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Climate vulnerability assessment for the Prutul de Jos biosphere reserve

Synthesis report and recommendations for adaptation

Geneva – Chisinau – Cahul
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1 CONTEXT AND KEY FINDINGS: EXECUTIVE SUMMARY

On 1 March 2019, following a proposal by over 70 countries worldwide, the United Nations General Assembly proclaimed the UN Decade on Ecosystem Restoration. “Preventing, halting and reversing the degradation of ecosystems worldwide” is the motto of the now ongoing UN Decade, which is to end in 2030. This is also the deadline for the Sustainable Development Goals and the timeline scientists have identified as the last chance to prevent catastrophic climate change.

The Republic of Moldova[1] already sees climate change and experiences its impacts in many ways, and the south of the country feels it strongly. The Lower Prut area, home to unique wetland and lake ecosystems with numerous valuable and threatened species, is facing hotter and drier weather, less water in rivers and lakes, and more severe extremes ranging from unpredictable floods to devastating forest fires. Over 100 species in the Lower Prut or Prutul de Jos biosphere reserve (PJBR) are particularly vulnerable to climate change, and to help them survive targeted measures will be needed. Fragile habitats will need to be protected, where possible expanded and connected together. Research and continuous monitoring will be needed to better understand the threatened species, populations and their environment. Special care needs to be taken of Beleu and Manta lakes at the heart of the reserve in order to maintain their decreasing water levels and to counteract other – often unrelated to climate change – existential threats to these unique bodies of water from excessive siltation, waste, poaching and even extraction of oil. A changing climate will also alter people’s living conditions and livelihoods, and the inhabitants in nine PJBR villages are to find ways to build more sustainable and climate-resilient lives. That may mean changes to how agriculture, tourism, trade and other activities are organised and practiced, water and other services are provided, and communities and the Cahul district develop as a whole. Talks with local residents clearly demonstrate that they are aware of these challenges and are willing to face them, but they need help, inspiration and resources.

This report summarises the results of a climate vulnerability assessment for the PJBR area, organised as part of the Austrian-funded project *Enhancing climate resilience in the Biosphere Reserve "Prutul de Jos”*. The assessment is based on a series of thematic reviews of the current situation, trends and issues at stake from various perspectives, such as hydrometeorology and natural disasters, species and ecosystems, economics, livelihoods and social issues. The study also incorporates the results of a survey among the residents of PJBR communities concerning their perspectives of the PJBR, climate issues and trends in the region, and measures to address them.

Combining international experience with local perspectives and priorities, the study proposes a package of 38 adaptation measures for the PJBR and its communities. A preliminary assessment of the cost of the measures indicates the total cost of about 30 million euros, including 5 million euros for the recommended fast-track actions. It is expected that the study can help guide further interventions in the area, including those financed the Austrian Development Agency (ADA) with funds of Austrian Development Cooperation (ADC), thus bringing together the necessary energy and resources to climate-proof the future of the PJBR, its ecological systems and its people.

The study also calls for creating and reinforcing synergies among the various efforts to protect the nature of the Lower Prut and to adapt to the impacts of climate change nationally in Moldova, regionally in the Lower Danube region and the Danube and the Prut river basins, and across the borders with Moldova’s neighbours Romania and Ukraine.

[1] Hereinafter for the sake of brevity referred to as Moldova.

2 LOWER PRUT AREA AND THE PRUTUL DE JOS BIOSPHERE RESERVE

The Prutul de Jos biosphere reserve, one among more than 700 similar reserves of UNESCO World Biosphere Reserve Network, is the first of its kind in Moldova. It was established in 2018 with the purpose to preserve physico-geographical elements and formations, ecosystems, and plant and animal species of national and international importance, to carry out research contributing to the global monitoring system, and to ensure environmentally sustainable economic and socio-cultural development, accumulation and transfer of knowledge and environmental education.

The area enjoys multiple designations with respect to nature conservation, as it includes a scientific reserve operational since 1991, a site designated in 2000 under the Ramsar Convention on Wetlands of International Importance, and Vadul lui Isac Natural Forest Reserve. The Lower Prut scientific reserve and the Ramsar Site are part of the Emerald Network under the Council of Europe's Bern Convention on the Conservation of European Wildlife and Natural Habitats.

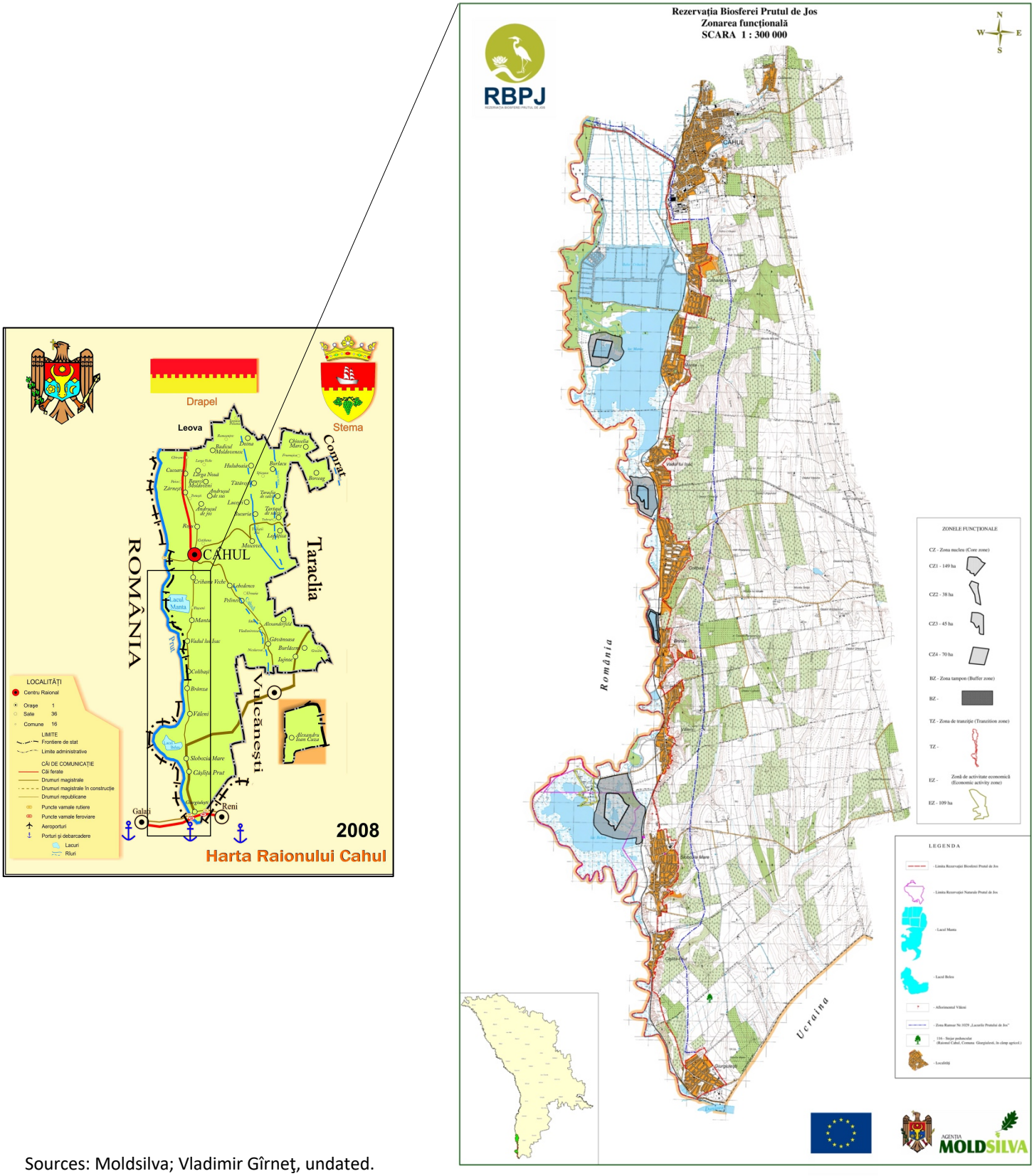
The PJBR protected areas and their conservation functions are managed by Moldsilva State Forestry Agency which presided over their creation and, together with the national Academy of Sciences, ensures their management by technical staff, draws up and implements management plans.

Lakes Beleu and Manta are unique ecosystems at the core of the PJBR, described as the last natural floodplains in the Lower Danube region. The whole area is important for groundwater recharge, flood control and sediment trapping, and supports an imposing list of rare and threatened species of flora and fauna. A number of heritage sites can be seen here too, including some of Roman Emperor Trajan's wall (ca. 100 AD), and altogether PJBR resources offer a strong potential for developing cultural and ecological tourism.

The PJBR area covers nine municipalities of the Cahul district of Moldova (figure 2.1), which are among the few in the country to be organised into a local action group (Lunca Prutului). The main occupation of the 30,000 population remains agriculture, and their livelihoods also depend on local resources such as fish and wildlife. However fish harvests have been decreasing in recent years, forests are generally seen to be deteriorating, and quite a few adverse conservation factors requiring attention include environmental pollution, e.g., with untreated wastewater, eutrophication, salinization of soil, over-harvesting of natural resources and, not least, the development of oil extraction at lake Beleu at the heart of the protected area.

From north to south the PJBR area is crossed by R-34 highway Hincesti-Leova-Cahul-Giurgiuleşti, which forms the main transport axis. Transversal connection is also provided by R-38 national road Vulcăneşti - Cahul - Taraclia. In the south the area is crossed by M3 international road Chişinău - Cimişlia - Vulcaneşti – Giurgiuleşti, then crossing to Ukraine. There are also railway stations at Colibaşi and Giurdiuleşti. The River Prut forms the western border of the area, as well as the state border with Romania. Danube is an important axis too.

The Cahul district to which the PJBR belongs is part of the Lower Danube Euroregion, which also includes the neighbouring counties in Romania, two other districts in Moldova and the Odessa oblast of Ukraine. Among the Euroregion's priorities are various forms of cooperation, promoting green tourism and protected areas (which exist in near-border areas of all three neighbouring countries and could benefit from stronger cooperation and interconnectivity). The region's population also benefits from a special agreement about border trade with Romania.



Sources: Moldsilva; Vladimir Gîrneţ, undated.

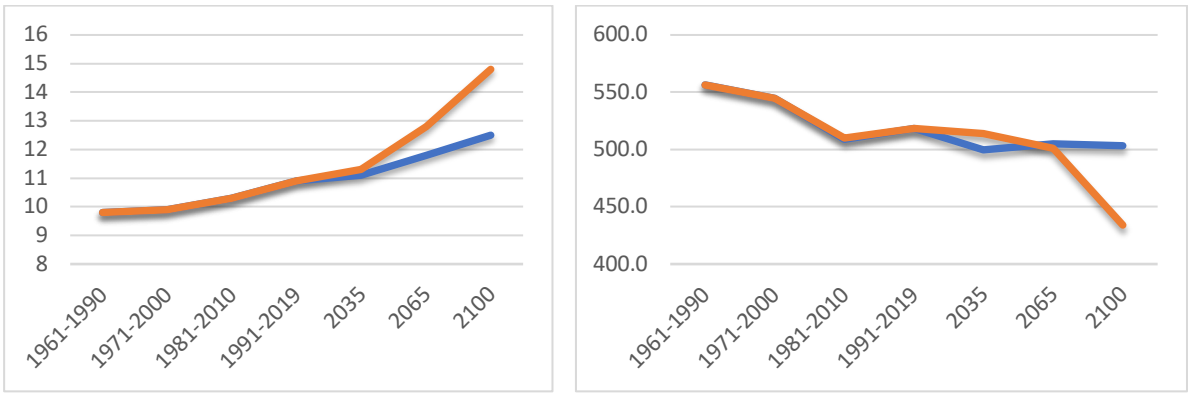
Figure 2.1 Maps of the Cahul district and Prutul de Jos biosphere reserve

3 CLIMATE CHANGE, ITS WEATHER AND HYDROLOGICAL IMPACTS[2]

Climate change has become a reality, and within the PJBR area it follows the patterns characteristic of the south of Moldova as well as the delta of the Danube. The past and likely future changes in the Prut river basin are similar to those in the basin or the neighbouring Dniester, also starting in Ukrainian Carpathians, and in the much larger basin of the Danube.

Throughout the 20th century, the global average annual temperature increased by 0.6°C. At 0.3°C in Romania the increase was below the global average, while in Moldova it was 0.9°C, that is 0.3°C above the global average. In the thirty years between 1981-2010 the average annual temperature in the PJBR area increased by 0.5°C. In 1991-2019 compared to 1961-1990, while the average seasonal temperatures in the region increased by 0.7°C winter, by 1.1°C in spring and by 1.7°C in summer and autumn. Climate projections indicate a likely increase of temperatures in the next 80 years for all seasons, with some exceptions in winter.

