Received: 03.06.2024. Revised: 09.08.2024. Accepted: 05.09.2024.

EKONOMIKA APK

https://doi.org/10.32317/ekon.apk/4.2024.23

Ekonomika APK, 31(4), 23-32

UDC 631.1:551.583

Farmers' adaptation to climate change in Southern Issyk-Kul

Gulnaz Jalilova*
Doctor of Natural Sciences, Acting Associate Professor
Kyrgyz State University named after I. Arabaev
720026, 51A Razzakov Str., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0007-6011-8587

Roza Orozakunova
PhD in Biological Sciences, Associate Professor
Kyrgyz National Agrarian University named after K.I. Skryabin
720005, 68 Mederov Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0002-7279-8512

Ermek Baibagyshev
PhD in Agricultural Sciences, Associate Professor
Naryn State University named after S. Naamatov
722600, 25 Lenin Str., Naryn, Kyrgyz Republic
https://orcid.org/0000-0001-5778-131X

Nurudin Karabaev
Doctor of Agricultural Sciences, Professor
Kyrgyz National Agrarian University named after K.I. Skryabin
720005, 68 Mederov Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0002-7204-7284

Uranbek Shergaziev
Doctor of Agricultural Sciences, Professor
Kyrgyz National Agrarian University named after K.I. Skryabin
720005, 68 Mederov Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0002-4203-4060

▶ **Abstract.** Agriculture is a key sector for people's livelihoods in Kyrgyzstan, which highlights the role of local people's perceptions of agricultural practices and optimisation of land use management. The purpose of this study was to assess the understanding of land use practices by local residents in four districts of the Southern Issyk-Kul. The level of awareness of sectoral issues was investigated by randomly selected farmers. The study found that modern farmers are aware of the existing problems and their contribution to the decline in agricultural productivity and increased vulnerability to environmental change. It was generalised that the solution of the problem under study requires practical interaction between government agencies and farmers aimed at providing the necessary information and resources for adaptation to climate-oriented agricultural practices. The potential of innovative precision farming technologies in the context of the studied issues was analysed. An important problem of the lack of a mechanism for the exchange of agricultural knowledge between farmers was identified, as it is difficult for them to determine where and from whom to gain experience. It was substantiated that the integration of agricultural consulting elements into the environment of farm operation has the potential to significantly stimulate the positive dynamics of agricultural development. Such an approach would allow for the most accurate selection of optimisation measures, which would affect the economic efficiency and environmental performance of farming. The practical value of the results of the

▶ **Suggested Citation**: Jalilova, G., Orozakunova, R., Baibagyshev, E., Karabaev, N., & Shergaziev, U. (2024). Farmers' adaptation to climate change in Southern Issyk-Kul. *Ekonomika APK*, 31(4), 23-32. doi: 10.32317/ekon.apk/4.2024.23.

*Corresponding author

study is seen in the possibility of using them to mitigate the process of adaptation of agricultural production in developing countries to inevitable climate change

▸ **Keywords:** soil; land use practices; perception; precision farming; agricultural consulting

▸ Introduction

Agriculture is an important sector in the livelihoods of the majority of the people in Kyrgyzstan. Kyrgyzstan's agricultural land can be divided into three main categories: arable land (7%), permanent meadows and pastures (48%), and forested areas (3%). Livestock plays a crucial role as a primary source of income for all rural residents (Kyrgyzstan country profile, 2021). Trends in the development of a modern integrated society prioritise organic production and the environmentalization of agricultural production technologies. In developed countries, numerous campaigns are being effectively implemented to adapt the agricultural sector to climate change, ecologise the agricultural sector, and decarbonise technical solutions in the industry, most of which involve a systemic transformation of the development strategies of agricultural enterprises participating in the market, especially the international market. In the context of Kyrgyzstan, the need to create significant competitive advantages in accordance with the new environmental and economic environment of social development deserves special attention today. The agricultural sector is developing within the framework of the strategy of prioritising sustainable development, which requires the gradual integration of precision and organic farming systems.

The analysis of publications on the subject matter suggests that modern researchers are focused on finding alternative technological opportunities in the agricultural sector that would allow them to more actively promote national agricultural progress in a manner complementary to the principles of sustainable development (Maharramova, 2023). For example, G. Jalilova (2018) investigated the specifics of organic farming in Kyrgyzstan, focusing on the analysis of the factors of climate change impact on crop production. The researcher analysed potential environmental risks to the adaptive capacity of agroecosystems. In the system of mitigating the negative impact of destructive climate dynamics, optimisation of production organisation, introduction of innovative technologies and advanced technological processes is of paramount importance (Identification of agroecological…, 2018).

Researchers R. Orozakunova & E. Baibagyshov (2019) considered technologies for intensifying the level of agricultural productivity through the integration of innovative technological solutions as the basis for optimising their position in the market and maximising their use. The study by J. O'Connell & P. Kiparisov (2018) proposed a stage-by-stage process of transition from traditional to organic forms of agricultural production, highlighted functional and structural elements and main parameters. A number of research papers by contemporary researchers, in particular, D. Glover *et al.* (2019) presented the criteria for assessing the effectiveness of modernisation measures of environmental, socio-economic, and managerial orientation aimed at intensifying the process of decarbonisation of agricultural production in different regions. Along with this, J. Clapp & S. Ruder (2020) pointed out the environmental orientation of organic agriculture, substantiated the need to implement decarbonisation technologies, and identified priority vectors of adaptation of the industry in the context of global climate change. Continuing this topic, the study by K. Henryson *et al.* (2019) emphasised the difficulties of implementing innovative agricultural technologies in a crisis economic environment.

