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ECOSYSTEM SERVICES IN THE FORMER ARAL SEA AREA: APPROACHES TO ECONOMIC VALUATION

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ABSTRACT--
The degradation of the Aral Sea has led to significant ecological, economic, and social transformations across Central Asia. In recent years, the need to assess and restore ecosystem services in the former Aral Sea region has become a strategic priority. This paper explores theoretical frameworks and practical approaches to the economic valuation of ecosystem services in this ecologically sensitive area. Emphasis is placed on methods such as contingent valuation, benefit transfer, and ecosystem accounting. By analyzing local environmental conditions, stakeholder needs, and regional policy frameworks, the study provides a structured approach to quantifying the economic value of biodiversity, climate regulation, soil fertility, and other critical ecosystem functions. The findings aim to support sustainable development initiatives, environmental compensation mechanisms, and policy decision-making in the region.
KEYWORDS: *Environmental Degradation, Sustainable Development, Contingent Valuation, Ecosystem Accounting, Central Asia*--

INTRODUCTION

The Aral Sea, once the fourth largest lake in the world, has become a symbol of one of the greatest environmental disasters of the 20th century. As a result of large-scale water diversion from the Amu Darya and Syr Darya rivers for irrigation since the 1960s, the sea's area has shrunk from ~67,000 km² in 1960 to less than 40,000 km² by 1990, accompanied by increased salinity and the death of most of the biota. By the end of the 1980s, commercial fishing had ceased completely, and the traditional fishing industry, which in its heyday provided up to one-sixth of the USSR's fish catch and employed about 40,000 people, was destroyed. The disappearance of the sea has dramatically worsened the regional climate: large bodies of water usually smooth out seasonal temperature fluctuations and provide moisture, but the loss of water surface has led to more extreme temperatures (the annual temperature range has increased by 4–12 °C) and more frequent dust storms. The dried-up salt bottom – the Aralkum Desert – has become a source of salt dust storms, carrying salt, pesticides and dust over long distances. These changes have caused a cascade of problems affecting the economy, health and livelihoods of the population of the Aral Sea region. In particular, dust storms lead to soil degradation, reduced crop yields and deterioration of human health (an increase in respiratory and other diseases). According to World Bank estimates, the annual economic damage in the Republic of Karakalpakstan (Uzbekistan) alone exceeds $44 million (≈2.1% of the regional GRP), and without intervention, cumulative losses over 20 years could exceed $844 million.

The dried-up bed of the Aral Sea (Aralkum Desert) has become a source of salt-dust storms and loss of ecosystem functions. The environmental crisis in the Aral Sea region has clearly demonstrated the value of ecosystem services that nature provides to humans. Ecosystem services are the benefits that people receive from ecosystems – from material resources (e.g. fish, fresh water) to regulatory functions (climate regulation, soil maintenance) and intangible goods (aesthetic and cultural values of nature). Economic valuation of ecosystem services allows us to quantify their importance for society in monetary terms, which is important for justifying environmental measures and sustainable resource management. In the context of the Aral Sea, assessing lost and potentially restored ecosystem services has become a pressing issue: it helps to understand the scale of damage, prioritize restoration, and attract resources to environmental projects. This review presents current scientific data on ecosystem functions in the former Aral Sea region, the main approaches to their economic valuation, as well as examples of implemented valuations in the region and similar conditions.

Current state of ecosystem services and literature review. The shrinking of the Aral Sea has led to a sharp decline in the total value of ecosystem services (ES) in the region. According to the et al. (2022), the total value of the Aral Sea basin ES fell by approximately 8.3% over 1993–2018, from $476.4 billion to $437.1 billion (in current prices). The largest contribution to the total value was made by services related to biodiversity, food (fisheries and agricultural resources), and water resources regulation, which together accounted for ~74.6% of the total value.

The main reason for the decline was the loss of aquatic ecosystems: a decrease in the area of the water surface caused the loss of wetlands and fisheries, which is estimated at a direct loss of ~$46.8 billion (the lost value of aquatic ecosystem services over 25 years). At the same time, other land use changes were taking place: an increase in the area of arable and desert lands and a reduction in forests and meadows, which also affected the ES. Current studies using remote sensing and modelling (e.g. InVEST) document ongoing deterioration of key services – such as water supply, carbon storage, soil conservation and habitat quality – under the influence of climate change and unsustainable land use. Projections to the end of the 21st century indicate possible further losses of ES in agricultural scenarios without changes in management approaches. This highlights the need to integrate ecosystem service valuation into regional planning and conservation strategies.

