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# State and Value of Natural Capital As the Basis for Regional Economic Decisions

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## Abstract

The economy of the Limansky district is based on the use of natural capital, and its preservation is of paramount importance for the region. Ecological-genetic-economic studies demonstrate the need for adequate economic accounting of natural capital and the environmental factor in economic decisions related to the development of the territory and transport infrastructure of the region.

**Keywords:** natural capital, transport infrastructure, mutagenic activity, ecological situation, level of mutagenic activity of water pollution

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## 1. Introduction

Adequate economic accounting for the value of natural capital and the environmental factor often fundamentally changes priorities in economic decisions, changes the idea of what is good and what is bad in the economy.

The economy of the Limansky district of the Astrakhan region is concentrated in agriculture, fisheries, the development of aquaculture, industry, major construction. In the region there is the port of Olya -- the southern outpost of Russia in the Caspian. The main activity is transshipment of general, container and car ferry cargo. A growing sector of the economy is the tourism and recreation business. Resort recreation centers with fishing and hunting facilities are concentrated in the villages of Yar-Bazar, Vyshka and Voskresensk. Protected areas of the region include the lands of a nature reserve.

The road network is an essential element of the regional economy. The unsatisfactory characteristics of the roads comprehensively affect the state and cost of natural capital in the region and the population: the quality of life deteriorates the level of health decreases and the development of the regional economy is hindered.

The purpose of the study is to determine the need for adequate economic accounting of natural capital and the environmental factor in economic decisions related to the development of the region's territory and transport infrastructure based on estimating the cost of natural capital in the Limansky district of the Astrakhan region.

The objectives of the research include conducting the following:

-- a comprehensive environmental and economic assessment of the natural capital of the Limansky district --- the estimation of the potential value of the natural capital of the Limansky district of the Astrakhan region (in monetary terms) based on the methodology for assessing eco-services and methodological recommendations on assessing and implementing a system of payments for ecosystem services in protected areas for representatives of the protected areas, regional authorities and businesses of the Limansky district;

-- ecological and genetic assessment of the quality of natural waters in the territory of the Limansky district of the Astrakhan region;

-- analysis of indicators of road quality in the region and the development of transport infrastructure;

-- rating the quality of life in the Limansky district of the Astrakhan region.

## 2. Results and Discussions

In economic reality, there is a strict rule: something that does not have an economic value does not exist, thus it is not taken into account when making economic decisions. And therefore, an important reason for the degradation of ecosystems is the underestimation of their real economic value, the value of natural resources and services in general.

In the ecological economy in the world, the so-called ``ecosystem approach'' has been formed to classify the elements of natural capital, according to which ecosystems are the structural units of renewable natural capital. This approach is a strategy for the integrated management of land, water and living resources, which stimulates their conservation and sustainable use on an equitable basis.

Recently, the consideration of ecosystems as natural capital has received its practical interpretation in the projects and developments of the Ecological Department of the World Bank. Ecosystems considered as natural capital have advantages over physical capital since under the condition of competent management they are able to recover, but, like physical capital, natural capital is subject to depletion. Ecosystems around the world are under tremendous pressure from human economic activity. In addition, there

is a growing demand for resources coming from ecosystems -- fresh water, food etc. The ecosystems are also experiencing the increasing burden of water and air pollution and waste generation in terms of assimilation of human waste. Thus, the load on ecosystems is growing, whereas their capabilities are being reduced due to degradation. Over the past half century, about 60% of global ecosystem services, including 70% of regulatory and cultural services, have been eroded by human impact. An assessment of the flow of benefits from ecosystems that contribute to wealth growth is needed. Obviously, a significant part of ecosystem services and functions still do not receive the economic valuation. The most important support services are the services necessary to support all other ecosystem services (photosynthesis, soil formation etc.) are much "farther away" from the real economy, compared with provisioning, regulatory and cultural services.

All these problems are extremely relevant for the project area of the Limansky district. Thus, adequate economic accounting of natural capital and the environmental factor often radically changes priorities in economic decisions, changes the idea of ``what is good and what is bad in the economy'' [1].