Despite the considerable scientific efforts of researchers in this area, the issues of developing programmes to effectively stimulate the modernisation of the agricultural sector in Kyrgyzstan remain fragmented, including the effective management of the strategic development of the sector using the capabilities of economic and legal instruments. Among the ways to solve these problems, the most effective, along with internal and external investment in promising agricultural projects, in particular in the farming sector, implementation of successful international practices, and establishment of mechanisms for financing organic production projects, is the awareness of modern farmers of the need to modernise approaches to agriculture in view of global climate change (Tanchyk *et al.*, 2024).

The agricultural sector in Kyrgyzstan faces the urgent need for modernization and integration of sustainable practices, including precision and organic farming, to remain competitive in the global market amidst climate change challenges. The purpose of the study was to assess the level of awareness of climate change issues in land use practices of local residents in four districts of the Southern Issyk-Kul. The process of achieving this goal involved solving a number of tasks: to investigate the level of awareness of sectoral issues by randomly selected farmers; to identify existing problems and their contribution to a decrease in agricultural productivity, increased vulnerability to environmental changes; to substantiate the need to integrate agricultural consulting into the farm environment to improve the economic efficiency and environmental performance of farming.

▸ Materials and methods

The study was conducted between June and October 2020 in four regions in the Southern Issyk-Kul lake: Jeti-Oguz, Aksuu, Tup, and Issyk-Kul districts, which have a combined population of 253,204 inhabitants (The population of the Kyrgyz…, 2020). The proposed plan for data collection and analysis represented the level of farmers' understanding of the problem and its impact on their operations, and identified ways to optimise the situation. To this end, a thematic analysis was carried out, focusing on farmers' perceptions of the economic consequences. The dynamics of certain indicators of agricultural production in the historical context was presented. These data were assimilated with the data from the farmers' survey to identify the dependence of production volumes, its quantitative and qualitative parameters, and, accordingly, economic efficiency, on the level of farmers' awareness of the main aspects of climate change impact. The sample size was 40 farmers and was limited in this aspect due to COVID-19 restrictions. The sample was represented by representatives of farms in regions of different specialisation and size. Qualitative data from open-ended questions were analysed using thematic analysis. The variance analysis was used to analyse the quantitative data. Statistical sources of information were used, in particular, data from the Agriculture (n.d.) on agricultural production in the region under study, indicators of economic efficiency. In addition, reports by Food and Agriculture Organization (FAO) (2022) and policy documents related to agriculture in Kyrgyzstan and, in particular in the Southern Issyk-Kul, were used (The United Nations…, 2017).

The questionnaire survey of farmers was conducted in four districts of the Eastern Issyk-Kul region in the form of open and closed questions. The questionnaire covered a wide range of information, including household and land ownership characteristics, agricultural production systems, perceptions of land use practices, soil improvement methods and familiarity with modern agricultural technologies (Tables 1 and 2). The questions were as follows: "Is climate change having a significant impact on farmers' livelihoods?", "How do you predict this impact and related changes in the future?", "Do you feel the pressure of pests and diseases increasing?", "Has there been a decrease in income due to climate change over the past two years?", "How aware are you of the benefits of precision farming technologies?". In total, 40 farmers with diverse backgrounds were selected using random sampling techniques. The interviews were conducted in Kyrgyz language, as all respondents were Kyrgyz speakers. At the beginning of each interview, respondents were informed that participation was voluntary. Initially, plan was to collect more data, aiming for a minimum of 20 respondents from each district. However, this became unfeasible due to COVID-19 restrictions in the country. A comprehensive analysis was conducted to address the defined objectives and questions. The results are presented in terms of qualitative and quantitative indicators, including tables, graphs, figures, and descriptive statistics. The statistical package for the social sciences 22 was used to analyse the informative data.

Table 1. Demographic factors of respondents and land distribution in study site

Factor	Classification	n = 40	Distribution
Age	20-40	19	47.5%
	40-65	21	52.5%
Gender	Male	31	77.5%
	Female	9	22.5%
Education	Secondary school	9	22.5%
	College	13	32.5%
	University	18	45%
Profession	State workers	16	40%
	Self-Employers	8	20%
	No extra job	16	40%

Source: summarised and systematised by the authors

Table 2. Land distribution of farmers-respondents in study sites

Land property	Classification	Land distribution for 1 household
Land area ha (mean)	Total land	2.98
	Irrigated land	2.38
	Rainfed land	0.6

Source: summarised and systematised by the authors

All survey participants were informed about how their anonymity is ensured, they were aware of the purpose of the survey, how the data they provided will be used, and the risks involved. The research was conducted in accordance with the rules of the Declaration of Helsinki (1975).

▸ Results

Agricultural products and land management practices. Based on the results, the primary food crops in the study site include wheat (43%), clover and sainfoin (80%), potato (58%), and barley (50%). Sugar beet, corn, and garlic are also grown in this region; however, respondents reported not producing these crops between 2017 and 2019. While bean products are not commonly grown, a few farmers have begun cultivating them due to their popularity in other regions for export, rather than for their role as nutrient-fixing activators or as a source of the healthiest protein for personal consumption (Fig. 1).

