

MODEL FOR ASSESSING THE SUSTAINABILITY OF INNOVATIVE CHANGES IN AGRICULTURE

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Annotation: *In the course of the study, an integral index model was developed to assess the stability of the innovative transformation process in the dehkan farms of Karakalpakstan. The interaction of innovation indicators, resource saving, and ecological and climatic risks has been determined, and the main determinants of sustainability have been identified.*

Keywords: *Innovative transformation, sustainability index, dehkan farms, environmental risks, resource conservation, integral index, digitalization.*

Abstract: *This study develops an integrated index model to assess the sustainability of innovation-driven transformation in farms in Karakalpakstan. The model assesses technological innovation, resource efficiency, and environmental risks to determine their combined impact on agricultural sustainability.*

Introduction: State policy on the introduction of digital technologies in agriculture has significantly intensified in recent years. In particular, the Resolution of the President of the Republic of Uzbekistan dated June 7, 2022 No. PP-273 "On Additional Measures for the Effective Organization of the Implementation of the Tasks Defined in the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030" defines the tasks of widespread implementation of digital solutions for agrarian monitoring, water resource management, increasing yields, and optimizing the activities of

dehkan farms[1]. This process emphasizes not only the economic effectiveness of innovative transformation, but also its necessity for sustainable development.

The Republic of Karakalpakstan is a region with a high ecological and climatic risk, a shortage of water resources, and a decrease in land fertility, which significantly affects the efficiency of dehkan farms. Despite the fact that existing studies highlight the economic effectiveness of innovations, a model for a comprehensive assessment of the stability of innovative transformation in the context of dehkan farms has not been sufficiently developed. In particular, scientific approaches to the use of integral indices that combine economic, environmental, and digital indicators are rare.

Therefore, the purpose of the research is to create a model based on an integral index for assessing the stability of the innovative transformation process in dehkan farms of Karakalpakstan and to determine the impact of environmental and economic risks.

Literature review: Innovative transformation is one of the main factors of economic development, and the theoretical approaches developed by Schumpeter, Rogers, Chesbrough, and Solow substantiated the role of innovation in the process of economic growth, technological renewal, and transformation [2,3,4]. These theories serve as a methodological basis for understanding the mechanisms for implementing innovative technologies in the agricultural sector.

In recent years, the sustainability aspect of innovative transformation in agriculture has been widely studied. The European Union's Smart Farming model, Korea's Smart Village concept, and the US experience in desert farming demonstrate mechanisms for ensuring sustainable production through resource conservation, digital monitoring, and environmental flexibility [5,6,7]. Also, in modern studies published in the journal *Sustainability*, comprehensive

approaches to assessing agrarian sustainability based on innovative indicators are proposed [8].

Environmental and economic risks, such as water scarcity, salinity, climate change, and productivity fluctuations in the conditions of Karakalpakstan, have a significant impact on the sustainability of innovative transformation [9]. Existing research, including the work of Mambetnazarov, shows the role of digital technologies and environmentally friendly innovations in agrarian sustainability¹⁴.

Methodology: The study used a comprehensive approach to assess the stability of the innovative transformation process in dehkan farms. The level of sustainability is determined by the functional relationship between innovative development, resource efficiency, environmental and climatic risks, and production results. According to this approach, the sustainability indicator is considered as the ratio between the value of the innovation index and existing environmental and economic risks.

For the purpose of assessing the level of innovation activity, an integrated index consisting of five blocks was formed. They include indicators of technological modernization (IoT, smart irrigation, the share of modern equipment), digitalization (agricultural platforms, GIS monitoring), resource saving (water and energy savings), production efficiency (increase in productivity, cost reduction), and social stability (labor productivity, income stability). Each indicator was evaluated based on weight coefficients, and the integral innovation index was calculated using the following formula:

$$I_{IT} = \sum w_i \cdot x_i$$

where (w_i) - coefficient determined by AHP or expert assessment, (x_i) - normalized indicator value.

Water scarcity, soil degradation, and climate fluctuations were selected as the main factors for assessing environmental and economic risks. These risks were calculated in an integrated form based on the following model:

$$R_{eco} = \alpha S + \beta D + \gamma C$$

where α , β , and γ are indicators of the strength of the influence of risk factors, respectively.

The overall sustainability index is determined based on the difference between the level of innovative development and risks.

$$S_{barqarorlik} = I_{IT} - R_{eco}$$

A positive value of this indicator indicates the stability of the transformation process, while a negative result indicates high environmental pressure.

Empirical analysis was carried out on the basis of statistical data for 2020-2024 and data for 50-70 dehqan farms of the Republic of Karakalpakstan. The relationship between indicators was assessed using correlation analysis, and the factors influencing innovation stability were assessed using a multifactorial regression model. All indicators were processed by the min-max normalization method for adaptation to the analysis.

