Assessment of wetlands benefits and ecosystem services along the Danube floodplain

Summary

Wetlands provide vital ecosystem services to the socio-economic system at different scales (e.g. water quality control, wastewater treatment, groundwater recharge). Such ecosystems are essential for local sustainable development, especially in the floodplain area of the large rivers. The wetlands loss and degradation have a significant social and economic impact translated into increased flood risk, lower water quality with consequences for human health and welfare. Restoration concerns in many countries focus on wetlands due to their hydrological functions,. The restoration of wetlands and supplied ecosystem services allows for providing cost-effective solutions for the watershed management issues.

The purpose of this study is to identify and assess the benefits and ecosystem services provided by Greaca agricultural polder, a former flooding area, according to different scenarios, respectively i) maintaining the agricultural area, as it is now (business as usual scenario), ii) restoring the former Greaca lake and using the rest of the polder for agriculture, iii) restoring the entire area for water storage at extreme events (high Danube water flow) and iv) restoring the entire area as close as possible to the reference state (the landscape structure in the 1900^{s}).

The study contributes to the right assessment of the wetlands benefits provided to the society and supports the decision-making process for implementation of ecological restoration program in the Danube floodplain.

Greaca agricultural polder (Gostinu-Prundu-Greaca) is among the 53 polders constituted by 1200 km embankment of the Danube floodplain. In this area the embankment consisted in 41.4 km of longitudinal dams and 9 km of partition dams, built in period 1964 -1966. The area was completely drained to be proper for agriculture. Thus, 6000 ha have been drained, 8000 ha have been irrigated and 2380 ha have been used for rice cultivation.
According to Corine Land Cover (2006), 13 land use categories have been identified in Greaca agricultural polder. Agrosystems are predominant, covering over 90% of the area (namely arable land and rice fields), as is shown in the table and figure below.

Table no. 1. Land use before embankment (CLC 2006).

No.	CLC code	Land use categories	Surface (ha) 2006
1	112	Discontinuous urban ecosystems	64.93
2	211	Arable land	**23 120.40**
3	221	Vineyards	232.17
4	242	Agricultural ecosystems – complex cultivation models	204.14
5	311	Deciduous forests	438.91
6	321	Natural meadows	154.62
7	511	Water bodies	1.43
8	243	Agricultural systems with significant areas of natural vegetation	451.71
9	324	Forest vegetation in transition - bushes	49.55
10	121	Trade and industrial units	16.81
11	331	Beaches, dunes, sands	10.82
12	213	Rice fields	**4 239.48**
13	231	Pasture	383.15
		TOTAL	**29368.12**

As administrative structure, the area belongs to Giurgiu and Călăraşi counties, which include six villages – Gostinu, Băneasa, Greaca, Căscioarele, Prundu and Chirnogi, the last two having the largest area. Main economic activity is agriculture, respectively land cultivation and livestock farming.

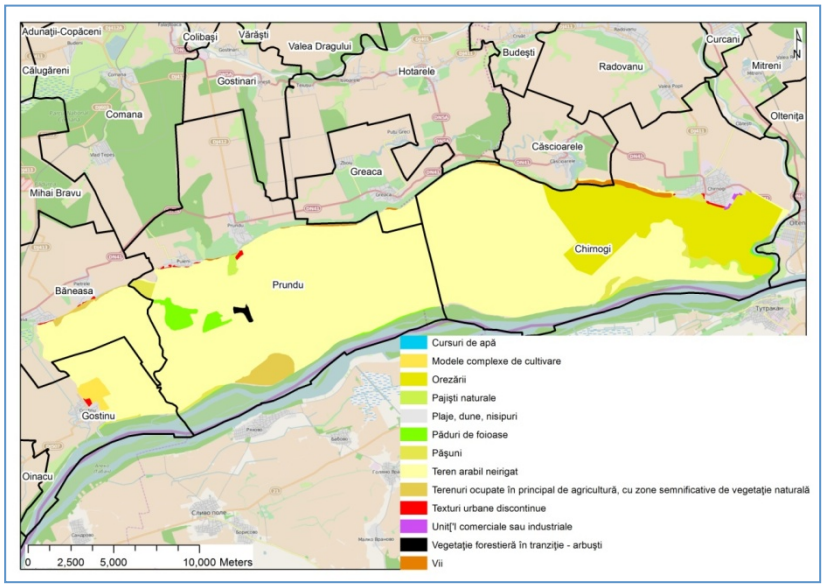

Figure 1. Land uses in the Greaca agricultural polder.