There has been an increase in the amount of annual rainfall over Moldova by 0.6 mm / year during 1891-2019. At the same time there has been an opposite trend in the PJBR, with a slight decrease of about 1.38 mm / year. These trends are however weak compared with the high variability of annual as well as seasonal rainfall. Yet overall, according to global climate projections, a decrease in annual (figure 3.1) and seasonal precipitation is expected in the next 80 years, though not as dramatic as in the case of rising temperatures.



Data source: UNEP, 2018b. Note: global climate projections RCP 4.5 (blue) and RCP 8.5 (orange)

Figure 3.1 Average temperature (°C, left) and annual precipitation (mm, right) in Cahul

During 1961-1990 the dryness and heat were on the average observed in the area for about 8 days a year, and for over 12 days in the period 1981-2010. In certain years, e.g., in 2015 heat duration 7-8 times exceeded the multiannual average, reaching 40 days in PJBR area and even higher at specific locations (figure 3.2). This has led to longer and more severe droughts.

Similarly, evaporation has increased during 1961-2019 from about 950 to more than 1050 mm / year. The annual loss of 100 millimetres of water can be critical for small water bodies, capable of entirely depleting them.

[2] The content of this chapter is based on (Bejenaru, 2020) which also includes detailed references to information sources.

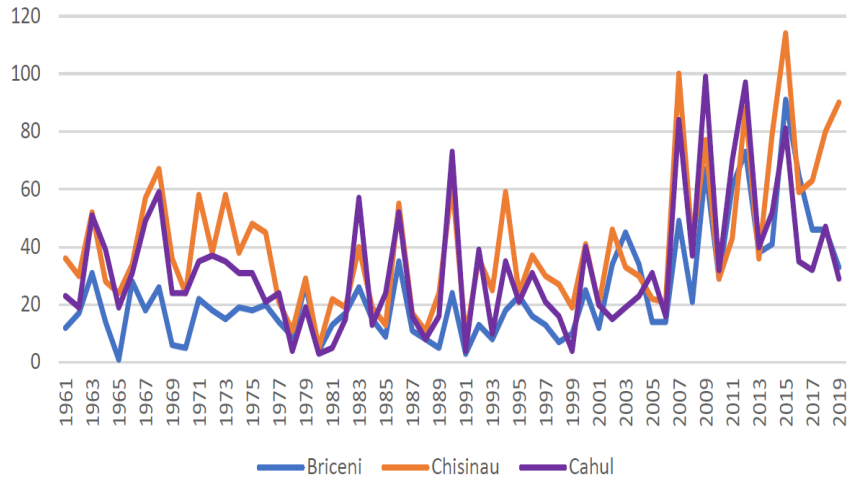


Figure 3.2 Change in the number of dry days in various parts of Moldova

Data source: Nedealcov, 2020

On par with drought (which in 2010-2020 occurred 41 localities in the Cahul district, further on referred to as 'cases'), the most frequent natural hazards in the area during the last ten years (figure 3.3) have been torrential rains and heavy hail (respectively, 50 and 49 cases). The highest economic damage was caused by frost (94,9 million lei), torrential rains (78,3 million lei) and drought (70 million lei). There are no precise data about natural or man-made forest or grass fires, however judging by the frequency of news in the media and the increase of alerts by the State Hydrometeorological Service during the last decade their number has considerably increased too.

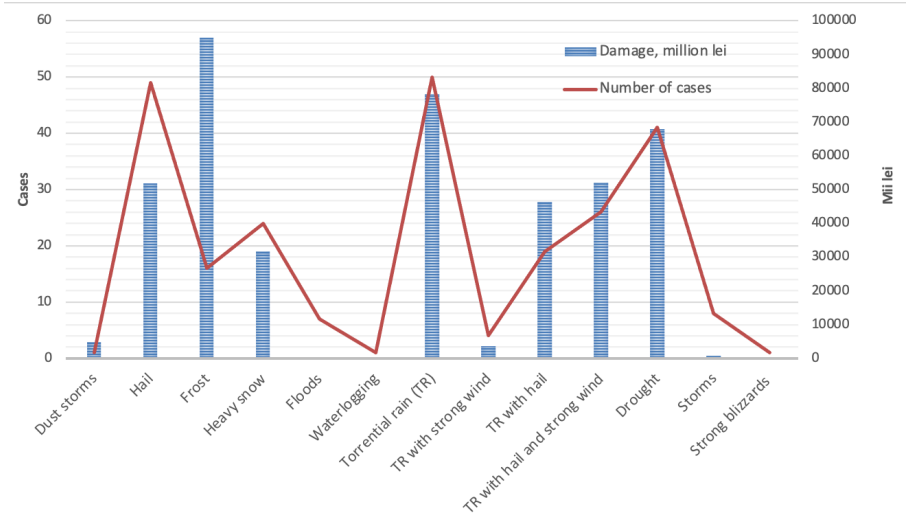


Figure 3.3 Cases of natural hazards and damage from them in the Cahul district, 2010-2020

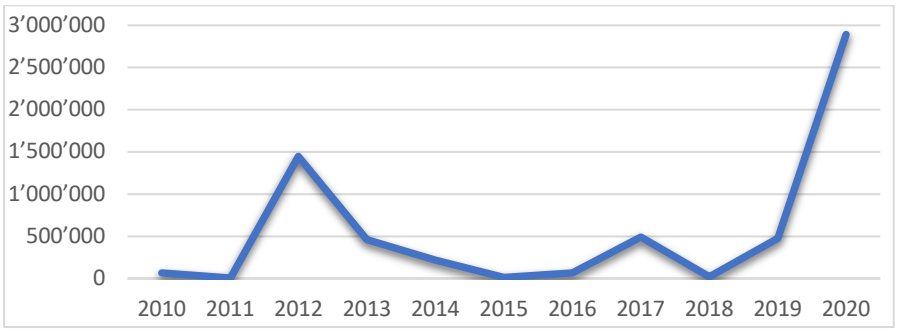
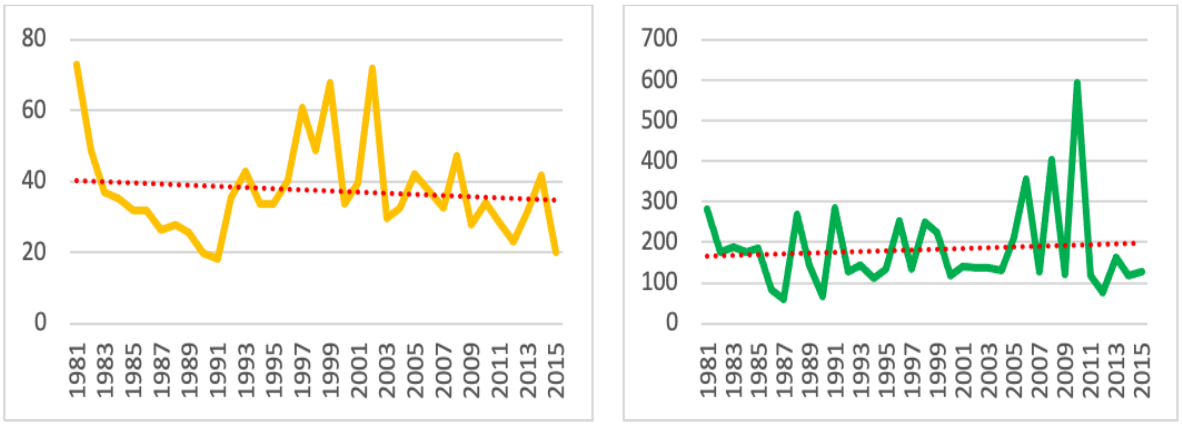


Figure 3.4 Damage from natural disasters in the Lower Prut region, USD

Data source: General Inspectorate for Emergency Situations under the Ministry of Internal Affairs

Water resources in the PJBR are formed predominantly by the Prut, less by local drainage through ephemeral watercourses fed by abundant precipitations with variable occurrence and intensity. The flow of the Prut is formed in the Ukrainian part of the Carpathian Mountains, and against the background of droughts and low flow in rivers formed within Moldova the hydrological regime of the Prut is characterized by high flow and floods. There is no monitoring of water flow in Moldova near PJBR (only water level is monitored), therefore the hydrological regime of the Prut can only be assessed in quantitative terms based on data from the Ungheni hydrological station located upstream (figure 3.5)[3].

The maximum flow at Ungheni is measured in July with the average of 594 m^3/sec. The minimum flow of approximately 20 m^3/sec is recorded during cold months. Lacking actual observations and based on modelling, the average annual flow with a 1 in 2 years return period (approximately an average runoff) in the lower course of the Prut adjacent to PJBR is 75,8 m^3/sec. Average annual flow with a 3 in 4 years return period (corresponding to a dry year) is 50.5 m^3/sec, and the average flow with a return period of 19 in 20 years (a very dry year) is 35 m^3/sec. During 1981-2015 the average flow was decreasing at the relatively slow rate of 0.12 m^3/sec per year. The minimum flow decreased in the same period more significantly, at 0.17 m^3/sec per year, while the maximum flow annually grew by 0.98 m^3/sec. These trends are in line with runoff studies in the Carpathians.



Data source: State Hydrometeorological Service

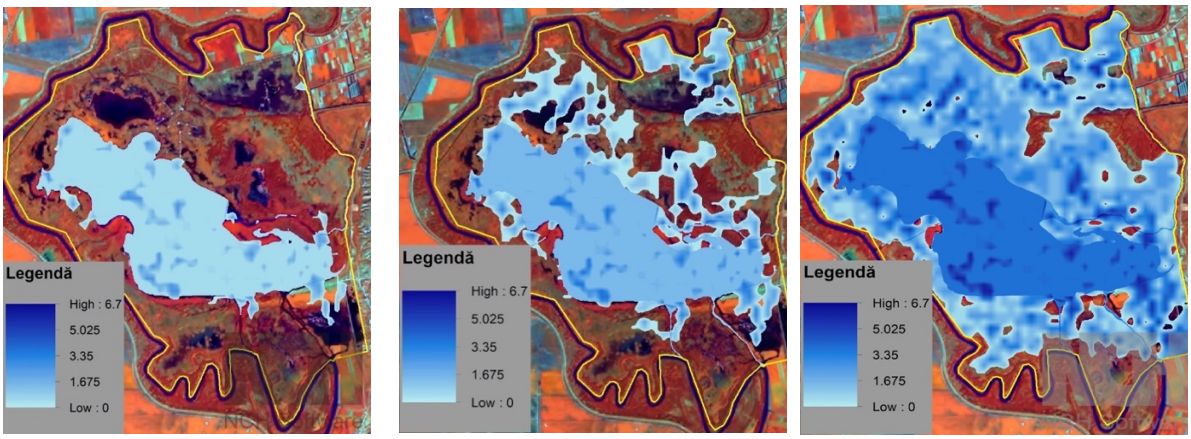
Figure 3.5 Minimum and maximum flow of the Prut at Ungheni, m^3/sec

The Costești-Stânca hydropower plant upstream of the PJBR regulates the flow of the Prut by redistributing it over time. High floods are therefore intercepted and flattened. Nonetheless, heavier rainfall in summer caused strong floods in 2008, 2010 and 2020. Excessive logging and the resulting deforestation in the Carpathian Mountains also contribute to the rapid concentration of runoff which generates powerful floods. On the other end, the frequent advances of Danube waters through the Prut riverbed, reaching as high as upstream of Cahul, also can considerably increase water level in the river and, consequently, in Beleu and Manta lakes connected to it.

Local intensive rains can flood the Prut floodplain too, reaching it through ephemeral and perennial watercourses[4].

[3] Data collected by Romania could possibly be used too, but obtaining them would require additional efforts.
[4] This is a very little studied phenomenon in the area. The maximum daily amount of local intensive precipitation was recorded in September 2013.

The projected steady reduction of the average runoff will threaten water levels at Beleu (figure 3.6) and other floodplain lakes within the PJBR. With evaporation already high and growing, the loss of water will unavoidably exceed its supply irrespective of frequent floods on the Prut and the periodic advances of Danube water. Furthermore, while water quality of the Prut remains moderately polluted, in the lakes it is additionally affected by local pollution from surrounding areas, while the decreasing water levels reduce the lakes' receptive capacity. Water quality in lake Manta is already qualified as poor[5], and is to decrease further as temperature and evaporation rise.



Source: Institutul Național de Cercetare - Dezvoltare "Delta Dunării", 2020

Figure 3.6 Lake Beleu at the maximum water depth of 2.75, 4.5 and 6.5 metres (left to right)

One way to keep Beleu in a state close to natural would be to create an aqueduct or a pumping station to supply the sufficient amounts of water from the Prut, complemented with locks for water retention (box 3.1). In parallel, actions are needed to limit siltation of the lake caused by the high turbidity of the Prut (see chapter 4). Similar problems apparently affecting lake Manta too call for similar solutions.

