ECONOMIC ASSESSMENT OF THE HABITAT SERVICES AND BIODIVERSITY LOSSES UNDER THE DNIESTER HYDROPOWER COMPLEX IMPACTS

**Olga Cazanteva^{1,2}, Roman Corobov², Ilya Trombitsky², Ghenadii Sirodov³,
Elena Zubcov¹**

¹ Institute of Zoology, Chisinau, Republic of Moldova;
e-mail: okazantseva56@gmail.com;

² Eco-Tiras International Association of River Keepers, Chisinau, Republic of Moldova;
e-mail: rcorobov@gmail.com; ilyatrom@mail.ru

³ Institute of Ecology and Geography, Chisinau, Republic of Moldova;
e-mail: syrodov_g@rambler.ru

Abstract. There are presented results of the economic valuation of the habitat service and biodiversity losses caused by the Dniester hydropower complex functioning. Habitat services were evaluated for two bird species (glossy ibis, *Plegadis falcinellus*, and yellow heron, *Ardeola ralloides*) and fish spawning grounds. The evaluation of biodiversity services was carried out for the Ramsar sites “Lower Dniester” and “Unguri - Holosnita”. The current cost of discussed losses in the Moldavian part of the Dniester basin is about USD 6.7-7.1 million.

Introduction

The habitats provide everything that an individual plant or animal needs to survive: food, water, shelter. In this structure, each ecosystem provides different habitats that are of great importance to the life cycle of species. At the same time, habitat services highlight the importance of the ecosystems themselves in providing habitats for both sedentary native and migratory species. Along with this, habitats contribute to the maintenance of biological and genetic diversity of various populations. Habitats with an exceptionally high number of species, making them the most biologically diverse, are known as “biodiversity hotspots”.

A significant part of the world’s biological resources is characteristic for developing and transitional countries where they are under the greatest threat of anthropogenic pressure, both inside and outside the developing world. These threats, along with population and economic growth, include new challenges, and the hydropower development is among them [12].

In particular, the Dniester River flow regulation, carried out in the interests of the Dniester Hydropower Complex (DHPC) functioning, significantly changes its natural seasonal flow [6]; this often leads to the drainage of Dniester delta in the spring-summer period. The flow regulation affects negatively not only the local population’s well-being, but also all living organisms: fish, amphibians, birds. Therefore, understanding the role of habitats and their economic value is extremely important as a tool for highlighting and quantifying the range of benefits through them obtained, thus allowing their direct comparison with other trajectories of sustainable development [3].

In recent decades, significant researches have been undertaken in this direction. Most of them have been done in developed countries [4, 5 8], but with limited use in developing world [3, 9]. This situation is due to the lack or weakness of local research capacity, which is in-

sufficient to raise awareness of the habitats importance in the ecosystems and biodiversity conservation. Alternatively, the use of non-economic methods, such as questionnaires, focus groups, participatory participation and other tools [10, 11], allows only the limited solutions of problems under consideration. Moreover, the results of such assessments vary significantly for different ecosystem services, sometimes by several orders of magnitude, due to the fact that their values were estimated without participation of market approaches [7]. Such methods do not provide meaningful results that can be used for policy development at the national and international levels.

Materials and methods

As an object of this study, the economic valuation of a number of habitats services and biodiversity in the Dniester basin, most affected by the DHPC functioning, has been carried out. Its destructive influence on main representatives of the Dniester delta's natural ecosystems has manifested in a catastrophic reduction (almost by 80%) of its fauna. In particular, in the last decades about 160 species of birds have disappeared here, and currently a number of their species that form a background for the Dniester delta's biodiversity are on the verge of extinction [16]. The economic valuation was carried out for two bird species: glossy ibis (*Plegadis falcinellus*) and yellow heron (*Ardeola ralloides*). They both are listed in the red books of Moldova and Ukraine.

Also, after the DHPC construction, due to a decrease in the Dniester runoff, most of the spawning wetlands ceased to be periodically flooded which has a significant impact on phytophilic fish, laying spawn on underwater vegetation. This led to a need to evaluate the loss of ecosystem services supporting the fish habitats.

