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SPECIFIC FEATURES OF ENVIRONMENTAL RISK MANAGEMENT IN ENVIRONMENTAL PROJECTS

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Abstract

The selection and justification of the feasibility of any environmental, including water projects, are always associated with the analysis of future events and uncertainty of the outcome of the project. Therefore, one of the most important tools of project management is a risk management framework. Risks usually arise from the uncertainty and variability of the economic, environmental, political, social environment, as well as the different operation conditions of a particular object. Weather and climate risk, as a subtype of general environmental risk, reflects the degree of loss of potential yields, and consequently the amount of income, as a result of uncontrolled meteorological factors. Reducing such risk provides a decrease in the impact of adverse natural factors on the efficiency of economic activity, and hence on the degree of technological excellence and environmental reliability of the selected alternative design solutions.

Key words: *environmental risk, weather and climatic risk, project management, environmental governance, modeling*

INTRODUCTION

The existence of global climate change is now recognized by the world community and is beyond doubt. The problem of global warming arose at the end of the last century. Addressing this problem requires the development and implementation of strategies to adapt to global climate change. The implementation of such measures will increase productivity, efficiency and profitability, especially agricultural production as an important component of nature management [7, 18, 19].

According to the UN Framework Convention on Climate Change, adaptation means adapting natural, social or economic systems to actual or expected climate change and its consequences [11, 24].

To clarify and make wider use of the concept of "adaptation to climate change", clear definitions of the following categories were considered and given: adaptation potential; propensity to influence; sustainability; risk; sensitivity; vulnerability [13].

Risk category is a combination of the probability (or frequency) of natural disasters and the scale of the consequences of their impact. Risk is a function of the object's propensity to influence and the perception of the consequences of that influence by the community or system.

According to the international policy documents on this issue in the field of climate diplomacy in Ukraine and the EU as a whole, based on real research by IPPC (International

Plant Protection Convention) criteria, on climate change in Ukraine until 2100, pursuant to the Decree of the President of Ukraine "On the decision of the National Security and Defense Council of Ukraine" of September 14, 2020 and "On the National Security Strategy of Ukraine" and others, Ukraine, like other member states, has committed itself to allocating funds for adaptation to climate change and preparation for its implementation [2, 7].

That is why the issue of disclosing the concept of "risk" and its use in the field of nature management, which is most affected by weather and climatic conditions and their changes, is extremely important [1, 5, 14, 20].

Ensuring the sustainable development of modern enterprises in the field of nature management is impossible without the introduction of innovative technologies. Innovative technologies reduce or avoid the negative impact of economic activities on the environment and provide more efficient use of natural resources [6, 15, 17, 22, 23].

The selection and justification of the feasibility of any environmental, including water projects, are always associated with the analysis of future events and uncertainty of the outcome of the project. Therefore, one of the most important tools of project management is a risk management framework. Risks usually arise from the uncertainty and variability of the economic, environmental, political, social environment, as well as the different operation conditions of a particular object.

At the present stage, taking into account the specific features of project implementation in the field of nature management, an environmental risk framework has become extremely popular due to the capability to predict the amount of such risk at the stage of project development in most cases will prevent the transformation of a potential environmental risk into a real one.

The urgency of taking environmental risk into account when implementing investment projects is growing due to global climate change, which requires the adaptation of natural and economic sectors to new conditions [8, 10, 12, 23].

Numerous aspects of environmental risk are studied in the works of many scientists. However, the issues of environmental impact assessment of projects in the field of nature management and their consideration when economically evaluating project decisions are still insufficiently studied.

MATERIALS AND METHODS

In the field of nature management, climatic or weather conditions dramatically affect the formation of technical, economic and environmental indicators [4, 8]. Such indicators are the basis for assessing environmental risk.