Box 3.1 Proposed actions to restore the natural environment of the Lower Prut floodplain

Elaboration of a system of periodic and controlled flooding of the entire lake complex and ensuring the maintenance of a minimum water level for a set period of time.

Creation of a system of hydrotechnical installations that would allow the periodic controlled flooding of the area and the maintenance of a water level in Manta-Beleu lakes.

Drainage of marshy lands in the Lower Prut area.

Restoration of deforested areas and extension of areas covered with forest vegetation composed of native species of willow and poplar.

Automated computerised monitoring of [species] migration.

Source: Platon, 2015

[5] See (EUWI+ 2019).

4 ECOSYSTEMS, SPECIES AND THEIR VULNERABILITY TO CLIMATE CHANGE[6]

As described above, the Prutul de Jos biosphere reserve includes the scientific reserve of the same name and a Ramsar site which are part of the European Emerald Network, as well Vadul lui Isac forest nature reserve and Lake Manta with adjacent territories. The available studies of the area's biodiversity reflect in more detail the flora and fauna of the scientific reserve, while unfortunately less is known about the biological diversity of forests, lakes (including Manta), steppes and other natural systems in other parts of the PJBR. Yet overall the ecosystems of this area are valued as the most important wetlands in Moldova, which also make part of the wetlands of international importance.

Based on official information, the total area protected for conservation purposes (initially, Prutul de Jos scientific reserve) has undergone changes from 1691 hectares in 1991 (the year of its formation) to 1755 hectares in 2013 (figure 4.1), and then to 14771 hectares with the creation of the PJBR.

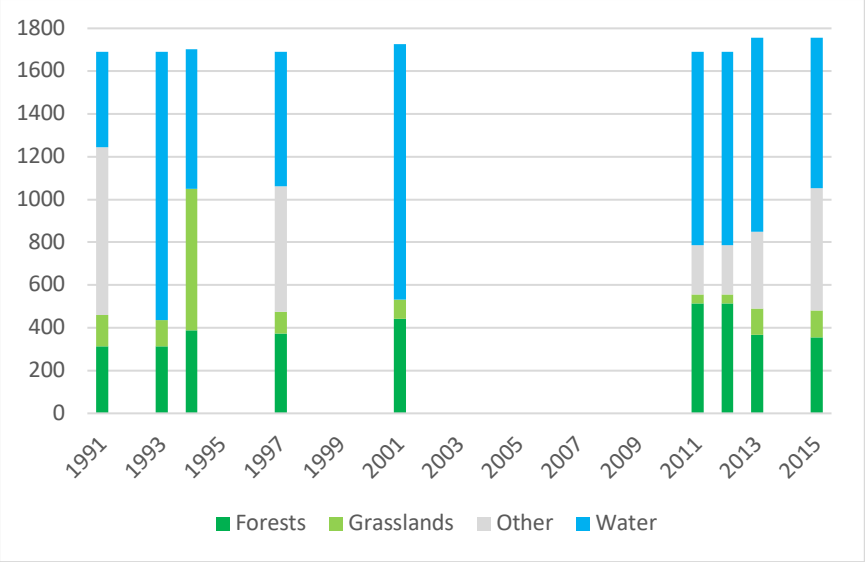


Figure 4.1 Change in the area of protected habitats prior to the creation of the PJBR, hectares

Data source: Begu, 2021

There have been strong fluctuations in the area covered by water, which sharply increased from 446 hectares in 1991 to 1255 hectares in 1993, with a return to 650-628 hectares between 1994 to 2001, up to about 800 hectares from 2011, with a decrease back to about 650 hectares in 2016. The variations in the surface of lake Beleu can be explained by the fact that in 1990 the lake was completely dry, while in 1991 long floods increased the surface and the water level to 3-4 metres almost over the entire lake. The result of these long floods was the expansion, in particular, of the areas of grasslands and forests, but also the increase of the number of species of birds and plants, and less so for mammals and fish. We can thus assume that the maintenance of the lake area of 700-900 hectares ensures an ecological optimum for water-sensitive species.

PJBR forest vegetation is made of two types of formations, which predominate in elevated locations. Willow forests (Salix alba) are more common in the higher sectors of the northern part of the scientific reserve, as well as in the south along the Prut as clusters or solitary trees. Wicker, another species of Salix, predominates in the north-east, forming a belt on the lake shore. The average age of trees is 35 years, while 39% are over 40 years and are thus in ecological decline. The reasons for that are prolonged floods as well as droughts accompanied by high temperatures. The vegetation of the forest fund is also affected by fires, especially so about 200 hectares of reeds. Droughts favour the

[6] The content of this chapter is based on (Begu, 2021).

appearance of diseases and pests, manifested by phytophagous and xylophagous invasions; to reduce negative effects of the latter it is thus recommended to stimulate the breeding of insectivorous birds. Measures are also required to retain waters on the slopes through afforestation and small dams.

Meadow ecosystems are represented by fragmented areas in the forested or riparian sectors of the steppe areas around or within the PJBR. They have higher stability due to the wider ecological tolerance of grass species. In the case of intensification of arid processes, meadow vegetation can benefit from groundwater reserves through well-developed root system or can survive critical periods through metamorphosed stems.

Marsh and aquatic ecosystems are represented by reeds and ponds. Siltation following floods on the Prut River, the erosion of nearby slopes as a result of torrential rains, as well as increasing droughts may accelerate the lowering of the water level in lakes and ponds (see chapter 3). Large sectors will then turn into marshy ecosystems, and their further siltation and drying will lead to their transformation into wet meadows where hydrophytic vegetation will be replaced with hygro- and mesophytes. In 2006-2008 reeds almost completely disappeared, yielding their place to other plants, especially the marsh pepper (Persicaria hydropiper).

Lake Beleu is subject to intense siltation as a result of torrential rains. In recent decades siltation has intensified, especially after the widening of the Manolescu gorge in 1960s, thus decreasing the depth of water and pushing wicker and willow to expand towards the centre. In the north and the northeast of Beleu, where floodwater enters through several channels, there is an intense accumulation of alluvium, which continuously silts these areas and thus diminishes the surface of the lake creating favourable conditions for wilting and the development of reeds (Phragmites australis) and rushes (Typha angustifolia). Willows (Salix alba, S. fragilis, S. viminalis, S. triandra) are widespread, with the presence of white and black poplar (Populus alba, P. nigra). White willow makes about 99.5% of the dendrological composition. Of great value are water caltrop (Trapa natans), the floating salvinia (Salvinia natans), the European white water lily (Nymphaea alba), the Eastern marsh fern (Thelypteris palustris), and other plants with the Endangered or Critically Endangered protection status (table 4.1).

Overall the flora of the Lower Prut is represented by a wide variety of – in total, about 270 – species of vascular plants, especially hygro- and hydrophytes, and their communities, many of which are endangered (table 4.1, figures 4.2-4.4).

The fauna complex is specific to aquatic ecosystems, as the area serves as a nesting place for birds, and – during seasonal migrations – as a resting and feeding place for migratory species. Some birds such as common pelican (Pelecanus onocrotalus), curly pelican (Pelecanus crispus), great egret (Egretta alba), yellow heron (Ardeola ralloides), spoonbill (Platalea leucorodia), glossy ibis (Plegadis falcinellus) are critically endangered.

The reserve also plays a special role in creating conditions for the reproduction of ichthyofauna. Over twenty species of fish (some are migratory species from the Danube) are present in the waters of the reserve and spawn there: carp, bream, ide, zander etc. In recent decades some fish species have become rare, such as freshwater bream (Abramis brama), pumpkinseed (Lepomis gibbosus) and European mudminnow (Umbra krameri), the latter being critically endangered.

Rare mammals in the reserve include otter (Lutra lutra), wildcat (Felis silvestris), European mink (Mustela lutreola) and stoat (Mustela erminea).

Table 4.1 Diversity, habitats and status of endangered species in the Lower Prut scientific reserve

Endangered species	Ecosystems and habitats	Protection status
PLANTS		
Wild grape (*Vitis sylvestris*)	lc, fr	EN
European white water lily (*Nymphaea alba*)	av, pl	EN
Water pineapple (*Stratiotes aloides*)	av, pl	CR
Floating fern (*Salvinia natans*)	av, pl	EN, CBr
Water chestnut (*Trapa natans*)	av, pl	CR, CBr
Eastern marsh fern (*Thelypteris palustris*)	pl, lc	EN
Fringed water lily (*Nymphoides peltata*)	av, pl	R
European water clover (*Marsilea quadrifolia*)	pl	CR
[Cîrligel] (*Mariscus hamulosus*)	lc	CR
Greater spearwort (*Ranunculus lingua*)	pl	CR
Bouché's star of Bethlehem (*Ornithogalum boucheanum*)	lc	EN
ANIMALS		
Otter (*Lutra lutra, Lutreola lutreola*)	lc, pl	VU, CITES, CBr
Wildcat (*Felis silvestris*)	fr, lc	VU, CBr, CBn
Stoat (*Mustela erminea*)	fr, lc	VU
Mute swan (*Cygnus olor*)	av, pl	VU, CBr, CBn, DPs
Eurasian bittern (*Botaurus stellaris*)	av, pl, reeds, bushes	VU, DPs, CBr, CBn, SPEC-3
Black stork (*Ciconia nigra*)	av, pl, fr	CR, DPs, CBr, CBn, CITES
White stork (*Ciconia ciconia*)	av, pl, poles, roofs	VU, DPs, CBr
Pygmy cormorant (*Phalacrocorax pygmaeus*)	av, pl, bushes	CR, DPs, CBr
Great white pelican (*Pelicanus onocrotalus*)	av, pl, reeds	EN, CBn, DPs
Dalmatian pelican (*Pelicanus crispus*)	av, pl, reeds	CR, CBr, CBn, DPs
Great cormorant (*Phalacrocorax carbo*)	av, pl, bushes	DPs, CBr
Grey heron (*Ardea cinerea*)	av, lc, pl	R
Black-crowned night heron (*Nycticorax nycticorax*)	av, lc, pl	R
Glossy ibis (*Plegadis falcinellus*)	lc, pl	CR
Little egret (*Egretta garzetta*)	av, lc, pl	R
Eurasian spoonbill (*Platalea leucorodia*)	lc, pl	CR
Great egret (*Egretta alba*)	lc, pl	EN
Squacco heron (*Ardeola ralloides*)	lc, pl	EN
European pond turtle (*Emys orbicularis*)	av, pl	EN, DHab, CBr
Sterlet (*Acipenser ruthenus*)	av, limn, nis-ptr facies, pr	VU, CITES, CBr
Ide (*Leuciscus idus*)	av, limn, nis-mâl	VU
Burbot (*Lota lota*)	av cold, ptr-nis-arg	VU
Danube streber (*Zingel streber*)	av deep, ptr-nis-arg	VU, CBr
Zingel (*Zingel zingel*)	av deep, ptr-nis-arg	VU, CBr
Sabrefish (*Pelecus cultratus*)	av, limn	VU, CBr
Black Sea chub (*Petroleuciscus borysthenicus*)	av, limn	VU
Tench (*Tinca tinca*)	av stagn., veg., innm	VU
Striped ruffe (*Gymnocephalus schraetser*)	av fast-flowing, limn, ptr	VU, CBr, DHab
Starry sturgeon (*Acipenser stellatus*)	av litoral, ptr-nis facies	EN, CITES, CBr
European mudminnow (*Umbra krameri*)	av cu veg, limn-ponds innm	EN
European eel (*Anguilla anguilla*)	av, limn, mâl-nis	CR
Volga pikeperch (*Sander volgensis*)	av deep	EN

Ecosystems: aquatic (av), marshland (pl), grassland (lc), forest (fr). Habitats: rock (ptr); sand-rock (nis-ptr); sand-mud (nis-mâl); aquatic with vegetation (av cu veg.); aquatic oxygen-rich (av-oxig); rock-sand-clay (ptr-nis-arg); mud (innm); lake (limn); rapids (pr). Protection status: endangered (EN), critically endangered (CR), vulnerable (VU), rare (R) species according to IUCN Red List of Threatened Species; Species of European Conservation Concern (SPEC); species protected under the Bern (CBr), Bonn (CBn), CITES (CITES) Conventions, EU Habitats (Dhab) and Birds (DPs) Directives.

