Study of methodology for the determination of environmental protection costs and their impact on the effectiveness of land management in case Uzbekistan

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Abstract. The importance of include environmental costs in the evaluation of land management projects—particularly with regard to agricultural activities in irrigated areas—is covered in this article. It looks at several approaches to determining and measuring environmental costs and evaluating the environmental effects of land management, both good and bad. According to the report, environmental costs must be taken into account when evaluating the financial viability of such initiatives. It also describes the kinds of environmental resources and expenses that have to be taken into account when developing a project, providing a thorough framework for managing land in agricultural contexts in a way that is both sustainable and profitable.

1 Introduction

Numerous urgent environmental problems have been brought on by the massive development of virgin areas for irrigated agriculture, which has had a significant influence on the current environmental condition [1]. Notably, the land development projects were frequently carried out without a thorough environmental evaluation, hence ignoring important signs and possible negative consequences. As a result, the area is currently dealing with severe water supply problems, increasing air pollution, extensive secondary soil salinization, accelerated wind and irrigation erosion, and severe deterioration of irrigation water quality [2,3]. These difficulties highlight the need for fresh approaches and standards to enhance the assessment of land management initiatives' economic and environmental impacts [4].

In Uzbekistan, the expansion of agricultural land and intensified resource extraction have led to substantial environmental degradation, posing complex challenges for sustainable land management. A key component in addressing these challenges is accurately assessing the environmental protection costs required to mitigate adverse impacts and enhance land-use

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efficiency. However, existing methodologies for determining these costs often fall short of providing a holistic picture, especially in arid and semi-arid regions like Uzbekistan, where water scarcity, soil degradation, and pollution are prevalent. Consequently, understanding the economic implications of environmental protection measures and their influence on land management effectiveness is critical.

Currently, when developing projects and land management schemes, the main attention is paid to the protection of land resources from salinity erosion, and almost no attention is paid to the protection of lands from the effects of pesticides, mineral fertilizers, atmospheric emissions, watering with contaminated irrigation water, etc [5,6].

Determining the environmental consequences of projects and land management schemes requires extensive environmental research, deep theoretical and methodological study of a large complex of various issues and identifying the degree of their interrelations and significance [7–9].

The goal of this study is to create and improve a system for precisely estimating the costs of environmental conservation in the particular ecological setting of Uzbekistan. It specifically aims to assess how these expenses affect the overall efficacy of land management plans, especially in areas with high agricultural productivity and water scarcity. This study will help develop more sensible and profitable land management techniques by estimating the costs of environmental protection and examining how they affect resource sustainability and land productivity. In the end, these observations should help land managers and politicians strike a balance between environmental protection and economic expansion, promoting sustainable development in Uzbekistan.

2 Materials and methods

The environmental effect of land management measures is to change the conditions of the natural environment and the quality of its resources. These changes can be both positive and negative[10,11]. These factors undeniably influence the economic outcomes of production. In project evaluations, it is essential to consider both positive and negative environmental impacts. Developing a methodology to assess the environmental impact of design projects presents several key challenges: Creating methods to evaluate ecological impacts［12,13]. Establishing a valuation metric for these impacts that remains comparable and integrated with economic efficiency by the time it is achieved. In irrigated areas, environmental protection costs encompass measures to prevent the use of polluted water for irrigation and domestic needs, mitigate wind and water erosion, prevent secondary salinization, and create sanitary protection zones. Additional costs include air purification systems, waste disposal, land allocation for facility construction, and organizing waste storage and disposal sites—all of which contribute to potential agricultural productivity losses［14,15]. The costs for environmental protection are determined by annual expenditures and capital investments required for implementing protection measures, adjusted to a yearly scale to account for time. For land management schemes and projects, capital investments for environmental measures are defined by regulatory indicators or estimated costs of environmental facilities. Such facilities include water and air treatment plants, protective forest zones, hydraulic and anti-erosion structures, sanitary protection zones, waste storage and disposal facilities, and collector-drainage networks［14,16,17］

3 Results

Currently, land management projects do not classify collector-drainage networks as an environmental protection measure, which we believe is an oversight, as these networks serve a purely ecological function by preventing soil salinization and waterlogging. Therefore, they should be included as environmental protection facilities, and their construction costs should be counted as capital expenses for environmental protection efforts. The number and composition of environmental protection facilities are determined based on an assessment of the current and projected ecological situation in the area being developed. These facilities address atmospheric emissions, soil contamination, and local water sources. A methodology has been developed to estimate the volume of harmful substances produced by agricultural enterprises and to determine the capital costs required to reduce or eliminate these pollutants.

We propose to determine emissions of gas, lead and other harmful substances from vehicles, agricultural machinery and heating systems into the atmosphere using the formula:

$$V_{ai} = \sum n \sum m \, \omega_j \beta_{ij} \qquad \text{Equation 1}$$

Where: V_{ai} is the volume of emissions into the atmosphere of the i-th type of pollutant, ω_j the need for the jth type of fuel or the quantity used. β_{ij} ; – volume of the i -th type of emissions generated from the combustion of the j -th type of fuel, i.e.

Dust and other harmful emissions into the atmosphere are determined individually for each site, based on the technological characteristics and production volume of each facility. These emissions are then aggregated across the entire land area.

The volumes of household waste and sewage water in populated areas can be determined using the formulas:

$$V_c = \frac{Hq}{1000}, \qquad V_0 = \frac{Hm}{1000} \qquad \text{Equation 2}$$

WhereV_c,V_0– volumes of waste and wastewater per day, respectively, t/day,m^3/day; N – project (existing) population, people;q- water disposal rate per inhabitant per day, l/day;m– calculated rate of bit waste generation per inhabitant per day, kg/day.