The economic valuation of biodiversity, considered as an ecological resource, was carried out for the Ramsar site "Low Dniester".

As to the methodic used, the economic valuation was primary carried out, using the method of replacement cost of an animal world representative. According to this method, the total cost of a biological species restoration C_i is determined as follows [14]:

$$C_i = V_i * N_i(1),$$

where: V_i replacement cost of one individual of i -type species;

N_i total number of individuals of i -th species living within the study area.

To calculate the replacement cost of one individual (V_i), there are used a resource value (kr) and increasing (km) coefficients indicating that species belongs to those included in the Red Book or subjected to international treaties, including Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) :

$$V_i = k_r * k_m(2),$$

where: k_r - resource value coefficient taking into account the resource value of wildlife objects; it is taken as a fine size for the destruction of one specimen species in accordance with the law;

k_m - increasing coefficients.

In particular, according to [14], k_m equal:

2 - for species, covered by international treaties;

3 - for wild animals belonging to species included in the Red Data Book.

The method of replacement cost was used to evaluate habitat services for bird species and fish spawning grounds. The estimation of costs of the Dniester River wetlands' biodiversity conservation was based on the approach using a so called "reference value" [2].

Results and discussions

Maintaining the bird habitats

Before the DHPC construction, one of the most widespread birds in the Dniester delta was glossy ibis, *Plegadis falcinellus*; in 1970-1982, 2500-3000 its adult individuals nested stably here. In 1988-2002 the number of ibis nesting in the delta decreased in 8-11 - 14-25 times, fluctuating only within 100-350 adults. In 2003-2009, the decline continued (up to 40-150 adults), and in subsequent years (2010-2015) this bird almost completely disappeared from the delta as a nesting species [16].

According to the Ukrainian legislation, a fine for the destruction of one glossy ibis specimen is 12,063 hryvnas (~ 434 US dollars) that, taking into account the increasing coefficient km, equal to ~1,302 USD. Considering the amount of the fine as a kind of compensation for the lost of this environmental service, the total losses from reducing the glossy ibises as a result of hydropower negative impacts on the environmental conditions in the Dniester delta is about 3.9 million USD, even without taking into account the coefficient of reproducibility. In reality, this figure could be much larger.

Another vulnerable bird species under this economic evaluation - yellow heron, *Ardeola ralioides* - plays an essential role in wetland ecosystems, being the most important link in food chains. Since the yellow heron is very sensitive to even minor changes in the habitat where it is developing, it can be used as an indicator of such changes. So, before the start of DHPC construction and operation (1970-1982), 600-900 adult specimens of yellow heron nested in the Dniester delta. In 1985-1999 its number decreased to 200-300 individuals, and in 2000-2012 only 30-120 adults nested here (*ibid*). According to the Ukrainian legislation, a fine for the destruction of one yellow heron is, as in the case of the glossy ibis, 12063 hryvnia, or taking into account the multiplying coefficient ($km = 3$) is also equal ~ 1300 USD. If to assume that during the period of this review the number of yellow heron decreased by 675 specimens, then the total amount of losses from such reduction is about 900 thousand USD, excluding the species reproduction rate.

These estimates are especially important, considering that according to the prognoses [16], in the next 20 years, with the continuing violation of the scientifically grounded rules of DHPC functioning, in the Dniester mouth the final degradation of freshwater ecosystems and the disappearance of water bird main species will occur.

Maintaining the fish spawning grounds

Currently, in the Dniester floodplain from Naslavcea to Dubasari about 4,098 hectares of flooded spawning grounds are practically lost, which is about 14% of their total area that ex-

isted here earlier, before the DHPC construction [13]. The most extensive lacustrine-over flow system was in the Lower Dniester part that began below Bendery. Here, the floodplain reaches 2-3 km, expanding in some places to 17-18 km. Before the Dniester flow regulation, during the spring-summer high water, when it rose to 1.5 m above the low-water level, the entire floodplain was flooded. When the water level rose to two meters, the floodplain from Bendery to the Dniester mouth turned into a continuous reservoir with a total area of about 35 thousand hectares, serving as a spawning ground for phytophilous fish species and feeding their juveniles [17]. However at present, more than 20 thousand ha of valuable spawning grounds have been lost in the Dniester lower reaches, on the territory of Moldova only. The total loss of spawning grounds in the Dniester basin within the country is about 24.1 thousand ha.