In scientific literature, the Aral Sea region is often cited as an example of the loss of regulating ecosystem services. Thus, the disappearance of a huge reservoir disrupted the local climatic balance, increasing extreme temperatures and droughts. Dust and salt storms from Aralkum are considered a transboundary environmental problem affecting the health of the Central Asian population and agricultural productivity. Research by the World Bank (2021) and other organizations assessed the economic consequences of these storms and substantiated forest landscape restoration programs: planting resistant tree and shrub species on the drained bottom can significantly reduce dust emissions, improve soils and bring up to $39 million per year in total benefits (in the form of prevented losses and new benefits). In Kazakhstan, a successful example was the implementation of the Kokaral Dam project (2005), thanks to which the level of the Small Aral Sea rose, salinity decreased, and fish and other aquatic organisms revived within a few years. Commercial fish catches in the North (Small) Sea have increased from several hundred tons in the 1990s to several thousand tons in the 2010s, supporting employment and income in coastal communities. These examples confirm that investments in ecosystem restoration can have significant economic and social benefits. The key ecosystem functions of the former Aral Sea basin and methods for their economic valuation are discussed below, summarized in comparative tables.

Main ecosystem functions and services of the Aral Sea region. In the conditions of the Aral Sea region, several key ecosystem services can be identified, the loss or restoration of which is especially significant for nature and people:

- Climate and atmospheric regulation. The Aral Sea historically moderated the region's climate by reducing temperature variations and evaporating moisture, which maintained a more humid microclimate. After the sea dried up, the climate became more continental and harsher – summer heat and winter cold increased by several degrees, extreme weather events became more frequent. In addition, the exposed seabed became a source of dust, salt and toxins, worsening air quality over a huge area. Climate regulation and air purification are important services that affect human health, agriculture and the global climate (through the absorption of carbon dioxide by vegetation). The loss of this function led to increased health care costs and decreased crop yields. Restoration of vegetation (shelter belts, saxaul groves) in Aralkum is considered a way to improve climate conditions and reduce the frequency of dust storms.
- Preservation of biodiversity. Before drying up, the waters and deltas of the Aral Sea were rich ecosystems supporting hundreds of species of fish, birds, invertebrates and plants. These ecosystems provided habitat for migrating waterfowl, commercial fish species (carp, pike perch, roach, etc.), and fur-bearing species (for example, the muskrat, which produced up to 500 thousand skins per year). With the loss of water, many species disappeared or decreased in size; bird migration routes were disrupted, and tugai forests in the deltas degraded. Biodiversity has its own value (aesthetic, scientific, cultural) and ensures the sustainability of ecosystems. Its restoration - through the creation of protected natural areas, fish farming, planting tugai vegetation - brings long-term benefits, including indirect ones (for example, predators control rodent pests, pollinators increase crop yields, etc.). It is estimated that services associated with maintaining biodiversity make up a significant part (more than 20%) of the total value of ecosystem services in the Aral Sea region.
- Soil fertility and regulation of soil processes. The former systems around the Aral Sea (deltas, river floodplains, coastal areas) previously provided natural maintenance of fertility – annual river floods fertilized floodplain lands, vegetation prevented erosion and soil blowing away. After the sea dried up and the runoff decreased, many fertile lands became saline or silted up, and soil formation was disrupted. Dust storms carry salt and pesticides to agricultural lands, reducing crop yields. The ecosystem function of soil maintenance includes preventing erosion, preserving nutrients, and regulating the salt balance of soils. Its value is expressed through prevented crop losses and reduced melioration costs. Thus, forest shelterbelts and salt-resistant plants on the dry bottom can reduce soil degradation and increase their productivity, which directly affects agricultural income.

- Water resources and ecosystem productivity. Previously, the Aral Sea and associated wetlands were a source of fresh water (groundwater, lakes) and ensured the productivity of biota - from fishing to pasture irrigation. Fish resources yielded thousands of tons of catch, fed the local population and were exported. With the disappearance of the sea, the fishing industry and related industries (processing, transport) practically disappeared, many coastal villages fell into disrepair. The area of irrigated land in the delta also decreased due to salinization and water shortage. However, the preservation of the remains of aquatic ecosystems (for example, Lake Sudochie in the Amu Darya delta, small reservoirs in the desert) and the creation of artificial reservoirs maintain some of the services - they provide water for livestock, support biodiversity hotspots (birds and fish). This category of services is valuable both directly (through the market value of fish catch, water for irrigation) and indirectly – for example, every cubic meter of water saved in the ecosystem can prevent more expensive engineering solutions for water supply. Within the framework of nature-oriented solutions, the possibility of expanding water areas (for example, through more rational water use in the basin) is currently being considered for partial restoration of these services.