Source: Begu, 2021

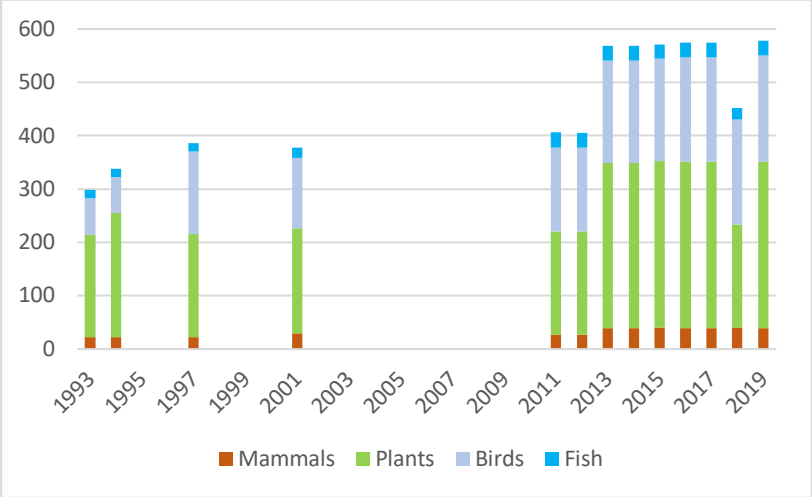


Figure 4.2 Observed number of species of selected taxonomic groups

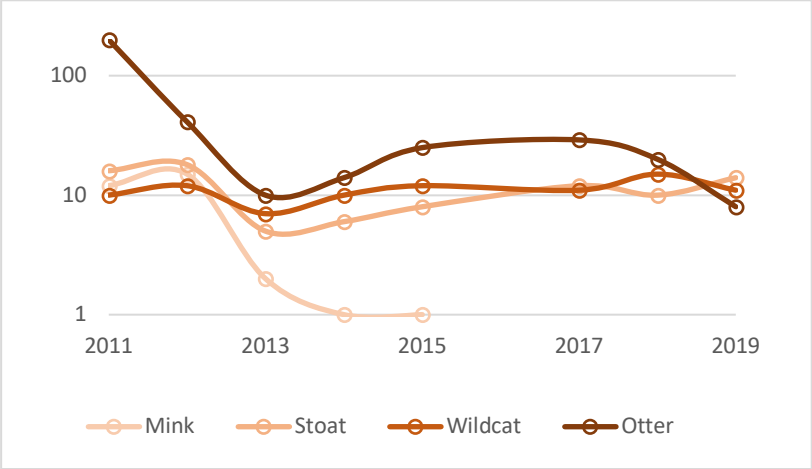


Figure 4.3 Observed changes in the populations of selected vulnerable mammals

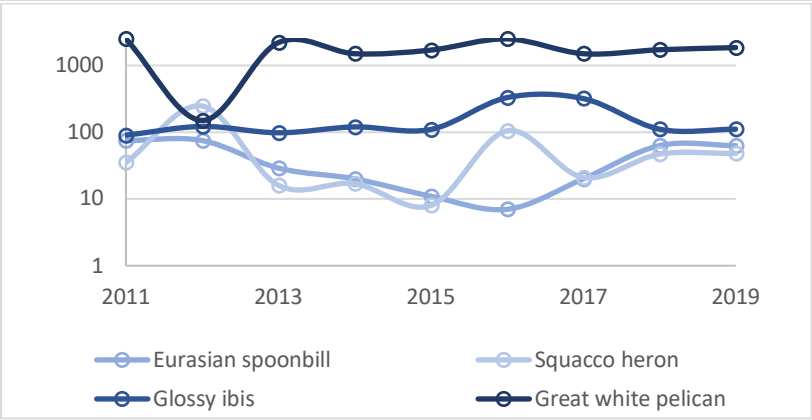


Figure 4.4 Observed changes in the populations of selected vulnerable birds

Data source: research data after (Begu, 2021)

Of all species in the territory of PJBR threatened with extinction, 118 are particularly vulnerable to climate change (figures 4.5-4.6). These include 27 species of plants, 16 species of mammals, 34 species of birds, 9 species of amphibians, 7 species of reptiles, 9 species of fish, 9 species of insects, and 7 species of molluscs. Plants, for the most part bound to the substrate, are the most vulnerable to climate change as they will not be able to react promptly to the impact of environmental factors, while spores, seeds and metamorphised vegetative organs offer low chance of survival. Among animals, the most vulnerable to climate change are bird species, followed by amphibians and reptiles, then mammals, fish and invertebrates.

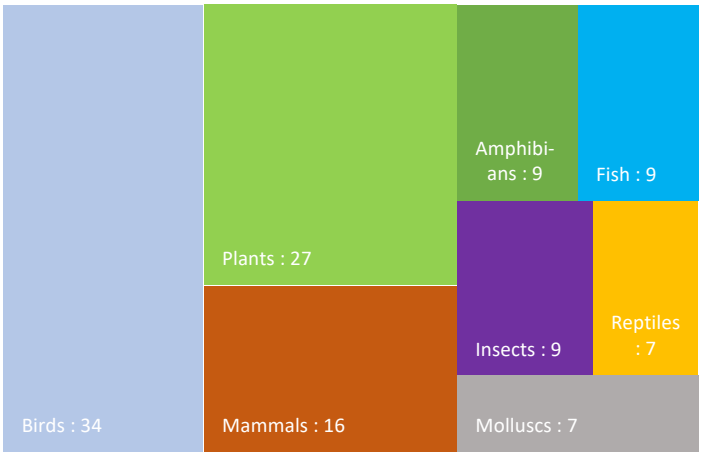


Figure 4.5 Number of climate-vulnerable species in the PJBR

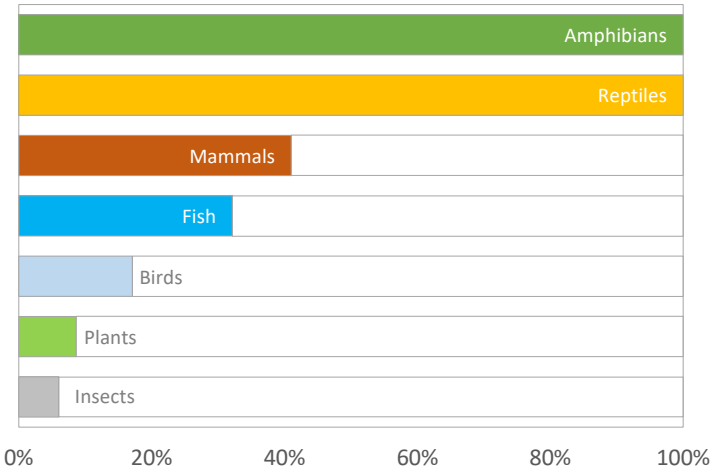


Figure 4.6 Share of climate-vulnerable species in the total number of PJBR species per taxonomic group

Data source: Begu, 2021

For the valuable species, the most important but also the most vulnerable habitats are aquatic and marsh ecosystems, meadows, forests and muddy areas with sandy-stony bottom, bushes, shrubs and reeds. The key risk factors associated with a changing climate are the increasing temperature, the decreasing air humidity, fires (including burning reeds), the drying up of water basins, and the insufficiency of plant and animal food resulting from climate impacts on the respective species down the food chain. The long droughts of recent years with very high temperatures, sometimes over 40°C, have been rather damaging for natural ecosystems. Floods cause negative impact on the local flora due to late flooding of areas covered with willows and their consequent freezing. In sectors where the underlying rocks contain soluble salts, salinization will favour the appearance of halophytic plants.

In order to reduce the negative effects of climate change, an integrated monitoring of water, soil, air, and biota is needed. This will help substantiate adaptation measures such as the reconstruction of degraded habitats, the formation of ecological corridors between fragmented habitats, and the exclusion of pressures that prevent the expansion of areas occupied by endangered species so that, depending on the evolution of climate, a sufficient number of individuals of each of the threatened species can survive. Being among such pressures, hunting, fishing, collection of snails, berries, mushrooms, plants as well as recreation, tourism, sports and any production activities and their legacies should be promptly regulated, and their limits enforced. It is also of utmost importance to finalise and officially adopt PJBR regulations and other elements of the reserve's legal basis.

5 ECONOMIC ACTIVITIES, LIVELIHOODS AND CLIMATE IMPACTS UPON THEM[7]

Determined by its geographical position and developed infrastructure, the economic life of the Cahul district is relatively intense. The number of enterprises is one of the largest in Moldova (735 units in 2012, including the town of Cahul which is outside of the PJBR). Thanks to the relatively high level of industrialization and intense economic activity (figures 5.1-5.2), district authorities benefit from a higher local tax base than the average in the region. The district has also become one of the main beneficiaries of the Convention on Small Border Traffic, which further boosted trade between local and foreign economic agents.

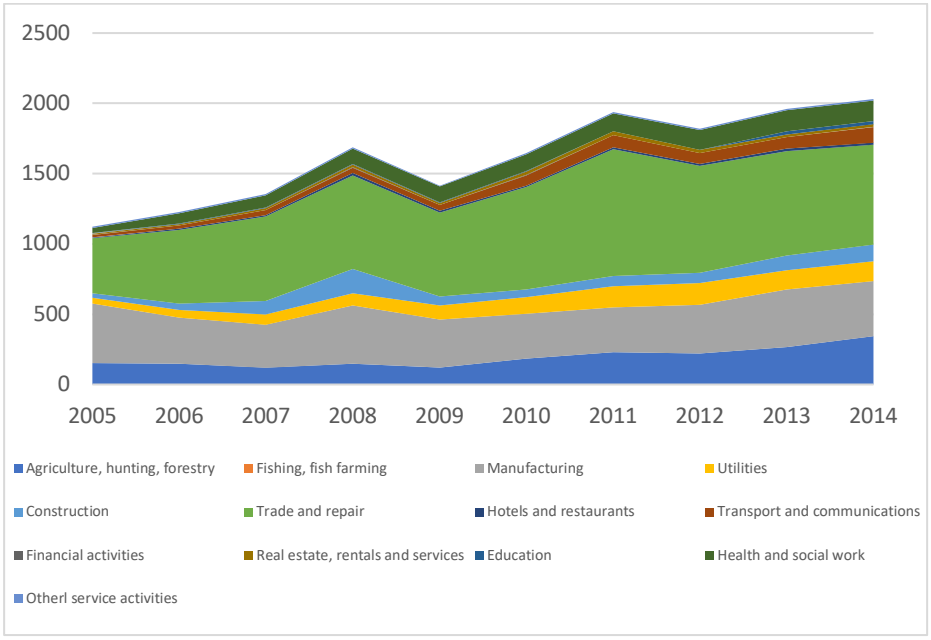


Figure 5.1 Economic activities in the Cahul district: revenue from sales, million lei

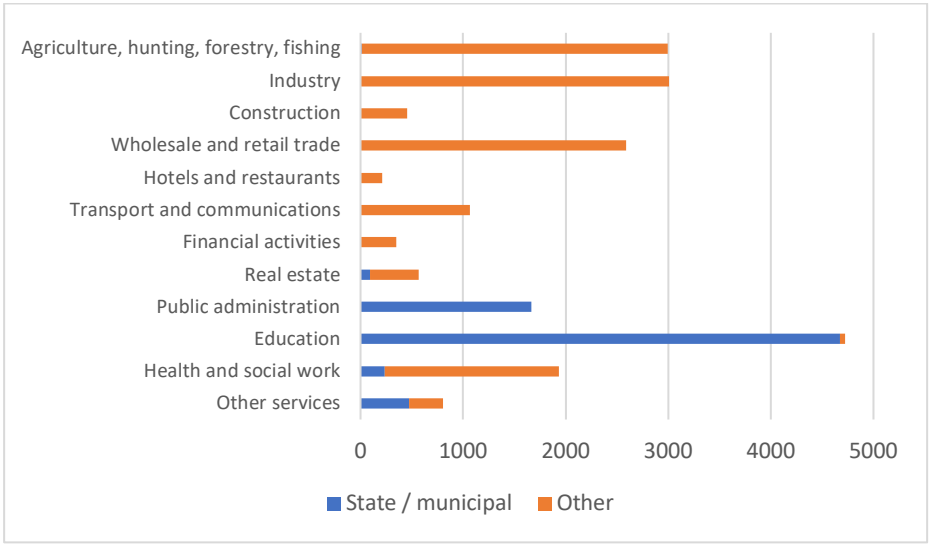


Figure 5.2 Employment by different sectors in the Cahul district

Data source: URBANPROIECT, 2013

[7] The content of this chapter is primarily based on (Staver și Guranda, 2020) as well as materials from (UNEP, 2018) and (URBANPROIECT, 2013). Note that some of the quoted statistical data cover the entire Cahul district which is larger than the PJBR area.

