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ECOSYSTEM SERVICES OF THE NORTH-WESTERN BLACK SEA WETLANDS

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Abstract. A significant part of wetlands of international importance in Ukraine is located on the North-Western Black Sea region territory. Wetlands are integral components of a natural reserve fund and ecological network; they perform very important functions in maintaining biological and landscape-biological diversity, as well as stabilizing climatic conditions. Ecosystem services of wetlands are of great importance, but their quality is subject to the negative influence of natural spontaneous processes and various forms of anthropogenic activity. An assessment of wetlands ecosystem services is necessary to understand how important is their role for the normal life of the population, as well as for the conservation of biological diversity and the maintenance of balanced natural processes. Therefore, the problems of rational use, conservation and restoration of the North-Western Black Sea region wetlands, as well as their ecosystem services assessment are important in environmental and socio-economic aspects.

Keywords: ecosystem services, wetlands, coastal zone, North-Western Black Sea region, natural systems.

1. Introduction

A significant part of wetlands of international importance in Ukraine is located on the North-Western Black Sea region territory. Wetlands are integral components of a natural reserve fund and ecological network; they perform very important functions in maintaining biological and landscape-biological diversity, as well as stabilizing climatic conditions. Ecosystem services of wetlands are of great importance, but their quality is subject to the negative influence of natural spontaneous processes and various forms of anthropogenic activity. An assessment of wetlands ecosystem services is necessary to understand how important is their role for the normal life of the population, as well as for the conservation of biological diversity and the maintenance of balanced natural processes. Therefore, the problems of rational use, conservation and restoration of the North-Western Black Sea region wetlands, as well as their ecosystem services assessment are important in environmental and socio-economic aspects.

The aim of the study is a critical analysis of the current state of ecosystem services of the North-Western Black Sea region wetlands, as well as an assessment of the prospects for their use.

2. Materials and Methods

Numerous studies have been devoted to the wetlands and their ecosystem services, but the ecosystem services of the Odessa region wetlands are considered only in a few publications. In the study of O. Rubel (Rubel, 2009) provided an ecological characteristics and economic benefits of the wetlands of the Ukrainian Danube region. The work of N. Zakorchevna (Zakorchevna, 2019) provides an assessment of ecosystem services of the Lower Dniester basin. The studies of T. Safranov et al. (Safranov et al., 2022; Slizhe et al., 2023) characterized the ecosystem services of the northwestern part of the Black Sea and the wetlands of certain parts of the Northwestern Black Sea region coastal zone.

The methodological basis of this study is a critical analysis of existing approaches to the assessment of ecosystem services. The analysis was

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carried out using previously published data, as well as materials from our own research devoted to the assessment of ecosystem services of wetlands.

3. Results and Discussion

Wetlands, according to Convention on Wetlands (UNESCO, 1994), "*are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres*". According to the UN Environment Program (UN Environment, 2024), the area of wetlands is about 5.7 million km^2, that is, approximately 6 % of the Earth's land surface, of which 2 % are lakes, 30 % − raised bogs, 26 % − lowland bogs, 20 % − wetlands and 15 % − floodplains. Despite their small area (only about 6 % of the Earth's land surface), about 40 % of all species of flora and fauna live in wetlands.

Wetlands perform many vital functions, in particular: accumulation and storage of surface waters; protection from storms and floods; strengthening the coastline and curbing water erosion; hydraulic connection with groundwater; surface water purification; nutrient content; deposit formation; pollutants retention; stabilization of local climatic conditions, especially the amount of precipitation and temperature of the near-surface layer of the atmosphere. They are the world's most productive ecosystems, focus of biodiversity, sources of water and primary productivity on which the existence of innumerable species of plants and animals depends. The biological diversity of wetlands is important for the supply of food and drinking water, recreational and tourism activities, the labor market, etc. Wetlands are vital to humans, other natural ecosystems and the climate, playing an important role in ensuring the regulation of water resources. More than a billion people around the world depend from wetlands, as a source of livelihood. Wetlands are extremely important for people and nature, taking into account their high value and the beneficial properties their ecosystem services. They are among the ecosystems with high rates of degradation. According to forecasts, due to the influence of direct and indirect factors (rapid population growth, unsustainable production and consumption and related technological development, as well as climate change), negative trends of reducing biological diversity and imbalance in ecosystem processes in wetlands are increasing in many regions of the world.

