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Assessment of the economic value of ecosystem services of the Oleksandrivskyi Reservoir of the South Bug River basin

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Abstract. The article considers the implementation of the ecosystem approach in the implementation of activities related to water use on the South Bug River in the area of the Oleksandrivskyi Reservoir. The relevance of the research topic is determined by the implementation of the Tashlyk Pumped Storage Power Plant construction project related to the increase in the level of the Oleksandrivskyi Reservoir. Methodological principles of ecosystem mapping and assessment of ecosystem services based on MAES ecosystem mapping typology and international classification of ecosystem services to the group level (CICES V5.1). Mapping of ecosystems in part of the South Bug River basin (within Voznesensky district) was carried out and the percentage distribution of the main types of ecosystems was estimated. The main valuable ecosystem services of the Southern Bug River in the area of the Oleksandrivskyi Reservoir are identified as supporting services: biotic (fishery use of the reservoir), abiotic surface drinking water, water for irrigation, water for industrial purposes and energy, regulating and supporting services, including life cycle support, habitat and gene pool protection, food chain preservation, self-purification, as well as cultural services, including rafting, leisure, recreation, whitewater rafting, eco-tourism, sport fishing, education and science. Approaches to its economic evaluation are presented. The results of the assessment of the economic value of the complex of ecosystem services of the Oleksandrivskyi Reservoir are presented, namely: the value of the ecosystem service of providing fish products (calculated by the method of direct monetary valuation), the value of the regulatory service, based on the method of replacing the lost self-cleaning service of the river, as well as the assessment of the cultural ecosystem service by the conditional valuation method by surveying tourist agents. Based on the economic costs of compensating for the assessed ecosystem services, the economic inexpediency of implementing the project to complete the Tashlyk Pumped Storage Power Plant and raise the reservoir level is shown, i.e., such planned activities are environmentally unjustified and unprofitable.

Key words: ecosystem services, water use, mapping of ecosystems hydropower, Southern Bug.

Оцінка економічної вартості екосистемних послуг Олександрівського водосховища басейну річки Південний Буг

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Анотація. У статті розглядається реалізація екосистемного підходу при здійсненні діяльності, пов'язаної з водокористуванням на річці Південний Буг в районі руслового Олександрівського водосховища. Актуальність тематики дослідження зумовлена реалізацією проєкту будівництва Ташлицької гідроакумулюючої станції, пов'язаного з підвищенням рівня Олександрівського водосховища. В статті використано методи картографування (QGIS) та наведено методологічні засади картування екосистем та оцінки екосистемних послуг на основі типології картування екосистем MAES та міжнародної класифікації екосистемних послуг вер. 5.1 (CICES V5.1) до рівня групита. Для оцінки екосистемних послуг застосовано методи ринкового оцінювання: такі як умовне оцінювання (CVM), економічна вартість визначена ринком, оцінка, яка базується на компенсаційної вартості (наприклад, тариф на послугу, відшкодування за втрату), метод заміни втраченої послуги. Проведено картування екосистем в частині басейну річки Південний Буг (в межах Вознесенського району) та оцінено відсотковий розподіл основних типів екосистем. Виділено основні цінні екосистемні послуги р. Південний Буг в районі Олександрівського водосховища такі як забезпечувальні послуги: біотичні (рибогосподарське використання водосховища), абіотичні: поверхнева питна вода, вода для зрошення, вода для промислових цілей та енергетики, регулюючі та підтримувальні послуги, серед яких підтримка життєвого циклу, захист середовища проживання та генофонду, збереження харчового ланцюгу, самоочищення, а також культурні послуги, серед яких рафтинг, дозвілля, рекреація, бьордвотчінг, екотуризм, спортивна риболовля, освіта та наука. Наведено підходи до їх економічної оцінки. Представлено результати оцінки економічної вартості комплексу екосистемних послуг Олександрівського водосховища: вартість екосистемної послуги забезпечення рибною продукцією (розраховано методом прямої грошової оцінки), вартість регулюючої послуги, на основі методу заміни втраченої послуги самоочищення річки, а також оцінку культурної екосистемної послуги методом умовного оцінювання шляхом опитування туристичних агентів. На основі економічних витрат на компенсацію оцінених екосистемних послуг показано економічну недоцільність реалізації проекту добудови Ташлицької гідроакумулюючої станції та підняття рівня водосховища, тобто така планована діяльність є екологічно невиправданою та нерентабельною.

