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Influence of industrial, production and economic activities on the ecological state of the soil cover of the Atyrau region, Kazakhstan

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ABSTRACT

The lack of scientific knowledge about the quantitative and qualitative dimensions of the economic value of products and ecosystem services obtained from the environment, especially soil, in line with various destruction factors, has justified the change of using forest land to other profitable activities. Failure to comply with such information caused in Kazakhstan, like many other developing countries, the political and economic decision-making process regarding the current uses and future existence of environmental resources was faced with many ambiguities. In this study, the current state of the environment in Atyrau district was obtained through the collection of information and tests of water, air, sound, and soil. Environmental effects were predicted based on scientific and technical documents and through knowledge, experiences, and numerical calculations. Direct and indirect, short-term and not long-term effects were investigated and introduced. The effort to obtain the correct selections and the optimal allocation of natural resources remains under the control of the problems related to the risks and the uncertainty of the remaining evaluations. The laziness of the theoretical foundations and the neglect of practical considerations in the selection of cognitive methods for conducting economic valuation studies can lead to the destruction of the remnants of environmental fields quickly in the middle of two extremes made. The results showed that production and economic activities increase the density of the soil, increase the apparent specific weight and reduce the porosity of the soil and damage to the environment. In addition, among its benefits can be the creation of employment and relative prosperity, reduction of immigration, reduction of social corruption and pointing out the mental health of the community, regional and national importance. It also help to increase the future development plans in the region, especially in the industry sector and increasing the added value caused by the labor force, converting raw materials into consumable products in industrial production, which causes economic prosperity in this region. In this article, based on the main theoretical foundations and practical considerations related to the methodology of economic valuation studies, the main research findings on environmental valuation are reflected, and the bottlenecks and arguments needed in this regard are clarified.

Keywords: Sustainable development, Ecology, Soil protection, Economy.
Article type: Research Article.

INTRODUCTION

Soil pollution is known as one of the major environmental problems in the world. In Kazakhstan, a small percentage of industrial and domestic wastewater is treated, and most of it enters the environment without

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treatment, which causes soil and groundwater pollution (Kumpula *et al.* 2011; orrelli *et al.* 2016; Chen *et al.* 2020 B). In addition, the amount of soil erosion in Kazakhstan is currently estimated to be about 2 billion tons per year, which is one of the highest soil erosion figures in the world and causes an annual loss of 40 billion dollars (Ram *et al.* 2024). Population growth and the increasing human need for food have increased the demand for agricultural products (Moulaei *et al.* 2024). The increase in agricultural production has required modern technology, which has been improved with the introduction of the green revolution and the use of chemical fertilizers, pesticides, and improved cultivars. Increasing production has caused destructive effects on natural resources, such as soil erosion, excessive use of underground water, air pollution caused by excessive use of chemicals, and environmental destruction. The environmental effects caused by implementing the agricultural development program based on green revolution technology led to the introduction of the concept of sustainability in the exploitation of agricultural resources (Sivkov *et al.* 2016; Pratikno; *et al.* 2023). Sustainable agriculture with environmental considerations is a new move towards change. Making agriculture dependent on chemicals and inappropriate technology was created in the mid-90s due to economic pressures and the necessary sensitivities to environmental issues and preventing the destruction of agricultural lands. FAO considers sustainable agriculture to be the management and protection of sustainable natural resources and technological guidance in a direction that guarantees the human needs of current and future generations (Ferrara *et al.* 2014). Sustainable agriculture is a system that efficiently uses resources and healthy food, produces and preserves the quality of the environment and resources for future generations and is economically dynamic (Liu *et al.* 2008). It emphasizes that as long as sustainability is the ultimate goal for development. This issue requires creating a balance between the environment. Society and economy are one system. In the agricultural sector, sustainability goals generally include maintaining and improving the natural environment and meeting human society's food needs and the society's welfare (Verheye 2009). Soil, environmental destruction, reduction of ecological diversity, creating risks in health and food hygiene, disrupting the balance in nature, increasing production costs, and reducing production capacity are reasons for destroying production resources (Cespedes Payret *et al.* 2009). Sustainable development is mentioned as one of the most central development goals in the agricultural sector, and it has been emphasized during the five-year plans and the development vision document. This reveals the necessity of conducting a study to measure the level of agricultural sustainability in opposite regions of the country and to identify the key and fundamental sustainability concerns. By evaluating the level of agricultural sustainability and determining the trend toward agricultural development and threats, it is possible to develop a realistic plan to improve sustainability in the agricultural sector. To measure sustainability and make judgments about this issue, it is necessary to use appropriate indicators. Several studies on the evaluation of the level of sustainability have proposed different sets of consistent indicators as an evaluation tool, which these methods are mainly focused on the three main dimensions of sustainability (economic, social and environmental). As a result, the diversity of sustainability assessment methods, especially at the farm level, is very high (Lubowski *et al.* 2006; Bajocco *et al.* 2012; Tayeva *et al.* 2023). Soil degradation is a regional and global phenomenon due to its diversity and range of effects. It is equally the cause and effect of poverty and long-term negative environmental effects, and its solution requires the adoption of joint, coherent, and effective international measures by all actors in this field. Therefore, protecting the soil and fighting against its erosion and destruction is considered one of the most necessary actions of any country to achieve sustainable development. The need for laws and policies related to soil protection has caused countries and organizations at the international level to approve conventions and particular documents in this field and develop and adopt new strategies, among the most important of which is the "Protocol for the Implementation of the Alpine Convention," in soil protection" which has an exclusive role in soil protection. In this regard, the Council of Europe approved the "European Soil Charter," the only non-binding regional document related to soil. Soil protection is also discussed at the level of certain international institutions according to its subject, nature, and consequences. For example, FAO and UNEP have determined and recommended strategies (with an ecosystem approach to soil) for countries in the field of sustainable use and soil protection, including the third UNEP Montevideo program. "Sustainable use of soil" means using soil to preserve the ecological functions and needs of the soil while maintaining the balance between the processes of soil formation and degradation. Here, the use of soil is defined as the role of soil in "biodiversity protection" and "human survival" (Kanianska 2016; Unanaonwi & Amonum 2017). Of course, it is worth mentioning that soil protection is not limited to ecosystem approaches. On the other hand, for more than a few decades, the aim has been to develop national and international