Currently, the economic assessment of ecosystems is extremely important for choosing a cost-effective option for the development of territories. The very existence and well-being of mankind depend on ecosystem services. According to the existing classification in the UNEP ``Millennium Ecosystem Assessment'', ecosystem services can fall into one of four broad categories: provisioning, regulating, and cultural services that directly affect people, and supporting services, needed to preserve other services. In this typology, services are divided by functional attribute.

The first fundamental economic study in the field of identification and economic valuation of ecosystem services was the work of R. Constanza with colleagues. In this work, the first known experience of the global assessment of ecosystem services was presented, which gave a total annual estimate of all the functions of the planet's natural ecosystems on average at 33 trillion US dollars, which is almost twice as high as the GNP created by mankind (18 trillion US dollars per year). The study showed gigantic benefits and the need to preserve ecosystems for the economy [2]. The formula of total economic value can be represented as follows:

TEV = DV + IV + OV + EV (1.3) where DV is the direct value of use; IV -- indirect value of use; OV is the value of the deferred alternative (option value); EV is the existence value.

The total economic value mainly includes two aggregated terms: use value and non-use value. In turn, the first term consists of three:

1) direct value -- sustainable fishing and hunting, agriculture, recreation and tourism, fuel etc.;

2) indirect value -- flood control, carbon dioxide binding, water treatment etc.;

3) option value -- potential benefits from future use of the territory [1, 2].

Based on the data collected, the article determines the potential value of the natural capital of the Limansky district of the Astrakhan region (Table 1).

Table 1: Total economic value of natural ecosystems in the Limansky district of the Astrakhan region.

| Components of total economic value | Value, mln. $ / Year |
|---|---|
| Direct value: | |
| fishing | 0.2 |
| wild harvest (medicinal plants, berries, etc.) | 3.0-4.8 |
| recreational activities | 0,001 |
| the use of individual (rare) species of plants and animals (aesthetic and scientific) | 0.02 |
| Total direct value | 3.2-5.0 |
| Indirect value: | |
| carbon dioxide (CO2) binding (photosynthesis) | 0.6-6.1 |
| effect on public health from recreation | 1 |
| Total indirect value | 1.6-7.1 |
| Non-use value by the method of subjective assessments (willingness to pay) | 0.1-0.2 |
| Total non-use value | 0.1-0.2 |
| Option value: | -- |
| Summary total: | 4.9-12.3 |

The potential cost of the natural capital of the Limansky district of the Astrakhan region is in the range of $ 4.9-12.3 million per year. Analysis of the state of natural water bodies in the Limansky district of the Astrakhan region showed the following. The main surface watercourse of the Limansky district is the Bakhtemir River and its continuation, the Volga-Caspian Canal. According to water quality indicators, the Bakhtemir River belongs to a watercourse subject to anthropogenic pollution. The Bakhtemir is a river in the Astrakhan region, the most western of the Volga delta spill streams. The river originates 18 km below Astrakhan and subsequently separates the Old Volga spill stream to the left. The channel network of the Bakhtemir system is sparse, which is associated with the concentration of runoff in the main direction, the continuation of which on the estuary coast is the Volga-Caspian Canal. On the territory of the Astrakhan region, monitoring of surface water pollution by hydrochemical and hydrobiological parameters was carried out at 11 posts by the laboratory for monitoring surface water pollution of the Astrakhan Centre Hydrometeorology and Environmental Monitoring (ACHEM). The

closest post to the borders of the Limansky district on the Volga River, Ilyinka, is at the source of the Bakhtemir stream. The main facilities polluting river waters are located upstream of the Bakhtemir and the Volga river. According to ACHEM, the waters of this water area are contaminated with compounds of copper, zinc, mercury, oil products and other organic substances. The long-term average value of the Volga River Water Pollution Index in the section of Ilyinka is 2.88. The data on the long-term average annual quality indicators of the Lower Volga river water in this water area according to the ACSMS is shown in Figures 1 and 2. The water area in the Ilyinka section retains the $4^{th}$ class of water quality -- ``polluted".