Ключові слова: екосистемні послуги, картування екосистем, водокористування, гідроенергетика, Південний Буг.

Introduction

In the conditions of climate change, water resources are of key importance for humanity and the preservation of the planet's ecosystems, and the problem of preserving fresh water occupies a key place among environmental problems around the world. Rivers, which provide the most important ecosystem services, due to significant anthropogenic load, which causes their changes and degradation, lose the ability to provide the population with drinking water, bio and recreational resources, support the circulation of substances in nature, self-purify, etc.

The full-scale invasion of russia against Ukraine, the genocide of the Ukrainian people, as well as the crimes against the environment by the aggressor country further aggravated the existing environmental problems, which forces to find the ways of restoration the environment and more effectively preserve ecosystems that were not disturbed by military actions.

Unlike the classic approaches that continue to dominate in Ukraine, the ecosystem approach allows avoiding a number of characteristic shortcomings. Among the shortcomings are the following: lack of coordination between different sectors of the economy, when the impact of certain activities on other sectors remains unevaluated; ignoring the relationship between nature and culture; focusing on species of flora and fauna rather than habitats; concentrating exclusively on areas with protected status, etc.

For the practical implementation of the ecosystem approach the great importance has the 5th of its 12 principles: «preserving the structure and functioning of the ecosystem in order to maintain ecosystem services should be the priority goal of the ecosystem approach (Havryliuk et al., 2019). This principle shows the importance of evaluating ecosystem services provided by ecosystems in decision-making processes. The application of the concept of ecosystem services in environmental assessments allows for the most comprehensive assessment of potential impact through consideration of changes in ecosystems and the services provided by it.

The implementation of the ecosystem approach must first of all take place through strategic environmental assessment (SEA) and environmental impact assessment (EIA). Within this framework, its necessary to carried out the establishment and mapping of ecosystems located in the zone of influence of the planned activity, determination of its condition, identification and assessment (including monetized) of the ecosystem services it provide.

The purpose of the work is to substantiate the principles of water use of the Southern Bug in the area of the channel Oleksandrivskyi Reservoir based on the assessment of the economic value of its ecosystem services.

Materials and methods

The state of study of the issue, the main developments. In recent years, the issue of estimating the economic value of river ecosystem services has been very actively studied all over the world. For example, recent research by Chinese scientists showed that the total value of ecosystem services in the Yellow River and Yangtze basins was higher than the country's GDP (Chunsheng Wu et al., 2021). The results of such research make it possible to clearly formulate and implement the policy of eco-compensation and payments for ecosystem services, as well as lay the foundation for spatial planning of territories. At the same time, different authors use different methodological approaches, which makes it impossible to compare the results obtained in different parts of the world. For example, the American author Loomis (Loomis, 2002) when evaluating the rafting service on the lower reaches of the Snake River (Washington State) under the condition of dismantling 4 dams, used an indirect evaluation method through a survey of respondents. The same method was applied by the same author in co-authorship (Loomis et al., 2000) to estimate the cost of restoration of 5 river ecosystem services – runoff dilution, self-purification, erosion prevention, biodiversity habitat, and recreation. So, the ecosystem services of the cultural and support-regulatory group were assessed using an indirect method. Other authors (Vicente et al., 2023) used the direct market valuation technique and the productivity method to estimate the consumer value of water supply for households and irrigation from the Balatin River (Philippines).

