tourism sector is highly developed, while Ukrainian part is still an unlikely destination. However, there is a great potential for developing environmental tourism provided sufficient investment can be found for renovating and bringing existing facilities up to modern standards. In the context of the regional expansion of tourism, it sheds light on how a local family adapts to new economic conditions. The local family's life revolves around tourism during the peak season, and unlike other tourist destinations, the members of the family are the first to benefit from this business. The Moldavian part is very poorly developed for tourist activities. The potential for that should be evaluated and a program for its development seems to be an important issue.	An extended summer season may possibly lead to more tourists and therefore more local people engaged in tourism business; more frequent extreme weather events may influence attractiveness of the region. **RO:** Even though tourism seems to be an important source of income, this type of activity is closely connected to the main subsistence strategy, which is fishing. Furthermore, the tourist season only lasts for two months and so does this particularly work division and organization in the family.

Transport	Irregularities in navigation on the Danube River occur due to extremely low water level or freeze up of the main navigation ways. **MD:** Navigation is possible only on a 300m distance from the confluence of Prut River with the Danube. Plans for its development after this segment are under discussions. **RO:** In most of the areas the terrestrial transport network is improper or inexistent. On the channel system it is appropriate in medium or high water table conditions. The transport links to and from Tulcea to the inner delta have been improved in the last decade.	**RO:** The channel system will remain the main connection transport within DDBR. For the terrestrial transport development there is an immense necessary cost. However, the system will enhance the pressure on natural areas. **UA:** Sea level rises can be expected to affect ports and infrastructure; more often low flow period may affect navigation at the Lower Danube; if flood protection dike collapses, it could destroy motor road Reni-Izmail.

Key sectors	What is happening now	What could happen further
Fisheries and aquaculture	**MD:** Fishing can become more intensive due to longer season and lower water can cause worsening of the habitat for the fish spawning, larvae deposition and protection.	Invasive species may become more significant in the catches.
	RO: Anadromous migratory fish is important to the Delta fishery and three species of sturgeon and Danube herrings are netted as they move upstream from the Black Sea to spawn in freshwaters. The herring is caught between April-June and catches vary from season to season. The fluctuation may vary between 200-2,400 tonnes per annum. Sturgeons are declining in numbers and catches of 300 tonnes in 1960 had fallen to 6 tonnes in 1994. There is no doubt that the construction of dams, Iron Gates in 1970 and Ostrovul Mare in 1984, near Drobeta-Turnu Severin interrupted the upstream migration of sturgeons. But they are able to reproduce below these dams as well, and a programme of breeding and re-introduction is being carried out to boost their numbers. These efforts need to be combined with effective controls of poaching and overfishing.	**RO:** The sturgeon population will decrease because of climate changes and human pressure. The diversity and structure of the fish community varied among lakes and can be regarded as a good indicator of the ecological state of lakes. The diversity of fish fauna is explained by changes in hydrology and water quality with effects on fish community distribution.
	UA: Earlier beginning of the fishing season due to less ice events; longer fishing season.	

Climate change impacts on human health

Availability of complex medical care is rather poor in rural areas. The number of TBC patients increases every year. The Danube Region of Ukraine is characterized by high mortality rates, frequency of oncologic diseases, diseases of gastrointestinal and blood circulatory systems exceed the corresponding figures for Odessa region. High mortality in the area is caused by a low income level, no access to medical services and low-quality drinking water.

Few rural settlements in Moldova and Ukraine are connected to a centralized water supply and there is a 60-70%, and 50% deficit of drinking water respectively. Especially difficult situation is in Gagauzia – till 80%. In Romania the water supply system is inappropriate in some settlements. Most of the consumption is sustained by bottled water brought from outside of the Danube Delta.