mechanisms for soil sustainability. One of the challenges in soil protection is that attention has been raised mainly at the national rather than the global level.

MATERIALS AND METHODS

This study used a simple checklist-questionnaire method to predict the project's environmental effects and determine the study area's positive, adverse, short-term, and long-term impacts. The Atyrau region, located in Western Kazakhstan, combines cultural heritage and economic importance uniquely. With its rich history and natural resources, this region plays an essential role in the country's development. It occupies a strategic position at the intersection of the Ural River and the Caspian Sea. Its geography has unique natural features, including diverse flora and fauna. This region has vast plains covered with steppe vegetation and magnificent mountain ranges, creating an impressive landscape.

Fig. 1. Studied area.

The active industry in the Atyrau region is the production and extraction of oil and gas, which has significant oil fields that have turned this region into an important center for the extraction and processing of energy resources. In addition to the oil and gas industry, it is also actively developing other industrial and economic sectors due to its geographical location and proximity to the Caspian Sea. Therefore, this development requires attention to the ecosystem and its environmental, social and economic consequences.

Environmental problems of soil resources

Pollution, erosion, subsidence, and soil smuggling threaten Kazakhstan's environment. These threats lead to the loss of water and soil and the country's dependence. In the following, we will briefly review each of these cases.

Soil erosion

International statistics show that Kazakhstan is the first country in the world regarding soil erosion. So, if the amount of soil erosion is reduced to a third of the current amount, it will still be the world's first rank of soil erosion which has powerful effects on food security, fine dust production, vegetation loss, and the country's livability capacity. The erosion of about 2.5 billion tons of soil in Kazakhstan has caused Kazakhstan alone to account for 7.7% of the world's soil erosion.

Soil pollution

The widespread use of fertilizers and pesticides in agriculture, the release of urban sewage, and the production of industrial effluents are among the main problems with soil pollution in Kazakhstan. According to a study, hundreds of polluted spots in the country's soil are contaminated with various pollutants, including heavy metals, oil, poisons, etc., and seriously threaten the environment and people's health. High oil pollution in provinces with oil and gas industries, industrial pollution in industrial cities, and heavy metal pollution are among the most important types of pollution.

Soil subsidence

The leading cause of soil subsidence in the country is the excessive extraction of water from underground sources. According to the Geological Organization report, annual land subsidence in some areas and plains in the west and southwest is 23 cm. It is 90 times the critical value (4 mm per year) set by the European Union.