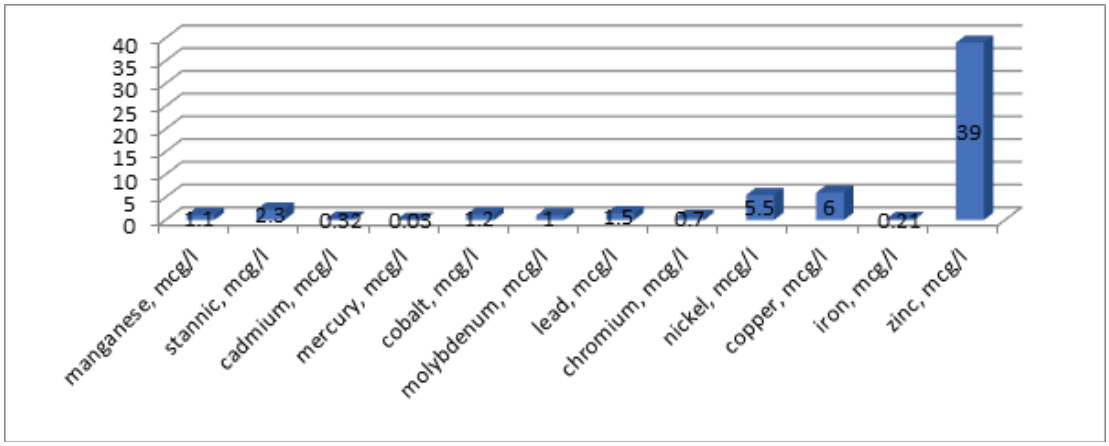


**Figure** 1: Long-term average concentration of trace elements in the river waters of Bakhtemir (Ilyinka post).

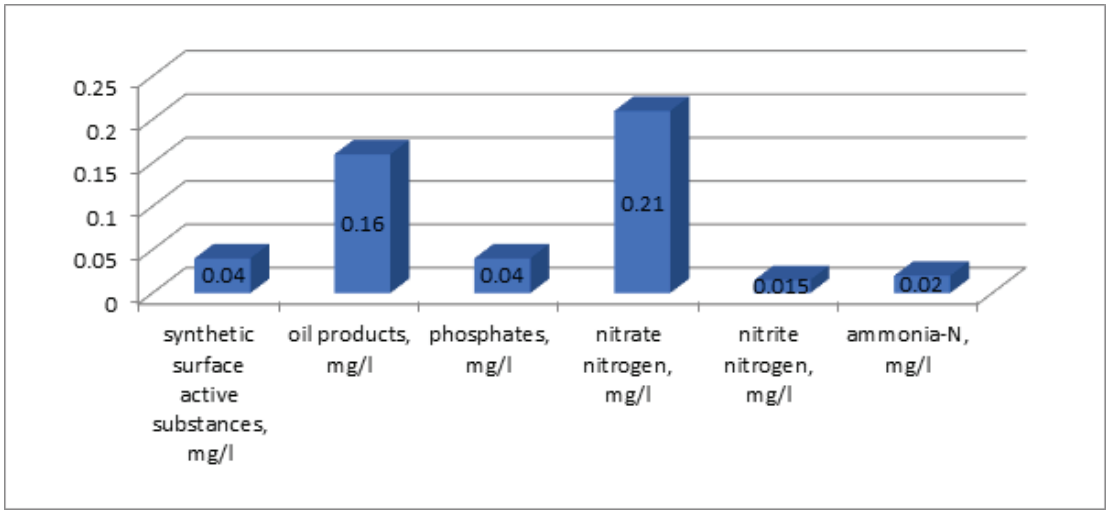


**Figure** 2: Average long-term concentration of pollutants in the river waters of Bakhtemir (Ilyinka post).

The environmental and genetic assessment of natural water bodies in the Limansky district of the Astrakhan region carried out in the course of this research, consisted in determining the resulting indicator of the level of pollution -- mutagenic activity.