Key issues	What is happening now	What could happen further
Floods and health	**RO:** In the last decade several infectious diseases with high infecting potential on humans were recorded. Most of the viruses are dependent on wetland conditions and certain host species. **UA:** The risk of infectious diseases spreading increased due to the inundation of the drinking water pumping station in Reni in 2005 and 2011, caused by flash floods.	**RO:** Increasing of pandemic frequencies and more resistance or large host's spectrum of the viruses. **UA:** Greater health risks connected with extreme floods (injuries, drowning, heart attacks, consumption of low-quality drinking water, etc.). The increased risk of dams failing on the small rivers may lead to large number of victims in case of severe rainstorm-caused flash floods.
Extreme temperatures and health	There has been an increase in cases of cardio-vascular and respiratory diseases supposedly because of more days with extreme temperatures; higher risk of health disorders resulting from worsening economic problems due to climatic changes.	Higher risk of cardio-vascular and respiratory diseases because of more days with extreme temperatures.

Key issues	What is happening now	What could happen further
Drinking water		Further worsening of water quality in both surface and groundwater sources may lead to a variety of medical, social and economic consequences. **RO:** There is already a deficit of water supply. Climate change effects will increase the pressure at regional level. The increased water consumption will generate extra costs.
Vector-borne diseases	**RO:** West Nile virus and other diseases are recorded as present in Danube Delta. A few decades ago, the reported incidences of human diseases associated with fish pathogens were rare and limited to certain countries, mainly due to their habits and lifestyle and thus little attention was paid to fish pathogens.	**MD, UA:** Appearance or more frequent outbreaks of vector-borne diseases (e.g. malaria). **RO:** Viruses could occur more often and their resistance to the wetland conditions could increase.

Water- and foodborne diseases	**MD:** Worsening of the sanitary conditions due to the floods (Lower Prut region) can be expected. **UA:** During floods the population is cut off from centralized water supply, which leads to depreciation of sanitary conditions and spread-out of enteric infections.	**UA:** An increase in diseases caused by consumption of low-quality drinking water, particularly during floods (cholera, hepatitis, leptospirosis, rotovirus infections). Local impacts can be caused by intense toxic algal blooming in drinking water sources.

Pilot settlement in the Danube Delta: Vilkovo Town

Vilkovo town has been selected as a pilot site to show how the climate change would impact local communities that depend on the natural resources of the Danube Delta.

The town is situated in the most downstream location, «inside» the Delta. There are no hydrotechnical constructions to protect Vilkovo from flooding from the Danube River. For this reason the town may be potentially among the most vulnerable to climate change, particularly, to changes in the Delta's hydrological regime.

In this section we analyse how the climate change would impact the town and how the main economic activities of Vilkovo's population depend on natural resources of the Delta.

Currently about 7,000 people reside in Vilkovo while as far back as 20 years ago (at disintegration of the USSR) the town counted at least twice as many inhabitants.

Vilkovo's decline is due to a sharp reduction in employment opportunities. There are only about 1,700 full-time jobs currently available in the town and 1/3 of them are on the brink of being cut in the near future. About 500 of these jobs are provided by local industries, 400 in fisheries, the others are jobs in the field of trade, services, medicine, education, nature conservation and civil service. In addition, some people are employed unofficially or work within their households without any registration of labour activities. The town industry virtually disappeared.

Apart from enterprises, the risk zone includes a relatively new and potentially productive reed business (harvesting, processing and exporting «roofing» reed) which recently provided about 1,000 seasonal jobs for Vilkovo mainly during the critical winter period. Recently local reed harvesting enterprises exported 1,200,000 bundles of reed, which is up to 10% of the global reed market. Main customers of the locally produced reed are thatching businesses in the Netherlands and Germany. During the season of 2011-2012 only half of the above mentioned quantity was produced. Additionally to the natural reasons (large-scale fires in the reed-beds), the cause of such sharp decline is a growing number of various permits, agreements and other legal acts required for reed harvesting exporters. Should trends go in the same direction the reed harvesting business for export may disappear in Vilkovo in 4-5 years.