This area has been identified as appropriate for water storage at high levels of Danube water flow, within a study requested by The Ministry of Environment and Sustainable Development after the catastrophic floods occurred in 2006.

Landscape structure in the reference state (before embankment)

The area is part of the Lower Danube River System which, as a whole, used to cover about 6400 km^2 (the Danube Delta excluded). The floodplain area consists of permanent large swamps, brooks and reed beds, smaller swamps and backwaters, sloughs (which most often run dry in summer), easily flooded lowlands, higher lands which only get flooded if the river overflows and high islets which get flooded only if the river reaches unexpected levels. According to the data and information provided by Antipa (1910) and the land use categories of Corine Land Cover, before the embankment the area was mostly cover by aquatic ecosystems, natural meadows, forests and wetlands, as can be seen in the table below.

Table no. 2. Land uses in the reference state (before embankment)

No.	CLC code	Land use categories	Surface (ha) in 1900^s
1	112	Discontinuous urban ecosystems	11.04
2	211	Arable land	54.08
3	221	Vineyards	117.21
4	242	Agricultural ecosystems – complex cultivation models	8.16
5	311	Deciduous forests	6 743.01
6	321	Natural meadows	9 532.20
7	411	Continental wetlands	2 554.42
8	512	**Water bodies**	**10 347.99**
		TOTAL	29 368.11

Greaca area also supplied goods and services. Thus, it produced about 5-7 kt fish/year; over 70 kt of reed and reedmace; up to 50 000 m^3 of wood; 10 kt of animal products. Besides, it provided flood regulation services, it contributed to the retention of N and P (between 10 and 20 kt/year, respectively 1-2 kt/year), it constituted habitat and refugia for numerous species of plants and animals and, finally, it was an aesthetic resource and a source of knowledge. Approximately 275 km^2 of land was flooded for more than 6 to 7 months per year.

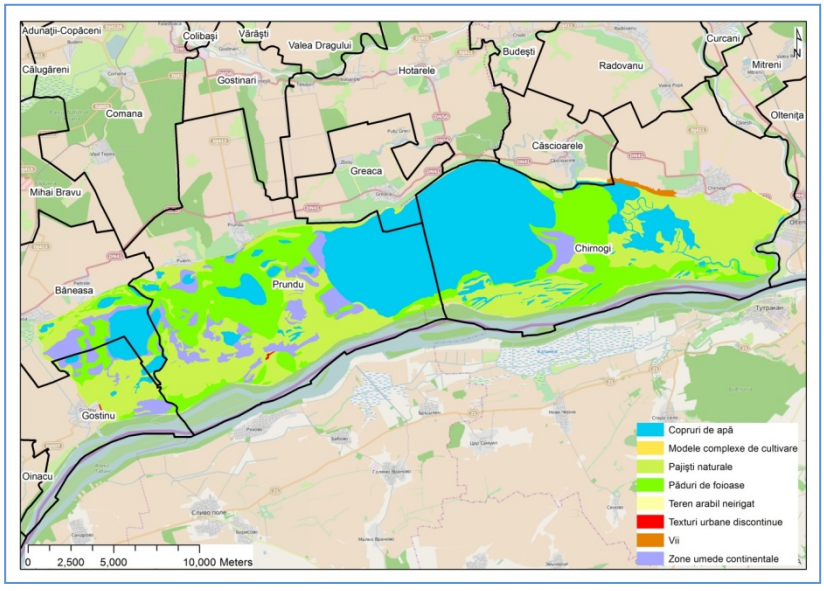

Figure 2. Land uses in the reference state (1900^s years).

The Greaca polder system has been examined in two states, reference and actual situation, taking into consideration ecological integrity and ecosystem services provided, respectively production, regulation and cultural services. This allowed to emphasize that for actual state all ecosystem services (production, regulation and cultural services) and ecological integrity decreased compared with the reference situation (see the picture below).