Mutagenic activity is the ability of a substance to modify the genetic information of living organisms (including humans). This indicator allows evaluating the effect of endogenous and exogenous mutagens on humans. The analysis of carcinogenic activity allows identifying environmental factors that determine the occurrence of malignant tumors. An analysis of teratogenic activity makes it possible to identify with a high probability the factors that can cause disturbances in the process of embryogenesis, i.e. lead to the occurrence of congenital malformations. The level of mutagenic, carcinogenic and teratogenic activity determines the degree of irreversible consequences at the gene level, predicting a decrease and termination of the reproductive ability of the object of study.

The research information database is the Shammas ecological-genetic pyramid of the quality of life matrices (see tab. 2-3). Measurements are carried out both at the level of nucleic acids (RNA and DNA), and at the level of interaction of electrons and protons.

Table 2: Ecological-genetic pyramid of Shammas matrices (information flow of quality of life variability determined by the method of "entropy/negentropy", bit). *

| PHASE TERATOGENICITY |
|---|
| Med. -- 1.40 ± 0.062; Avg -- 1.10 ± 0.061 |
| Min -- 0.90 ± 0.037; Max. -- 1.90 ± 0.037 |
| CARCINOGENITY PHASE |
| Med -- 1.85 ± 0.072; Avg -- 2.10 ± 0.106 |
| Min -- 1.50 ± 0.071; Max. -- 2.20 ± 0.095 |
| MUTAGENITY PHASE |
| Med -- 2.40 ± 0.125; Avg -- 2.35 ± 0.112 |
| Min -- 1.50 ± 0.071; Max. -- 2.70 ± 0.128 |

Note: *All phases have 4 gradations of measurements:

Min -- minimal; Avg. -- averaged; Med -- medium; Max. -- maximum.

The higher level of the total mutagenic activity increases the risk of developing diseases and reducing the time and quality of life of the population. There is a direct economic dependence between the level of mutagenic activity and the reduction in the value of ecosystem objects (humans, animals, plants, recreational potential etc.). When the background level of mutagenic activity of 0.22-0.36% is exceeded, the loss of ecosystem value begins. A value of 1% is critical for the existence of an ecosystem. The level affecting the reproductive function is estimated. It is known that the effectiveness of the use of biological resources of fishery reservoirs is directly dependent on the level of mutagenic activity of water pollution. Its increase by every 0.1% above the background level (in the Astrakhan region -- 0.37%) is accompanied by a drop in fish

Table 3: Ecological and genetic pyramid of Shammas matrices (material flow of variability in the quality of life, determined by the Meller-5 method, %). *

| PHASE TERATOGENICITY |
|---|
| Min. -- 0.80 ± 0.033; Med -- 1.10 ± 0.047 |
| Avg -- 0.90 ± 0.042; Max. -- 1.40 ± 0.063 |
| CARCINOGENITY PHASE |
| Min -- 0.60 ± 0.028; Med -- 0.70 ± 0.034 |
| Avg -- 0.78 ± 0.035; Max. -- 1.00 ± 0.046 |
| MUTAGENITY PHASE |
| Min -- 0.31 ± 0.011; Med -- 0.51 ± 0.019 |
| Avg -- 0.50 ± 0.018; Max. -- 0.71 ± 0.033 |

Note: *A method for taking into account the frequency of recessive, lethal mutations linked to the sex X-chromosome. 4-gradation measurements of 3 phases are encoded in qubits: Minimum -- 0; medium -- 01; averaged -- 10; the maximum is 1.

Table 4: Ecological-genetic pyramid of Shammas matrices (energy flow of life quality variability, as measured by the NMR relaxation method, $s^{-1}$). *

| PHASE TERATOGENICITY |
|---|
| Min. -- 0.30 ± 0.012; Med -- 1.50 ± 0.022 |
| Avg -- 0.48 ± 0.021; Max. -- 1.70 ± 0.028 |
| CARCINOGENITY PHASE |
| Min -- 0.60 ± 0.037; Med -- 1.15 ± 0.042 |
| Avg -- 0.50 ± 0.061; Max. -- 1.70 ± 0.074 |
| MUTAGENITY PHASE |
| Min -- 0.60 ± 0.072; Med -- 2.10 ± 0.095 |
| Avg -- 2.00 ± 0.093; Max. -- 2.50 ± 0.128 |

Note: *The time of spin-spin and spin-lattice interaction of particles and antiparticles, i.e. relaxation time was measured on a specially designed NMR relaxation facility (N.I. Lobachevsky Kazan State University), operating on the principle of a pulsed, coherent NMR spectrometer, in combination with a Fourier spectrometer integrated moment of impulse accumulator.

productivity by 0.15 parts per hectare of water, and exceeding the critical level (1.00%) causes irreversible disturbances in the life processes in living organisms.