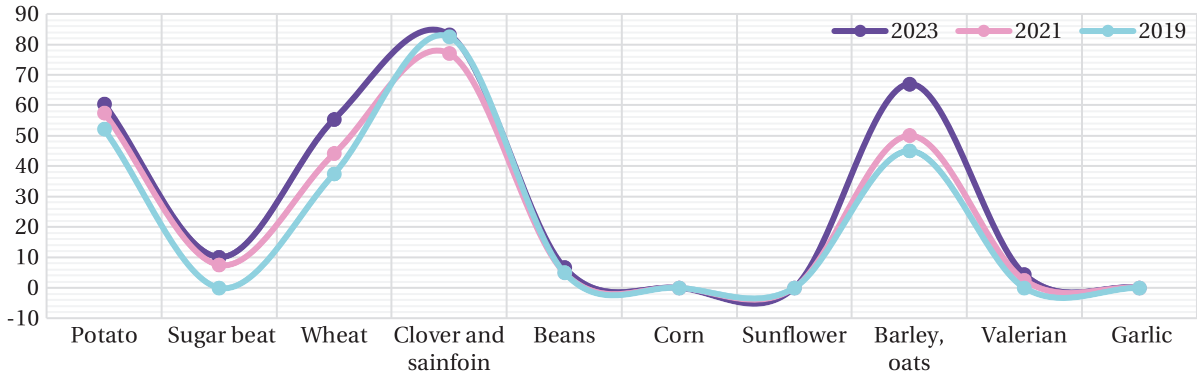

Figure 1. Produced agricultural products between 2018-2023, % of respondents
Source: Agriculture (n.d.)

Various land use practices are employed by farmers on their plots, including crop rotation (72%), the use of organic fertilisers (72%), and the application of mineral fertilisers (potassium, phosphorus, and nitrogen), as well as the use of herbicides and pesticides (25-40%). Upon closer examination of the crop rotation scheme, where the results for three years showed considerable similarity, the reliability of the crop rotation scheme is questionable. However, any significant relationships between independent variables (sex, age, etc.) and plot size in relation to the crop rotation scheme for agricultural products were not identified. Furthermore, 12% of farmers practice mulching to conserve soil moisture and enhance soil fertility. Unfortunately, they do not achieve positive outcomes due to cattle grazing from late autumn to early spring. Notably, all respondents (100%) confirmed this situation, with approximately 63% of them asserting that cattle grazing negatively impacts soil health through trampling.

The next question focused on the challenges they face in farming. The major problems identified were a scarcity of water during the high season (60%), limited access to improved crop varieties (38%), and poor marketing of harvested products (38%). Additionally, 5% of respondents mentioned that they lack sufficient agricultural techniques and rely on observing other farmers' activities (Fig. 2).

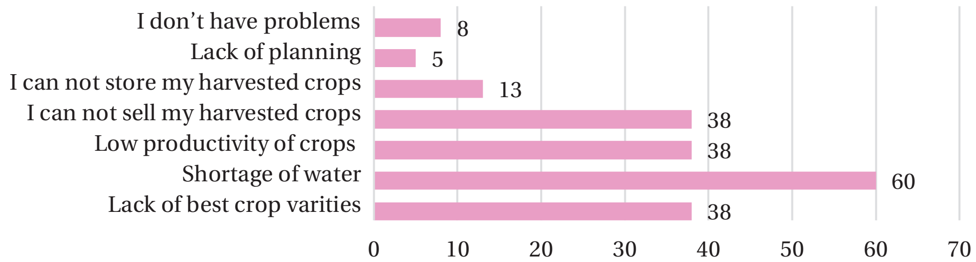

Figure 2. Challenges of farmers in farming, % of respondents
Source: Agriculture (n.d.)

Subsequently, authors inquired about irrigation scheduling in farmlands. As a result, 42% of respondents reported irrigating their land twice per season, while 32% of respondents have access to irrigation water once per year, especially in the Ak-Suu region.

Food security and income from agricultural products. The results show that 78% of respondents sell their agricultural products. Among them, 55% sell their harvest directly to wholesalers from their farms, while 32% of farmers sell at regional markets or even in Bishkek. The primary products for sale include potatoes (averaging 16,000-17,000 kg/ha), wheat (1,800-2,500 kg/ha), and sainfoin or alfalfa (2,000-3,000 kg/ha).

Additional questions were asked regarding their earnings over the three years (net income). Most farmers found this question relatively straightforward yet sensitive; consequently, only 50% of respondents were willing to share their incomes. Interestingly, some farmers who utilise up to seven hectares of land also reported more or less the same income figures (Fig. 3).

The next question was about whether they have additional income at home. Overall, 95% of farmers confirmed that they are involved in livestock farming within their households. Additionally, 40% of the respondents work for the government, and 20% of farmers are engaged in small-scale businesses or provide various private services. Therefore, no farmer solely focuses on farming; almost all farmers are involved in different activities to secure enough income to support their livelihoods.

Furthermore, the study explored the strategies farmers intend to employ to cope with climate change on their farmlands. As a result, 50% of farmers indicated that they need to prioritise the improvement of irrigation facilities and the selection of drought and pest-resistant crops. Approximately 43% of respondents recognised the significance of soil health and fertility as key concerns in a changing climate. Some farmers (18%) mentioned their intention to focus on livestock management, while 3% of respondents expressed a potential inclination to discontinue farming in the near future (Fig. 4).