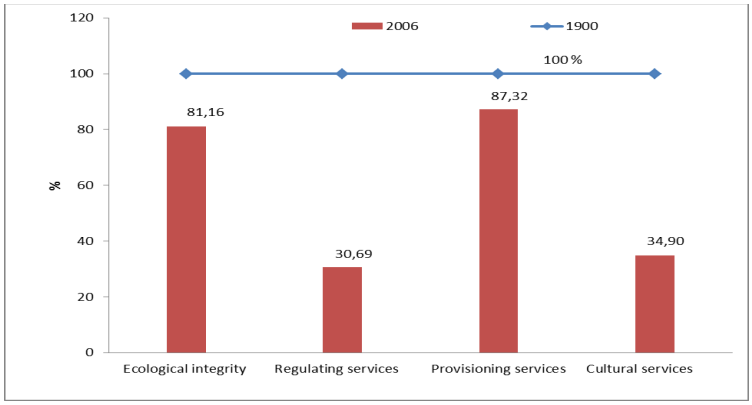

Figure 3. Ecosystem services provided by Greaca polder reported to the reference state.

The most important decreases occurs for the regulation services (31%) and for the cultural services (35%), and the smallest for the production services (87%). In this case the fish, reed, reedmace and animal production has been replaced by the agricultural production.

Mapping ecological integrity and ecosystem services before embankment

As it can be saw in the figure below, the highest ecological integrity is associated with the wetland system. Wetlands also provide most regulation and cultural services. The production services have the highest value (respectively dark green) in aquatic systems, namely Greaca Lake and the other interconnected shallow lakes . Wetlands provide a high production, too.

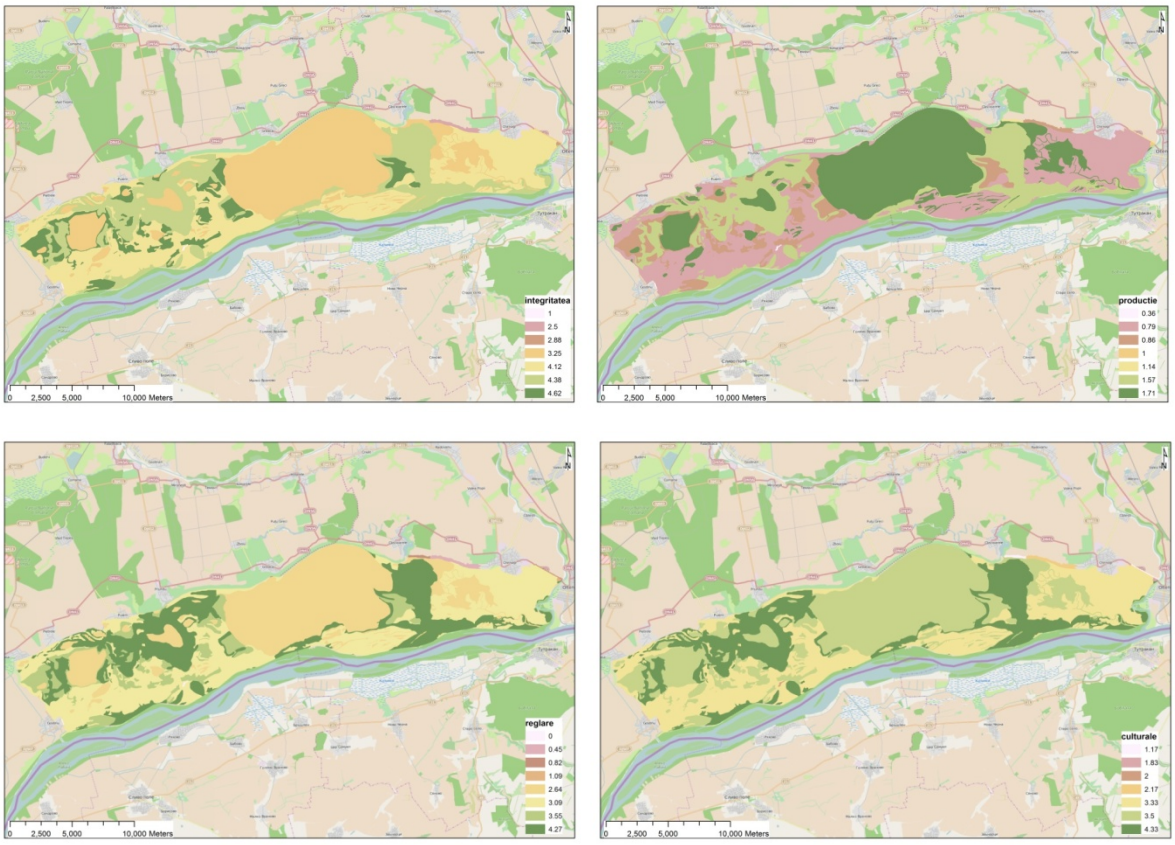

Figure 4. Map of ecological integrity and ecosystem services before embankment.