Wetlands play an important role in the regulation of global and regional climate due to the sequestration and release of significant amounts of carbon. Wetlands absorb the main greenhouse gas (CO_2), helping to slow global warming, reduce pollution and are a physical barrier that mitigates the impact of the changes themselves, and on the other hand, they are important carbon sinks (for example, peatlands). Despite the fact that peatlands occupy only 3-4 % of the total land area, they contain up to $540 \cdot 10^9$ tons of carbon. Peat swamps store twice as much carbon as the world's forest ecosystems. However, when wetlands drain and degrade, they can release huge amounts of carbon (iron and hydrogen peroxide from bacteria react and form oxygen radicals, which destroy plant residues in soils and contribute to the release of CO_2). Therefore, despite large-scale processes of degradation and drainage of wetlands, these areas still remain sources of CO_2.

Wetlands act as a regulator of such processes as fresh water accumulation and storage, water filtration, absorption from the atmosphere and accumulation of CO_2. Wetland plants absorb CO_2 in the 50 times more than tropical forests, after which they are covered with silt when the water level rises. They are sources of O_2, which is released during photosynthesis, and maintain a balance between CO_2 and O_2. In addition, wetlands are characterized by powerful natural sources of CH_4 generation CH_4. The annual emission of biogenic CH_4 (swamps, rice paddies, livestock complexes, polygons and landfills of solid household waste, etc.) is 302–665 million tons, which exceeds the annual emission of abiogenic CH_4 (development of coal deposits, losses and leaks from wells, etc.) – 48–155 million tons. At the same time, the main natural source of biogenic CH_4 is wetlands, which emit up to 30 % from volume of CH_4 entering to the atmosphere (Snakyn et al., 2017). It is biogenic methane CH_4 plays a major role in regulation, stabilization and formation of climate conditions. As noted by the authors of the global biological control hypothesis (Lovelock & Margulis, 1974), as a result of the interaction between biological and geochemical processes, a constant amount of O_2 is maintained in the lower layers of the atmosphere. It is known that an increase of O_2 by 1 % increases the possibility of fires by 60 %, and with an increase of O_2 content by 4 %, the entire planet would be covered by napalm and all biota would be destroyed. Despite the increase of solar activity, the number and diversity of living organisms for more than 400 million years (since the Devonian period), the O_2 content remains within a very narrow range of values (20–21 %). This is due to the fact that excess of O_2 is "quenched" by CH_4 (the main component of swamp gas) during the reaction: $CH_4 + 2O_2 = CO_2 + 2H_2O$. Consequently, the biochemical formation of CH_4 plays an important regulatory role on both global and regional scales.

Recent literature often describes the links between natural ecosystems and the economy using the concept of ecosystem services, or the flows of value incoming into human societies, and being the result from the state and magnitude of natural capital. The term "ecosystem services" began to be actively used in 1981, after the publication of the work of P. Ehrlich and A. Ehrlich (Erlich & Erlich, 1981), emphasizing the social significance of the functions of natural ecosystems. There is no single definition of the term "ecosystem services" yet, and there is also no single methodology for their assessment. Ecosystem services are all the useful resources and benefits that modern humanity can receive from nature (both material and intangible benefits from abiogenic and biogenic components of various natural ecosystems). Exactly from them depends meeting humanity's needs in the environment and food, as well as the level and quality of his life. Therefore, in the UN document "Millennium Ecosystem Assessment" (Millennium, 2005), ecosystem services are called "direct and indirect contributions to human well-being".

The fundamental dependence of humanity from ecosystem services, from their condition and dynamics is systematically analyzed in the report "Millennium Ecosystem Assessment" (Millennium, 2005), prepared under the leadership of the UN by an international scientific team. This study proposes four groups of ecosystem services: 1) *provisioning services* are services that describe the material or energy result of the functioning of ecosystems (food, wood and fiber, fuel, fresh water, medicines, etc.); 2) regulating services are services for regulating ecosystem processes (air quality regulation, water purification, water flow regulation, erosion prevention, climate regulation, pollination, biological control); 3) *cultural services* are the intangible benefits that people receive from contact with ecosystems (cultural, artistic, recreation and tourism value, aesthetic value, knowledge and educational value, spiritual and religious value); 4) supporting services are the services needed to support all other ecosystem services (soil formation, nutrient cycling, photosynthesis, biodiversity).