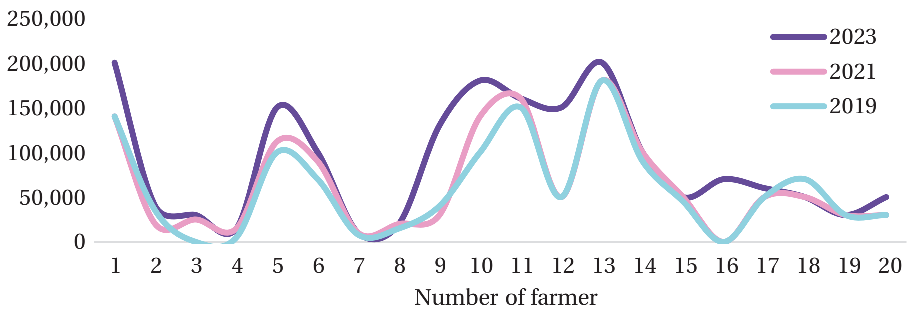

Figure 3. Income of farmers from agricultural products in between 2019-2023, soms
Source: Agriculture (n.d.)

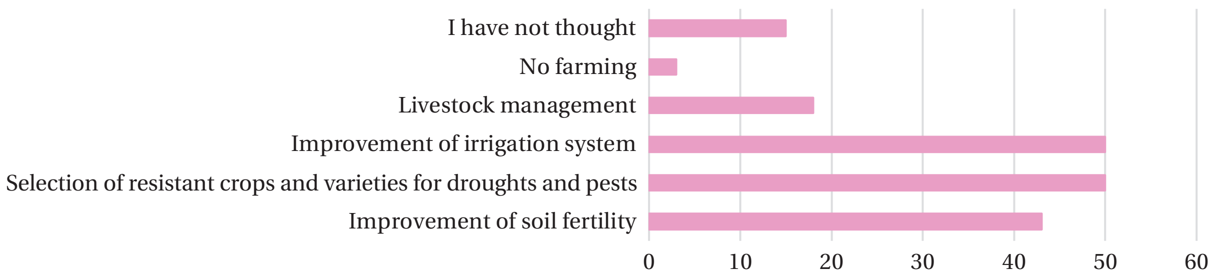

Figure 4. Future plans of farmers in their farmlands towards climate change, % of respondents
Source: Agriculture (n.d.)

Evidently, the economic implications of climate change for agriculture in the Southern Issyk-Kul are representative of global trends in this area. Reduced precipitation and uneven distribution caused by climate change could potentially lead to a shortage of water for irrigation. The level of grain production is significantly reduced. Climate change is shifting the dynamics of the traditional production structure and agricultural technologies. The soils of the Southern Issyk-Kul are facing a potentially dangerous situation, as drought conditions are leading to an increase in the risk of soil degradation.

Farmers' adaptation strategies to these changes demonstrate the effectiveness of crop rotation. Crop rotation is seen as appropriate in the context of livestock development, which involves sowing fodder crops that are less draining on soils (Tykhonova *et al.*, 2021). Thus, support for the livestock sector, including at the state level, is currently needed. Another problem is the lack of effective monitoring and control of soil conditions. Currently, a number of farmers emphasise the importance of using modern irrigation technologies, which is the main available means of adapting to aridity due to climate change on a global scale, ensuring that yields are maintained and, consequently, producer incomes increase (Miroshkina & Borko, 2023). A separate problem is financing the modernisation or construction of irrigation systems, as the expansion of irrigated areas costs an agricultural producer about USD 2.6 thousand per hectare (Kyrgyzstan country profile, 2021). The difficulty of predicting the factors of climate change impact on the factor intensity of agriculture, its profitability, and economic efficiency is caused by the low level of implementation of scientific and practical developments on adaptation of the economy to global environmental dynamics, despite Kyrgyzstan's active integration into the global economic system. The amount of expected losses will vary depending on the ability of modern farmers to effectively adapt their farming to climate change. In this regard, the primary focus should be on diversifying agricultural production, applying energy-saving technologies, and adjusting crop production processes.

The distinctive feature of modern technologies in agricultural production is a precise scientific approach to active influence on crops and soil parameters through the integration of precision land management and organic production systems. This approach ensures high productivity and yields of farmland. The implementation of precision farming technologies in the agricultural sector of Kyrgyzstan to increase the level of resilience to destruction should include the development of a system of monitoring, control, data collection and analytics, an effective management paradigm based on innovative solutions, including the creation of electronic field maps.

Accessibility of information, knowledge management and financial facilities. According to the survey, 95% of farmers have internet connections, while 5% regularly follow television and radio channels. Therefore, all farmers have access to information, but not necessarily to proper agricultural knowledge, as some farmers have mentioned. Furthermore, also was investigated the respondents' participation in educational activities related to farming, livestock, horticulture, and milk production. About 58% of farmers mentioned that they have participated in various workshops organised by the District Agricultural Development Department in collaboration with non-governmental organisations such as "Agrolead", "Rural Advisory Services", or other initiatives. Additionally, open-ended questions were used to determine whether farmers utilise credit facilities for agricultural development. In general, 48% of respondents take advantage of these opportunities.

However, many farmers noted that these credits are not always accessible to everyone and often depend on decision-makers at the Local Self Government level (Ayil-Okmotu). The leading credit organisations mentioned were Ayil-Bank (6-10%), the Kumtor credit system (up to 50,000 soms only – 7%), and other institutions like "Cash and Savings Company" bank and Bakai-Bank with similar loan rates. Moreover, the authors inquired about the respondents' willingness to enhance their practical knowledge. As a result, the primary interest lies in acquiring knowledge about advanced agricultural technologies such as greenhouses, value chain systems, or organic farming (68%). This was followed by livestock management, with a particular focus on the best breeds and veterinary services (33%). Other areas of interest include the selection of drought-resistant crops and varieties, pest management, and addressing other external factors (23%). Soil fertility (15%) and advanced horticultural techniques (10%) are listed among as important fields to learn (Fig. 5). Further, the final question pertained to the necessary facilities for farmers in general. Consequently, 43% of farmers indicated that local farmers need a continuous knowledge-sharing mechanism (resource centre), 33% suggested the availability of agronomists and veterinary technicians at the LSG level, who can guide farmers in monitoring, evaluation, and planning. Meanwhile, 28% of respondents mentioned the need for the organisation of agricultural logistics centres.