TOURISM IS RELATIVELY NEW BUT FASTLY GROWING INDUSTRY FOR VILKOVO

Fishing is a traditional source of income in Vilkovo. The relatively new tourism industry emerged but nowadays these are, most probably, far from required standards. Their contribution to the actual budget of the town and the population's income is relatively small. Though the region has good prospects for tourism development, the industry revenues (classic tourism, without recreation) will hardly exceed 10% of the gross domestic product of Vilkovo. The importance of the fishing industry in its classical meaning will gradually decrease because of a steady reduction of fish stock in the Danube and a stable and global re-orientation of the fishing industry, particularly fresh-water fishing, to artificial fish breeding farms.

Service industries have some potential for the Vilkovo residents. First of all these are linked to the construction and maintenance of cottages, as well as maintenance and management of small size vessels and other facilities for water recreation activities. The main constraint for the successful development of these services is the inadequately high land rent costs.

Thereby, if the social and economic processes in the region and in Ukraine as a whole will develop according the existing trends, only about 1000 full-time jobs may remain in Vilkovo, which correspond to about 3-5000 of permanent population, taking into consideration significant aging of the population. The town might step-by-step transform into a small fishing-recreational-tourist settlement.

In conditions, when ratio of direct or indirect utilisation of limited extent of natural resources in social and economic development of Vilkovo has significantly grown, the town becomes crucially vulnerable to the present and expected effects of climate change, especially to changing hydrological conditions.

<table>
<tr><th>Key sectors</th><th>What is happening now</th><th>What could happen further</th></tr>
<tr><td>Safety and infrastructure of Vilkovo</td><td>Vilkovo is the only town among all riverside settlements in the Ukrainian Danube Delta which has no protection against flooding. On the opposite bank of the Kiliya branch (Romanian side of the Danube) the flood protection dyke by-passes Vilkovo to as far as the sea (to the seaside Mussura lagoon). It makes the town very susceptible to any fluctuations of the water level in the river.

At the same time, the water level regime in the river near Vilkovo depends on several natural factors:

– changes of water level in the river caused by its seasonal and “rain caused” flash floods;

– changes of water level in the river caused by wind-caused fluctuations.

– loose ice accumulations at the outlets of the main Delta branches leading to the sea is still another factor which takes place very rare, but causes catastrophic rises of water level in the Vilkovo area.</td><td>Possible threats for Vilkovo which are associated with the climate change are, basically, connected with a change of water regime in the Danube.

Undoubtedly, with the course of time when the climate becomes warmer together with all associated hydrological changes, the issue of Vilkovo protection against floods will be imminent. Higher average water level in town channels will facilitate an accelerated settling down of Vilkovo in soil. Indeed, the main town territory is located on a thick layer of muddy river sediments which, due to their physical and mechanical properties and with higher water saturation, makes the town susceptible to flooding which can easily destroy buildings and constructions. This fact will also increase, to a certain extent, the risk of under flooding of the area. Of special significance is the Belgorodskiy channel.

A certain threat is presented by the more and more frequent rise of salt seawater during strong win-caused water level fluctuations. It will become a necessity to have a protection flood gate (lock-type) at the town water intake in order to avoid regular inflow of salty water into the town municipal water supply pipeline or to shift to another source of water supply for Vilkovo (not from the river).</td></tr>
<tr><td>Crop seasons</td><td>Fruit-farming and vegetable growing, including growing of strawberries, in Vilkovo area are losing their importance because of an extremely high labour intensity, fragmentation of the sites, difficulties to access them (the sites are located, primarily, on islands) and an impossibility to use modern equipment.</td><td>In terms of the observed and forecasted weather and climatic changes in the Danube Delta it is expected that the vegetation period will commence earlier and the general vegetation period will be longer. Concerning vegetable growing, it will actually become possible to harvest two crops, particularly potatoes, as well as early and late vegetables which are more convenient from an economic viewpoint. The stable position in home gardening will gradually be occupied by more warm-season crops, primarily figs and persimmon, and later, possible pomegranate and tangerines.</td></tr>
</table>