The specified groups of ecosystem services can be applied to wetlands, the ecological features of which are a set of their ecosystem components, processes and services at one or another specific moment in time.

Their useful properties mean benefits received from them: supply services (water and food); regulation services (regulation of floods, droughts, land degradation, etc.); supporting services (soil formation, cycle of biogenic elements, photosynthesis, biological diversity); cultural services (cultural and entertainment, spiritual, religious and other intangible benefits).

All ecosystem services are free, because people do not pay for their use or consumption, but some of these services can be conditionally valued in monetary terms in order to assess the scale of losses resulting from the disappearance of the beneficial properties that constitute natural ecosystems. Assessment of ecosystem services is necessary to understand how important it is for the normal life of society to preserve the landscape and biological diversity of natural ecosystems and maintain them in an equilibrium state. In addition, the assessment of ecosystem services is an important step towards determining their contribution to various sectors of the economy, and also allows us to determine their potential to provide these services in a specific context and for specific recipients of material requirements.

It should be noted that a number of scientists are against "assigning a price tag" to the riches of nature. They believe that the value of nature is infinite and cannot have a monetary expression, and it is simply absurd to evaluate its individual elements. Others, on the contrary, believe that this is necessary (Commoner, 1974; Bobylev & Zakharov, 2009; Akimova & Khaskin, 2012). Currently, the economic assessment of ecosystem services (useful properties) of natural systems is important for effective environmental management and can be the basis for making informed management decisions. Economic assessment of the beneficial properties of natural systems makes it possible to rationally use available resources, evaluate the investment attractiveness of environmenttally oriented projects, and also contributes to the development and implementation of a system of compensation payments. It is believed that the main reason of the natural systems degradation is the underestimation of their real economic value, the cost of their resources and services in general. In cases where the financial resources needed to solve serious economic problems are limited, fees for the beneficial properties of natural systems can provide additional resources for the implementation of environmentally friendly technologies, create incentives for investment and increase business involvement in environmental protection (Zakorchevna, 2019). The ethical aspect of valuation and payment for ecosystem services is discussed in detail in the article (Villagomez-Cortes , del-Angel-Perez, 2013).

The concept of “ecosystem services” is absent in Ukrainian legislation, so taking them into account in decision-making is not a very common practice (Vasyliuk, Ilminska, 2020). Although the Law of Ukraine “Basic principles (strategies) of the state environmental policy of Ukraine for the period until 2030” notes the advisability of “introducing the ecosystem approach into sectoral policy and improving the system of integrated environmental management”. The urgent need to create institutional conditions for the introduction of the ecosystem approach into business practice actualizes the development of specific recommendations to government authorities in Ukraine. Therefore, in the work of A. Veklich et al. (Veklych et al., 2019) presented a systematized array of scientific and applied proposals and legislative initiatives to reform the environmental management system on an ecosystem basis, taking into account the general processes of decentralization and European integration. Due to the fact that mechanisms for introducing the concept of ecosystem services and institutional norms to prevent contradictions between producers of ecosystem services and their consumers have practically not been developed in Ukraine, in the near future it is proposed to implement the concept of “ecosystem services” into the legislation of Ukraine, to conduct an inventory and assessment of ecosystem services in order to implementation of ecosystem payments and their inclusion in market circulation. Previously undervalued services that need to be identified and integrated into business activities require in-depth research. This can be one of the reliable guards against further degradation of ecosystem services and a tool for Ukraine’s future entry into international markets for ecosystem services (Havrylenko, 2019).

Some researchers (T. Brown, J. Bergstrom, J. Lumys, D. Darbalaeva, etc.) consider the term “ecosystem services” to be unsuccessful, since natural ecosystems cannot provide services, because services are an act or some kind of conscious action. Nature exists, but does not provide services, and natural resources and conditions exist independently of humans. The term “services” is incorrect to use in relation to the natural ecosystem, since in economic theory “services” are understood as the purposeful activities of a person, the result of which has a beneficial effect that satisfies any human needs. A service is a result of an activity, a tangible or intangible product that the manufacturer provides to the consumer in accordance with the established requirements and properties of this product or result. The concept of “service” can be interpreted as a specific form of labor, and as a result of labor (environmental, educational, informational, consulting, legal, medical, etc.). For example, environmental services are a type of service whose direct or indirect result is an improvement in the state of the environment and a reduction of harmful effects on humans (Tolstoukhov, 2008).