Ukrainian authors O. Vasenko and G. Milanich. (Vasenko and Milanich, 2018) evaluated the ecosystem services of water ecosystems of Ukraine based on the results of the assessment of the ecological state of the rivers and water storage main basins in the country, carried out according to hydrobiological indicators. The assessment of ecosystem services of river ecosystems is devoted, in particular, to the works of O. Veklych, V. Kolmakova, N. Degtyar and other Ukrainian scientists. The implementation of the ecosystem approach in the procedures of environmental impact assessment and strategic assessment of small hydropower projects on the rivers of Ukraine is based on the example of plans for the development of hydropower in the Ukrainian Carpathians (Berezhnyj et al., 2016). The first attempts to apply an ecosystem approach to hydropower development through ecosystem mapping and assessment of their services were made by R. Havrylyuk's team (Havrylyuk et al., 2019; Havrylyuk et al., 2021).

The research of Joachim Mahes, Benjamin Burkhard and other scientists, who actively developed the concept of ecosystem services in the EU during the last decade, is devoted to the mapping and assessment of the state of ecosystems at the European level. The importance of ecosystem services is increasingly reflected in the legal and policy instruments of the European Union. Ecosystem services are taken into account in planning documents defining the policy of nature management. In particular, the EU has already implemented the development of a pilot integrated system of accounting for ecosystems and its services for each member state (Accounting for ecosystems…, 2021) and an integrated system of accounting for natural capital in the EU, which also includes accounting for ecosystem services (Ecosystem Services Accounting…, 2021). This was preceded by the identification of typical European ecosystems and its mapping. In the light of the European integration of Ukraine, it is emphasized that Ukrainian legislation must harmonize with European legislation in the field of ecosystem services, and the ecosystem approach should be implemented in territorial management, which should be based on European approaches to the classification of ecosystems and their services and the assessment of the value of ecosystem services (Prykhodko et al., 2020).

At the same time, the assessment of ecosystem services of the river ecosystems of Ukraine and its mapping has not been carried out fully.

Research methods. The work uses instrument of mapping (QGIS), method of statistical data processing of basin management of water resources of the Southern Bug River, materials of the environmental impact assessment report on the completion of the Tashlyk PSPP (Pumped Storage Power Plant) construction, methods of market evaluation of ecosystem services: such as conditional valuation (CVM), economic value determined by the market, evaluation based on the mechanism of compensation value (for example, service tariff, compensation for loss).

The work is based on the typology of MAES ecosystems (Table 1). The Ecosystem Typology proposed by the MAES Working Group distinguishes 12 main types based on the higher levels of the EUNIS , habitat classification, and is a European reference classification cross-linked with the habitat types listed in Annex I of the Habitats Directive.

For the mapping of ecosystems in part of the basin of the Southern Bug River (Mykolaiv Oblast), was used data from the open service Copernicus Global Land Service (CGLC) with a resolution of 100 m, which reflects the coverage of ten basic classes of the land surface for the entire planet.

The main source data for the service are PROBA-V satellite observations organized into millions of equivalent Sentinel-2 tiles of 110x110 km. Processing in this tile grid in the UTM projection ensures high quality and contributes to the continuity of Sentinel-2 observations.

An important feature of the Copernicus Global Land Service is the display of land surface classes in accordance with the UN FAO Land Cover Classification System (LCCS), which are comparable to the MAES classification (Vysna, et al., 2021). Since the data on the types of land cover are comparable to the types of ecosystems given in the MAES classification,

Table 1. A typology of ecosystems for mapping (MAES et al., 2018)