At the same time, the specific feature of fish spawning migrations in the Dniester is their direct dependence on floods water level, their number, duration, and water temperature. The condition of the Dniester lacustrine-flooded system directly determines the fishery catches both in the river and Dniester Liman [17]. The required depth of spawning grounds is 0.5-1.0 m.

The economic valuation of fish spawning habitat losses was carried out, using the replacement cost of regulated spawning grounds. The importance of such facilities is confirmed by the experience of their use near the village of Hlinaia (area 2.98 ha, water volume 54.2 thousand m³). This experiment was organized to compensate for the lost areas of natural meadow spawning grounds due to the Dniester swallowing and its hydrological regime deterioration [15].

So, in 2019, about 4,742 specimens of larvae of different fish species were released from this spawning ground (by catching with a net). By catching with a Kori net this figure was 493,700 specimens of common carp larvae. Consequently, 165,671 fries can be obtained per ha. Since 3,456 ha of spawning grounds were lost, the possibility of reproduction of 573 million larvae was lost. Taking into account the current cost of 1 million larvae is 9,000 lei, the cost of spawning grounds loss is 5.2 million lei, or about 287 thousand USD per year.

However, this loss is underestimated, because it does not fully reflect the value of spawning grounds as reproductive ecosystems and the costs of their creation. At the costs of one hectare of regulated spawning grounds creation of 10-12 thousand lei, the compensation cost for lost spawning grounds will amount to 35-41 million lei (~ 1.9-2.3 million USD at the exchange rate of 18 lei per USD).

Economic evaluation of biodiversity

Economic valuation of the costs of the Ramsar site “Lower Dniester” biodiversity was based on the approach using a so called “reference value”. Such reference value was obtained based on available information on the cost of maintenance/conservation of biodiversity services, by calculating the average cost per unit area. This approach is close to the “*benefit transfer*” method that is used in situations where significant local expert knowledge and resources cannot be provided (GEF, 2018).

Figure 2. Economic value of biodiversity in the Ramsar site “Lower Dniester”

Spatial interpolation of the evaluation results (fig. 2) demonstrates clear territorial differences in the biodiversity values. Based on the total area of especially valuable territories of the Lower Dniester (11,160 hectares), the assessment of its biodiversity is estimated at 11.3 thousand USD according to the average minimum value and 21.5 thousand USD - according to the average maximum value. Hence, the loss of biodiversity of this unique natural system will lead to colossal economic losses of its ecosystem services, ranging from 126 to 240 million USD.

The obtained estimates of the economic value of the Lower Dniester's biodiversity, with a certain degree of conditionality, were used for the analogous estimation of the Ramsar site "Unguri - Holosnita". The territory of this site includes six natural complexes with a total area of ~ 3720 hectares. The economic value of this site's biodiversity services ranges from US \$ 42 million to US \$ 80 million, depending on the selected "reference value".

The study showed the current cost of maintaining the habitat and biodiversity services in the Moldavian part of the Dniester River basin, lost as a result of the impacts, is about 6.7-7.1 million USD. The cost of these ecosystems service potential loss that, with varying degrees of risk, could result due to the DHPC continued operation, is estimated at USD 168-320 million.

Certain expenses of the performed economic valuation are objectively caused by the ab-

sence in Moldova of an appropriate regulatory framework for this type of assessment, which leads to the use of available analogues. Moldova desperately needs the development of official, scientifically grounded methodological documents on the economic valuation of ecosystem services, which should be based on advanced world and European approaches. A high-quality and reliable evaluation of the ecosystem service losses caused by the intensification of hydro-power development is unthinkable without the creation and permanent functioning of an environmental monitoring system, including a full set of indicators of impact on ecosystems and their state, with free access to its data.