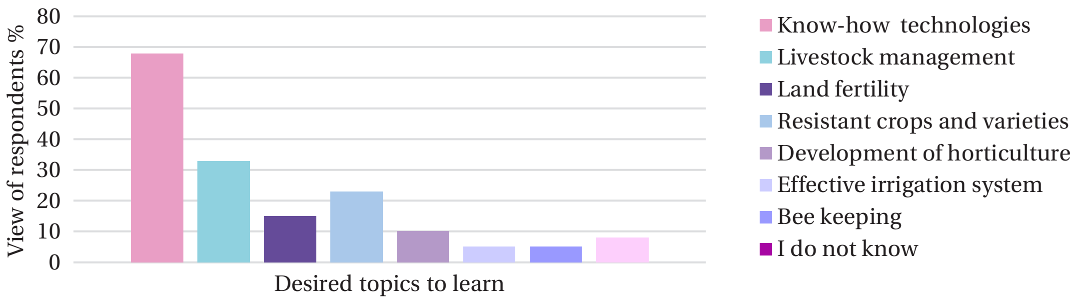

Figure 5. Willingness of farmers to learn

Source: Agriculture (n.d.)

It is obvious that climate change affects the sustainability of agroecosystems, which is especially noticeable in the transformation of conventional crop production to organic. The best preventive way to minimise the destructive ploughing of land affected by farming activities is currently seen as a buffering approach – the creation of field protection strips to regenerate areas and protect biodiversity (Lacoste *et al.*, 2022). Another necessary technological measure within the concept of precision farming is the use of special crop rotations. Irrigated land should be based on crop rotation with plant species that are able to guarantee preventive fertility protection (Clapp, 2021). Effective implementation of the adaptation policy requires a number of managerial, financial, and technological measures, including those at the national level. These include providing agricultural producers with access to innovative opportunities in the areas of organic farming, farming technologies, certification and quality standards, grants, investments and partnerships, international programmes, and consultancy. A modern communication strategy to raise awareness among farmers requires the integration of an agricultural consulting system, stimulation of scientific and practical research and implementation of innovations in the field of organic farming (Gras & Cáceres, 2020; Aldieri *et al.*, 2021).

The basic concept of the modern approach to the development, implementation and improvement of the strategy of innovative development of farms in the context of climate change adaptation covers several key areas of activity. Firstly, the technological and technical direction involves monitoring, accumulation, processing, and control of informative data and diverse information on the state of the environment, productivity of farming methods, economic efficiency of agricultural activities, and effectiveness of the introduction of new technologies, technical means, and crop rotation principles. Secondly, the scientific and legislative aspect includes clarification of the legal and regulatory framework for farming, exploration of investment opportunities, use of grants and international support, modelling and forecasting of potential legislative changes, and research of successful foreign practices. Ultimately, the human resource aspect focuses on the use and development of regional farming potential, motivation to farm, incentives from local authorities, and agricultural advice.

▸ Discussion

The findings of the study indicate that farmers have knowledge about the existing challenges related to climate change, including adaptation in land-use practices and the factors contributing to land degradation. The results highlight that the most significant concern for farmers is the shortage of water. Kyrgyzstan plays a crucial role as a major water supplier for the region. Moreover, water management presents a challenge for agricultural development because water supply often does not align with seasonal needs, primarily due to organisational and management issues. Access to quality seeds for agricultural products is another major issue. Farmers frequently persist in using seeds long after their productivity has diminished (Shahini *et al.*, 2023).

The absence of a crop rotation scheme is a major contributor to land degradation on farms (Mero *et al.*, 2023). Crop rotation is a fundamental agricultural strategy that enhances nutrient availability, controls pest cycles, improves soil composition, and helps combat biodiversity loss. Recent research suggests that crop rotation schemes can optimise energy use efficiency, preserve or enhance fertility, reduce chemical use, and decrease greenhouse gas emissions (Khakbazan *et al.*, 2019; Liang *et al.*, 2019; MacLaren *et al.*, 2021). According to Crop rotation and its importance in improving soil fertility and protecting soils from erosion (2018), Kyrgyz farmers increased crop yields by up to 20% by implementing crop rotation schemes in their farmlands within pilot projects. Organic mulching has been a long-standing practice in various regions of Kyrgyzstan. However, other mulching systems (like compost, rubber, plastic, or gravel) are rarely used. In selected site, only organic mulching is practiced, but it has become less effective due to livestock overgrazing during the off-season (Steinke *et al.*, 2020; Volanti *et al.*, 2021).

The findings of contemporary researchers (Yin *et al.*, 2022) synergise with the results of this study. In particular, they have highlighted a significant issue: there is a lack of a mechanism for sharing agricultural knowledge among farmers, and they struggle to identify where and from whom to learn. The training of farmers in crop and livestock management primarily falls under the responsibility of the District Agricultural Development Departments within this ministry. These departments organise seminars on agricultural development, covering crop production and livestock breeding, at the beginning of each agricultural season in Local Self-Governments. These seminars feature information provided by specialists from these departments and the Plant Quarantine and Veterinary Control from the Veterinary Services Department. The topics are chosen based on the interests and requests of farmers, though the extent of these activities depends on the ministry's financial resources. Agrolead and FAO (2022) report that 95% of extension services to farmers are carried out by international donors and projects.