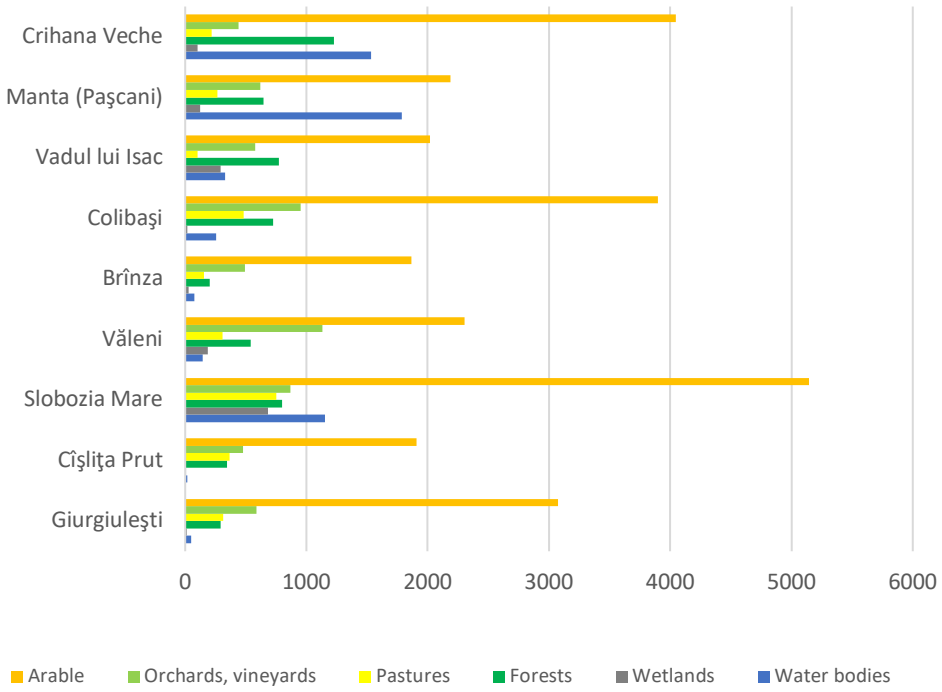
Table 5.1 Economic agents in the Cahul district by their legal form

	2017	2018	2019
Natural-person enterprises			
Individuals and SC	14	16	18
Farming households	255	256	259
Total	**269**	**272**	**277**
Legal-person enterprises			
Limited liability companies	4	5	**5**
Municipal enterprises	1	1	**1**
Total	**5**	**6**	**6**

Source: Staver și Guranda, 2020.

During the early 2000s there has been an increase in the number of economic agents carrying out activities in the district. The most developed fields are agriculture, with more than 70 economic agents in 2012, manufacturing industry with 90 economic agents, and wholesale and retail trade and repair. More than 90% of economic agents are micro or small enterprises (cf. table 5.1).

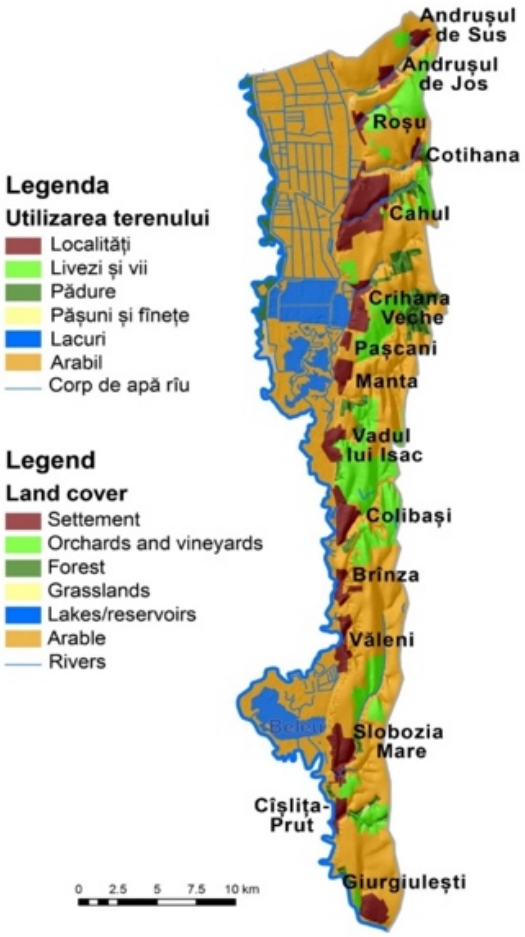
Climate conditions and fertile soils of the district are very favourable for agriculture, which is an important branch of the local economy occupying two thirds of the land in the nine PJBR communities (figures 5.3-5.4) and, together with forestry, hunting and fishing, employing about 15% of the district's workforce. The value of agricultural products is comparable to that coming out of industrial production (much of the latter being in the city of Cahul outside of PJBR borders).



Data source: URBANPROIECT, 2013

Figure 5.3 Area of selected land-use classes in PJBR communities, hectares

The largest part of agriculture is plant cultivation, which in 2013 amounted to 86% of the total value of agricultural production. The most important crops were winter wheat, autumn barley, corn, sunflower and grapes. The livestock sector is mainly represented by households, which at the end of 2013 concentrated 85% of the total number of cattle. No dramatic expansion of agricultural land is foreseen in future, but its structure will likely change as the area of arable land may be reduced while the area occupied by grapevine and fruit is projected to expand.



Source: Institute of Ecology and Geography of Moldovan Academy of Science

Figure 5.4 Land-use map of the Cahul district

A network of factories processes agricultural products (dairy, meat, fruit dryers, flour production, wineries), and this industrial potential can be capitalized on provided that direct (i.a. foreign) investments are attracted to the region. At the same time, a persistent exposure to natural hazards somewhat discourages long-term investment into agriculture, and new ways are needed to promote and introduce technological solutions that are efficient in terms of energy, water and financial resources and are adapted to the current situation of small farmers.

Due to the insufficiency and the poor state of irrigation systems, the current use of irrigation is marginal. Its development and maintenance would require an inventory, rehabilitation and expansion of existing irrigation systems and water distribution networks, as well as support to water user associations on irrigated land.

With the climate in the region changing, optimal farming conditions and thus areas under specific crops are likely to change too. Cultivation of wheat, maize, fruit, grapevine will be threatened by reduced yields, water scarcity, physical damage to crops and the decrease of their quality due to cold spells, floods and fires, pests, diseases, weeds, and the reduced fertility of the soil.

Livestock will be at an increased risk due to heat waves and the conditions favourable for spreading viral and infectious diseases. Decreasing availability of water may lead to higher production prices, reduced employment opportunities and a drop of competitiveness of local produce on international markets. At the same time, climate change may also bring positive effects by offering the possibility of cultivating secondary crops due to prolonged vegetation periods as well as new crops which can thrive in warmer temperatures. It may also improve the quality of grapevine and reduce energy costs for glasshouses. If agriculture is to remain the backbone of the local economy, targeted support will be required for addressing the climate-related risks and for capitalising on new opportunities.

Fishing has for a long time been part of the local economy. Before the creation of the PJBR, a fishing enterprise was engaged in fishing on Beleu and Manta lakes which present very favourable conditions for the reproduction of various species entering from the Prut and the Danube during spring and summer floods. However the near-complete drying of Beleu in 2007 led to the disappearance of much of the fish. Trial catches in 2014 showed that, of the most common species, only those characteristic of calm, swampy and reed-rich waters remained, and in very limited numbers. Today legal fishing takes place within the PJBR throughout the year, except for the periods of prohibition, with the use of traditional tools and methods such as active fishing with driftnets or passive fishing with fixed nets, rods etc. Catches are dominated by various carp species and bream; crayfish is caught too. However as yet there is no reliable catch monitoring system to provide a basis for planning fish-stock recovery and for approving catch quotas for residents of the reserve. Fish caught for consumption by the local population, as well as the volume of illegal fishing, are particularly difficult to estimate.

Higher water temperature and more frequent droughts will be major drivers shaping the future of fish stocks, although the projections are of high uncertainty as relations between species and their individual responses are not well known. At the same time the number of days suitable for fishing as well as the growing period of commercial species will be prolonged, which will increase pressure on them.

Even though very scarce in southern Moldova, the PJBR forest fund exceeds 5000 hectares, of which nearly 4000 hectares are actually covered with forests (table 5.2).

Table 5.2 Forest statistics for PJBR communities, hectares

	Total forest area	**Forest vegetation**		**Other vegetation**		
		Total	Covered by forests	**Total**	Shrubs	Protection strips
Crihana Veche	**1176**	**1174**	978	**2**	2	
Manta	**456**	**456**	82			
Vadul lui Isac	**771**	**700**	635	**71**	38	33
Colibaşi	**669**	**628**	449	**41**		41
Brînza	**200**	**130**	117	**70**	35	35
Văleni	**534**	**465**	452	**69**		69
Slobozia Mare	**781**	**615**	589	**166**	56	110
Cîşliţa-Prut	**345**	**313**	313	**32**		32
Giurgiuleşti	**269**	**181**	181	**88**	6	82

Data source: Studiu privind starea actuală … 2015

Moldsilva Agency manages forest lands through its enterprises Silva-South and Manta-V and through the Prutul de Jos scientific reserve. Regeneration and expansion of forests is one of the main tasks of the national forestry sector. The forestry branch is thus quite present in the PJBR, offering a considerable number of jobs to the local population, as well as a certain volume of timber. For the Cahul district, characterized by significant alternations of temperatures, frequent droughts, water deficit and areas affected by soil erosion, the protective role of forests is of vital importance and it will only grow with further climate changes. At the same time per 2014 data more than 200 hectares of Cahul district's forests, including close to 130 hectares in PJBR communities, were degraded in particular due to erosion (table 5.3).

A changing climate will cause further changes in the forest structure and species composition, with those better adapted to climate pressures set to benefit and advance. Forest fires will play an important role too. Targeted forest management will thus be necessary to both adapt to climate change and to ensure that the protective role of forests can be sustained and strengthened.

Table 5.3 Management, protective functions and degraded forests of PJBR communities, hectares

	Forest management company	Protective forests for			Degraded forests (affected by ravines)
		Soil	River and lake banks	Bio-diversity	
Crihana Veche	IS ISC "Manta-V"	757	316		20
Manta		121			3
Vadul lui Isac		536	35	68	
Colibaşi	ISS "Silva-Sud"	367			8
Brînza		241			1
Văleni		585			40
Slobozia Mare		448			7
Cîşliţa-Prut		354			52
Giurgiuleşti		223			

Data source: URBANPROIECT, 2013

Mineral resources for construction purposes are extracted at several locations within the PJBR perimeter. But the most notable and controversial case of mineral extraction is the Văleni oil field, located in the Prut floodplain in the territory of the Prutul de Jos scientific reserve (figure 5.4). Thirty wells were constructed to extract crude oil, and the construction or revitalization of another 30 wells has been envisaged. At the maximum capacity it was planned to extract 120-150 tonnes of oil per day for the twenty-year duration of drilling and extraction on 21.7 hectares of land.

Figure 5.5 Oil extraction infrastructure on lake Beleu

Data source: Google Maps / satellite view

According to expert estimates[8], by 2009 the annual extraction of oil at Văleni exceeded 15,000 tonnes, and the current daily production is estimated at 30 tonnes of oil (making it above 10,000 tonnes a year with uninterrupted production) and 12 m^3 of associated gas. In addition to being a major non-climate stressor for biodiversity and water quality at the heart of the Ramsar site (i.a. creating notable noise pollution which scares nesting birds[9]), oil wells are potentially vulnerable to floods, the intensity of which is projected to increase.

The increasing intensity and frequency of floods also threatens the environment, settlements and roads as a whole, as the existing flood-proofing of the flood-protection infrastructure may not be sufficient, and plans have been drawn to strengthen it[10]. Climate change extremes will also affect constructions and residential buildings due to greater thermal stress on building materials, their corrosion and building-related illnesses (e.g. caused by mould build-up) as well as and a higher demand for cooling.

While southern Moldova already suffers from a limited supply of water resources coupled with a generally poor access to water utilities, demand for water is likely to increase as a result of growing population, economy and the need for irrigation. This growing disparity will need to be addressed through investments into water supply – and wastewater treatment, currently practically inexistent within the PJBR. The increased frequency of drought and water scarcity, higher temperature and washout of suspended matter, pesticides and fertilizers from the fields will also contribute to the deteriorating quality of water, which needs to be systematically addressed through investments and adapted practices both on the regional, the basin and the local scales.

Although tourism is less developed in the PJBR than in Moldova as a hole, private tourism sector is beginning to enter the area, and there is a strong potential for tourism. Particularly attractive can be ecotourism in PJBR wetlands given their yet relatively untouched core areas and the presence of aquatic birds during migration and nesting. Among the most important ecotourism locations are lake Beleu and wetlands around it, lake Manta, the valuable geological / palaeontological area at Văleni gorges, and water basins near Brînza village.

There are also museums and numerous cultural monuments in the area, and in most of the villages there are craftsmen specialized in traditional folk crafts. Tourism may offer strong economic opportunities to the local population away from or in addition to agriculture, and, two areas have been proposed to boost it with centres in Cahul and Giurgiuleşti. However tourism resources such as natural areas, iconic species and cultural monuments will in their turn be affected by climate change. Tourism will also increase pressure on PJBR environment, and will need to be developed and managed in a well-coordinated and sustainable manner to ensure that the influx of people does not cause additional environmental stress.