MAES Level 1 Categories of ecosystems	MAES level 2 Ecosystem type	Description
Terrestrial	Urban	Urban ecosystems are areas where most of the human population lives. This class includes urban, industrial, commercial, and transport areas, urban green areas, mines, dumping and construction sites.
	Cropland	Croplands are the main food production areas including both intensively-managed ecosystems and multifunctional areas supporting many semi-natural and natural species along with food production (lower intensity management). It includes regularly or recently cultivated agricultural, horticultural and domestic habitats and agro-ecosystems with significant coverage of natural vegetation (agricultural mosaics).
	Grassland	Grasslands are areas covered by a mix of annual and perennial grass and herbaceous non-woody species — including tall forbs, mosses and lichens, with little or no tree cover. The two main types are managed pastures, semi-natural and natural (extensively managed) grasslands
	Forest and woodlands	Woodlands and forests are areas dominated by woody vegetation of various age, or they have succession-climax-vegetation types on most of the area, supporting many ecosystem services. Information on ecosystem structure, e.g. age group, species and diversity, is especially important for this ecosystem type
	Heathland and shrub	Heathlands and shrubs are areas with vegetation dominated by shrubs or dwarf shrubs. They are mostly secondary ecosystems with unfavourable natural conditions. They include moors, heathland and sclerophyllous vegetation.
	Sparsely vegetated land	Sparsely vegetated lands often have extreme natural conditions that might support particular species. They include bare rocks, glaciers and dunes, beaches and sand plains.
	Wetlands	Inland wetlands are predominantly water-logged, specific plant and animal communities that support water regulation and peat-related processes. This class includes natural or modified mires, bogs and fens, as well as peat extraction sites.
Freshwater	Rivers and lakes	Rivers and lakes are the permanent freshwater inland surface waters. This class includes water courses and waterbodies.
Marine	Marine inlets and transitional waters	Marine inlets and transitional waters are ecosystems on the land-water interface under the influence of tides and with salinity regimes higher than 0.5 ‰. They include coastal wetlands, lagoons, estuaries and other transitional waters, fjords and sea lochs as well as embayments.
	Coastal	The coastal ecosystems include coastal, shallow, and marine systems that experience significant land-based influences. These systems undergo diurnal fluctuations in temperature, salinity and turbidity, and are subject to wave disturbance. Depth is between 50m and 70m.
	Shelf	The shelf refers to marine systems away from coastal influence and down to the shelf break. They experience more stable temperature and salinity regimes than coastal systems, and their seabed is below wave disturbance. They are usually about 200m deep.
	Open ocean	The open ocean refers to marine systems beyond the shelf break with very stable temperature and salinity regimes particularly at the deep seabed. Depth is beyond 200m.

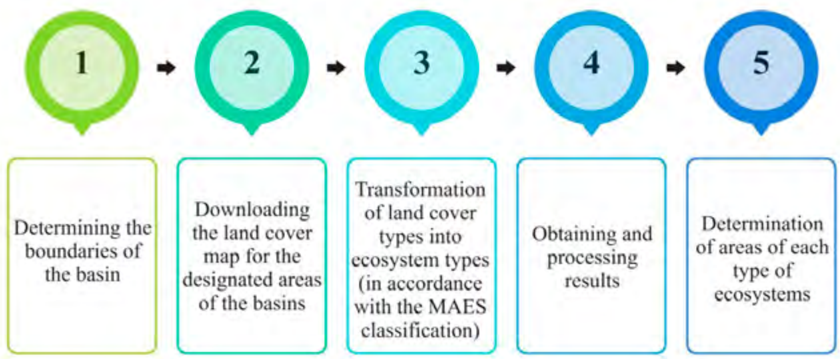

Fig.1. Algorithm for creating a map of ecosystems

the Copernicus Global Land Cover map was taken as the basis for the development of the ecosystem map of the Southern Bug River Basin (Fig. 1).

For the identification and assessment of the economic value of ecosystem services, the international classification of ecosystem services CICES V5.1 was applied (to group level) (Table 2).

To evaluate the services of the river ecosystem using the example of the Oleksandrivskyi Reservoir on the South Bug River, previously developed methodological approaches were used (Stankiewicz-Volosianchuk O. et al., 2023), Table 3.

Results and their analysis

Ecosystems mapping. The Oleksandrivskyi Reservoir, located on the South Bug River in the Mykolaiv region, which is part of the Southern Ukrainian energy complex, in particular, the lower reservoir of the Tashlyk PSPP, was chosen as the object of the study. The normal support level of the reservoir is 16 m, while it is planned to raise it to levels of 16.9 and 20.7 m over many years.

The mapped ecosystems of a part of the river basin (within the Voznesensk district) (Fig. 2) show the existing diversity of ecosystems in the valley of the Southern Bug and its tributaries. The diversity of ecosystems depends on the diversity of both biotic and abiotic components. Water is the determining factor of such diversity for the Southern Bug basin.