Key sectors	What is happening now	What could happen further
Reed businesses		Climate change will cause deterioration of quality of reeds used for roofing. Gradually, it will have larger but weaker stem. What is more, the general productivity of reeds will be higher because of the longer vegetation period. It will make additional pros to use reeds as a renewable natural energy resource.
Rice farming		Due to artificial and complete regulation of the rice-growing farms, this activity will be less susceptible to the risk associated with the observed and forecasted weather and climatic changes in the Danube Delta. Without any doubt, the longer vegetation period will benefit this crop within longer growing period and reduced losses caused by late harvest.
Fishing		Two main trends are expected for the fishery near Vilkovo: the fishing season will last longer, as the "ice" period becomes shorter in the Delta water basins and as the herring fishing season, so important in the Delta, will take place earlier. In the long-term perspective it is very possible that warm-loving invasive species will be introduced in the Delta due to climate change, including the commercial species.

Bee-keeping		Bee-keeping in the Danube Delta floodplains will benefit as a result of climate change. However, the adjacent continental territories will experience a longer warm season including a late autumn, which will have an adverse effect on bee-keeping. Prolongation of the active period of bee colonies until late autumn, in the absence of flowering plants (as distinct from Delta areas), will wear and weaken bee colonies.

ADAPTIVE CAPACITY

Hydrometeorological records and climate projections provide abundant evidence that natural resources are and will be strongly affected by climate change, with wide-ranging consequences for society and ecosystems. However, climate change can also have positive local consequences, such as a prolonged growing season. But both negative and positive effects of climate change require the ecosystems and especially human activities to adapt to them. In this context such parameters of both social and natural systems as adaptive capacity (adaptability) should be assessed and analysed. The adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities or to cope with the consequences (IPCC, 2007a).

Socioeconomic development

Only 65% of the population in the Romanian part of the Delta is connected to public water supply networks, which is very low in comparison with the European average.

Ukraine is aging nation: aging coefficient is more than 18%. Birth rate in the Ukrainian Danube Region was twice lower in 2000 than in 1900 but since 2005 there's slow trend to growth, as a response to greater benefits (USD 3400) paid at a child birth; this remuneration increases with the birth of the next child in the family.

The Danube Region of Ukraine is characterized by high mortality rates, frequency of oncologic diseases, diseases of gastrointestinal and blood circulatory systems exceed the corresponding figures for Odessa region. The number of TBC patients increases every year. High mortality in the area is caused by a low income level, inaccessible medical services and low-quality potable water.

The remoteness of the Ukrainian part of the DDR, the relatively low income of local population and living standards (especially in rural areas), high level latent unemployment and lack of opportunities for employment at the local level make the region critically vulnerable to climate change and its possible social and economic consequences. At the same time, poor living conditions and significant dependence on natural resources and own labour can characterize local people as more flexible to changing conditions.

The relatively low income of local population in Moldova and limited opportunities for employment cause large labour migration from the region to urban areas in Moldova and abroad. Since the main occupation in the region is agriculture and further climate change can worsen agricultural conditions in the region, one could expect further worsening of living conditions in the area and deterioration (damage) of the infrastructure (houses, roads, etc.). Maintenance will need more resources and the lack of resources could lead to more intensive emigration of population from the region.

Infrastructure

The ecological balance of the Danube River has suffered alteration processes because of the continuous development of human society. The natural environment and landscapes have been destroyed and instead industrial structures were created with economical purpose such as navigation, hydro-energy, agriculture, harbours that are damaging the Danube River by losing the floodplains and its natural morphological structures. In this context the necessity of enhanced measures for ecological restoration is an inevitable consequence of ecosystem degradation at functional and structural level.