Further improving the approaches and methods for the economic valuation of ecosystem services is an important area for new research in this field. From this viewpoint, the study makes a certain contribution to the search for these problems solution. It demonstrates the country's national experience in such solution scientific substantiation based on quantitative analysis and study of the composition and state of important ecosystems and natural complexes on the whole.

Acknowledgements. *The current work was realized in frames of the BSB165 HydroEcoNex Project, realized in frames of the EU Black Sea Regional Operational Programme (2014-2020), and UNDP Project "Study of social and environmental impacts of the Dniester HPC". The contents of this publication are the sole responsibility of the authors (implementing team members from the Institute of Zoology and Ion Ionescu de la Brad Iasi University of Life Sciences) and can in no way be taken to reflect the views of the European Union or of the Joint Operational Programme Romania-Republic of Moldova 2014-2020 management structures.*

Bibliography

1. Andreev A, Şabanova G, Izverskaia T et al., 2012. Register of the core areas of the National Ecological Network of the Republic of Moldova. Chişinău, „Elena-V.I.” SRL, 700 p.
2. Cazanteva O., Sirodoev G., Corobov R. and Trombitsky I., 2019: Some approaches to the economic valuation of the wetland's biodiversity in Moldova. J. Sci. Res. Stud. 6(3): 34-45.
3. Christie M., Fazey I., Cooper R., et al., 2008: An Evaluation of Economic and Non-economic Techniques for Assessing the Importance of Biodiversity to People in Developing Countries. Report to Defra, London, 118p.
4. Christie, M., Hanley, N., Warren, J., Hyde, T., Murphy, K., & Wright, R., 2007. Valuing Ecological and Anthropocentric Concepts of Biodiversity: A Choice Experiments Application. In A. Kontoleon, P. Unai & T. Swanson (Eds.), Biodiversity Economics: Principles, Methods and Applications. (pp. 343 - 368). Cambridge: Cambridge University Press.
5. Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., & Hyde, T., 2006: Valuing the Diversity of Biodiversity. Ecological Economics, 58(2): 304-317.
6. Corobov R., I. Trombitsky, A. Matygin, E. Onishchenko, 2021: Hydropower impact on Dniester River streamflow. Environ Earth Sci 80, 153. <https://doi.org/10.1007/s12665-021-09431-x>
7. Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M., 1997: The value of the world's ecosystem services and natural capital. Nature 387:253–260.
8. DEFRA, 2007: An introductory guide to valuing ecosystem services, London, 65 p.
9. Georgiou, S., Whittington, D., Pearce, D., Moran, D., 2006. Economic Values and the Environ-

- ment in the Developing World. Cheltenham: Edward Elgar.
10. Grizzetti B., Langanova D., Liqueste C., Reynaud A., 2015: Cook-book for ecosystem service assessment and valuation in European water resource management. European Commission, Luxembourg, 136 p.
 11. Maes J, et al., 2013: Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020. EU, Luxembourg.
 12. MEA (Millennium Ecosystem Assessment), 2005: Ecosystems and Human Well-being: Current State and Trends Assessment. Washington: Island Press.
 13. UNDP, 2021: Study on social and environmental impacts of Dniester HPC (project).
 14. ТКП, 2013: Порядок проведения стоимостной оценки экосистемных услуг и определения стоимостной ценности биологического разнообразия. Минск, 23 с. Available at: http://www.ecoinv.by/images/pdf/tkp_fond/_17.02-10-2012_.pdf
 15. Филипенко С.И., Чур С.В., Мустя М.В., Богатый Д.П., 2019: О первом в Приднестровье регулируемом нерестилище. В сб.: Hydropower impact on river ecosystem functioning. Proceedings of the International Conference, Tiraspol, October 8-9, 2019. Tiraspol, Eco-Tiras, cc. 343-347.
 16. Щеголев И.В., Щеголев С.И., Щеголев Е.И., 2016: Вымирающие водно-болотные птицы в дельтах рек Северного Причерноморья. Том 1, Одеса, 258 с. https://www.eco-tiras.org/books/dead_birds.pdf
 17. Ярошенко М.Ф., 1957: Гидрофауна Днестра. М., Изд-во АН СССР, 168 с.