The percentage distribution of ecosystem types (by area) is as follows: Cropland- 91,7%, Grassland (Steppes and meadows) – 2,78%, Forest and woodlands- 2,28%, Urban – 1,74%, Wetlands– 0,92 %, Rivers and lakes – 0,54 %.

Assessment of ecosystem services. Cultural, historical and archaeological monuments of different periods are concentrated in the area of the Oleksandrivskyi Reservoir, some of which are currently flooded. This territory is included in the register of cultural monuments of national significance as «Historical landscape of the center of the Bugo-Gardiv palanka of the Zaporizhia Army» (protection number 140001 – H).

It is necessary to highlight the supporting abiotic service for the needs of energy – water.

The water from the Oleksandrivskyi Reservoir is used for the needs of the Tashlyk PSPP, for cooling the reactors of the South Ukrainian NPP, by recharging the Tashlyk cooling pond. According to official data, 54-72 million cubic meters of water are supplied to the cooling pond annually, while the irrecoverable evaporation costs of this pond are 32-37 million cubic meters per year.

Another service of the Oleksandrivskyi Reservoir is the discharge into its reservoir of the flushing water of the cooler reservoir. Reverse (waste) heat exchange water from NPPs is significantly mineralized, and the volume of its discharge, according to official data from NNEGC «Energoatom», is more than 108161.018 cubic meters per hour (or 30 cubic meters per second)). This volume of reclaimed water is almost twice as much as the environmental release rate from the Oleksandrivskyi Reservoir, which is 17 cubic meters per second.

The existing use of water resources of the Southern Bug for industrial purposes, as well as the planned goals to increase the volume of the Oleksandrivskyi Reservoir and increase the use of water resources and flooding of new areas of the «Buzky Gard» National Park, which are of exceptional natural and cultural value, determine the increase in negative impacts on such ecosystem services:

– fish products and feed organisms, as a result of increased mineralization of water and subsequent changes in hydrological, hydrophysical and hydrochemical characteristics of the reservoir;
– water supply of the population due to the deterioration of water quality caused by an increase in the volume of mineralized wastewater, slowing of the flow and reduction of natural aeration of water due to flooding of rapids, siltation and destruction of coastal vegetation, which today serves as natural filters;
– cultural services due to the flooding of particularly valuable territories of the Buzkiy Gard National Nature Reserve and the historical landscape, which attracts thousands of tourists every year.

For example, the cost of the ecosystem service of providing fish products of the Oleksandrivskyi Reservoir is calculated using the method of direct monetary assessment.

The evaluation of the cultural ecosystem service was made by the method of conditional evaluation by interviewing (CVM) of tourist agents who have experience in organizing tourism in the given territory. For the assessment, a survey of 10 travel agents was conducted in order to determine how much tourists are willing to pay for services and how many such services can be provided by the company per year.

Regulatory and support services play an important role in the assessment of ecosystem services. The value of granite rapids on the Southern Bug in the reservoir area, habitats of rare species, including aquatic vegetation, biodiversity to support the life cycle, preservation of the natural flow and hydrological regime

Table 2. General international classification of ecosystem services ver. 5.1 (CICES V5.1) to the group level