That is why the following research methods were used: methods of qualitative risk analysis (to identify the main factors and the corresponding risks that affect environmental projects); methods of quantitative risk assessment – statistical analysis and matrix modeling (to assess the probability of achieving project objectives and the degree of risk impact on project results); retrospective statistical observations (to create databases of meteorological conditions in different climatic zones); system approach (to consider of nature management projects as complex ecological and economic systems), methods of economic and mathematical modeling.

When studying climate change and its impact on various aspects of agricultural production on the drained lands of the Forest-Steppe zone of Ukraine, in order to develop appropriate adaptive measures, a set of forecasting and simulation models was used. Such a set includes: a model of the local climate; model of water regime and water control of drained lands; model of development and crop formation of cultivated crops. Such models are mostly implemented on the basis of long-term forecast [4, 8, 9]. In addition, the main methods of general experimental theory were used: analytical, experimental, statistical, mathematical modeling, machine experiment using modern information and computer technologies.

Such research methods are based on the application of systems theory along with a systems approach, systems analysis and modeling. These methods are focused on the widespread use of computers and related software and information support when developing modern approaches to justify technical and technological solutions in the projects in the field of nature management in a changing climate.

RESULTS AND DISCUSSIONS

The basis for quantitative risk assessment is, first of all, the idea of the concept of "risk". In addition, it is a distinction between different types of risk depending on the content and the field of detection.

Currently, there is no unambiguous interpretation of the term "risk". However, most often in the literature, "risk" is considered as the possibility of deviating from the goal for which the chosen alternative is realized or material, environmental, moral and other losses associated with the implementation of the chosen alternative in conditions of uncertainty.

When systematizing risks as to an economic object, it is customary to distinguish between external and internal risks. By the field of detection, the impact of economic, market, political, industrial, financial, environmental and other risks is more often assessed. However, in the process of planning and justifying projects, first of all it is necessary to determine which specific types of risks are a priority and directly affect the effectiveness of their implementation.

The analysis of the implementation of water management projects allows making conclusions. First, the implementation of water management projects has an impact on the environment, thereby generating anthropogenic environmental risk. Secondly, the results of project activities directly depend on changing and difficult to predict meteorological conditions, which leads to natural environmental risk.

Such features of environmental risk have different nature and content. In our opinion, that necessitates the identification of different types of environmental risk, which must be determined by different quantitative methods.

So, depending on the regularity and impact areas, environmental risks of water management project may include:

1. *Weather and climatic risk.* This type of risk arises under the influence of uncontrolled environmental factors that cause uncertainty and cyclicity of meteorological conditions. Weather and climate risk as a type of environmental risk provides extremely important information about the degree of the maximum possible economic result when using different ways of project implementation and allows choosing the best option.

2. *External environmental risk.* External environmental factors that cause this type of risk include: possible natural disasters, accidents, environmental cataclysms; radiation and chemical pollution of soils, water and air; extreme manifestations of natural phenomena (cyclones, hurricanes, downpours, floods, inundations, droughts, frosts, squalls, hail, etc.). Such risk is probabilistic and should be determined on the basis of statistics, long-term studies and forecasts.

3. *Internal environmental risk.* Irrational actions within the project activities can cause some damage to the environment. The most stringent criterion for assessing environmental risks is the assessment of changes in the state of environment: extinction of plant and animal species, changes in the chemical composition of environmental components, and so on. Various economic or other decisions must be made in a way preventing exceeding the limits of harmful effects on the environment.

Considering the planning of projects in the environmental field, including water management projects, it should be noted that one of the most important stages is the development of alternative design solutions, their comparison and selection of the best option for implementation according to certain criteria.

When analyzing the above types of environmental risk, it can be concluded that the weather and climate risk is decisive at the planning stage of project decisions, as meteorological conditions determine the

results of economic activities within the project, based on the following arguments:
– agricultural productivity, including on reclaimed lands, is affected not only by biological capabilities of crop varieties, available agronomic tools and mechanisms, timely and high-quality tillage, fertilizer application, crop rotation, etc., but also the results of interaction of a number of meteorological factors;
– randomly compiled weather conditions of each current year and long-term climatic characteristics, specific to a particular area, cause significant fluctuations in crop yields;
– it is the weather conditions in the relevant or estimated year have a decisive influence on the annual effect of the reclamation project and its deviation from the expected scale. Accordingly, the weather conditions will have a great influence on the final integrated effect for the entire period of operation of the facility.