Discussion: The results of the study showed that as the index of innovation indicators increases, the level of farm sustainability also increases significantly. Technological modernization, digitalization, and resource conservation were identified as the most important factors of sustainability. This confirms the classical scientific approaches to the decisive role of innovation in economic growth.

Karakalpakstan is an ecologically and climatically complex region, and the processes of innovative transformation face a number of limitations. The imbalance of water resources, outdated technology, slow digitization processes, and insufficient financial support are hindering innovation.

International experience confirms the important role of innovative transformation in increasing sustainability. The USA has achieved efficiency in desert conditions through water-saving technologies, the Netherlands has established intensive production through innovative agricultural clusters, and

Korea has implemented digital transformation in small farms using the Smart Village model. These experiences will help determine flexible innovative directions for Karakalpakstan.

Table 1

Main factors influencing innovative transformation and comparison with international experience

Direction	The situation in Karakalpakstan	International Good Practice	Degree of influence
Technological modernization	Outdated equipment, low IoT	USA - water-saving technology	High
Digitization	Few GIS and platforms	Korea - Smart Village	Medium-high
Resource saving	Severe water shortage	USA - drip irrigation	Very high
Efficiency	High yield fluctuations	Netherlands - agro-clusters	Middle
Financing	Not enough loans	Korean grants	High

As can be seen from the table, the effectiveness of the innovative transformation process in Karakalpakstan is limited by a number of systemic factors. The most influential factors are technological modernization, resource saving, and the level of financing. The obsolescence of the technical park in the region and the low use of IoT technologies indicate the need to implement the US model based on water-saving innovations.

The slowness of digitalization processes makes a big difference compared to the Korean experience of Smart Village, which means the importance of accelerating digital transformation for Karakalpakstan. Water scarcity is the most serious factor, and the widespread introduction of drip irrigation technologies can significantly increase sustainability.

In regions with high yield fluctuations, the Dutch agro-cluster model serves to strengthen production stability. The limited funding confirms the need to expand state grants and subsidies, as in the Korean experience.

In general, the table identifies the main obstacles to innovative transformation in the conditions of Karakalpakstan and shows the corresponding international solutions. This will allow us to determine priority areas for accelerating the transformation.

Conclusion: The research results showed that the integral index model is effective in assessing the stability of the innovative transformation process in dehkan farms. Innovative indicators, resource saving, and production efficiency have emerged as the main determining factors of sustainability. Environmental and climatic risks were confirmed as the most important limitation that reduces sustainability. In general, it was found that increasing the innovation load strengthens the possibilities of sustainable development.

- Development of a package of innovative technologies (IoT, smart irrigation, agricultural platforms) suitable for dehkan farms.
- Implementation of a regional monitoring system that regularly assesses environmental risks.
- Establishing digital agro-service centers and expanding consulting and digital services for small farms.
- Phased widespread implementation of smart irrigation systems for the efficient use of water resources.
- Differentiated distribution of grants and subsidies by region based on the results of the innovation index.

REFERENCES

1. [Resolution](#) of the President of the Republic of Uzbekistan dated June 7, 2022 No. PP-273 "On Additional Measures for the Effective Organization of the Implementation of the Tasks Defined in the Strategy for the Development of

Agriculture of the Republic of Uzbekistan for 2020-2030" . <https://lex.uz/acts/-6556006>.

2. Schumpeter J. The Theory of Economic Development. Schumpeter, J. The Theory of Economic Development. Cambridge: Harvard University Press. - 255 p.

3. Rogers E. Diffusion of Innovations. Rogers, E. Diffusion of Innovations. - New York: Free Press, 2003. - 576 p.

4. Chesbrough H. Open Innovation: The New Imperative for Creating and Profiting from Technology. Chesbrough, H. Open Innovation. - Boston: Harvard Business School Press, 2003. - 227 p.

5. Solow, R. Technical Change and the Aggregate Production Function // Review of Economics and Statistics. - 1957. - Vol. 39, No. 3. - Pp. 312-320. DOI: <https://doi.org/10.2307/1926047>

6. EU Smart Farming Report. European Commission. Smart Farming and Precision Agriculture Report. - Тошкент, 2022.

7. Korea Ministry of Agriculture. Smart Village Pilot Study. Korea Ministry of Agriculture. Smart Village Pilot Report. - Seoul, 2021.

8. Israel Innovation Center. Desert Farming Technologies. - Тошкент, 2020. Sustainability Journal - Article (2024). Li, H., Ahmed, A., Kumar, S., et al. Assessment of Agricultural Innovation Sustainability Using Composite Indicators // Sustainability. - 2021. - Vol. 16, Issue 11. - Article 4431. doi: <https://doi.org/10.3390/su16114431>

9. Mambetnazarov, B. The impact of digital technologies on the development of the agricultural sector: foreign experience // Green Economy and Development. - 2021. - Vol. 2, No. 11. - Pp. 45-55. DOI: <https://doi.org/10.5281/zenodo.10625422>