Section	Class	Group	Group code
Biotic ES			
Section	Class	Group	Group code
Provisioning	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	1.1.1
		Cultivated terrestrial plants for nutrition, materials or energy	1.1.2
		Reared animals for nutrition, materials or energy	1.1.3
		Reared aquatic animals for nutrition, materials or energy	1.1.4
		Wild plants (terrestrial and aquatic) for nutrition, materials or energy	1.1.5
		Wild animals (terrestrial and aquatic) for nutrition, materials or energy	1.1.6
	Genetic material from all biota (including seed, spore or gamete production)	Genetic material from plants, algae or fungi	1.2.1
		Genetic material from animals	1.2.2
Regulation & Maintenance	Transformation of biochemical or physical inputs to ecosystems	Transformation of biochemical or physical inputs to ecosystems	2.1.1
		Mediation of nuisances of anthropogenic origin	2.1.2
	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	2.2.1
		Lifecycle maintenance, habitat and gene pool protection	2.2.2
		Pest and disease control	2.2.3
		Regulation of soil quality	2.2.4
		Water conditions	2.2.5
		Atmospheric composition and conditions	2.2.6
Cultural	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	3.1.1
		Intellectual and representative interactions with natural environment	3.1.2
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	3.2.1
		Other biotic characteristics that have a non-use value	3.2.2
Abiotic ES			
Section	Class	Group	Group code
Provisioning	Water	Surface water used for nutrition, materials or energy	4.2.1
		Ground water for used for nutrition, materials or energy	4.2.2
		Other aqueous ecosystem outputs	4.2.3
	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or energy	4.3.1
		Non-mineral substances or ecosystem properties used for nutrition, materials or energy	4.3.2
		Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or energy	4.3.2
Regulation & Maintenance	Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes	5.1.1
		Mediation of nuisances of anthropogenic origin	5.1.2
	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	5.2.1
		Maintenance of physical, chemical, abiotic conditions	5.2.2
	Other type of regulation and maintenance service by abiotic processes	Other	5.3.3
* Cultural	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Physical and experiential interactions with natural abiotic components of the environment	6.1.1
		Intellectual and representative interactions with abiotic components of the natural environment	6.1.2
	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with the abiotic components of the natural environment	6.2.1
		Other abiotic characteristics that have a non-use value	6.2.2
	Other abiotic characteristics of nature that have cultural significance	Other	6.3.3

Table 3. List of services of river ecosystems and approaches to estimating their economic value

Section	Division	Group	Class	Code	Class type	An example of a service	What is evaluated
Provisioning services (Biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy	Animals reared by in-situ aquaculture for nutritional purposes	1.1.4.1	Freshwater fish	Growing fish in a fish farm	Fish productivity of the reservoir
Regulation & Maintenance	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats (Including gene pool protection)	2.2.2.3	Providing habitats for wild plants and animals	Support of the life cycle, protection of the habitat and gene pool, preservation of the food chain	The number of species of hydrobionts listed in the RBU. Fertility of females. The value of benthos and plankton
Cultural services	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3.1.1.1	Using the environment for sports and recreation	Rafting, surfing, leisure recreation	Annual number of vacationers
				3.1.1.2	Observation of plants and animals	Birdwatching, ecotourism, sport fishing	Annual number of tourists.
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water for drinking	4.2.1.1	Drinking water from springs on the surface of the earth	Volume and characteristics of water from natural sources, drinking water in the communal system water supply	Costs for surface water treatment to drinking quality.
			Surface water used as a material (non-drinking purposes)	4.2.1.2	Surface waters	Reactor cooling or irrigation	Annual volume of fresh water for reactor cooling and irrigation.
			Freshwater surface water used as an energy source	4.2.1.3	Hydroelectric power stations	Electricity	The amount of electricity
		Ground water for used for nutrition, materials or energy	Ground (and subsurface) water for drinking	4.2.2.1	Drinking water from underground	Volume and characteristics of the aquifer Drinking water in the communal water supply system; mineral water	Surface water treatment costs
	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or energy	Mineral substances used for material purposes	4.3.1.2	Natural inorganic materials from nature that we can use	Sand-gravel mixture	Production volumes of sand and gravel mixture

of the river form the basis of the river ecosystem's ability to self-purify (Tymchenko et al, 2021). Estimating the economic value of the whole range of regulatory and supportive services of the river ecosystem, such as biodiversity, filtering properties of riparian vegetation, aeration of water at rapids, oxidation rates of pollutants, etc. is not an easy task. The solution to this problem requires a large amount of data collected as a result of various studies, as well as methods. At the same time, the ability of the river to cleanse itself directly affects the ability of communities living in the river valley to receive a number of important