It is known that in environmental management the main object of research is the natural system, which is sometimes considered as a synonym for the term “ecosystem”. Having a large number of similar elements and connections, an ecosystem and a natural system differ by the direction of intrasystem connections. The ecosystem model is characterized by the direction of connections from the factors of the “environment” (object), first of all, to the main object – the “owner” (subject), and the natural system model is characterized by the recognition of the equality of all connections (Preobrazhensky, 1982). From the standpoint of environmental management, both biogenic and abiogenic components of the natural system may be of interest, but optimization of environmental management presupposes the preservation of favorable conditions for the existence and development of living organisms and, above all, the human popular-tion. For example, if the sea basin is considered as a natural ecosystem, then the main object is a set of communities of organisms (biocenosis), but if the sea is considered as a natural system, then the biogenic and abiogenic components are equivalent. In a natural system, both biological resources and mineral resources may be of interest, the priority of which is determined by the urgent needs of the economy. Optimization of environmental management presupposes the exploitation of biological and/or mineral resources that would not significantly disturb the homeostasis of the ecosystem and maintain favorable conditions for biota and humans. This is often not followed, for example, in the event of an acute shortage of hydrocarbon raw materials, the search, exploration and exploitation of oil and gas deposits in the ecologically vulnerable shelf zone of the seas is carried out, but the problems of preserving biological diversity are relegated to the background, or in some cases there is a need to rezone territories of natural reserves, etc.

When optimizing environmental management, it is more correct to talk not about the use of natural resources, but about the use of a certain part of them, that is, natural resource potential – the ability of natural systems, without harming themselves and people, to produce useful products or perform useful work within the framework of an economy of a given historical type (Rejmers, 1990) (as we see, this definition is quite close to the concept of "ecosystem services").

Based on the above, it is proposed that instead of the term "ecosystem services" we use the concept '*useful properties of natural systems'*, namely providing, regulating, cultural and maintaining beneficial properties of natural systems. The beneficial properties of natural systems are limited by spontaneous natural processes, as well as various physical, chemical and biological pollution of anthropogenic origin.

Data quantity, indicating of the degradation of many natural systems (including wetlands) has approached to the critical thresholds or "tipping points", after which the ability to provide useful services may be radically reduced. Wetlands are disappearing three times faster than forests. During the period from 1970 to the present day, 35 % of all wetlands in the world have been lost. Anthropogenic activities that lead to wetland loss include: drainage of areas for agriculture and construction, pollution of surface waters and soil cover, overfishing and ruthless exploitation of biological resources, introduction of certain species of flora and fauna, climate change, etc. The main task aimed on preserving wetlands is to change the perception of these territories in order to encourage society to take care of them, to direct financial, human and political capital to protect them from complete disappearance. Therefore, the problem of rational use of wetlands, preservation of their ecological character in the context of sustainable development, which is ensured through the implementation of ecosystem approaches, is extremely relevant (Vasyliuk, Ilminska, 2020).

As noted above, wetlands play an important role in stabilizing climate conditions at the regional and global levels (Bisvas, 1975). Wetlands play an important role in the accumulation of water and its purification in the process of participation in natural and artificial hydrological and chemical processes, and serve as a source of replenishment of groundwater resources.

The wetlands of the North-Western Black Sea region are an important component of ecological corridors and an indispensable link in the ecological network. They are part of the *Emerald Network*, which is an area of special conservation interest and intended for long-term survival that, in accordance with the Berne Convention, is subject to conservation (Fig. 1).