The ecological and genetic assessment of natural water bodies of the Limansky district based on the determination of the resulting indicator of the level of pollution -- mutagenic activity, is 0.399 ± 0.009 in the aquatic environment, macrophytes (Potamogeton) 0.398 ± 0.011. The fact of exceeding the background level of the analyzed parameter in the aquatic environment by 0.029% and the level of mutagenic activity measured by macrophytes (aquatic vegetation) by 0.028% was revealed.

As a result of the study, it was found that under the influence of water pollution, the physiological state of fish gradually deteriorates, which can lead to disturbances in the evolutionarily determined balance between ichthyo- and parasitofauna, which in turn leads to a decrease in the immune status of fish and the occurrence of parasitic diseases.

Parasites often affect the reproductive system of fish, reducing the effectiveness of its functioning. This is especially characteristic of young fish, which have a higher level of metabolism and are less resistant to changes in environmental factors. Recently, as a result of the influence of various factors, including the level of pollution of fishery water areas, fish stocks in the reservoirs of the Limansky district have significantly decreased and, as a result, have led to a decrease in the volume of fish caught, and therefore one of the strategic ways of developing fisheries, became pond fish farming. One of the most important tasks of fisheries is the production of environmentally safe fish products, which meet established organoleptic, general hygienic, technological and toxicological standards and do not adversely affect the health of people and animals as well as the state of the environment. Therefore, the state of fishery ponds is of paramount importance for this task. Environmentally friendly is fish products obtained by using environmentally friendly fish resources, appropriate environmental technologies for production, storage, transportation. All of the above steps must be certified.

The concept of development of fisheries of the Russian Federation until 2020 defines the main areas of research indicating the need for the development and implementation of technologies that ensure the rational use of raw materials, expanding the range of products, improving its quality and safety.

For a comparative assessment of the quality of life of the population inhabiting the territories, a wide range of indicators is used.

The group rating score was determined by aggregating the rating score of indicators included in the group. The quality of life index is compiled on the basis of a statistical analysis of 61 indicators, which are combined into eleven groups. In 2016, the Astrakhan region was in the 49th place in the ranking of 82 regions. In 2018, the position of the Astrakhan region deteriorated to a rating score of 37.714 and the 56th place, the indicator of the quality of life in the Limansky district of the Astrakhan region decreased as well.

Poor maintenance of roads can lead to emergencies: automotive fatalities, environmental pollution -- this will not only reduce the quality of the environment, but also, as a result, will lower income from such business areas as fishing, the development of aquaculture, and recreation business [7].

When calculating the effectiveness of transport infrastructure, three indicators are taken into account: the density of public roads; the share of public roads that meet regulatory requirements; the proportion of public roads with hard surface in the total length of public roads [7].

Using the statistical indicators, assessing the territory of the Limansky district by the criterion of rating the quality of life of the population is carried out. Three indicators

are taken as a basis: the density of public roads; the share of public roads that meet regulatory requirements; the proportion of public roads with hard surface in the total length of public roads.

When calculating the importance coefficient, we take it for 0.33 for each indicator due to the equivalence of the influence of the assessment factors.