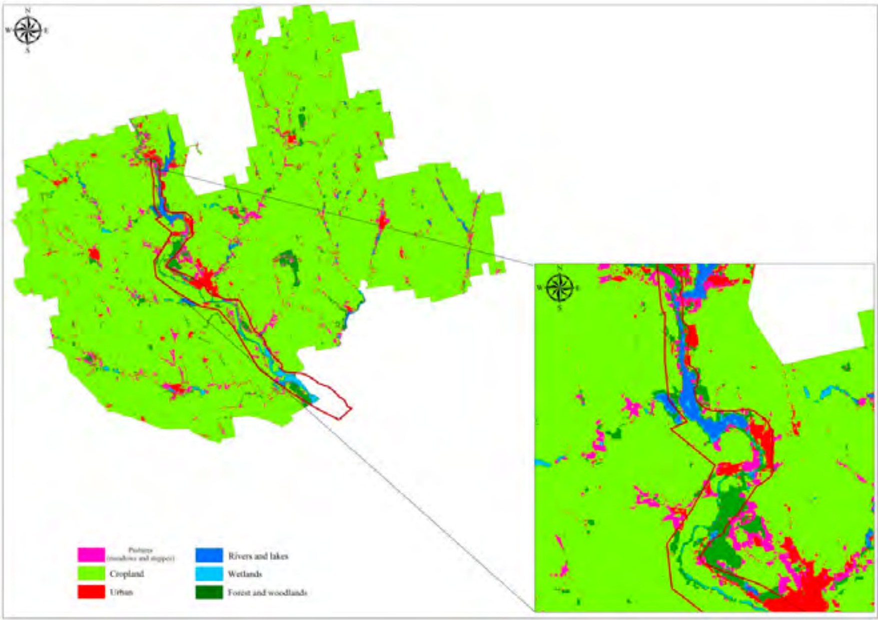

Fig.2. Typology of ecosystems in the part of the Southern Bug River basin (within Voznesensky district)

services such as «surface drinking water», «surface water for irrigation», «groundwater for drinking», «groundwater for irrigation». The monetary value of these support services using the proven methods was estimate.

To calculate the monetary value of the ecosystem service «surface drinking water», a method was used according to which the ecosystem service is assessed through the mechanism of compensating the value of the lost service. Thus, the value of this ecosystem service is correlated with the cost of water purification from the Southern Bug by reverse osmosis treatment systems. The calculation took into account data on water shortages downstream the Oleksandrivskyi reservoir. This also includes the supply of drinking water to partially Voznesensk, Nova Odesa and smaller settlements in Mykolaiv Oblast with a total population of 78,000 people and for irrigation systems with a total area of 25,000 hectares. These purification systems are the best of those that can purify highly mineralized water.

If the salinity of the Southern Bug River increases further, surface water will not be able to be used for irrigation. Then you will have to irrigate agricultural land with water from underground sources. Taking into account that the average rainfall in the Voznesensk district of Mykolaiv region is about 400-500 mm per year, irrigation of one hectare of land usually requires from 5000 to 10000 m^3 of water per year, depending on the conditions and soil type. The calculation of the cost of replacing the loss of one ecosystem service with another is shown in Table 4. The table shows only those ecosystem services that will be adversely affected by the further construction of the Tashlyk PSPP and the raising of the level of the Oleksandrivskyi reservoir.

The monetary value of only 4 assessed ecosystem services associated with the Oleksandrivskyi Reservoir today is $25,299,351 per year. As a result of the reservoir expansion project, reduced ability of the Oleksandrivskyi reservoir and associated ecosystems to provide these services will cost communities and residents of the Southern Bug Valley a monetary amount equal to this or even higher costs. The total losses also include irrecoverable evaporation losses of the Southern Bug, which will increase by 660,000 cubic meters per year with the increase in the reservoir's water level. Taking into account the amount of rent for special use of surface waters of the Southern Bug River, this will amount to an additional $7000 per year.

At the same time, the capacity of the Tashlyk PSPP is estimated at 700 million kWh per year in generator mode (output). Taking into account electricity prices for individuals, it can be calculated that the value of the electricity generation service is $49,945,946 per year (at a tariff for households of 2.64 UAH per kilowatt-hour).