Management and use of water resources in the Danube region are primarily based on a departmental and industry-wise approaches and do not meet the principles and methods of integrated management. The region has no comprehensive inter-departmental strategy of permanent water use aimed at preservation of water resources and their quality. The approach prevailing in water use is oriented on one consumer, which complicates development of appropriate water quality standards for various water uses, and generates conflicts among users.

Although both the Land and the Water Codes exist in Ukraine and the Republic of Moldova, some of their provisions are not implemented because of outlawry and the lack of funding.Absence of the integrated management of water resources and inefficient methods of water use bring plenty of social problems. The region currently faces a crucial situation regarding potable water supply.

The existing flood protection constructions along the Ukrainian and Romanian river bank do not guarantee protection of territories against flooding in case of high and catastrophic floods.Higher intensity and frequency of floods, pollution of the Danube and its tributaries resulting from emergence discharges of pollutants necessitate the development of a transboundary comprehensive system of risk management and coordination in emergencies and flood warning.

Effective transboundary monitoring is needed to make the basis for adoption of management decisions in the boundary regions of Ukraine, Romania and Republic of Moldova. National hydrometeorological monitoring systems in the boundary areas are in a critical condition because of short state funding, morally and physically obsolete equipment and obsolete methods of observation, sampling and analysis of samples (in Ukraine more than 90% of the instruments are applied with a prolonged service life certificates and about 50% need to be urgently replaced; there are practically no modern automated technologies to make observations, hydrometeorological forecasts and support) This is particularly topical for Ukraine and Moldova.

Formerly well-developed irrigation infrastructure is still in place, covering almost 25% of the area of the Ukrainian part of the region. It consists of 3 independent irrigation systems, divided into 40 separated irrigation sections. During the Soviet period the electricity costs for operating the irrigation systems were covered by the state. Now, when resources are expensive and large-scale agricultural production units are absent, many of the irrigation systems are not used, some being totally abandoned. This infrastructure can become one of the key resources for the region's adaptation to climate change under the condition that it will be restored and rationally managed with the governmental support.

Currently modern water-saving methods of irrigation are being introduced (e.g. drip irrigation). The soviet irrigation system in Moldova was based on the reservoirs constructed on the Yalpugh river. At the same time high TDS did not allow their use and therefore, there is no irrigation in the Yalpugh basin (small areas are irrigated from the wells). The Lower Prut irrigation system is under reconstruction with assistance from the WB. By the year 2015 around 25 ha are going to be irrigated from the Prut water resources with irrigation norm 2-3 th/m^3/year.

People

The local population has specific labour skills which have been formed during a long period of work in the region – people are engaged in fishing, marine industries, livestock farming, cultivation of vegetables and crops, including irrigation, rice growing, reed harvesting, hydrotechnical land development, hunting and provision of services to tourists.

Most skills of local residents (especially in rural areas) are closely linked to various types of use of natural resources. This can become crucial in the context of adaptation to climate change in case of severe alterations of availability of these resources.

The Ukrainian part of the region is characterized by a relatively high level of education (51,5% of people have full secondary education, 25,9% – higher education).

The population in the MD part is mainly involved in agricultural activities (>90%). Due to possible climate extremes the level of employment can drop. Some industrial enterprises (very small scale) have appeared in Comrat, Cahul and Vulcanesti, but their capacity to hire personnel is very low (lack of skilled personnel, old equipment, etc.).

As for the Romanian part of the region, agricultural activities have much smaller share, while traditional fishing and fish-farming has more local and regional value. Traditional fishing tools and techniques are preserved in wide extent in the Romanian part of the Danube Delta. Besides this, tourism industry is highly developed in the area.

Physical features

The largest storage facilities (grain, oil) are available at the ports of Izmail and Reni as well as in Kiliya.

A number of storages of expired pesticides and fertilizers exist in the region. Most of them are abandoned and do not provide safe storage of potentially dangerous substances.