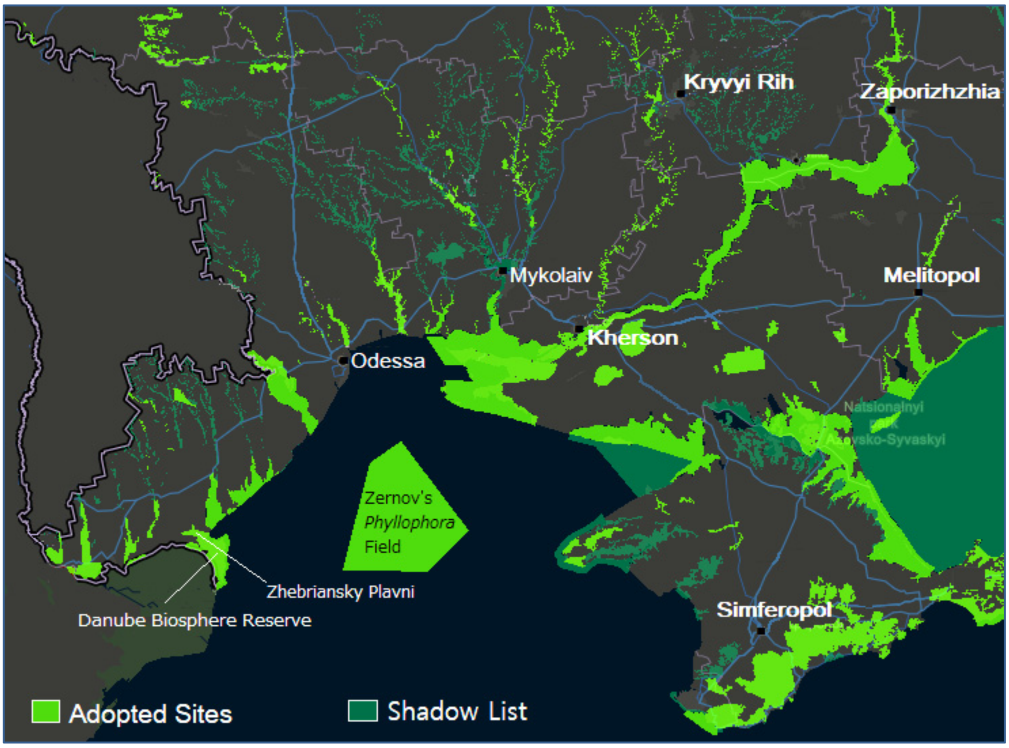

Fig. 1. North-Western Black Sea region. The network of European significance protected areas 'Emerald Network of Ukraine' (highlighted in green)

The processes of pollution and degradation of the wetlands of the North-Western Black Sea region are associated with industrial, agricultural and recreational tourism activities, as well as with the influence of the local population, eutrophication of water bodies, etc.

Industry is one of the main sources of pollution, both air and water bodies. In the Odessa region alone, there are 615 enterprises that have a significant harmful impact on the state of the air and human health. Of these, 20 enterprises, predominantly in the oil, energy and cement industries, have the greatest impact.

In the Danube Delta there are artificial wetlands (rice paddies). Previously, these lands were practically unproductive for growing crops due to their high salinity levels. Now this area is dominated by specialized rice paddies with a large share of rice crop rotations in the total arable land. Due to lack of drainage, rice cultivation in this area will lead to secondary salinization of rice fields and water logging. Wetlands are also negatively impacted by: burning rice stubble after harvest, using agrochemicals and pesticides, and discharging untreated irrigation water into surface water bodies.

Coastal wetlands have rich and attractive biodiversity. Due to this, many vacationers visit them throughout the year, and this leads to pollution in the form of household waste (plastic waste, food packaging, broken glass bottles, etc.). The pollution caused by local residents is also quite significant. Changes in consumption patterns over the past three decades have led to an unprecedented increase in the amount of municipal solid waste, which, in turn, has led to the emergence of numerous unauthorized waste dumps. Vacationers and local residents impact on wetlands, creating spontaneous landfills in places of visiting, fishing and recreation.

A significant portion of plastic materials (up to 80 %) and other components of household waste from unorganized landfills and other coastal sources of pollution are carried by air and water currents into the waters of the northwestern part of the Black Sea. Waste plastic materials from the coastal zone are the main component of marine litter (accounting for 83% of marine litter found in the Black Sea). Macroplastic particles can be transported over long periods of time by sea currents, winds and waves and pose a direct threat to the marine ecosystem. The process of biodegradation of macroplastics is difficult in the marine environment, so its transformation is limited to destruction processes and dispersion into micro- and nanoparticles. Coastal wetlands are a natural barrier that limits the flow of waste plastic materials into the sea basin, but during sea transgression they can enter wetlands.