At the same time, when the PSPP operates in pumping mode, the electricity consumption for pumping water into the upper reservoir is 960 million kWh per year, which corresponds to 34,248,649 USD (at a nightly rate of 1.32 UAH per kilowatt-hour). That is, in fact, the value of the electricity generation service

Table 4. Estimation of the economic value of the complex of ecosystem services of the Oleksandrivskyi Reservoir on the Southern Bug River

Ecosystem Service	Evaluation method	Initial data	Monetary value, USD/year
Provisioning services (biotic and abiotic)			
Fish products (biotic) provisioning services	Direct monetary valuation method (market value)	Fish productivity of the reservoir, 102.6 kg/ha by fish species, market value of fish (estimated by the State Agency of Land Reclamation and Fisheries in Mykolaiv region for 2022).	325 000
Surface drinking water (abiotic)	Direct monetary valuation method (compensation value)	Treatment of water for drinking purposes by reverse osmosis for 78,000 consumers in downstream settlements, 0.15 cubic meters per person per day, cost of treatment 150 UAH/cubic meter	17 312 838
Fresh water for irrigation (abiotic)	Direct monetary valuation method (compensation value)	Special water use for groundwater irrigation, irrigated area 25000 hectares, water volume 8000 cubic meters per year per 1 hectare, rent 1.39 UAH/cubic meter	7 513 513
Cultural services			
Tourism (cultural services)	Метод опосередкованої грошової оцінки (опитування (CVM) туристичних агентів)	Кількість рекреантів, які готові платити за туристичні послуги (за видами послуг)	99 000
Total			25 299 351

is $15,697,297 (excluding maintenance costs, salaries, and construction costs of the Tashlyk PSPP).

In current situation, the Southern Bug River is viewed more as an energy resource, and further projects in the Oleksandrivskyi Reservoir are focusing on only one ecosystem service of the entire river ecosystem. The residents of the Southern Bug Valley are entitled to and do receive a number of other important ecosystem services, no less important than electricity. Many of these services are difficult to value in monetary terms.

The above calculations of the four ecosystem services are based on current data and methodologies and show that any planned activity, in addition to economic benefits, entails financial losses, if not for local budgets, then for the budgets of each individual household. These losses can result from a decrease or complete loss of the ecosystem's ability to provide certain ecosystem services as a result of intensive use of one of them, for example, energy.

The concept of ecosystem services is based on sociocentrism. Ecosystem services directly and indirectly affect human well-being, so environmental impact assessment and strategic environmental assessment procedures should also include a procedure for identifying all ecosystem services received by residents of the territory where an infrastructure project is planned to be implemented. Such approaches will allow to reach a compromise between business and the environment in line with the goals of sustainable development.

Conclusions

The international classification of ecosystem services CICES V5.1 was used to assess a number of supply, regulatory, support and cultural services of the freshwater ecosystem in the section of the Oleksandrivskyi Reservoir on the South Bug River. As part of this classification, we used previously developed methodological approaches to calculate the economic value of selected ecosystem services. The developed methodological approaches are based on direct valuation, which is based on market value, compensatory value mechanism and conditional valuation (CVM). All ecosystems of the lower reaches of the South Bug River, where the Oleksandrivskyi Reservoir is located, were also identified and mapped. Mapping was carried out according to the MAES typology.

The applied methodical approaches to the assessment of the economic value of a number of ecosystem services of the Oleksandrivskyi Reservoir made it possible to establish that it amounts to 25,299,351 UAH for a year. The assessment of the economic value of the fish productivity of the analyzed ecosystem, the provision of drinking water, water for irrigation and water for energy purposes, self-purification services, and recreational services (rafting, climbing, swimming, gastronomic tourism, recreation) which have been carried out made it possible to draw the main conclusions. Calculations showed that the benefit from receiving one ecosystem service – energy, which causes the reservoir level to rise and the further development of the Tashlytsky PSPP, will not be able to compensate for the monetary losses from the decrease in the ability of the ecosystem to provide other ecosystem services. In other words, such planned activities are environmentally unjustified and unprofitable. The application of the ecosystem approach, which is based on ecosystem mapping and assessment of its services, to the SEA and EIA procedure would make it possible to assess not only the negative impact of economic activity on the environment and biodiversity, but also the profitability of projects based on the use of natural resources.

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