[8] The estimates could not be formally verified as annual reports of the oil extracting company (VALIEXCHIMP S.R.L.) with precise production data do not seem to be publicly available.
[9] See (State Hydrometeorological Service, 2014).
[10] See e.g. (EUWI+, 2020 a, b, c) and (Administraţia Bazinală de Apă Prut – Bârlad, undated).

6 PRUTUL DE JOS COMMUNITIES AND WHAT THEY THINK

With about 125 thousand inhabitants in 2014, the population of the Cahul district is relatively constant. The same can be said about the rate of urbanisation, with rural population making a stable majority of about 85 thousand people. The population density of about 80 inhabitants per km^2 is higher than overall in Moldova's south. The largest urban agglomeration is the town of Cahul, outside of PJBR, with over 1000 inhabitants per km^2. Two thirds of the population (less than the national average) are economically active, and are mostly engaged in agriculture. The largest share of the population, both male and female, belongs to young age groups. The share of women and men is equal between the ages of 15 to 50 years, and overall the situation does not differ much from that in the Moldova's south altogether with an average of 107 women per 100 men at the beginning of 2014.

The nine communities within the perimeter of the PJBR are home to more than 30,000 inhabitants (figure 6.1), and 2014 projections did not expect significant changes in the coming decades (a "minimal" demographic scenario does project by 2030a 3% reduction of the rural population in the Cahul district)[11].

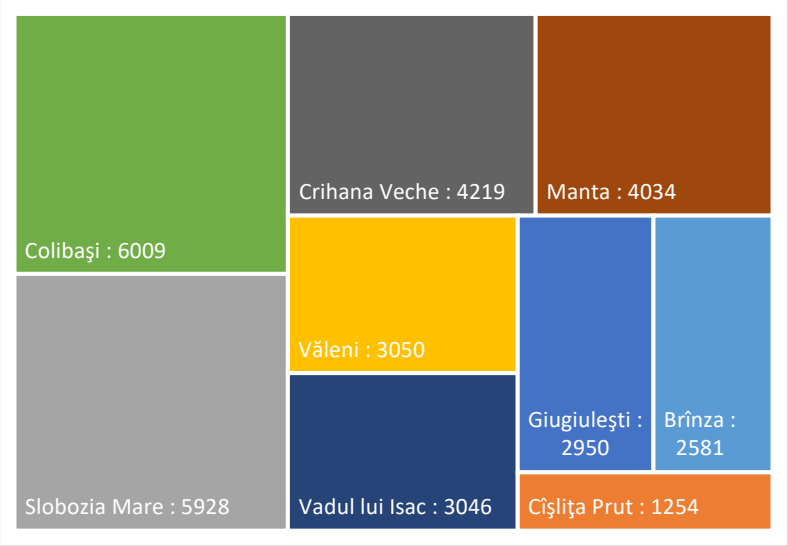


Figure 6.1 Population of PJBR communities

Data source: URBANPROIECT, 2013

Among Moldova's 843 rural communities examined in 2014 for their level of socio-economic development (table 6.1)[12], by their overall development score the PJBR communities were firmly within the top two-thirds, with Brînza, Cîşliţa Prut and Văleni somewhat lower than the rest. Crihana Veche, Colibaşi, Slobozia Mare and Giurgiuleşti were within top 10% for the whole country. At the same time, with the exception of the southern communities and in particular Giurgiuleşti with its international port on the Danube, relatively lower scores were obtained for economic development. Lower scores for financial wellbeing were also obtained by Brînza and Cîşliţa Prut. With implications for addressing vulnerability to climate change, external support to adaptation of local economy and livelihoods may need to focus on the relatively poorer communities, while richer communities are more likely to co-finance adaptation measures which they believe to be important.

Except for the two northern villages, and somewhat striking for communities located within the only biosphere reserve in the country, low scores corresponding to the lowest third of rural communities

[11] See (IURBANPROIECT, 2013) and (Staver și Guranda, 2020) for further details.
[12] See https://mei.gov.md/en/content/socio-economic-indicators-locality.

nation-wide were obtained for environmental wellbeing. This was based on the share of housing with access to sanitation (access to sewers is only available in Cahul within the district), the share of unauthorized landfills, the share of land contaminated with pesticides and the share of eroded land, which all are indeed well-known concerns.

Table 6.1 Deprivation indices for PJBR communities

	Total rank	Demographic	Economic	Financial	Educational	Health	Infrastructure	Social	Environmental
Crihana Veche	**827**	713	495	783	641	519	793	833	759
Manta	**652**	626	81	535	664	405	744	704	746
Vadul lui Isac	**708**	686	337	602	540	604	802	750	146
Colibaşi	**807**	610	309	654	566	795	663	835	472
Brînza	**553**	630	295	196	540	519	694	749	264
Văleni	**534**	451	359	470	670	604	779	556	143
Slobozia Mare	**803**	506	633	633	322	795	824	808	103
Cîşliţa-Prut	**403**	355	646	144	394	496	752	410	296
Giurgiuleşti	**826**	440	782	777	698	676	823	816	161

NOTE: the deprivation indices, calculated for 843 rural communities of Moldova, indicate the place occupied by each locality depending on the level of socio-economic development. They are calculated based on 48 relative indicators, so that rank 1 indicates the most deprived locality (the poorest communities, lacking certain services), and rank 843 - the lowest deprivation (most prosperous, developed communities). Cell colour in the table: green for ranks 566 to 843, yellow for ranks 279 to 565, orange for ranks 0 to 278.

Data source: Ministry of Economy and Infrastructure

To complement the objective picture of communities' well-being, a survey was conducted through the project among the residents of PJBR communities and the town of Cahul[13].

Table 6.2 Breakdown of the participants of the social perception survey

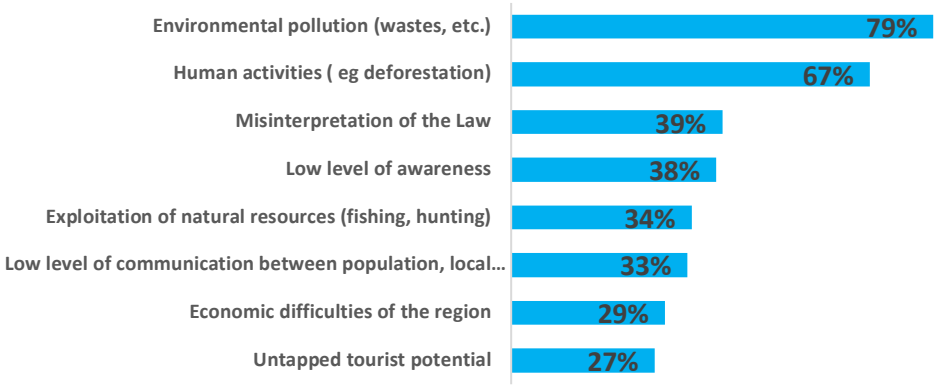
		Number	**Percentage**
Localities	Cahul municipality	50	19%
	PJBR communities	212	81%
Gender	Female	171	65%
	Male	91	35%
Age	18-25 years	43	16%
	26-40 years	91	35%
	41-55 years	71	27%
	56-70 years	57	22%
Education	Higher education	139	53%
	High school / professional studies	113	43%
	Primary education	10	4%
Language	Romanian	247	94%
	Russian	15	6%

[13] See ([Bahnaru], 2020).

The survey was designed to assess people's knowledge and perceptions with respect to the state and the value of the PJBR and its ecosystem services, as well as to the impact of climate change on the PJBR itself, people's lives and livelihoods. The study covered 301 persons between 18 to 70 years of age, specifically targeting such groups as local authorities, businesses, opinion leaders including teachers and the representatives of the civil society, and women as a major gender group. 262 people were interviewed through questionnaires and 39 persons participated in 4 focus groups (table 6.2)[14].

More than half of the interviewees appreciated the PJBR as a place of beauty and care for the environment, and 20 to 40% referred to its tourism potential. Meanwhile 11% complained about the excessive bureaucracy hindering access to PJBR areas and development there as well as inadequate or restrictive actions by authorities such as the border police, the state environmental inspectorate, Moldsilva etc. – thus pointing to conflicts between livelihoods and the conservation regime and/or the ways the latter is enforced. At the same time 60% of the respondents noted that in fact environmental legislation was not sufficiently respected.

People acknowledge environmental pressures on the reserve (figure 6.2), which include waste and garbage (including unauthorised and unmanaged landfills), deforestation, fishing and hunting (including illegal, in prohibited quantities or time periods, or with illegal equipment), and insufficient communication both vis-à-vis the population within the reserve and towards the outside world. Economic difficulties, lack of investment into infrastructure and protection measures, and inability to open up new areas of economic development such as tourism were also highlighted as factors preventing the full use of PJBR potential. Uncontrolled exploitation of oil and gas, the lack of wastewater treatment and the mismanagement of natural assets (e.g. setting reeds on fire in winter) were mentioned too.

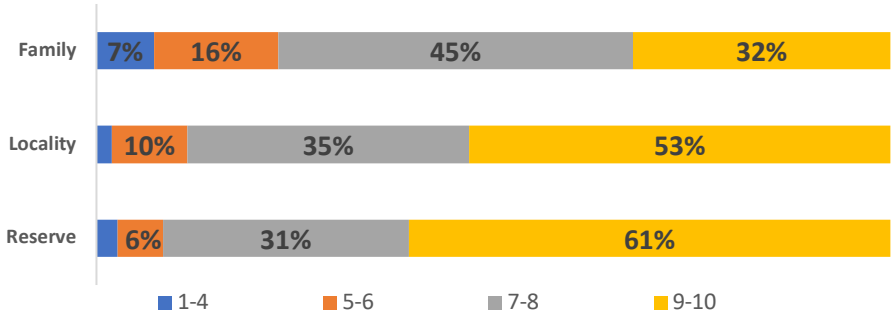


Source: [Bahnaru], 2020

Figure 6.2 Perception of key environmental issues affecting the biosphere reserve

The overwhelming majority of the respondents (99%) have seen evidence of climate change in the last ten years, as well as changes in the PJBR and around their villages (97%). People believe that they or their households are directly affected by climate change, although the strongest impact is seen at the level of the reserve (figure 6.3).

[14] It should be noted that the analysis of survey data did not relieve significant differences in perception due to gender or geographic differences. Disaggregated data are available in ([Bahnaru], 2020).



Note: 1 – the weakest impact, 10 – the strongest impact

Source: [Bahnaru], 2020

Figure 6.3 Perception of climate impact to-date at different scales

The majority among the respondents (86%) experienced natural disasters in their community during the last two decades, the most often pointing to droughts (91%) and the increase of temperature (66%). Specifically, people noted more frequent and longer droughts (84%), longer periods of dry weather (77%), less rain (74%) and more frequent very hot days (68%). A quarter of respondents mentioned hail (figure 6.4).

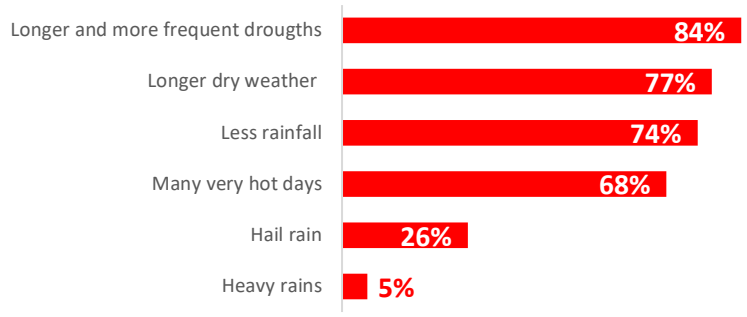


Figure 6.4 Perceived changes in climate-related disasters

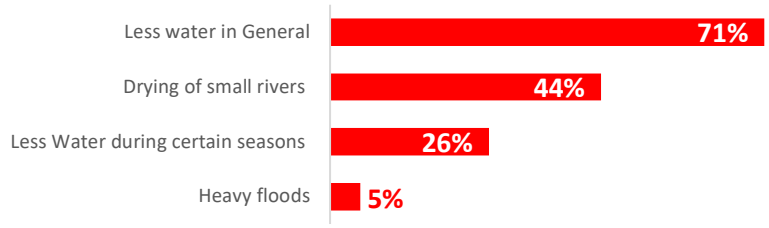


Figure 6.5 Perceived climate-related changes in the water cycle

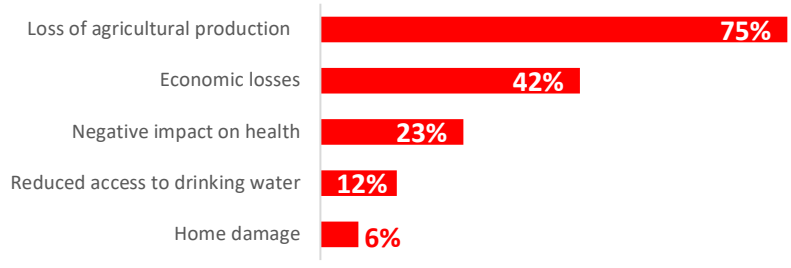


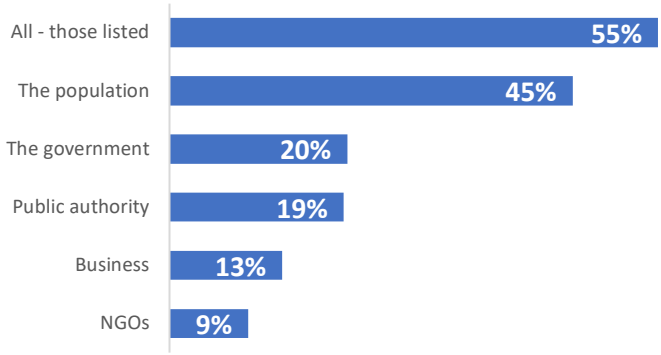
Figure 6.6 Perceived damage from climate impacts

Source: [Bahnaru], 2020

For water-related disasters (figure 6.5), seven out of ten respondents believe that there is now less water available overall. In terms of concrete consequences, 44% pointed to the drying of small rivers and 26% to less water during certain seasons. A connection was also made between the lack of water and the diminishing number of tourists visiting the reserve – except for 2020 with heavy rains in May-June and the impossibility of travelling abroad due to COVID restrictions. Only 5% of respondents pointed to heavy floods, and 24% said that they were affected by floods in summer 2020 while more than half said that they were not affected at all. This can be explained by the fact that directly affected was only a small number of the respondents that live in close proximity to lakes or rivers.