According to D. Rose *et al.* (2021), Local Self-Government is responsible for connecting farmers with District Agricultural Development Departments through village leaders. However, this mechanism does not always effectively inform farmers about upcoming seminars or workshops, as reported by many farmers. Therefore, there is a pressing need to establish agricultural centres at the Local Self-Government offices across the country. These centres would provide all farmers with the skills necessary for farming, efficient water resource management, income generation, and adaptability to climate dynamics. For example, an agroforestry training centre was established in 2021 in Kara-Bak Local Self-Government in Batken region, in collaboration with the local non-governmental organisation "Agents of Changes". This centre serves as an educational hub and resource centre for all farmers. Alternatively, appointing an agronomist at the Local Self-Government level, who can take on the responsibility of imparting advanced agricultural knowledge to farmers and providing day-to-day support to those in need, would also be a viable solution.

According to L. Rocchi *et al.* (2020), strategic planning of innovative and technological development of agricultural enterprises is positioned as a priority strategic area of modern management systems of agro-ecological landscape complexes and increase of economic efficiency of agricultural activities. This approach, according to researchers, would allow for effective and rapid adaptation to new competitiveness requirements, including the transformation of agricultural activities in accordance with global market dynamics, product quality requirements and environmental guarantees.

In the process of implementing the research by A. Raihan *et al.* (2022), it was emphasised that the innovative modernisation of farming activities in actively developing countries should be based on the gradual replacement of extensive methods of land cultivation with intensive methods, which is in line with the principles of sustainable agricultural development. The researchers have identified the effectiveness of integrating successful practices of international experience, investment and grant funds for the development of organic farming and precision land use systems. It is worth agreeing with the researchers on the expediency of these measures in the context of optimising agricultural activities at a low level of overall socio-economic development and identifying adaptive reserves.

The economic impacts of climate change on agriculture were analysed by F. Caffaro *et al.* (2020) in the context of the specifics of Italy as a representative country of the modern world community, which is open to innovations in agriculture, but expects practical economic results from them. Italy's experience shows similar results to the findings of the current study, indicating the need to raise farmers' awareness, including through agricultural professional advice, of the possibilities of adapting farm production to global climate change.

Based on the findings of F. Farrokhi & H. Pellegrina (2023), it was found that the main approaches to the process of forming competitive market advantages in farming activities under conditions of drought and disruption of precipitation and hydrology due to destructive changes in climate factors. According to the researchers, they are based on the principles of rationalisation and diversification. The researchers assure that the synergy of managerial and technological innovation measures, the introduction of monitoring and control systems can minimise the negative impact on natural resources, while increasing the quality and quantity of farm production, its profitability and economic efficiency.

According to X. Yang *et al.* (2021), the paradigm of agricultural production modernisation to ensure innovative strategic development of the industry is to ensure the sustainability of farming activities in the concept of maintaining a stable and fair income for producers, increasing their competitiveness; climate-oriented adaptive agriculture, mitigating the effects of climate change. This strategy requires, in turn, the modernisation of farming based on digitalisation, consulting and the active exchange of practical knowledge and skills. The results of scientific research are convergent with the conclusions of the current study on the direct dependence of the economic efficiency of agricultural production on the level of its adaptability to global environmental dynamics – primarily climate change.

As stated by S. Ruzzante *et al.* (2021), the purpose of a promising study in this area is the development and integration of innovative monitoring capabilities. It is considered today as the basis for the production of analytical information on the search for resources to increase competitiveness, investment in agriculture based on regeneration and sustainable land use.

▸Conclusions

The assessment of local people's understanding of land use practices in four districts of the Southern Issyk-Kul, in synergy with the analysis of economic aspects, represents the level of farmers' awareness of the problem and its impact on agricultural activities, and identifies ways to optimise the situation. When asked how farmers intend to combat climate change on their farmland, 50% of farmers said they need to prioritise improving irrigation facilities and selecting crops that are resistant to drought and pests. Approximately 43% of respondents recognised the importance of soil health and fertility as key concerns in the face of climate change, with some farmers (18%) indicating that they intend to focus on livestock management, while 3% of respondents expressed a potential inclination to stop farming in the near future.

The main interest of farmers, according to the survey, is to gain knowledge about advanced agricultural technologies, such as greenhouses, value chain systems or organic farming (68%). This is followed by livestock management, with a particular focus on the best breeds and veterinary services (33%). Other areas of interest include breeding drought-resistant crops and varieties, pest management and other external factors (23%). Soil fertility (15%) and advanced horticultural technologies (10%) were cited as important areas for study. In addition, the survey covered the issue of necessary equipment for farmers in general. Thus, 43% of survey participants indicated that local farmers need a mechanism for continuous knowledge exchange (resource centre), 33% suggested the availability of agronomists and veterinary technicians at the local government level who can help farmers with monitoring, evaluation and planning. 28% of respondents noted the need for agricultural logistics centres.

In general, the adaptation of the agricultural sector development process in the Southern Issyk-Kul to climate change is based on ensuring the sustainability of farming activities, climate-oriented adaptive technologies, and active modernisation, development of agricultural advisory services, digitalisation of the industry, and improved access to research and innovation. Prospects for further scientific development of the studied issues are seen in the development of adaptive agricultural modelling programmes and practical consulting for farmers, which will raise awareness of innovations, environmental sustainability and financial instruments to prevent losses in the industry.

▸Acknowledgements

None.

▸Conflict of interest

The authors of this study declare no conflict of interest.