TABLE 5: Comparative assessment according to the criterion of equipment of the territory and the development of transport infrastructure.

| Territory | Density of paved public roads | Proportion of roads with improved pavement surface over the length of paved public roads, % | Proportion of paved public roads in the total length of public roads, % |
|---|---|---|---|
| Limansky district | 105 | 60.6 | 66.0 |
| Astrakhan region | 88 | 74.2 | 64.0 |
| Reference sample (Belgorod region) | 733 | 96.7 | 91.2 |

According to the table, we get the result for the Limansky district of the Astrakhan region:

Rating = (105/733 * 0.33 + 60.6 / 96.7 * 0.33 + 66.0 / 91.2 * 0.33) * 100 = (0.143 * 0.33 + 0.626 * 0.33 + 0.723 * 0.33) * 100 = 49.2

According to the table, we get the result for the Astrakhan region:

Rating = (88/733 * 0.33 + 74.2 / 96.7 * 0.33 + 64.0 / 91.2 * 0.33) * 100 = (0.120 * 0.33 + 0.767 * 0.33 + 0.701 * 0.33) * 100 = 52.4

The calculation results reveal that the Limansky district has a rating lower than the Astrakhan region, but this deviation is not very significant.

In order to assess the actual quality of roads in the Limansky district, we use the formula which includes a comprehensive indicator of the assessment of the roads (CIAR). The transport-operational condition of the roads (TOCR), the indicator of engineering equipment and road furniture (EEF) and the indicator of road maintenance (RM) are estimated.

Rating scale: 2 (two) -- not an acceptable level of maintenance; 3 (three) -- a permissible level of maintenance; 4 (four) -- an average level of maintenance; 5 (five) -- a high level of maintenance [6, 7]. The evaluation of the section of the road from the village of Olya to the village of Voskresenovka is performed. A preliminary assessment of the secondary data (https://www.youtube.com/watch?v=x-JQv61KbgQ) gave the following expert opinion, presented in Table 6.

$$CIAR = (2.2 + 3.5 + 2.4)/3 = 2.7$$

The composition of the transported goods includes metal; lumber; loads in big bags; bulk cargo; grain cargo; fuel; vegetables; gravel, pebbles etc. The list also contains mutagenic cargoes. Accidents on the roads during the transportation of highly mutagenic goods can lead to emergencies, irreversible negative consequences for the health of the population and the natural capital of the Limansky district of the Astrakhan region.

Table 6: Initial data for calculating the quality of the road.

| | TOCR | EEF | RM |
|---|---|---|---|
| Limansky district road section from the village of Olya to the village Voskresenovka before reconstruction | 2.2 | 3.5 | 2.4 |
| Limansky district road section from the village of Olya to the village Voskresenovka after reconstruction | 4.65 | 4.4 | 4.5 |

Thus, the current situation with the quality of roads in the Limansky district and the assessment of the actual quality of roads in the region using indicators (a comprehensive indicator for assessing the road CIAR); an indicator of the transport and operational condition of the road (TOCR), an indicator of engineering equipment and road furniture (EEF), and an indicator of road maintenance (RM) confirm the need for modernization of roads and road infrastructure.

## 3. Conclusion

The ratio of the cost of eco-services in the territory of the Limansky district (provisioning, regulating, cultural and supporting) to the total value of the ``Economic Turnover'' of the Limansky district is of scientific and practical interest. The economy of the region is more concentrated in agriculture, fisheries, tourism and recreation, and the development of aquaculture. A significant part of the income of enterprises and organizations of the Limansky district (more than 1/3 of the ``Economic Turnover'') is generated by nature. Currently, 38 aquaculture farms of various forms of ownership are operating in the district. The total area of the ponds is 8,834 ha. The total volume of fish caught and sold in 2018 was 729 ton. The territory of the Limansky district municipality has significant recreational potential. The area is located in unique climatic conditions, has a centuries-old cultural and historical heritage, and has a relatively developed recreational and tourist infrastructure. The tourist recreational and sanatorium potential of the region can play one of the leading roles in the socio-economic development of the territory, attracting investments, increasing the flow of tourists and income from inbound and domestic tourism. Along the coast of the Volga delta, there are 7 recreation centers of European level. In the area there are salt lakes rich in medicinal mud, brine that

may serve the basis for building hospitals, boarding houses, sanatoriums. Thus, the economy of the Limansky district is focused on the use of natural capital of the region. Ecological-genetic-environmental studies have shown the need for adequate economic accounting of natural capital and the environmental factor in economic decisions related to the development of the territory and transport infrastructure of the region.

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