Below, Table 1 summarizes the key ecosystem services of the Aral Sea region, their significance and approaches to economic assessment.

Table 1 – Main ecosystem services of the former Aral Sea and approaches to their economic assessment

Ecosystem service	Regional significance (example of influence)	Possible methods of economic evaluation	Examples of indicators/assessments
Climate and air regulation	Softening of the microclimate, reduction of extreme temperatures; dust/salt protection of the atmosphere, improvement of air quality (less dust and pollution)	- Cost assessment of carbon sequestration (at CO_2 price per ton) - Avoided cost method (e.g. savings on cooling/heating, avoided health damage from dust)	*For example, planting a forest on 1 ha fixes ~3 t C/yr (~11 t CO_2/yr), which at a price of $10/t CO_2 gives ~$110/yr;< br >reducing dust storms by X% can reduce health costs by Y million $ per year*
Preservation of biodiversity	Maintenance of species (fish, birds, animals) and their habitats; presence of rare and endemic species; ecotourism and recreation in nature	- Contingent valuation method (WTP survey for conservation of species and territories) - Transfer of benefits (species values from other studies) - Calculation of the value of ecosystem services of pollination, biocontrol (through contribution to harvest and cost savings)	*For example, the hypothetical willingness to pay of households in the Aral Sea region for a program to restore bird and fish populations is $A per person per year;< br >restoration of wetlands increases fish catch by N tons/year, which is ~ $M/year at market prices*
Fertility and soil protection	Maintaining topsoil; preventing erosion and dust storms; maintaining crop productivity	- Method of replacement costs (cost of melioration, application of fertilizers to restore fertility) - Method of production function (relationship between soil quality and crop yield and farmers' income)	*For example, 1 t/ha of topsoil loss results in a yield reduction of Z%, equivalent to a loss of $Q/ha;< br >afforestation plantations in the Aralkum desert prevent the removal of P tons of soil annually, saving ~$R on combating desertification*
Water resources and productivity	Availability of water for drinking, irrigation and support of delta ecosystems; fish stocks for catching; nutrition of wetlands (hunting, gathering)	- Direct market valuation (cost of fish caught, price of water for irrigation) - Replacement cost method (cost of alternative water sources, fish imports, etc.) - Cost-benefit analysis of water conservation projects	*For example, historical fish catch of ~40 thousand tons/year ≈ $20–30 million/year at current prices;< br >preservation of 1 million m^3 of water in the delta is equivalent to an additional harvest of $X;< br >the Sudoche Lake restoration project brings an increase in local income of $Y per year due to fishing and tourism*

Note: Numerical examples in the table are hypothetical or simplified to illustrate the methods. Actual values depend on local conditions and research data. For example, a reduction in salt storms can result in savings in health care costs (avoided cases of illness), and the value of biodiversity is often demonstrated through society's willingness to pay for the conservation of iconic species or through benefits from fishing and hunting. Taken together, climate regulation, maintenance of biodiversity, soils and water resources determine the ecological well-being of the Aral Sea region and are directly related to the well-being of the population.Approaches to the economic valuation of ecosystem services

METHODOLOGY

There are several groups of methods that allow ecosystem functions to be translated into economic indicators. Different approaches are applicable depending on the type of service (market or intangible), data availability and the purpose of the assessment. Let us consider the main ones, often used to assess ecosystem services, including in the context of the Aral Sea region:

Method conditional Contingent Valuation Method (CVM)

The contingent valuation method is based on identifying people's willingness to pay (or accept compensation) for maintaining or improving ecosystem services. Sociological surveys are conducted in which respondents are offered a hypothetical scenario (for example, a program to restore the Aral Sea or green the desert) and asked how much they would be willing to pay for the implementation of this project. CVM allows one to estimate intangible and non-contractual services, such as the aesthetic value of the landscape, the existence of rare species, and improved health from clean air. The advantage of the method is that it covers the full economic value, including non-financial benefits. For example, CVM can be used to estimate how much residents of the Aral Sea region conditionally value the reduction of dust storms or the return of fish to the small Aral Sea. Limitations include the hypothetical nature of the answers, possible (nobility, strategic behavior), and the dependence of the results on the formulation of the scenario. Nevertheless, with the right design, CVM provides important indicators: for example, the total willingness to pay of the population for a certain environmental project, which can be compared with its cost. In the Aral Sea region, similar studies could identify social demand for environmental improvements – for example, in the 1990s, preferences of local residents were assessed when developing a strategy for restoring the Amu Darya delta (using a simplified survey to identify priority services). The resulting monetary valuations of intangible benefits are integrated into cost-benefit analysis.