As most of the interviewees were from rural areas, people suffered the most from natural disasters (figure 6.6) through the loss of agricultural production (75%) which has negatively influenced household income (42%). Almost all respondents (91%) were affected by the 2019-2020 drought, with 50% affected by it seriously. A quarter of the respondents mentioned impact on health. Reduced access to drinking water and damage to houses were acknowledged by, respectively, 12% and 6%.

More than half of the respondents believe that all stakeholders are responsible for solving the problems caused by climate change: local authorities, the national government, business, the civil society and the population at large. Interestingly and reassuringly, 45% of people believe that they themselves can make a significant contribution to the solutions (figure 6.7). At the same time 9 out of 10 persons asked believe that their locality is not sufficiently prepared to cope with the extreme phenomena associated with climate change.



Source: [Bahnaru], 2020

Figure 6.7 Who is responsible for solving problems caused by climate change?

Many people in PJBR communities rightly see the reserve as a solution to some of the current problems, although some are not yet certain about it and still want to be convinced.

In other words, people see the issues and want to change, but need guidance, resources and targeted support. And in addition to pointing to areas of concern and new opportunities, the interviewees have themselves proposed an impressive range of measures in order to reduce pressures on the natural environment and to develop the PJBR economically. Even if many of such measures do not directly address climate change, many of them are intrinsically related to creating the context in which resilience to a changing climate will be necessarily improved, and these suggestions are included in the recommended measures that follow.

7 PROPOSED ADAPTATION MEASURES

The end purpose of the PJBR climate vulnerability assessment is to help all interested parties, including the Austrian Development Agency and other donors, identify, design and eventually implement measures to adapt the PJBR to the unfolding climate change in the best possible way.

Although relatively little is still known about what climate change will actually bring in the next two-three decades what exact consequences it will have for species, ecosystems, people and economy, the key trends and impacts are already becoming clear. The proposed set of adaptation measures is based on the analysis of the current and projected risks as described in the preceding chapters, and responds to broadly formulated concerns about current and future climate impacts.

Some of the proposals result from discussions in PJBR communities as part of the social perception survey (see chapter 6), where local residents had opportunities to suggest solutions to climate and environmental challenges.

The proposed adaptation measures are split in four functional groups, as described below.

(A) MEASURES TO EXCLUDE / LIMIT NON-CLIMATE PRESSURE ON THE ENVIRONMENT

These measures address the overall, primarily environmental, conditions for improving PJBR resilience to climate change. Therefore they focus on pressures that are not climate-specific but nonetheless need to be reduced in order for climate adaptation to be effective and efficient. Part of these measures address specific pressures such as oil extraction, solid waste and wastewater, the degrading state or overuse of natural resources in the PJBR area. Other measures are concerned with improving the overall environmental governance, including the due enforcement of environmental regulations and completing the establishment of the PJBR legal and institutional basis.

(B) MEASURES TO PROTECT AND SUPPORT VULNERABLE SPECIES AND ECOSYSTEMS

In a direct relation to the core of the PJBR's nature conservation mandate, these measures respond to the specific identified threats from climate change to the reserve's ecosystems and species, in particular those already recognised as endangered on the national, the European or the global levels. Addressing the already happening and the projected changes in the PJBR area, these measures are meant to prevent or mitigate their negative effect and to ensure that a sufficient number of individuals of threatened species and their habitats can survive in still suitable ecological conditions. Adaptation measures in this group range from enhanced monitoring and in-depth studies to gain the still lacking but necessary information basis to the direct restoration, re-naturalisation and defragmentation of vulnerable habitats and ecosystems. This group of measures also includes studying and executing solutions for maintaining the water balance of Beleu and Manta lakes threatened by the current and future climate dynamics, as well as cleaning lake Beleu from the results of many years of intensive siltation and improving protection from floods.

(C) F MEASURES TO ACILITATE CLIMATE-RESILIENT LIVELIHOODS AND DEVELOPMENT

On par with other species and their ecosystems, people and their livelihoods are equally important parts of any biosphere reserve. Measures in this group are intended to help minimise, and where possible capitalise on, the climate impacts on people's livelihoods in the PJBR area while supporting new and environment-friendly alternatives to current economic activities. The latter include the development and promotion of tourism, especially its ecological variation which is intrinsically built into the PJBR concept. Sustainable agriculture, energy production and water supply are addressed too.

Climate-resilient development can be altogether promoted by making adaptation an integral part of local and regional development planning.

(D) MEASURES TO BUILD AWARENESS, CAPACITY AND COOPERATION FOR ADAPTATION

Building people's awareness and capacities to act are necessary preconditions and elements of any adaptation programme, while local, regional and cross-border cooperation (the latter of particular importance for this part of Moldova) are mechanisms to enhance synergies and learn from each other's successes.

All the initially proposed measures were assessed in terms of their scale and potential synergies with other processes on the national, regional and local scales. This information was used as an input to consultations with the aim to determine the relative importance and urgency of each of the proposed measures as seen by the PJBR stakeholders. The consultations were organised as two tracks: with the representatives of PJBR communities; and with experts in Chisinau and Cahul, besides project experts including representatives of the PJBR and of the regional branch of the Environmental Agency of the Republic of Moldova.

In addition to ranking adaptation measures, project experts also reviewed and helped revise the initial cost estimates. The initial cost estimates were based on the available knowledge and the analysis of economic information for similar tasks performed in comparable circumstances[15], and the further revision has helped make them better founded. Still it is to be noted that the current estimates remain preliminary, and the actual implementation of most of the specific measures would require a more precise economic assessment based on further analysis and / or feasibility studies.

In addition to reviewing and ranking the proposed measures, the representative of PJBR suggested several further measures. These were again ranked by all communities, and the measures thus deemed the most important were added to the set as new entries or integrated with the earlier included ones[16].

Table 7.1 presents the resulting set of the proposed adaptation measures together with their ranking in terms of their importance and urgency, and with the estimates of their cost.

Mapping the proposed measures by their urgency and cost (figure 7.1), one can distinguish their different kinds as candidates for financial support as four clusters of measures with distinctly different characteristics.

[15] The initial cost analysis was performed by Adrian Staver.

[16] Not included in the final set were the extension of coverage of anti-hail protection, limiting the number of transport units within the PJBR, and studying nature-protection experience of other countries. No community representative judged these measures as urgent, and some communities believed these are not important. The latter measure can also be productively integrated in transboundary and regional cooperation programmes with Romania and Ukraine.

Table 7.1 Proposed measures for adaptation to climate change in the Prutul de Jos biosphere reserve

	Adaptation measures	Priority scores [a]			Cost estimates €M	Investment clusters				Synergies [c]
		Communities	Experts	Average score		FINANCE	EXPLORE	INITIATE	PROMOTE	
A	EXCLUDE / LIMIT NON-CLIMATE PRESSURE ON THE ENVIRONMENT									
1	Addressing biodiversity impacts and vulnerability to floods of oil extraction facilities	0.56	0.33	0.44	0.150	■				R
2	Strengthening waste management and addressing unauthorised landfills	1.00	0.56	0.78	3.700			■		N I
3	Wastewater treatment and limiting non-point sources of water pollution	0.67	0.44	0.56	1.500			■		N
4	System of monitoring fish catches for stock planning and setting resident quotas	0.33	-0.22	0.06	0.050		■			L N
5	Afforestation including forest curtains, corridors and riparian protection strips	0.67	0.33	0.50	0.350	■				N E R I
6	Strengthening and enforcing nature-use regulations (hunting, fishing, grazing etc.)	0.22	0.11	0.17	0.020	■				N
7	Completing and formalising the legal and institutional basis for PJBR operation	-0.22	0.25	0.01	0.050		■			N
B	PROTECT AND SUPPORT VULNERABLE SPECIES AND ECOSYSTEMS									
1	Integrated environmental monitoring to help define adaptation needs and effects	0.56	0.33	0.44	0.150	■				N I
2	In-depth systemic studies of all groups of organisms and their adaptation needs	0.33	-0.22	0.06	0.200		■			N I
3	Reconstruction and expansion of habitats of selected climate-sensitive species	0.33	0.11	0.22	1.000				■	E R
4	Connecting fragmented habitats of climate-sensitive species (ecological corridors)	0.00	0.11	0.06	1.000				■	E R
5	Breeding of insectivorous birds to protect forests from drought-induced pests	0.33	-0.33	0.00	0.100		■			L N
6	Cleaning bottom sediments of lake Beleu	0.00	-- [b]	0.00	5.000				■	L
7	Water supply and retention infrastructure to manage lake Beleu water level	0.89	0.33	0.61	2.000			■		L
8	Water supply and retention infrastructure to manage lake Manta water level	0.22	-- [b]	0.22	3.000				■	L
9	Regulating Costești-Stânca water releases for optimal flood management	0.67	0.33	0.50	0.010	■				R
10	Re-naturalisation / restoration of riverbed, floodplains, wetlands for flood protection	0.00	0.63	0.31	0.250	■				E R I
11	Climate-proofing and strengthening flood protection dykes along the Prut	0.67	0.22	0.44	1.000			■		N E

C	FACILITATE CLIMATE-RESILIENT LIVELIHOODS AND DEVELOPMENT									
1	Facilitation of climate-efficient agriculture (technologies, investments, insurance)	0.11	0.11	0.11	1.000				■	R I
2	Inventory, rehabilitation, expansion of irrigation systems	0.22	0.11	0.17	2.000				■	I
3	Active management of reeds as economic activity	0.33	0.22	0.28	0.100	■				R L
4	Setting planning framework for tourism at PJBR optimal receptive capacity	0.33	0.11	0.22	0.100	■				L I
5	Tourist infrastructure: access roads, guesthouses, leisure areas, information boards	0.78	0.44	0.61	1.000			■		L
6	Defining and cleaning recreational areas / public beaches on the lakes	0.67	0.22	0.44	0.100	■				L
7	Defining and marking (eco)tourist routes, diverting them from sensitive habitats	0.44	0.22	0.33	0.100	■				L
8	Developing water-supply networks and facilities	0.56	0.22	0.39	2.000			■		N R I
9	Developing local sources of alternative energy (solar, wind, biomass)	0.44	0.11	0.28	0.500				■	N I
10	Supporting and promoting local producers	0.22	-- [b]	0.22	0.100	■				L
11	Including adaptation into community, district and PJBR development planning	0.67	0.33	0.50	0.150	■				L I
D	BUILD AWARENESS, CAPACITY AND COOPERATION FOR ADAPTATION									
1	Climate change Information through various channels for PJBR residents	0.56	0.22	0.39	0.050	■				L I
2	External promotion of PJBR and adaptation needs (films, photos, festivals)	0.11	0.11	0.11	0.500				■	L I
3	Empowerment programmes for local activists, influencers and civil society	0.44	0.22	0.33	0.100	■				N I
4	Re-education programmes for economic diversification and business development	0.33	0.11	0.22	0.150	■				N I
5	Facilitating women's access to tourism and trade market opportunities	0.00	-0.12	-0.06	0.150		■			N I
6	Building adaptation capacity of PJBR staff	0.56	0.33	0.44	0.100	■				N I
7	Promoting inter-community adaptation projects	0.11	-- [b]	0.11	0.100	■				L
8	Cross-border adaptation programmes with protected areas in Romania and Ukraine	0.56	0.33	0.44	0.100	■				R L I
9	Participation in regional adaptation programmes in the Danube basin / delta	0.33	0.33	0.33	0.100	■				R

a Based on quantifying the responses as follows: -1 = neither important not urgent; 0 = important but not urgent; 1 = important and urgent

b Only ranking by PJBR communities is available

c Synergies: implementation of EU directives (E); other national processes including national adaptation planning, sectoral development plans etc. (N); local development planning (L); regional and cross-border cooperation (R); international cooperation such as UN and bilateral assistance programmes (I).