Mapping ecological integrity and ecosystem services after embankment

In the post-embankment structural configuration, which is dominated by two land uses – agricultural land and rice fields, one can notice that the ecological integrity continues to be high only by the remaining forest ecosystems (in dark green in the upper left picture). All the other ecosystem services are also provided at the highest level by the forest ecosystems. Production services are provided at a high level by the remaining natural meadows (the area close to the Danube River).

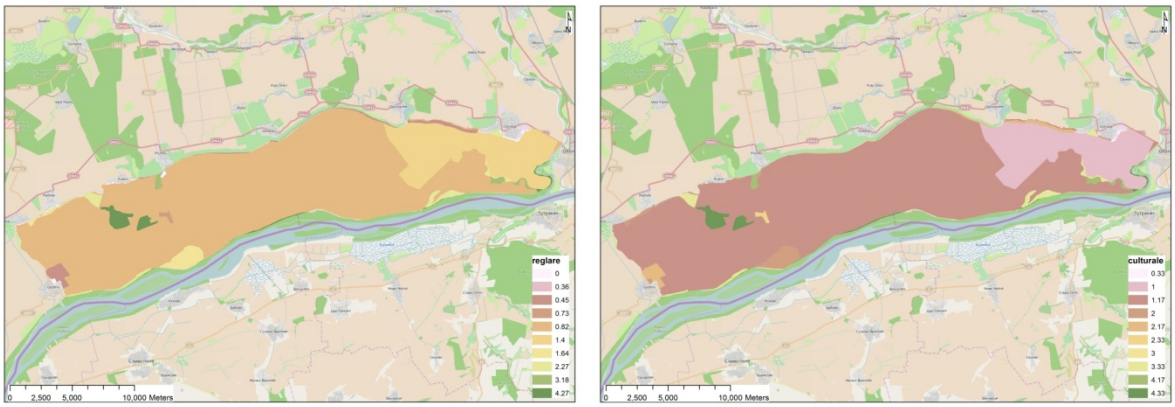

Figure 5. Map of ecological integrity and ecosystem services after embankment.

After applying the methodology of economic assessment of ecosystem services provided by the main ecosystem types, before and after embankment, it was found that the total economic value before embankment was of about 40 million dollars and, after embankment, it reached about 11 million dollars, as it can be seen in the table below.

Table no. 3. Total economic assesment ($/ha/an) of agrosystems in Greaca

Type of ecosystem	1900 (value in USD)	2006 (value in USD)
Forests	9 406 485	680 760
Pastures	8 483 480	488 610
Lakes	22 009 106	2 439
Agrosystems	80 622	10 607 400
Total*	39 979 693	11 779 209

** Mentioned values should be interpreted with caution - they are an estimate of VET*

The total costs of Danube floodplain changing from a complex system that provided a wide range of goods and services towards a simplified system focused on high agricultural production have been about 1 billion dollars (costs updated with the inflation).

Restoration scenarios

Ecological restoration is a complex activity that must take into account the characteristics of the baseline system, the current state and the projection of the restored system.
In the case of Greaca polder, the baseline status (before embankment) was characterized by a high complexity of the ecological systems, with multiple interacting elements, which provided a wide range of ecosystem services. The complex was embanked so that, at present, it has a simple structure dominated by agricultural systems with a much lower capacity of providing ecosystem services. In this context, the purpose of the ecological restoration would be the rehabilitation of the formerly provided services. This is feasible by restoring the ecosystems structure and functions occurred in the baseline situation. In our opinion, making breaches in the dams would not be the best solution for the restoration of Greaca area. It would take complex works to restore the ecosystems and the channels that connect with the Danube (up- and downstream), which ensured the ecosystems functioning in the past.

Scenario A) maintaining the agricultural area, as it is now (business as usual scenario)
Purpose: maximizing agricultural production
Implementation patterns: no changes; funds are invested in the restoration and maintenance of the protection dams
Ecosystem services provided: production services
The system's capacity of providing other ecosystem services (regulation, cultural or support) is strongly reduced. There is a high likelihood of dam failure in case of extreme floods.