Benefit Method transfer (transfer of benefits) involves using the results of assessments carried out in other places and contexts to assess the area of interest when local data are insufficient. In other words, economic coefficients of the value of ecosystem services (in $/ha or $/unit of service) are taken from published studies on similar ecosystems and transferred to the Aral region with adjustments. This approach has often been used in macro-assessments of ES changes. For example, in the work of He et al. (2022) used value coefficients for different land types (water surfaces, forests, pastures, etc.) borrowed from global studies to estimate the total value of the Aral Sea basin ES. Similarly, to estimate the carbon sequestration service, one can take the world price per ton of CO_2 or the social cost of carbon, and for fisheries, the average profit per ton of catch from other lakes. Benefit transfer – efficiency and cost-effectiveness (does not require lengthy field studies). However, accuracy may suffer if conditions differ significantly. Therefore, the method requires adjustments: taking into account local purchasing power, biophysical differences, cultural characteristics. In the case of the Aral Sea, the transfer of benefits is appropriate for preliminary assessments: for example, for a rough estimate of the cost of restored wetlands, data on the value of ecosystem services of similar deltas (fish feeding, water filtration, tourism) from other countries can be used. This approach was used in the 1996 strategy for restoring the Amu Darya delta, where, based on the experience of foreign projects, the transition from man-made solutions to the restoration of natural processes was justified as more profitable.

Ecosystem accounting and natural capital accounting (Ecosystem /Natural Capital Accounting)

Ecosystem accounting is a modern, comprehensive approach that integrates the value of natural capital into national accounting and decision-making systems. It is based on UN standards (System of Environmental - Economic Accounting – Ecosystem Accounting, SEEA EA) and provides for the systematic collection of data on the state of ecosystems, physical indicators of services and their monetary assessment. In the context of the Aral Sea region, this approach is supported by international projects (for example, the Global Program on Sustainability of the World Bank). Natural Capital Accounting (NCA) allows the government to track how landscape changes (desertification or restoration) affect the benefits to the economy and society over time. NCA for the Aral Sea considers both "on-site" services (within the former sea area itself: timber from forest plantations, grazing,

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prevented erosion, carbon sequestration) and "off-site" services (outside the intervention zone: cleaner air in populated areas, reduced incidence of disease, increased harvests in the surrounding area). All these effects are translated into quantitative indicators: for example, tons of retained soil, tons of absorbed CO_2, the number of avoided cases of disease, an increase in agricultural production - and then valued in dollars at the appropriate rates (market prices or shadow prices). Ecosystem accounting allows calculating the benefit/cost ratio for different restoration scenarios. According to research, the integration of NCA into the Aralkum greening project has proven highly effective: investments in planting saxaul and other shrubs have a positive socio-economic effect, preventing the loss of ecosystem services worth tens of millions of dollars annually. The advantage of the approach is its strategic nature: the value of natural assets is reflected equally with economic indicators, which stimulates sustainable management. The complexity is the need for big data and interdisciplinary interaction (ecologists, economists, statisticians), but the international methodology (SEEA) simplifies implementation. Uzbekistan and Kazakhstan are currently taking steps to introduce elements of natural capital accounting into official statistics, based on the experience of projects in the Aral Sea region.

In addition to the above, there are additional methodological approaches to assessing ecosystem services that can be applied depending on the specific service:

- Direct market valuation. If a service has a market price, it can be valued directly by income. In the Aral Sea region, this applies, for example, to fish (the cost of the catch on the market), to timber and other direct products of restored ecosystems.
- Cost-benefit analysis (CBA) and cost-based methods. Used for regulatory services. For example, the avoided cost method estimates the value of a service through the damage that can be avoided thanks to it. In the Aral Sea region, it is possible to estimate how much money healthcare and agriculture will save by reducing dust storms (fewer patients, less crop losses). The replacement cost method similarly calculates how much it will cost to replace a service with a man-made method. For example, if an ecosystem filtered water, then the cost of the service will be the cost of building a filtration station of similar capacity.
- Behavior-based methods. These include the Travel Cost method – assessing recreational services through visitor expenditure (relevant if ecotourism is developing, for example, trips to the northern Aral Sea or to the delta reserves). The hedonic method – identifying the influence of natural conditions on the price of real estate (for example, improving the climate or ecology increases the value of housing). In the Aral Sea region, the hedonic method is limited in its applicability due to the low mobility of the real estate market, but theoretically, improving the ecology should increase the attractiveness of the region for living.