A series of dams are constructed on all small rivers of the region creating a big number of fresh-water ponds and nowadays causing the degradation of small rivers and their basins.

A large-scale system of feeding and discharge channels and sluices exists in order to provide regulated water regime of the Danube lakes, which are used as a water source both for household and agricultural needs.

A continuous line of wire fencing is established on the flood protection dyke along the section of the Danube River from Reni to Izmail.

The oil terminal in Moldova's Djurdjulesti village has a capacity for 2 million tons of stock of oil products/year. Flood events in 2008 and 2010 caused damages and required dike maintenance costs (approximately 5 million MDL or 350000 euro).

Natural features

A wide belt of dykes and dried lands is located along the whole Ukrainian section of the Danube River. It was modified with the purposes of extension of agricultural activities in the region and flood protection of riverside settlements. Currently some of the agricultural polders are not used systematically or are totally abandoned. This suggests high potential for restoration of former floodplains with an increase of areas of wetland ecosystems, which are seen as one of the key elements of the Danube Delta's adaptive capacity to climate change.

The polders for cultivating agricultural crops were made in the 70s. They are actually used on 40-50% (Prut wetlands). It creates good opportunities for the wetland restoration activities in the region and potential sites for restoration were identified in the Prut and Yalpugh river valleys in the frame of the Danube Regional Project in 2007-2008.

In the Romanian part of the Danube Delta 58.2% of the area is in a natural state (river and marine levees with forests and pastures, canals, lakes, swamps – part of them protected). At the same time, many of the agricultural polders were abandoned because of an inefficient administrative system and are now turning into grazed meadows. Many revitalization projects were planned or realized in the Romanian Danube Delta without prior knowledge of their potential for success or failure. Those implemented contributed to the present understanding of river-floodplain systems and this experience should be used as a base for one of the main adaptation measures in the region – the restoration of former floodplain areas.

Finance

The four administrative districts composing the Ukrainian part of the study are characterized by relatively low indicators of investing activities, both nationally and internationally. Due to its remoteness the region is not considered a priority at the government level and in the context of regional development. For this reason lack of financial resources can become one of the most crucial constraints for the region to adapt to the effects of climate change.

In Moldova, the Lower Prut region is included in the Lower Danube economic area. For the last years financial allocations were made in order to improve infrastructure (roads, natural gas and water supply etc.). Due to the financial crisis and austerity measures the region suffers insufficient financing for projects and activities associated with climate change adaptation.

VULNERABILITY OF MAJOR GROUPS

Climate change is expected to have significant impacts on natural resources in the Danube Delta Region. All main social and economic sectors will be affected, but certain groups will be more vulnerable to these impacts than others and will have different needs. This should be taken into account while elaborating the adaptation strategy and plans.

Many residents of the region depend on the natural resources for their subsistence and income, such as reed beds, private vegetable gardens, fish, as well as agricultural activities as a whole. All these resources may be impacted both, negatively or positively by climate change. Furthermore, low living standards, poor levels of income, health, diversity and availability of local jobs can make socially disadvantaged people more vulnerable to the effects of climate change. People in rural areas are already more vulnerable than their urban counterparts to such events as droughts, floods and extreme weather conditions and are likely to be more affected by climate change.

The key (most numerous) vulnerable groups in the Danube Delta Region are determined by the structure of local economy and its main sectors – agriculture and fishery.