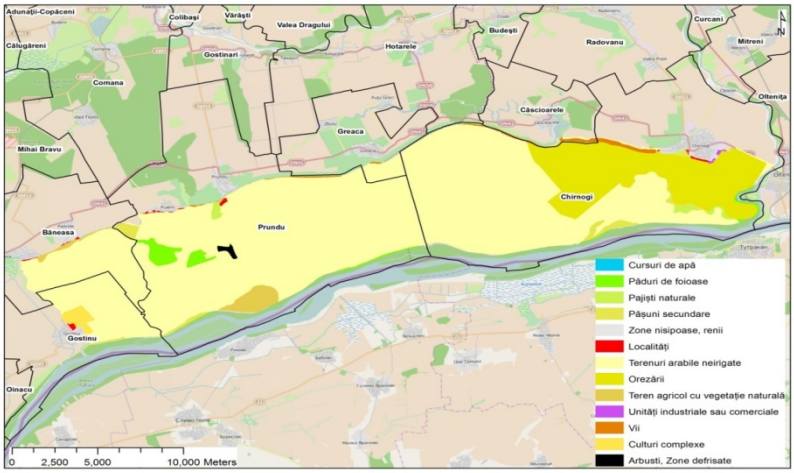

Figure 6. Structural configuration in Scenario A

Scenario B) restoration of the former Greaca lake and the rest of field used for agriculture

Purpose: partial restoration of Greaca complex, restoration of the lake area, increase of the water retention capacity on a long and medium term

Implementation patterns: breaches in the protection dam

Ecosystem services provided: production, cultural, regulation and support services

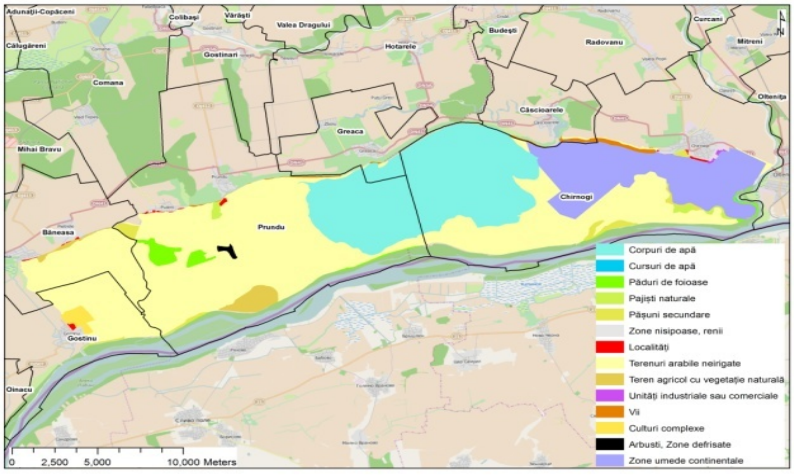

Figure 7. Structural configuration in Scenario B

Scenario C) restoration of entire area for water storage at extreme events (high Danube water flow)

Purpose: increasing the water retention capacity on a short term

Implementation patterns: breaches in the protection dam; no restoration actions inside

Water retention only occurs on a limited term and only in special situations

Ecosystem services provided: production, water storage (regulation service)

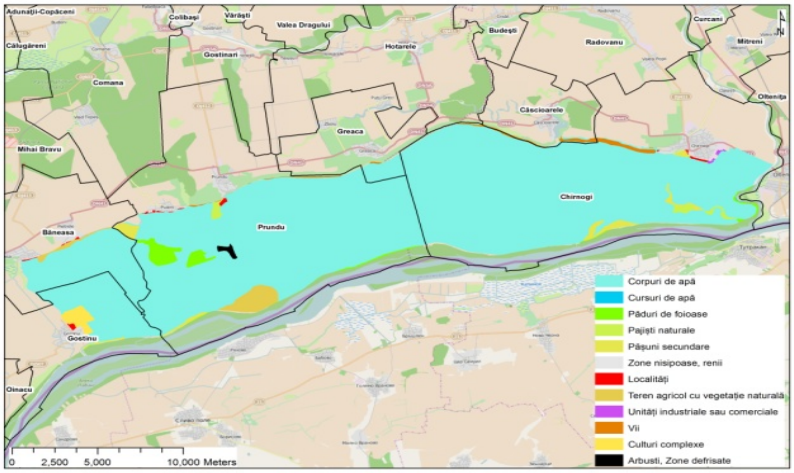

Figure 8. Structural configuration in Scenario C

Scenario D) restoration of the entire area as close as possible to the reference state (the landscape structure in the 1900^{s}).