Eutrophication is also known as secondary pollution, in which wastewater with high concentrations of phosphates and nitrates from agricultural, domestic and industrial sources increases the levels of nutrients in water bodies. This leads to excessive growth of blue-green algae, which provokes hypoxia and fish death. The Lower Danube lakes are especially vulnerable in this regard, since they are shallow and receive large amounts of nutrients from the Danube during periods of flooding, as well as from the eroded soil cover of the surrounding agricultural land.

The beneficial properties of natural systems can be divided into "use values" and "non-use values" according to the concept of "*total economic value*". This is a common approach in economics of environmental management to create a single monetary metric that combines all activities within an area and expresses the levels of each activity in terms of a common monetary measure such as US dollars. This helps in determining the estimation methods needed to obtain these values (Admiraal et al., 2013).

Before the advent of the concept of "total economic value", so-called "amenities" were defined quite narrowly. Natural systems values were assumed only for raw materials and physical products provided for human production and consumption. However, this direct use represents only a small proportion of the total economic value of natural systems. The concept of "total economic value" allowed consideration of natural and non-market values, environmental functions and benefits from non-use. In a broad sense, the concept of "total economic value" in relation to wetlands has made it possible to fix:

1) use value – direct use, where people use a resource through consumption (fishing and agriculture), or without consuming it (water for cooling); indirect use, where people benefit from the properties supported by a particular resource rather than from its use (flood control, carbon sequestration, etc.);

2) *non-use value* is associated with the benefits from useful properties aimed at maintaining the necessary conditions for the existence of the natural environment; *altruistic value* is the ability to use goods and services provided by the natural environment; *testamentary value* relates to the knowledge

that the natural environment will be passed on to future generations; *existence value* is satisfaction with the fact that ecosystems continue to exist, whether they are used now or will be used in the future.

Public ownership of wetlands is another factor that may limit the use of wetland benefits (Emerton et al., 2016). Private owners may become parties with an economic interest in pursuing the proposed management options. Long-term environmental goals and wetland protection aspects are also often less important than the immediate needs of the irrigation and hydropower sectors. There is also limited willingness of various stakeholders and sectors to pay for the benefits of natural systems, one reason for which is the underdevelopment of the economy in most countries.

The integral cost assessment of the natural resource potential of the Danube Delta (including the Danube Biosphere Reserve) is about 21,145 million US dollars, which is 459 thousand US dollars per hectare (Rubel, 2009). An example is also the cost assessment of individual ecosystem services of wetlands between the Dniester and Turunchuk rivers, that is: 1) water for domestic drinking and irrigation water supply – 15.53 million euros per year; 2) reed harvesting – 6.893 million euros per year; 3) recreational and tourism activities – 0.145 million euros per year (Zakorchevna, 2019). It is clear that this is a very small proportion of the beneficial properties provided by the wetlands shown in the framework of the study. Even taking into account the cost assessment of all the useful properties of the wetlands between the Dniester and Turunchuk rivers, their total cost will be significantly higher, since it is impossible to provide a cost assessment of the aesthetics of the wetland landscapes and their unique natural areas (for example, the value of Lake Beloye with its unique aquatic plants and birds).

4. Conclusions

The wetlands of the North-Western Black Sea region are an important habitat for valuable species of birds, mammals, amphibians, reptiles and perform extremely important functions of supporting landscape and biological diversity.

Wetlands play a major role in the formation of special and general water use, in the development of fisheries, forestry and hunting potentials. The essential economic function of wetlands is transport, associated with river and sea navigation. In addition to their high recreational and tourist attractiveness, they are resources of medicinal mud, brine, mineral medicinal waters and energy resources. Wetlands play an important role in stabilizing climate conditions.

The wetlands of the North-Western Black Sea region are an integral part of the region's natural reserve fund and play an important role in the formation of the ecological network.

The processes of pollution and degradation of the wetlands of the North-Western Black Sea region are associated with agricultural and recreational tourism activities, the influence of the local popular-tion, as well as with the processes of eutrophication of water bodies.

Rational use of wetlands of the North-Western Black Sea region, their conservation and restoration, assessment of their ecosystem services (useful properties) are of very important environmental and socio-economic importance.

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