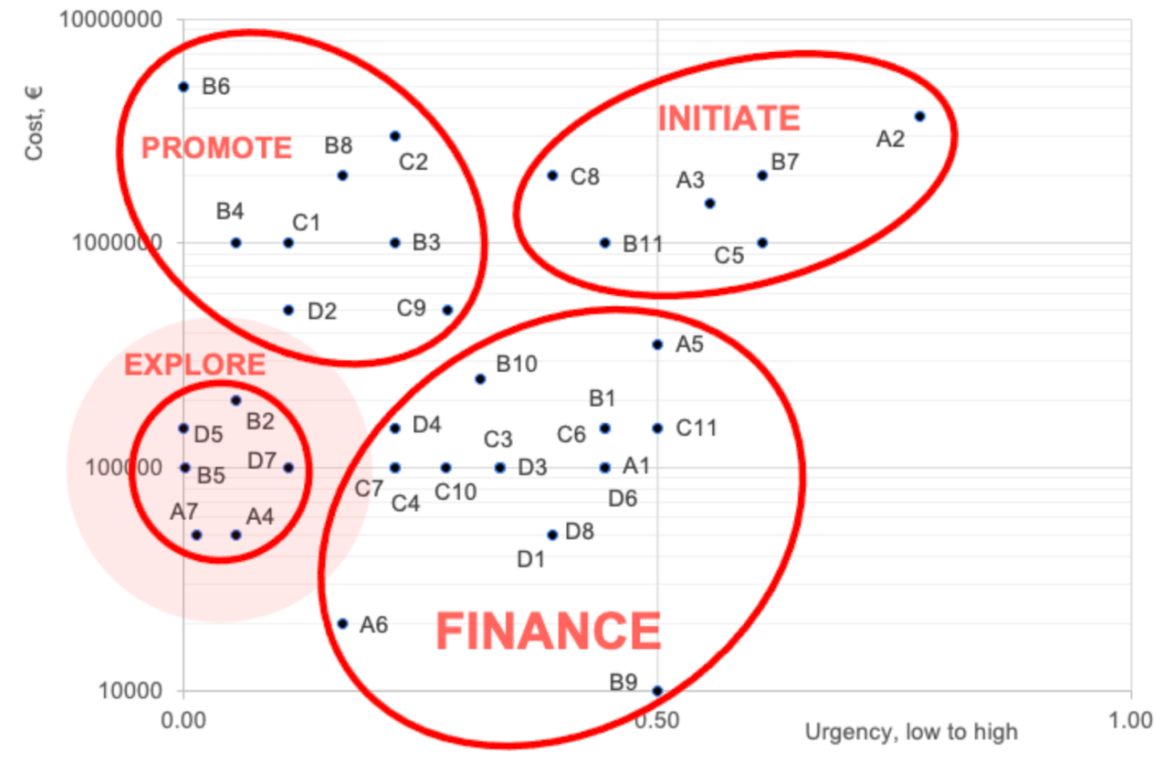


Figure 7.1 Investment clusters of PJBR adaptations measures

- The "lowest-hanging fruits" are measures with moderate urgency and relatively low cost. These can be implemented literally at once, immediately reaping a wide range of adaptation benefits (cluster FINANCE, the suggested fast-track investment is 100% of the total cost of the measures).

- Measures in the upper-right corner are important but expensive (one million euros and above). They address solid and liquid waste, water supply, tourist infrastructure – and the water level of lake Beleu. Preparatory work, such as analytical and feasibility studies, can and should be initiated as these measures are important and urgent, but their full-scale implementation may be beyond the capacity of a single donor and financing them requires a longer process (cluster INITIATE, the suggested fast-track investment is 15% of the total cost of the measures).

- Measures in the upper-left corner are important but less urgent, and are relatively expensive. They include the re-naturalisation of ecosystems, support to climate-sustainable agriculture and energy, building awareness of PJBR issues outside of the region. Here the best approach may be to help promote the needs vis-a-vis the extended donor community, leaving the actual financing and implementation to actors with the adequate and sufficient resources (cluster PROMOTE, the suggested fast-track investment is 5% of the total cost of the measures).

- Finally, there is a small group of low-urgency but low-cost measures, about each of which there has been a relatively wide difference of opinions between experts and community representatives. Some of these measures – e.g. empowering economic activities by women – did cause controversial discussions, indeed not uncommon in other similar contexts (see box 7.2). With the highest of the scores taken, most of these measures would fit in the FINANCE cluster, it is thus suggested to further explore and partially finance them to the possible extent (cluster EXPLORE, the suggested fast-track investment is 70% of the total cost of the measures).

Box 7.1 Promoting opportunities for women in the protected areas of Afghanistan

Compared to men, women often lack opportunities to fully benefit from the establishment of Afghanistan's protected areas and to participate in their daily life. When Afghanistan's first Band-e Amir National Park was established in 2009, the Wildlife Conservation Society engaged four female rangers to complement a male ranger team, in particular to work with tourists along the lakeshore area of the park and to prevent uncontrolled littering. This was a pioneering move which strongly raised the park's profile among local residents and attracted attention of numerous national and international media. Having taken over the management of the Band-e Amir National Park a few years later, the Government in a controversial decision reclassified the jobs of female rangers as 'cleaners', provoking strong protests from the women and the international community.

In the central village of the National Park the WCS supported the construction of five women-only market stalls, with rights to trade distributed among fourteen villages of the area. Initially very popular, the stalls were widely used for selling goods and services and hosted the only female tailor workshop in the area. However, after a while, male traders illegally installed their improvised stalls in front of those constructed by the WCS, which greatly reduced the flow of customers and made women trade at that spot unprofitable. As a result, to the disappointment of village authorities who would like to restore the status quo, women trade only continued at illegal locations in other parts of the park, and without paying the annual tax to the state.

Source: Zoï Environment Network, 2019

Tables 7.2-7.3 and figure 7.2 show the estimated cost of adaptation for the four investment clusters above against the different functional groups of measures. Of the total estimated cost of adaptation in the PJBR of 28 million euros, the recommended fast-track investments are of the order or 5 million euros or of 18% of the total cost.

Table 7.2 Preliminary estimates of PJBR adaptation costs (million euros)

	FINANCE	EXPLORE	INITIATE	PROMOTE	**TOTAL**
TOTAL ADAPTATION COST					
Adaptation measures group A	0.5	0.1	5.2		**5.8**
Adaptation measures group B	0.4	0.3	3.0	10.0	**13.7**
Adaptation measures group C	0.7		3.0	3.5	**7.2**
Adaptation measures group D	0.7	0.2		0.5	**1.4**
TOTAL COST, €M	**2.3**	**0.6**	**11.2**	**14.0**	**28.0**
FAST-TRACK INVESTMENTS					
Share of total adaptation cost	100%	70%	15%	5%	*18%*
FAST TRACK COST, €M	**2.3**	**0.4**	**1.7**	**0.7**	**5.1**

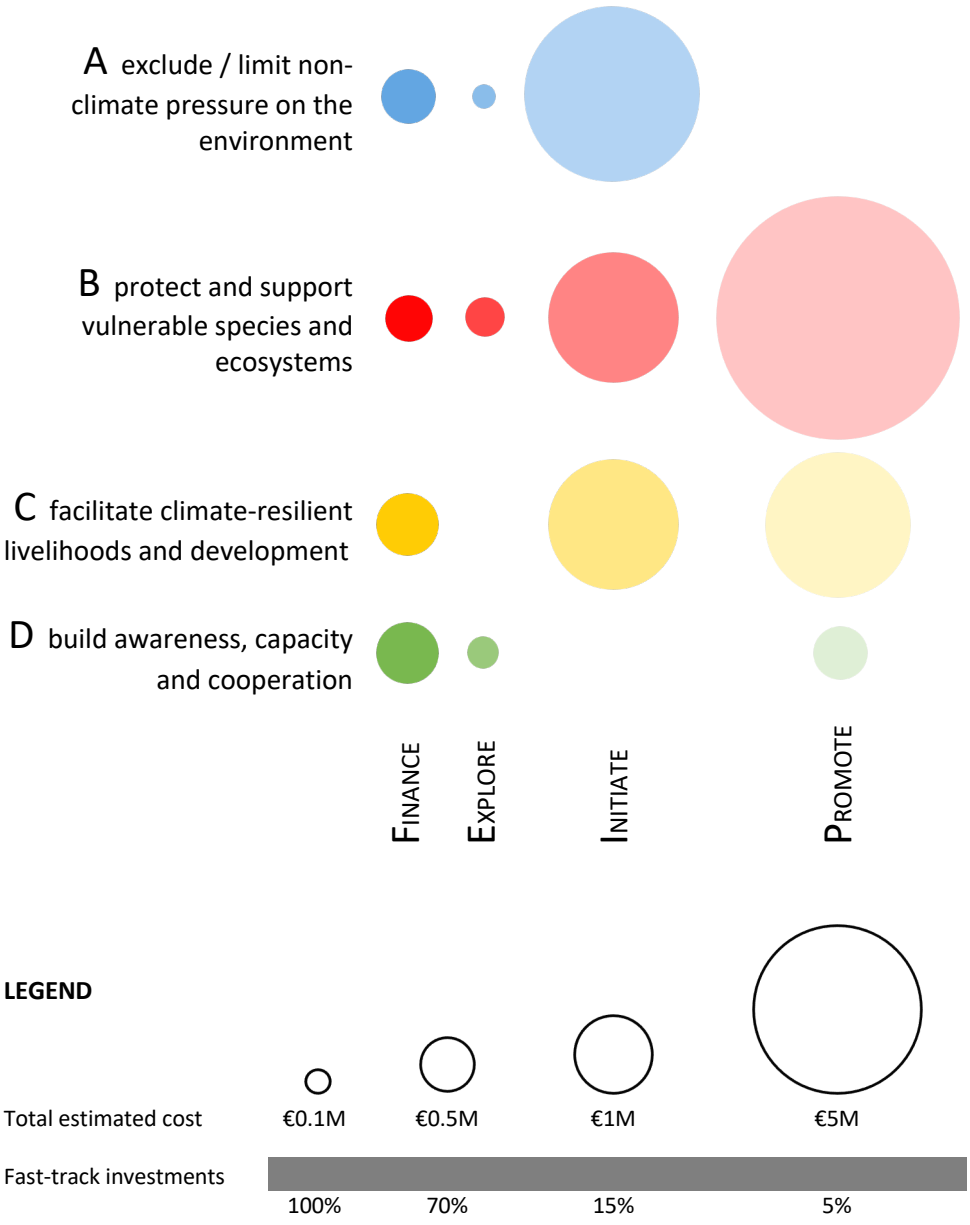


Figure 7.2 Preliminary estimates of PJBR adaptation costs

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INTERACTION WITH STAKEHOLDERS

Inputs and feedback were sought on numerous occasions from stakeholders within in the region and on the country level. Key such interactions are listed below.

- Consultations on the methodology of climate vulnerability assessment for Prutul de Jos biosphere reserve (by correspondence, August 2020)
- Public perception survey (questionnaire and focus groups) among the residents of the Prutul de Jos biosphere reserve (September-October 2020)
- On-site expert consultations with the administration of the Prutul de Jos biosphere reserve (October 2020)
- Consultations on key preliminary findings of the climate vulnerability assessment for the Prutul de Jos biosphere reserve and the proposed adaptation measures (by correspondence, February 2021)
- Consultations on key preliminary findings of the climate vulnerability assessment and the proposed adaptation measures with the representatives of Prutul de Jos biosphere reserve communities (Cahul, 26 February 2021)
- Presentation of key preliminary findings of the climate vulnerability assessment for the Prutul de Jos biosphere reserve and the proposed adaptation measures at Moldovan NGO Forum, Section 10 Climate Change (Chisinau, 26 March 2021)
- Assessment and rating of adaptation measures by representatives of Prutul de Jos communities, other local stakeholders and experts (by correspondence and through visits to communities, April 2021)

At various stages of the assessment, consultations were also held with a number of Moldovan, local and international experts as was required (please see the Acknowledgements section for details).