Purpose: restoration of the structure and functioning of Greaca area, the baseline being the 1900s – before the embanking of the system

It involves the restoration of the whole wetlands system functioning .

Ecosystem services provided: production, cultural, regulation and support services

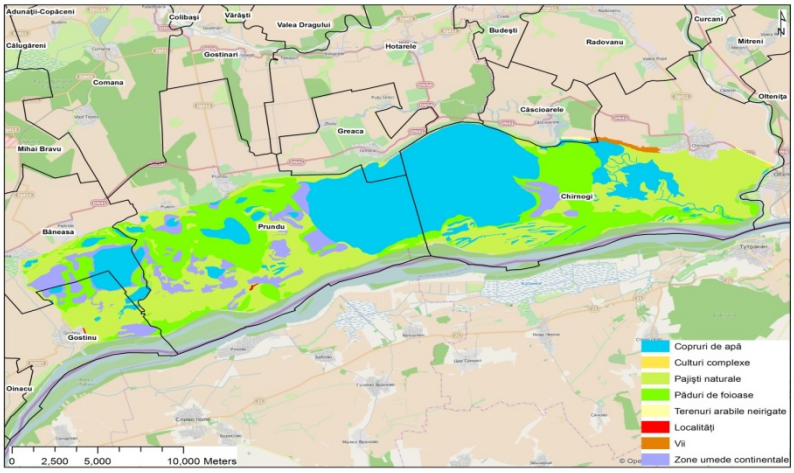

Figure 9. Structural configuration in Scenario D

Assessment of ecological restoration scenarios using multicriteria decision analysis

The proposed ecological restoration scenarios have been discussed with the local communities. The discussions concerned both the ecosystem services provided and their supplied level in each state, allowing for decision making.

The multicriteria decision analysis took into account data and information provided by focus-groups organized with the local communities in order to identify perceptions, attitudes and concerns regarding the opportunity for ecological restoration of Greaca agricultural polder. The main steps were: defining the problem and the goals; setting out the criteria; defining alternatives; assessing each ecological restoration scenario according to the established criteria (calculating scores); obtaining the final values of the alternatives; performing an analysis of the sensitivity of the results to changes in the weight of some criteria.

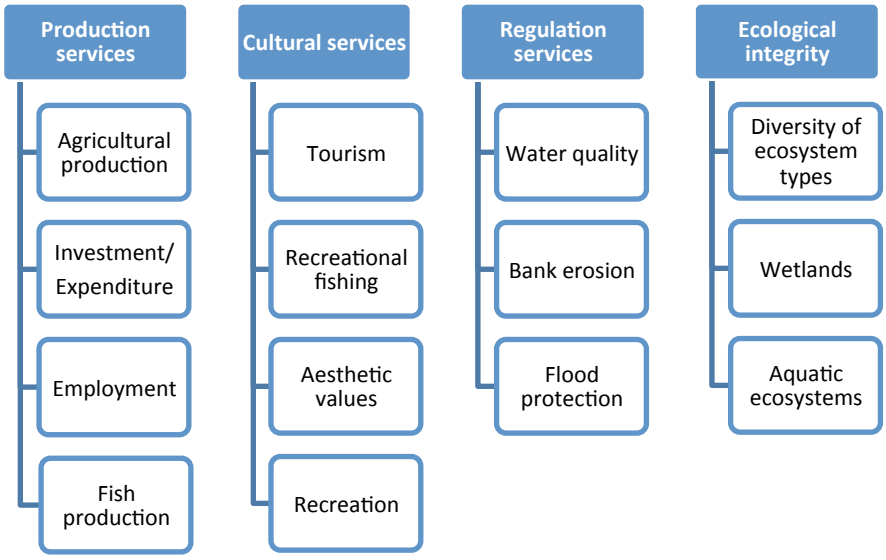

Figure 10. Criteria considered within the multicriteria decision analysis

The production services considered were following:

- *Agricultural production* (production of wheat, rape, maize, barley, sunflower, vineyards, orchards, vegetables etc) including also animal production (from animal husbandry, e.g. meat, eggs, milk, cheese etc.)