Major groups vulnerable to the effects of climate change in the Danube Delta Region

Exposure unit	Threat (adverse effect)	Location scale	Notes
Local population			
Farmers	Water scarcity results in reduced crop yields and less employment opportunities	All settlements of the Danube Delta region	Lack (insufficiency) of precipitation during vegetation period
	Damage of crops due to cold spells		Physical damage to crops caused by extreme weather events and natural disasters
	Damage of crops due to flash floods		
	Damage of crops due to fires		

Exposure unit	Threat (adverse effect)	Location scale	Notes
Fishermen	More frequent droughts lead to more fish mortality	Danube, Lower Prut	Drop in the water level in the Danube, sometimes causing a delayed spawning
	Increasing temperature leads to less fish breeding places	Danube lakes, Lower Prut lakes and artificial ponds in the Yalpugh river	Reducing the depth of the lakes due to increased evaporation, lack of oxygen
	Increasing water temperature leads to more frequent fish kills	Danube River, Danube Lakes, small inner water bodies Lower Prut lakes and artificial ponds in the Yalpugh river	Lack of dissolved oxygen
	Fish mortality in hibernation pits	Advanced Danube Delta and its small water bodies	Salinization of water due to sea level rise and sea water intrusion
	Low water table	The hydrological system of DDBR	Changes of vegetation structure and species composition. Limited fish resource and high pressure on spawning areas.

Local residents	Extreme heat waves lead to mortality and diseases	All settlements of the Danube Delta region and the Lower Prut region	Possible growth of cardio-vascular and respiratory diseases because of more days with extreme temperatures
	Increased costs for household maintenance		Increased costs for air conditioning, heating, increased water consumption due to temperature changes

Exposure unit	Threat (adverse effect)	Location scale	Notes
Local residents	Injuries, deaths	All settlements of the Danube Delta region and the Lower Prut region	Harm caused by extreme weather events and natural disasters
	Further decrease of living standards		Decreased local availability of natural resources. Low diversification of main economic sectors.
	Diseases, deaths	Riverside settlements	Harm caused by consuming water contaminated during toxic algae bloom
	Dykes failure	All settlements and economic areas of the Danube Delta region	Physical damage to crops caused by extreme floods events
Owners of buildings in potentially flooded area	Damage to/ destruction of buildings, infrastructure	Banks of all water bodies; areas under risk of flash floods	
Authorities, management bodies and businesses			
Management bodies	Damage of infrastructure	Whole Danube Delta Region	Damage caused by extreme weather events together with the increased resources and energy consumption.
Reed harvesting businesses	Decrease of reed yields due to sea water level rise and intrusion of sea water	Area of Vilkovo, SZP	Increased salinization may lead to lower productivity of reed-beds and lower commercial value of harvested reed
Administrations of RO and UA reserves	Unsuitable management plans in accordance with climate changes effects	Both sides of the Danube delta	Low efficiency of applied measures will conduct to more economic losses.
Navigation	Low water table	All navigable branches and channels of Danube Delta	Reduced traffic of large ships will result in a negative impact on the economy.
Forestry managers	Low wood production due to water shortages	All forested areas of Danube Delta	Additional pressure on natural forested areas.

Project "Climate proofing the Danube Delta through integrated land and water management"

The three-year project "Climate proofing the Danube Delta through integrated land and water management" involves three countries - Ukraine, Moldova and Romania. The project is implemented with the support of the International Commission for the Protection of the Danube River (ICPDR). The premise of the project is that the common approach for solving a common problem will be more effective than the individual targeted efforts of each country. After all, nature does not recognize borders and the Danube Delta represents an integrated ecosystem, albeit divided by law between the three countries.

The project goal is to lay the foundations for timely and thorough adaptation of Ukrainian, Moldovan and Romanian territories of the Danube Delta region to the conditions of the changing climate. The adaptation to the new environmental conditions must be integral and systematic and must happen at all levels, including administration, local business, municipalities and ecosystems.

A comprehensive study of the possible impact of climate change on the Danube Delta has been carried out. Based on the findings, a **trans-boundary Climate Change Adaptation Strategy** for the Danube Delta is developed to achieve the goal of the project. The two documents will help the governments and environmental organizations in the three countries to comprehend the general picture of the expected changes and the necessary activities to adapt the region to them. Thus, the foundations of a complex solution will be established, which will be more effective than separate actions for climate adaptation.