The volumes of industrial waste and wastewater are determined considering the characteristics of production facilities separately for each of them, and then summed up over the entire territory.

Livestock waste is determined based on the project (existing) livestock of farm animals using the formula:

$$V_j = \sum n \frac{N_i n_i}{1000} \qquad \text{Equation 3}$$

Where V_j– total daily volume of livestock waste t/day. N_i- project (existing) livestock of farm animals of the first type, heads. n_i– rate of excrement output from one structural head of animals of the i-th species per day, kg/day.

The volumes of pollutants supplied with irrigation water depend on the qualitative composition of the water and are determined separately for each harmful substance contained in it according to the following formula:

$$V_B = \sum n \sum m \frac{P_i M_{jdi}}{1000} \qquad \text{Equation 4}$$

Where V_B– the total volume of harmful substances supplied with irrigation water, i.e. P_i– sown areas I – crops, hectares. M_j– irrigation norm I – crops,м^3/ha.d_i– content of j – th harmful substances in 1м^{3}irrigation water, kg/м^3.

Capital costs for environmental protection measures in land management schemes and projects are determined by the formula:

$$К = \sum \quad К_i \qquad \text{Equation 5}$$

Where K is the cost of construction of the i-th environmental facility, thousand soums.

The amount of capital costs for water treatment, air purification, hydraulic engineering and other anti-erosion structures and installations, waste storage and disposal facilities are determined by their estimated cost.
Capital costs for the creation of shelterbelts (Cl) can be determined by the formula:

$$К_л = Р_л С_л \qquad \text{Equation 6}$$

Where$Р_л$ shelterbelt forest belts, hectares;$С_{л-}$ costs for planting 1 hectare of forest belts, rub.
Capital costs for the construction of a collector-drainage network (CDN) are determined by the formulas:
A) for farms in areas of new development and irrigation

$$К_{кд} = \sum \quad P_i \frac{N_{Hi}}{1000} S \qquad \text{Equation 7}$$

Where Pi is the land area of the i-th massif, hectares.N_{Hi}– standard (rational) length of CDN per 1 hectare for the I-th massif, m/ha.
S – Integrated costs for the construction of 1 km of collector and drainage network, sum.
b) for farms in the old irrigated zone:

$$К_{кд} = \sum \quad P_i(P_{Hi} - N_{Ci})S \qquad \text{Equation 8}$$

WhereN_{Ci}– the existing length of the collector-drainage network of the i-th massif, m/ha.
Current costs include operating costs for the maintenance and servicing of environmental facilities, depreciation and losses associated with the withdrawal of agricultural land for the construction of environmental facilities and are determined by the formula:

$$C = \sum \quad C_{ij} \qquad \text{Equation 9}$$

WhereC_{ij}– current costs of the i – environmental object of the j – type.
Operating costs and depreciation charges in projects and land management schemes are determined according to standards as a percentage of capital investment allocations for environmental protection measures.
Losses associated with the acquisition of land for the construction of environmental facilities (Co) are determined by the amount of net income lost from the area occupied by environmental facilities:

$$C_o = \text{Р}D \qquad \text{Equation 10}$$

WhereR -area of land occupied by environmental objects, hectares; D – average net income per farm per 1 hectare.
The area of land occupied by environmental objects (P) is defined as the sum of the areas of various environmental objects (P_i):

$$P = \sum \quad P_i \qquad \text{Equation 11}$$

The predicted cost of waste storage and disposal facilities, water and air treatment facilities and installations, etc., determines the amount of capital spent in them. The most ecologically friendly design choices must be chosen when creating land management plans and initiatives. The well-known formula (1) states that the minimal total year costs and capital investments, reduced to annual dimensions, are the indication of environmental efficiency when comparing solutions that offer the same degree of natural environment quality.

$$C_i + E_H K \longrightarrow min \qquad \text{Equation 12}$$

When comparing options for schemes and land management projects, the implementation of which requires longer periods, when the capital investment is not simultaneous, and the annual costs for them change over time, the reduced costs are determined considering the time factor using formula (2).

$$\Pi = \sum \quad \frac{K_T + C_T}{(I + E_H)^{t - t_\delta}} \qquad \text{Equation 13}$$

WhereK_T-capital investments, thousand soums in the tth year;C_T- annual costs in the tth year, thousand soums;
E_H–standard coefficient for reducing multi-time costs;t_δ– the base point in time to which the costs of the tth year are reduced.
To compare design options for land management, which because of their implementation provide different levels of environmental quality, it is necessary to use the difference in the environmental effect from improving the quality of natural resources and the reduced costs. The best option is determined by its maximum;

$$E_{Ei} - \Pi_i \longrightarrow max. \qquad \text{Equation 14}$$

WhereE_{Ei}-environmental effect of the i-th option, thousand.
The total economic damage from environmental violations is used not only for the economic justification of projects, but also for a comprehensive assessment of the impact of the polluted environment on various sectors and divisions of the economy.

4 Conclusion

When creating an environmental justification for land development projects, it is essential to evaluate the techniques used to evaluate the project's environmental effect, including modifications to resource quality and environmental conditions. Both the advantages and disadvantages of these modifications may be thoroughly examined by developing a mathematical model of these techniques and carrying out an exhaustive investigation. According to this research, a rise in the economic value of natural resources improved by the project's operations indicates the beneficial environmental effects of land development initiatives. A framework for assessing the overall costs is provided by the environmental costs related to any negative effects of land management, which combine direct environmental expenses with the financial losses brought on by environmental violations connected to project operations.

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