As a result of this analysis, the economic content of weather and climate risk was made, based on the following considerations:

1. The assessment of such risk is carried out at the design stage according to a long-term forecast, which is based on a certain technological basis. Such calculations enable: firstly, to determine the objective potentially possible yield of each crop on a certain object, which is formed in ideal (optimal) conditions as to climate, solar radiation, soil quality, agricultural technology, water regime, etc. Secondly, depending on the weather conditions of a particular estimated year and the technological capabilities of the reclamation system, the projected technological yield is determined for each design solution. The projected technological yield, as a rule, does not reach the potentially possible yield. The difference between them characterizes weather and climatic risk.
2. In general, reclamation measures are carried out in areas with adverse natural conditions. Thus, weather and climate risk has a predominantly negative impact on the economic effect and in this sense it can be classified as "pure" risks.
3. Therefore, in our study, the weather and climatic risk of the water management project is considered as an absolute or relative deviation of the actual effect of the design solution from its potential value due to the mismatch of real weather conditions - optimal. In this context, weather and climate risk can also be considered as environmental losses from the increased potential income as a result of adverse natural factors. After all, the maximum yield is limited by the optimal ratio of environmental components [3, 10, 16].

The economic aspect of the assessment of water management projects on the example of the drainage system reconstruction project is also the aim of our study. Therefore, it is necessary to assess the impact of weather and climate risk on the economic performance of the object. Conditionally, it can be called a production effect (E_i) in the corresponding estimated year. To apply statistical methods to assess the impact of risk on the outcome of production activities on reclaimed land, it is necessary to know exactly how the effect depends on changes in weather conditions.

General approaches to making and implementing the models of business decisions optimization at different levels using climate data and meteorological forecasts when creating and operating complex meteorological and economic systems are outlined in our studies [8].

In view of natural seasonal cyclicity of agricultural production on reclaimed lands, there are different in terms of heat and moisture supply periods of vegetation, which can be grouped into estimated (typical) groups of years. The distribution of these groups of years within the project life cycle is uneven. This distribution can be done using a share coefficient (probability of detection) of the relevant group of years in the total project implementation period [4, 9].

In addition, the type and design of water management system affects the amount of the expected yield and, consequently, the overall economic effect. The type and design of water management system determine the appropriate technology of water regime control (water regulation) on reclaimed lands.

That is why the results of agricultural production on reclaimed lands during the project period of operation of the water facility depend on three main factors:

1. Meteorological conditions in the relevant typical estimated years, an aggregate of sets $P = \{p_j\}, \quad j = \overline{1,m}$.
2. Frequency (probability) or detection share of the relevant group of years over the design period of object operation – $\{\alpha_{p_j}\}, \; j = \overline{1,m}$.
3. Type and design of reclamation system by the appropriate method, water regulation scheme, an aggregate of sets $S = \{s_i\}, \; i = \overline{1,n}$.

Thus, in the general implicit form, the utility function of the water management project can be presented as:

$$E_{ps} = E(P, \alpha_p, S), \qquad j = \overline{1,m}, \quad i = \overline{1,n}$$
....(1)

For greater clarity and simplicity of calculations, this function can be presented in the form of a payment matrix [9, 21].