The most critical challenges in the field of soil resources

Recognizing and focusing on the challenges facing the country's water and soil resources helps us manage crises and choose appropriate coping strategies and optimal measures. The most important of these challenges are:

• The decreased quantitative and qualitative indicators of underground water resources due to the increase in human activities;

• Failure to change environmental laws by the growth of human activities and the diversity of polluting sources;

• Failure to pay attention to environmental considerations in the establishment or operation of the country's development plans or ignoring environmental standards when issuing permits;

• Unprincipled change of land use regardless of land preparation and irrigation of agricultural lands with unconventional waters such as sewage and industrial effluents;

• Lack of environmental management of regular, special, industrial, agricultural, and medical waste as well as lack of control of leachate related to urban waste and its flow on the ground or penetration into underground water tables;

• Weakness of technology and wear and tear in some of the influential industries as well as their majority being state-owned;

• Failure to equip a major part of cities, villages, industrial towns, and hospitals with a collection network and a suitable and central wastewater treatment plant system;

• Failure to observe the correct consumption pattern in water and soil resources and their excessive consumption.

RESULTS

Being located at a relatively high latitude, significant altitude, special topographical conditions of the plain and surrounding mountains, and finally close to the Caspian Sea's moisture source, the studied area has almost exclusive weather and climate characteristics. For the climatic studies of the region, the data of the meteorological station was used for ten years (Salahi, 1383). According to the data of this station, the annual average temperature is 9.5, and the average monthly temperature changes between -9.2 ℃ in January and 25.5 ℃ in August. The temperature variation is very high in the year's cold months and moderate in the hot ones. The absolute maximum temperature in August reaches 38.2 ℃, and the absolute minimum temperature in February reaches -28.3 ℃, which shows a range of changes of about 67 ℃ throughout the year. This region's cold winter and cool summer is related to the high altitude and the high mountains surrounding the plain, which causes cold air to accumulate due to the advection of cold air from the upper supply and cold air drained from the nearby heights. For this reason, the number of frost days (123 days per year) is related to these conditions.

Soils of the region

During field research, a soil pit was laid on brown desert solonetzic soil (Fig. 2) 40 km east of Atyrau (coordinates: N-47^0 22′ 976″ and E-052^0 25′ 273″, absolute height: - 28 m).

Table 1. Soil section profile

Soil section profile	Depth of horizon, cm	Description of the horizon
Section № 2K	A 0 – 10	Gray, dry, loose, dusty-loamy, plant roots, light loamy, sharp transition.
	B_1 10 – 26	Brownish-brown, dry, very dense, lumpy-nutty-blocky, rare thin roots, loamy, the transition is noticeable in density.
	B_2 26 – 54	Yellowish-brown, moist, compacted, weakly rooted, rare small spots of carbonates, medium loamy, gradual transition.
	C 54 – 85	Yellow-brown, moist, compacted, veins of finely crystalline gypsum, lumpy, medium loam.

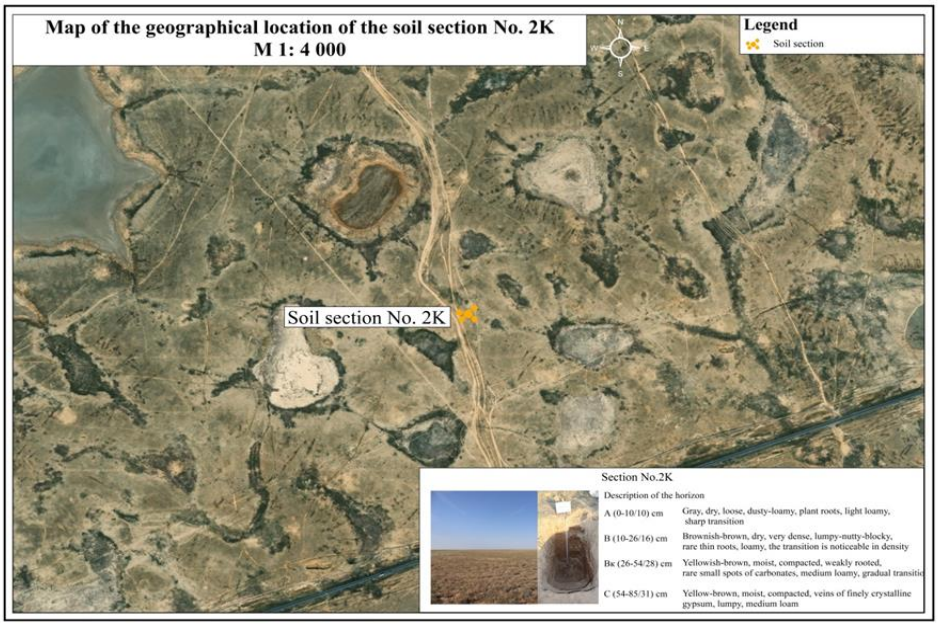

Fig. 2. Geographical location of soil section № 2K.