- *Investment/expenditure* (costs of fertilizers, pesticides, various operations – sowing, weeding, tilling etc.)
- *Employment* (number of local people employed in the enterprises/SMSs which operate in the Greaca area)
- *Fish production*

The cultural services considered were following:

- *Tourism* (number of tourists per year, number of tourist hostels in the Greaca area or income resulted from tourism in the region)
- *Recreational fishing* (being an attractive area for recreational fishing)
- *Aesthetic values* (landscape is pleasant to look at/provide relaxation to people or is an inspiration source for artists)
- *Recreation* (e.g. walking in nature, boating, jogging, cycling etc.)

The regulation services considered were following:

- *Bank erosion* (river bank failure)
- *Water quality* (improving water quality by reducing fertilizers and pesticides, and by enhancing nutrient retention capacity of wetlands; e.g. water purification for drinking, fishing, swimming)
- *Flood protection* (e.g.annual flood frequency/decrease of flooded households)

The ecological integrity considered criteria were following:

- *The diversity of ecosystem types* (different types of ecosystems, for example: agrosystems, forests, pastures, wetlands, marshes, lakes etc.)
- *Wetlands* (frequently flooded areas, swamps, marshes, shallow lakes)
- *Aquatic ecosystems* (permanent water cover areas, for example lakes, ponds, rivers).

The integrated analysis of the results of the four meetings with local communities shows that scenario B, i.e. *"restoration of former Greaca wetland and use of the remaining polder for agriculture"* is preferred by the locals of Greaca and Gostinu villages and scenario A, i.e. *"maintaining the exclusively agricultural destination of the area, as it is now"* is the second option, as can be seen in figure 11. For the local communities of Căscioarele village the first option is scenario D, i.e. *"total restoration and transformation into a complex of wetlands as close as possible to the status of the 1900s"* and the second option is scenario B, i.e.

"restoration of former Greaca wetland and use of the remaining polder for agriculture" . For the local communities of Chirnogi, scenarios D and B were the first options, the difference between them being very small, irrelevant.

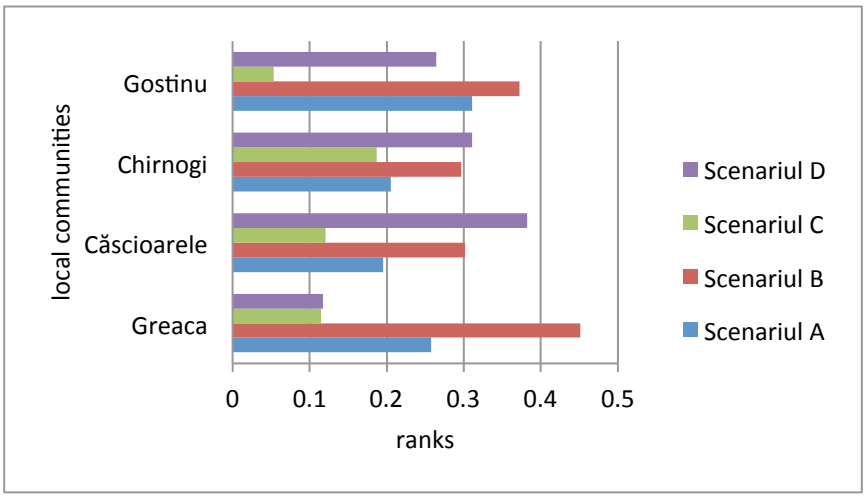

Figure 11. Local communities options for the proposed scenarios.

Scenario C, i.e. *"total restoration for water storage during high flows of the Danube"* is the last option, the least-liked by the local communities.

Generally, local communities prefer production services. However, regulation services are also given careful attention (for example, flood protection), and so are cultural services. Ecological integrity, which constitutes the basis for the supplied ecosystem services, is the least appreciated. The exception was the local community of Chirnogi which expressed its appreciation for this component in three of the discussed scenarios. Thus, they showed a higher degree of understanding of the link between the ecological state and the potential benefits for economic activities.

Within this study and during the discussions, the feasibility, technical or financial aspects of potential ecological restoration projects have not been approached. The local communities have expressed the hope that the socio-economic system will be reorganized towards an increase of social welfare, by a more efficient capitalization of the existing natural potential of the area.

The results of this study may support discussions and debates related to investments in ecological restoration projects for a sustainable development of the Danube floodplain.

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