As we have noted, risk can be considered as an absolute (*R*) or relative (*f*) deviation from the potentially possible effect. Then, in general, the elements of the risk matrix are a deviation from the weighted average potential effect ($\overline{E}_n$)

$$R_{ij} = (E_{ij} - \overline{E}_n), \qquad i = \overline{1,n} \quad j = \overline{1,m}$$
.... (2)

In economic statistics, the standard deviation has become the absolute variation measure. Therefore, the absolute amount of risk for each of the alternative design solutions is determined by the formula:

$$\overline{R}_i = \sqrt{\sum_{j=1}^{m} (E_{ij} - \overline{E}_n)^2 \cdot \alpha_{pj}} = \sqrt{\sum_{j=1}^{m} R_{ij}^2 \cdot \alpha_{pj}},$$
$i = \overline{1,n}$ .... (3)

When addressing the issues of increasing the economy resilience to the influence of meteorological factors, it is better to consider not the variance of fluctuations, but some complex criterion that takes into account both the variance of results and their average degree. Therefore, a relative degree of weather and climatic risk, as a risk degree per an unit effect in the form of shares or percentages, can be calculated by the formula:

$$f_i = \frac{\overline{R}_i}{\overline{E}_n} \cdot 100, \qquad i = \overline{1,n}$$
....(4)

Thus, in general, the criteria for selecting the best option for the project, including water management project, taking into account the impact of weather and climatic risk on the final result, can be given as:

a) by the criterion of effect maximization

$$E(s_o) = \max_{\{i\}}(\overline{E}_i - \overline{R}_i), \qquad i = \overline{1,n}$$
....(5)

б) by the criterion of cost minimization

$$B(s_o) = \min_{\{i\}}(\overline{B}_i + \overline{R}_i), \qquad i = \overline{1,n}$$
....(6)

As an example, the impact of weather and climate risk on the choice of design solution can be considered on the example of the reconstruction of drainage system located in Kiev region (the Forest-Steppe zone of Ukraine) in an area of 360 hectares.

Predictive calculations in simulation are performed on the following multiple variable conditions:

– by the typical for this zone grown crops of the aggregate of sets $\{k\}, \; k = \overline{1,n_k} \; (n_k = 6)$, and the corresponding share of their sown areas f_k: winter grains (with a share $f_k = 0.2$), sugar beets ($f_k = 0.1$), potato ($f_k = 0.1$), root crops ($f_k = 0.1$), perennial grasses ($f_k = 0.4$), corn for silage ($f_k = 0.1$).

– by the typical (estimated) in terms of heat and moisture supply periods of the growing seasons of the aggregate of sets $\{p\}, \; p = \overline{1,n_p}$ $(n_p = 5)$;

At the stage of formation of design solutions, the most rational of them were selected, which were technologically possible for implementation in natural-agro-ameliorative conditions of the studied object: option 1 – preventive sluicing (PS); option 2 – sprinkling on the background of preventive sluicing (SPS); option 3 – moisturizing sluicing (MS); option 4 – drainage (D); option 5 – sprinkling on the background of drainage (SD).

Based on simulation modeling when the corresponding set of optimization and forecast-simulation models was used, the main technical and economic indicators of the considered options of design solutions were obtained. At the same time, the influence of meteorological conditions on the options of design solutions in different by heat and moisture supply years was taken into account.

Generalized results for the changes in the relative degree of weather and climatic risk for a particular studied object by individual crops and estimated groups of years by heat and moisture supply on the example of moisturizing sluicing are presented in Fig. 1. These results showed that the greatest risk of crop loss is inherent for perennial grasses and winter grains in wet and very wet years. In average and dry years, the risk for these crops is reduced by means of humidifying measures. The expected degrees of weather and climate risk by the options of design solutions in terms of different technology of water regulation of drained lands in the years of different weather conditions are presented in Fig. 2.

It is obvious that the use of more advanced technology of water regulation on drained lands can significantly reduce the degree of weather and climatic risk compared to drainage in adverse dry years (40 ... 55%): for preventive sluicing – on average up to 30%, for moisturizing sluicing – up to 20 ... 25% and for sprinkling on the background of drainage – 5 ... 20%.