Section № 2K is laid on a flat plain (Fig. 3). The soil surface is cracked. Vegetation: eremopyrum, anabasis, Salsola. Projective cover is 25-30%. Effervescence from HCl from the surface along the entire profile.

Fig. 3. Soil section № 2K.

The soils of the plain are brown soils, which are found in the form of brown, typical brown, hardened brown soils, and brown gray more than other soils. Most of the soils in the project's indirect impact area are classified as green soils and the project's direct one as dark brown soils. The soils in the immediate area of the project and the major part of the soils of the direct impacts of the project are very limited in terms of soil suitability for agriculture (class 5).

Vegetation and fauna of the area

In terms of soil variety along with topographical changes, the vegetation of the studied area has been investigated in three levels. Within the bounds and direct effects of the project, plants with less ecological demand and resistance to very limited soil, including halophyte plants, have been allowed to grow. Diversity increases with soil capacity in the large study area (indirect effects of the project). The wildlife of the study area has been investigated based on the habitat situation (plain, sea, river, and wetland)-the habitat of waterways due to fluctuations.

Demographic characteristics of the region

The population of 355,900 is distributed in the study area, which includes 4 villages, 80 settlements and two urban areas. 57.4% of the urban population and 46.6% of the rural population expect that many people will be added to the number of job seekers every year due to the youth of the population. Since the total number of jobs created annually does not correspond to the labor force supply, the unemployment rate continues at a constant rate, and posing a significant challenge for the local population. The survey of land uses in the area of direct effects of oil projects shows that most of the lands in this area, especially those parts of the land that are very restricted for agriculture, have become part of national lands and are used for pasture. Part of these pasture lands are covered by development programs (see Table 1). The results of the survey of farmers regarding the level of income was presented in Fig. 5. Before and after the occurrence of soil erosion, they show that there is a significant difference in their income according to the environmental conditions, underscoring the urgent need to address the income impact from soil erosion.

Table 2. Predection of Income variaton by echological effects in long term.

Income	Before		After	
	Amount	Rate (%)	Amount	Rate (%)
very High	95	29.8	12	3.8
High	115	36.2	25	7.8
Medium	81	25.5	45	14.1
Low	19	6.0	212	66.6
Very Low	8	2.5	24	7
Total	318	100	318	100

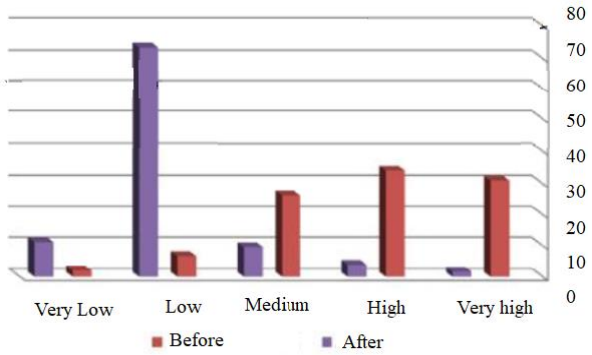

Fig. 4. Prediction of income rate before and after soil erosion.

Investigating the presence of erosion in plain and mountain agricultural lands

As seen in Table 3, in the mountainous environment of the sample community, out of the five households that answered this question, 81 households, i.e., 3.85%, believed that the village's agricultural lands were subject to erosion. In the plains villages of the sample community, out of 218 households that answered this question, only 73 households, i.e. about 33.5%, stated that the agricultural lands of the village are subject to erosion, and a large number of households living in the plains, i.e. about 5.66% had the opposite opinion, so it can be concluded that the problem of soil erosion is felt more in mountainous areas.

Table 3. The impact of soil erosion based on the type of region.