One of the effective adaptation measures may be **the restoration of the wetlands** in the Danube Delta which have been significantly destroyed in the past 50 years. Wetlands represent a natural buffer system, which can adapt to changes and mitigate the impact of severe weather conditions. They help water purification, increase soil fertility, act as "kindergartens" for juveniles of valuable fish stocks and help the regulation of the water levels of the Danube. The project includes a model restoration of wetlands within the Ukrainian part of the Danube Delta.

The training of qualified staff is an important part of the project. Thematic trainings will be carried out which will help the local administration, municipal governors, businesses, farmers and fishermen to understand the possible meaning of climate change for the region and how the new environmental conditions may become beneficial.

An **extensive awareness raising campaign** about climate change adaptation, which will be carried out in 20 settlements of the region, will demonstrate to local people ways to solve climate related issues for the benefit of the region.

The project will also help local municipalities to reduce greenhouse gas emissions by the use of biomass instead of fossil fuels as a source of heating. A pilot project for the generation of "green" energy from reeds and shrubs biomass will be implemented in the Ukrainian part of the Danube Delta. Harvesting of the biomass will contribute to the restoration of wetlands and become a new source of income for the local business and people. After the implementation of the pilot project, stakeholders will be involved in trainings and meetings in order to exchange experience on the implementation of such projects.

Find out more at wwf.panda.org/dd_climate_adaptation

Project partners

«Center for Regional Studies» (Odessa, Ukraine)

The Centre for Regional Studies is a non-governmental and non-for-profit organization founded in October 1998 in Odessa by a group of researchers, public officers and experts in regional development. The centre's goal is to facilitate sustainable development of the Odessa Oblast and the Ukrainian Black Sea Region through research and professional project management in various fields of regional development.

Danube Biosphere Reserve (Ukraine)

The Danube Biosphere Reserve is an independent environmental research institution located in the extreme south-west of Ukraine, in the Killia and Tatarbunar regions of the Odessa Oblast. The administrative office is located in Vilkovo. The Danube Biosphere Reserve aims to solve major environmental problems of the surrounding region. It is made of an active research department integrated with an ecosystem-monitoring department; it services the ecological state of the reserve, as well as the Department of Environmental Education and an eco tourism company in Vilkovo. The reserve is subordinate to the National Academy of Sciences of Ukraine.

Danube Delta Biosphere Reserve (Romania)

The Danube Delta Biosphere Reserve Authority in Tulcea is the public institution established in 1990 with the purpose of implementing a special administration regime of the natural heritage belonging to the national interest public domain of the Danube Delta Biosphere Reserve, in order to preserve it and to reconstruct degraded habitats, in parallel with economic activities of the local population.

The main objectives followed by the Danube Delta Biosphere Reserve Authority in the ecological management of the reserve territory are: to preserve and protect the existing natural heritage; to promote the sustainable use of the resources generated by the natural ecosystems of the Reserve; to ecologically reconstruct the areas degraded by the human activities impact.

NGO «Ecospectru» (Chisinau, Moldova)

NGO Ecospectru has participated in projects supported by the World Bank, UNDP, UNEP and WWF Romania on biodiversity conservation. The NGO has participated in the elaboration and implementation of the National Strategy and Action Plan on biodiversity conservation, has published 5 monographs in the field.

World Wide Fund for Nature (WWF)

WWF is one of the world's largest and most respected independent conservation organizations, with almost five million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the earth's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

The European Union is made up of 27 Member States who have decided to gradually link together their know-how, resources and destinies. Together, during a period of enlargement of 50 years, they have built a zone of stability, democracy and sustainable development whilst maintaining cultural diversity, tolerance and individual freedoms.

The European Union is committed to sharing its achievements and its values with countries and peoples beyond its borders.

This publication is an output from the project “Climate proofing the Danube Delta through integrated land and water management” implemented with the financial support from the European Union. The views expressed are not necessarily those of the EU.