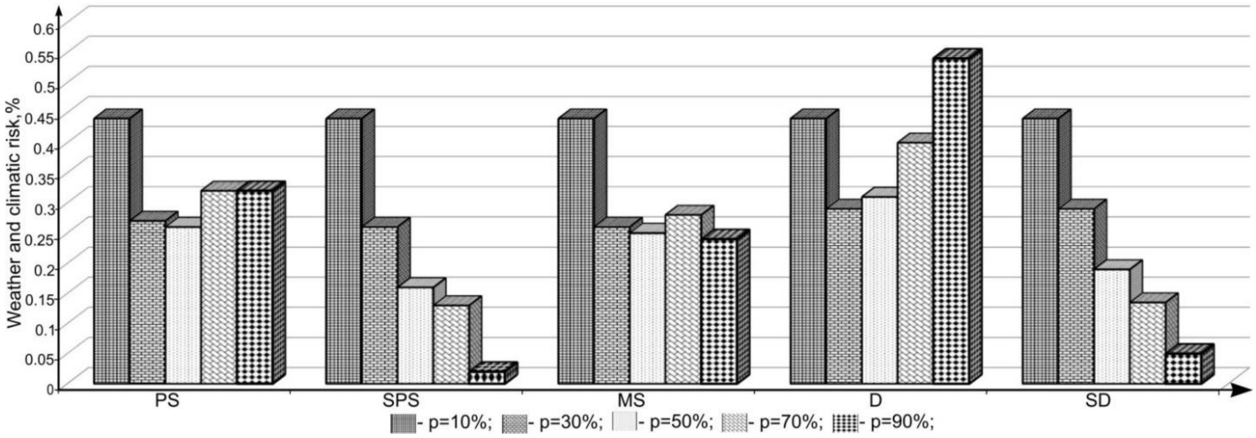

Fig. 1. Characteristics of the relative degree of weather and climatic risk when applying moisturizing sluicing for the crops of project crop rotation by the years of different weather conditions in the Forest-Steppe zone of Ukraine
Source: Own research.

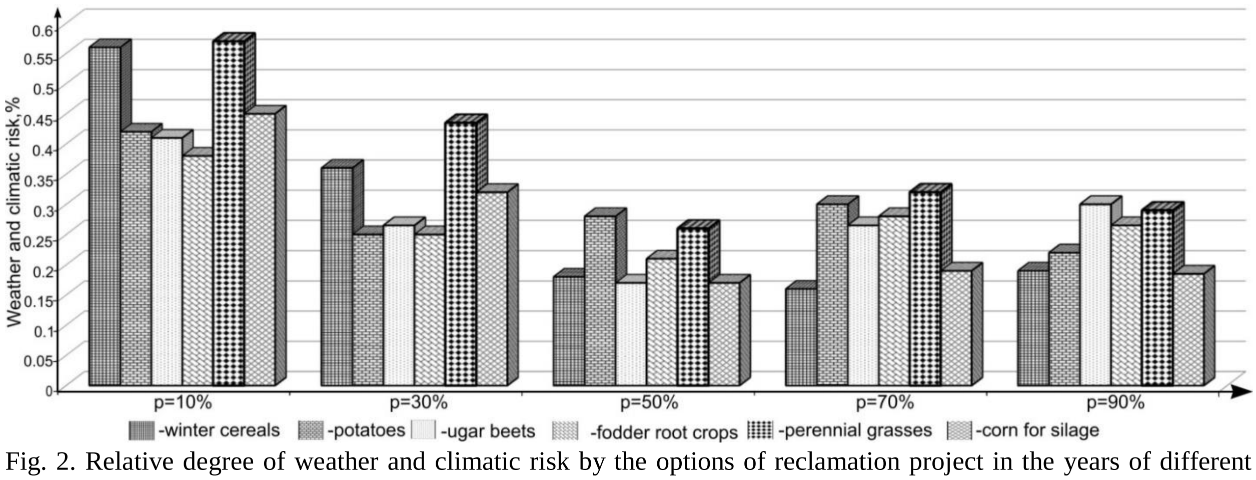

Fig. 2. Relative degree of weather and climatic risk by the options of reclamation project in the years of different weather conditions in the Forest-Steppe zone of Ukraine
Source: Own research.