Zone	Variables	Erosion	Not erosion	Total
mountainous	Amount	76	21	97
	Percent	78	22	100
plain	Amount	61	153	214
	Percent	28.5	71.5	100

Positive (beneficial) consequences and negative (unfavorable) effects of project implementation

The predictions made about the possible effects of the activities of the industrial town project on the different parts of the environment of the studied area are summarized in Table 3:

The predicted impact in this evaluation, regardless of the nature (result) of the positive or negative effects, can be separated from each other from the point view of specific characteristics; these characteristics are:

A. Probability of the effect including definite and possible effects.

B. The duration of the effect, including long-term, medium-term, and short-term effects.

C. The effect's intensity includes severe, medium-intensity, low-intensity, and no effects.

The importance of the work, particularly in the context of the industrial town project, cannot be overstated. It includes work of high importance, work with medium importance, work with low significance, and work with no importance. This categorization underscores the potential impact of the research on the decision-making process. The range of effects, as detailed in Table 4, provides a comprehensive understanding of the potential impacts of the industrial town project. It includes the scope of the project, the range of direct effects of the project, the range of indirect effects of the project, and effects beyond the scope of macro studies. This detailed breakdown is crucial for informed decision-making.

In Table 4, the forecast of the possible effects of the industrial town project's activities on the influential components of the environment is summarized in the order of the results.

Table 4. Prediction of the economic actives on ecology.

Environment	Effect		Probability			Duration			Intensity				Importance			
	Pos.	Neg.	Cert.	Possib.	Improb.	Lon.	Med.	Sho.	Hig.	Med.	Lo.	Negl.	Hig.	Med.	Lo.	Negl.
Physical-chemical	1	4	3	1	6	5	1	0	2	1	2	1	2	1	3	0
Biology	2	5	7	1	1	9	0	1	5	2	1	3	1	1	5	0
Economy-social	12	4	17	4	1	16	1	2	9	3	5	1	12	3	3	1
Industry	3	4	1	2	3	10	1	2	7	5	4	1	10	2	1	2
Total	18	17	28	8	11	40	3	5	23	11	12	6	25	7	12	3

Note: Pos. = positive; Neg. = negative; Cert. = certain; Possib. = possible; Improb. = improbable; Lon. = long; Sho. = short; Hig. = high; Med.= medium; Lo. = low; Negl. = negligible.

CONCLUSION

The evaluation of the industry development shows that, practically, it is impossible to eliminate the effects and negative consequences of the project. On the other hand, the evolution of environmental protection strategies indicates the evolution of ecological approaches in the industry in connection with the expansion of the concept of sustainable industrial development. In this review, the approach to environmental considerations through the use of structures (equipment and specific technology to prevent or remove adverse effects), corrective measures (recycling, modification, control, and reducing the intensity of the effect), and non-structural methods in the form of an environmental management program. Attention has been paid, and an attempt has been made to emphasize the major negative signs. The approach recommended in this program is to create an environmental management system based on cleaner production. According to the definition of this system, "the continuous application of comprehensive preventive environmental strategy in processes, products, and services to increase efficiency and reduce human and environmental risks" is identified with three parts: continuous, preventive, and comprehensive. The priorities of this management, which is considered an integrated part of product and process production, are suggested and recommended as follows:

A. Prevention of pollution through pollution at the source

B. To minimize

C. Producing products that are compatible with the environment

D. Recovery and recycling of waste and residues

E. Proper and principled disposal of waste

F. Purification of pollutants

The environmental management system should be continuously upgraded and improved, and measures should always be applied in some parts of the system to eliminate the weak points and improve the current situation of the micro-activities of the project. We should use the best available technology as much as possible, aiming to use technical knowledge, improve technology, reduce waste, high efficiency, less energy consumption, less pollutant emission, and optimal waste treatment methods. Disposal of waste materials is placed. To achieve the environmental management system with the above objectives by employing an ecological expert in large and

polluting units, as well as creating an environmental management unit of an industrial city with an organizational structure and a description of tasks defined according to our implementation, review, and maintenance of ecological policy. It is mandatory. This unit should put the following measures in its activity priorities:

1- Quality care and monitoring of surface water sources in the declared stations.

2- Monitoring and quality monitoring of underground water sources in specified stations.

3-Monitoring noise pollution within the recommended limits.

4-Monitoring soil pollution and comparing it with the soil condition before the project's Implementation.

5- Implementation of specialized, semi-specialized, and general educational programs.

6- Compilation of a comprehensive solid waste management program within the city limits.

7- Supervising the creation, operation, and pre-treatment system of industrial units and central wastewater treatment facilities of the industrial town.

8- Protecting existing dams in the immediate area of the project

9- Management of the precise Implementation of green space spaces in production units, maintenance of public green spaces, and optimization of the environment.

10-Establishing communication with the Provincial Environmental Protection Department and non-governmental organizations (NGOs) to exchange information and use their opinions and specialized guidelines.

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