▸References

[1] Agriculture (n.d.). Retrieved from https://stat.gov.kg/en/statistics/selskoe-hozyajstvo/.
[2] Aldieri, L., Brahmi, M., Chen, X., & Vinci, C. (2021). Knowledge spillovers and technical efficiency for cleaner production: An economic analysis from agriculture innovation. *Journal of Cleaner Production*, 320, article number 128830. doi: 10.1016/j.jclepro.2021.128830.
[3] Caffaro, F., Micheletti Cremasco, M., Roccato, M., & Cavallo, E. (2020). Drivers of farmers' intention to adopt technological innovations in Italy: The role of information sources, perceived usefulness, and perceived ease of use. *Journal of Rural Studies*, 76, 264-271. doi: 10.1016/j.jrurstud.2020.04.028.
[4] Clapp, J. (2021). Explaining growing glyphosate use: The political economy of herbicide-dependent agriculture. *Global Environmental Change*, 67, article number 102239. doi: 10.1016/j.gloenvcha.2021.102239.
[5] Clapp, J., & Ruder, S. (2020). Precision technologies for agriculture: Digital farming, gene-edited crops, and the politics of sustainability. *Global Environmental Politics*, 20(3), 49-69. doi: 10.1162/glep_a_00566.
[6] Crop rotation and its importance in improving soil fertility and protecting soils from erosion. (2018). Retrieved from http://www.fao.org/3/ca0858ru/CA0858RU.pdf.
[7] Declaration of Helsinki. (1975). Retrieved from https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/.
[8] FAO. (2022). *Global status of black soils*. Rome: FAO. doi: 10.4060/cc3124en.
[9] Farrokhi, F., & Pellegrina, H. (2023). Trade, technology, and agricultural productivity. *Journal of Political Economy*, 131(9), 2509-2555. doi: 10.1086/724319.
[10] Glover, D., Sumberg, J., Ton, G., Andersson, J., & Badstue, L. (2019). Rethinking technological change in smallholder agriculture. *Outlook on Agriculture*, 48(3), 169-180. doi: 10.1177/0030727019864978.
[11] Gras, C., & Cáceres, D. (2020). Technology, nature's appropriation and capital accumulation in modern agriculture. *Current Opinion in Environmental Sustainability*, 45, 1-9. doi: 10.1016/j.cosust.2020.04.001.
[12] Henryson, K., Hansson, P.A., Katterer, T., Tidåker, P., & Sundberg, C. (2019). Environmental performance of crop cultivation at different sites and nitrogen rates in Sweden. *Nutrient Cycling Agroecosystems*, 114(2), 139-155. doi: 10.1007/s10705-019-09997-w.
[13] Identification of agroecological farming and other agroecology related activities IN Kyrgyzstan. (2018). Retrieved from https://www.agroecology-europe.org/wp-content/uploads/2023/02/FINAL-REPORT-KYRGYZSTAN.pdf.

[14] Jalilova, G. (2018). *Climate-resilient agriculture in the Kyrgyz Republic*. Retrieved from https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA%20_Profile_The%20Kyrgyz%20Republic.pdf.

[15] Khakbazan, M., *et al.* (2019). Effects of crop rotation on energy use efficiency of irrigated potato with cereals, canola, and alfalfa over a 14-year period in Manitoba, Canada. *Soil and Tillage Research*, 195, article number 104357. doi: 10.1016/j.still.2019.104357.

[16] Kyrgyzstan country profile. (2021). Retrieved from http://www.fao.org/countryprofiles/.

[17] Lacoste, M., *et al.* (2022). On-farm experimentation to transform global agriculture. *Nature Food*, 3(1), 11-18. doi: 10.1038/s43016-021-00424-4.

[18] Liang, L., Wang, Y., Ridoutt, B.G., Lal, R., Wang, D., Wu, W., Wang, L., & Zhao, G. (2019). Agricultural subsidies assessment of cropping system from environmental and economic perspectives in North China based on LCA. *Ecological Indicators*, 96(Part 1), 351-360. doi: 10.1016/j.ecolind.2018.09.017.

[19] MacLaren, C., Labuschagne, J., & Swanepoel, P.A. (2021). Tillage practices affect weeds differently in monoculture vs. crop rotation. *Soil and Tillage Research*, 205, article number 104795 doi: 10.1016/j.still.2020.104795.

[20] Maharramova, S. (2023). Changes in the chemical composition of extracts of wild berries growing in the Republic of Azerbaijan due to enzimatic pretreatment of their pulp. *Ukrainian Food Journal*, 12(4), 542–555. doi: 10.24263/2304-974X-2023-12-4-5.

[21] Mero, G., Skenderasi, B., Shahini, E., Shahini, S., & Shahini, E. (2023). Main directions of plants integrated protection in the conditions of organic agriculture. *Scientific Horizons*, 26(3), 101-111. doi: 10.48077/SCIHOR3.2023.101.

[22] Miroshkina, N., & Borko, T. (2023). Philosophy of agriculture as a way of understanding agrarian practice. *Ukrainian Black Sea Region Agrarian Science*, 27(1), 85-94. doi: 10.56407/bs.agrarian/1.2023.85.

[23] O'Connell, J., & Kiparisov, P. (2018). *Assessment of agribusiness environment in Kyrgyzstan.* Budapest: Food and Agriculture Organization of the United Nations.

[24] Orozakunova, R., & Baibagyshov, E. (2019). Chernozem soils of Kyrgyzstan. In *Proceedings of the international scientific conference "Eastern European Chernozems-140 years after V. Dokuchaev"* (pp. 219-223). Chisinau: Nicolae Dimo Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo".