This convincingly demonstrates the high overall efficiency of double regulation of water regime of drained lands.

These results of the study confirm that the more technologically advanced the design of a reclamation system is, the lower the weather and climatic risk it expected. Such advanced water regulation technology on drained lands provides higher crop yields and reduce the dependence of agricultural production on the effects of unpredictable weather conditions.

As noted above, the most optimal way to take into account the influence of meteorological factors in economic calculations is to introduce an indicator (absolute or relative) of weather and climate risk in the formula for calculating criteria for comparing alternative design solutions. Traditionally, the criterion for comparing reclamation projects is the minimum given costs [21].

For example, we calculated the indicators of given costs for design solutions by a traditional approach, which takes into account only the direct production costs, as well as by a modified approach taking into account weather and climatic risk, Table 1.

It is obvious that by the traditional approaches, the best option for reclamation project in humid areas is drainage, which is considered to be an obsolete technology for today and provides the least increase in yield. In addition, it is estimated to be characterized by the highest degree of weather and climatic risk, that is almost 40%. That is, by the assessment scale it is between medium and high degree. When using the proposed approach, taking into account weather and climatic risk the best options are more technologically advanced options of design solutions that reduce the dependence of yields on meteorological conditions.

Table 1. Results of the comparison of the efficiency of water regulation technology by the traditional and modified criteria of cost minimization in the Forest-steppe zone of Ukraine

	By the traditional criterion of given costs		By the criterion of given costs taking into account weather and climatic risk	
	Options of design solutions	Value	Options of design solutions	Value
1.	Drainage	0.867	Moisturizing sluicing	1.321
2.	Preventive sluicing	0.874	Preventive sluicing	1.323
3.	Moisturizing sluicing	0.935	Sprinkling on the background of drainage	1.385
4.	Sprinkling on the background of drainage	1.114	Sprinkling on the background of preventive sluicing	1.408
5.	Sprinkling on the background of preventive sluicing	1.163	Drainage	1.519

Source: Own research.

Thus, modeling different scenarios of economic activity taking into account weather and climatic risk enables to choose a more advanced technology of water regulation as an optimal model at a particular object in specific natural and agro-ameliorative conditions.

In addition, the forecast assessment of the degree of weather and climate risk can also be effectively used for other purposes – when determining a discount rate in investment calculations; when making decisions on the feasibility of using credit resources to finance projects; when substantiating the degree of agricultural insurance risk, etc.

CONCLUSIONS

The introduction of scientifically sound and effective methods of using climate information in economic calculations will significantly reduce losses (up to 40%) caused by natural conditions as well as get a greater effect due to the implementation of the optimal strategy for sustainable agricultural production on reclaimed lands.

The introduction of scientifically sound and effective methods of using climate information in economic calculations will significantly reduce losses (up to 40%) caused by natural conditions as well as get a greater effect due to the implementation of the optimal strategy for sustainable agricultural production on reclaimed lands.

Weather and climate risk, as a subtype of general environmental risk, reflects the degree of loss of potential yields, and consequently the amount of income, as a result of uncontrolled meteorological factors. Reducing such risk provides a decrease in the impact of adverse natural factors on the efficiency of economic activity, and hence on the degree of technological excellence and environmental reliability of the selected alternative design solutions.

The use of the proposed author's approaches as to taking into account weather and climatic risk in economic calculations enables:

– to model different scenarios of economic activity and to optimize the number of crops in crop rotation by the years with different climatic conditions to achieve the greatest effect;

– to reduce weather and climatic risk in adverse dry years (on average up to 40 ... 55%): for preventive slicing – up to 30%, for moisturizing sluicing – up to 20 ... 25%, for sprinkling on the background of drainage – up to 5 ... 20% due to introducing the most advanced and relevant to local conditions water regulation technology at a particular object

– planning the measures to reduce the negative impact of weather conditions in the years of the greatest risk.

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