Each method has its strengths and limitations (see *Table 2*). Ideally, for a comprehensive assessment of restoration projects, *several methods should be used in combination* to capture different aspects of value. For example, the direct market would value fishermen's income, the CVM would value people's reluctance to pay for an environmental project, and the NCA would value the long-term impact on national income and welfare. Together, these would provide a more robust assessment.

Table 2 – Comparative characteristics of approaches to economic valuation of ecosystem services

Approach (method)	**What it evaluates and where it is applied**	**Advantages**	**Restrictions**	**Example of application to the Aral Sea**
Contingent Valuation (CVM)	Non-market values (aesthetics, health, biodiversity) through a public willingness to pay survey. Suitable for unique local services.	Takes into account intangible, indirect benefits; reflects population preferences directly.	Biases and hypothetical nature of responses are possible; requires careful survey methodology.	An assessment of residents' willingness to pay for a program to prevent dust storms or restore part of the Aral Sea (surveys show, conditionally, $X/household per year).
Benefit Transfer (BT)	Any services, if there are analogous data: transfer of monetary coefficients (USD/ha or USD/unit of service)	Fast and cost-effective; allows you to evaluate many services without field work.	Inaccuracy due to differences in conditions; requires calibration for local realities.	Used to calculate the total value of the Aral Sea ES: international estimates of $/ha for wetland, forest and desert lands were taken and applied to land use maps

	from other studies to local ecosystems.			
Eco-accounting (NCA)	A full range of services in the region through the integration of eco-data and economics; includes physical volumes of services and their price, is carried out continuously.	Comprehensive: takes into account all major services, links them to national accounts; useful for strategies and monitoring.	Requires big data and a multi-agency approach; difficult to implement without expert support.	In the Aralkum greening project, NCA estimated annual benefits of ~$39 million from restoration (summing up effects: carbon, dust, health, production), which justified the cost-effectiveness of the intervention.
Market/cost valuation.	Direct goods (fish, timber) or avoided costs (health, crops). Uses market prices or costs.	Easy to interpret (based on actual transactions or costs); high reliability for direct goods.	Does not cover all services (not applicable to intangible goods); may underestimate systemic effects.	Calculation of damage from dust storms: annual losses of $44 million (medical costs, loss of GRP, etc.) in Karakalpakstan; the cost of lost fish catch is tens of millions of $/years at market prices.

Note: The choice of assessment method depends on the purpose of the study. For a socially informed decision (e.g. whether a large-scale restoration program is needed), eco-accounting and cost-benefit analysis, supported by CVM data on public preferences, are preferable. If the objective is a rapid assessment to attract attention, *benefit can be used. transfer* or calculating direct losses (as in the $44 million/year storm damage example). Ideally, the different methods complement each other, providing a more reliable estimate of ecosystem value.

Examples of economic valuation of ecosystem services in the Aral Sea region
Over the past decades, several projects and studies have been implemented in the former Aral Sea region and in similar situations, demonstrating the practical application of the approaches described:

- Strategic Assessment of the Restoration of the Amu Darya Delta (Uzbekistan, 1996): In the mid-1990s, recognizing the catastrophic state of the delta (only ~10% of its original wetlands remained), the government, with the support of the World Bank, developed a Restoration Strategy. As part of this process, a stakeholder-based ecosystem services assessment (SEA) approach was applied for the first time in the region. The losses of biodiversity, vegetation, fisheries, water quality and soils, affecting the health and employment of local residents, were taken into account. The assessment showed that the restoration of natural wetland systems (through recharging lakes, planting tugai forests, regulating flow) has a greater socio-economic return than man-made measures (e.g. building new canals). This resulted in investment in a pilot project – the restoration of Lake Sudochie – which was successfully implemented and improved conditions for fisheries and birds. This case became one of the first examples in Central Asia where the valuation methodology of ecosystem services influenced the decision in favor of an environmentally sustainable scenario.
- Assessing the Economic Damages of Dust Storms and the Benefits of Restoration (2021): A recent World Bank study, "Value of Landscape Restoration …» focused on quantifying the losses from dust and salt storms from the dried-up bottom of the Aral Sea and the potential benefits of its greening. It was calculated that the storms annually carry up to 75 million tons of salt and dust, causing damage to the economy of Karakalpakstan alone >$44 million/year (loss of agricultural products, morbidity, deterioration of infrastructure, etc.). Modeling showed that large-scale forest reclamation of the desert (saxaul seedlings, etc.) can prevent a significant share of these losses. Taking into account the gain from improved human health, increased crop yields and other factors, the cumulative effect is estimated at ~$39 million per year of net benefit. In other words, investments in green spaces on the site of the Aral Sea pay off in a few years, giving an economic effect in the form of prevented costs and new products (fixed carbon, forage base, possibly suitable timber). The data from this assessment formed the basis of the Resilient programs Landscapes (RESILAND CA+) and others, justifying the budget and expected results.
- Restoration of the Small Aral Sea (Kokaral project, Kazakhstan): although the dam project was initially aimed at water management, its effect can be translated into ecosystem services. The cost of building the dam (~$85 million) and related activities resulted in the return of permanent water to ~3,000 km² of the Northern Aral Sea. Economic benefits include: revival of the fishing industry (the catch reached ~7 thousand

tons/year by the 2010s, which brought millions of dollars in income to fishermen and businesses), reduced unemployment in coastal areas (Aral city, villages), local climate improvement (summers around the Small Sea have become milder, precipitation has returned) and partial restoration of biodiversity (waterfowl have returned, some extinct fish species have been reintroduced). It is estimated that each hryvnia (dollar) invested produced a multiplier effect of several hryvnias in profits from fishing and related sectors. In addition, the population received non-material benefits – the return of the sea improved mood, reduced outflow of population. This example illustrates the concept of ecosystem capital: relatively small investments in the restoration of the natural system ensured the resumption of the flow of services (food, cultural and regulatory) for society. This is confirmed by the research of Micklin et al., who recorded an increase in bioproductivity and improvement of socio-economic indicators of the Aral region since 2006 after the implementation of the project.

- Comparisons with other drying bodies of water: The Aral Sea experience has served as a lesson for other regions as well. For example, similar assessments are being conducted on Lake Urmia (Iran) and Lake Chad (Africa), examining the economic costs of shallowing (dust storms, loss of fisheries) and the benefits of water conservation and ecosystem restoration programs. In the United States, the Great Salt Lake situation has inspired studies of the cost of lost services (birds, tourism, climate) and the benefits of preventing complete drying. These parallels show that the economic valuation of ecosystems is becoming a recognized tool for arguing for action to save degraded natural sites. The Aral Sea region is one of the most well-documented cases where a range of services (from local to global, such as climate regulation of carbon) are at risk, and is therefore actively studied in the scientific literature as a model for developing evidence-based conservation strategies.

CONCLUSION

The ecosystem services of the former Aral Sea – from climate regulation to biodiversity and fertility – are of great value to the Central Asian region. Their loss as the Aral Sea dries up has resulted in serious economic and social losses that can now be quantified using economic valuation methods. Current research confirms that ecosystem degradation is costly: reduced quality of life, loss of income from natural resources, increased costs for health care and protection from natural disasters. However, these same studies also offer hope: by investing in nature restoration, significant economic benefits can be achieved – both direct (new jobs, products, tourism) and indirect (improved health, climate mitigation, preservation of unique natural heritage).

The use of various approaches – from population surveys to integrated natural accounting – allows us to cover the entire range of values provided by the Aral Sea ecosystem. In combination with scientific data (hydrology, ecology, climatology), the economic assessment creates a solid basis for decision-making. For example, it substantiates the need for transboundary cooperation between Kazakhstan and Uzbekistan in matters of rational water use, shows the effectiveness of investments in forest plantations on the site of the former sea, and also serves as an argument for attracting international assistance.

Ultimately, approaches to the economic valuation of ecosystem services are a toolkit that helps to recalculate in economic terms what previously seemed to be a subject of exclusively ecology. For the region of the former Aral Sea, such an approach is especially in demand. It allows us to connect environmental science with the interests of the population and the state, translating abstract concepts of natural value into the language of costs and benefits. The experience of the Aral Sea region is already becoming a model example of how ecosystem restoration can simultaneously save nature and bring tangible benefits to people. This understanding is important not only for solving the current problems of the region, but also for preventing similar crises in the future, through the proactive inclusion of ecosystem values in development calculations.

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