[25] Raihan, A., Muhtasim, D., Farhana, S., Pavel, M.I., Faruk, O., Rahman, M., & Mahmood, A. (2022). Nexus between carbon emissions, economic growth, renewable energy use, urbanization, industrialization, technological innovation, and forest area towards achieving environmental sustainability in Bangladesh. *Energy and Climate Change*, 3, article number 100080. doi: 10.1016/j.egycc.2022.100080.

[26] Rocchi, L., Boggia, A., & Paolotti, L. (2020). Sustainable agricultural systems: A bibliometrics analysis of ecological modernization approach. *Sustainability*, 12(22), article number 9635. doi: 10.3390/su12229635.

[27] Rose, D., Wheeler, R., Winter, M., Lobley, M., & Chivers, C. (2021). Agriculture 4.0: Making it work for people, production, and the planet. *Land Use Policy*, 100, article number 104933. doi: 10.1016/j.landusepol.2020.104933.

[28] Ruzzante, S., Labarta, R., & Bilton, A. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. *World Development*, 146, article number 105599. doi: 10.1016/j.worlddev.2021.105599.

[29] Shahini, E., Luhovyi, S., Kalynychenko, H., Starodubets, O., & Trybrat, R. (2023). Rational use of oilseed waste to increase dairy productivity. *International Journal of Environmental Studies*, 80(2), 442-450. doi: 10.1080/00207233.2022.2147727.

[30] Steinke, J., van Etten, J., Müller, F., Ortiz-Crespo, B., van de Gevel, J., Silvestri, S., & Prieble, J. (2020). Tapping the full potential of the digital revolution for agricultural extension: An emerging innovation agenda. *International Journal of Agricultural Sustainability*, 19(5-6), 549-565. doi: 10.1080/14735903.2020.1738754.

[31] Tanchyk, S., Pavlov, O., & Babenko, A. (2024). Theoretical substantiation and development of ecologically friendly farming system in Ukraine. *Plant and Soil Science*, 15(2), 55-66. doi: 10.31548/plant2.2024.55.

[32] The population of the Kyrgyz Republic by region, cities and rayons. (2020). Retrieved from http://www.stat.kg/ru/statistics/naselenie/.

[33] The United Nations development assistance framework for the Kyrgyz Republic 2018-2022. (2017). Retrieved from https://kyrgyzstan.un.org/en/35640-united-nations-development-assistance-framework-undaf-kyrgyz-republic-2018-2022.

[34] Tykhonova, O., Skliar, V., Sherstiuk, M., Butenko, A., Kyrylchuk, K., & Bashtovyi, M. (2021). Analysis of setaria glauca (L.) p. beauv. population's vital parameters in grain agrophytocenoses. *Environmental Research, Engineering and Management*, 77(1), 36-46. doi: 10.5755/j01.erem.77.1.25489.

[35] Volanti, M., Savarino, F.O., Passarini, F., Vassura, I., & Grosso, S.A. (2021). Environmental analysis of crop rotations through the application of the Cereal Unit approach. *Ecological Indicators*, 121, article number 107199. doi: 10.1016/j.ecolind.2020.107199.

[36] Yang, X., Shu, L., Chen, J., Ferrag, M.A., Wu, J., Nurellari, E., & Huang, K. (2021). A survey on smart agriculture: Development modes, technologies, and security and privacy challenges. *Journal of Automatica Sinica*, 8(2), 273-302. doi: 10.1109/JAS.2020.1003536.

[37] Yin, X., Chen, J., & Li, J. (2022). Rural innovation system: Revitalize the countryside for a sustainable development. *Journal of Rural Studies*, 93, 471-478. doi: 10.1016/j.jrurstud.2019.10.014.

Адаптація фермерів до зміни клімату на Південному Іссик-Кулі

Гульназ Жалілова
Доктор природничих наук, виконуючий обов'язки доцента
Киргизький державний університет імені І. Арабаєва
720026, вул. Раззакова, 51А, м. Бішкек, Киргизька Республіка
https://orcid.org/0009-0007-6011-8587

Роза Орозакунова
Кандидат біологічних наук, доцент
Киргизький національний аграрний університет ім. К. І. Скрябіна
720005, вул. Медерова, 68, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0002-7279-8512

Єрмек Байбагишев
Кандидат сільськогосподарських наук, доцент
Наринський державний університет ім. С. Нааматова
722600, вул. Леніна, 25, м. Нарин, Киргизька Республіка
https://orcid.org/0000-0001-5778-131X

Нурудін Карабаєв
Доктор сільськогосподарських наук, професор
Киргизький національний аграрний університет ім. К. І. Скрябіна
720005, вул. Медерова, 68, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0002-7204-7284

Уранбек Шергазієв
Доктор сільськогосподарських наук, професор
Киргизький національний аграрний університет ім. К. І. Скрябіна
720005, вул. Медерова, 68, м. Бішкек, Киргизька Республіка
https://orcid.org/0000-0002-4203-4060

► **Анотація.** Сільське господарство є ключовим сектором для забезпечення засобів до існування людей у Киргизстані, що підкреслює роль сприйняття місцевим населенням сільськогосподарських практик та оптимізації управління землекористуванням. Метою цього дослідження було оцінити розуміння практик землекористування місцевими жителями в чотирьох районах Південного Іссик-Кулю. Рівень обізнаності з галузевими питаннями досліджувався за допомогою випадково обраних фермерів. Дослідження показало, що сучасні фермери усвідомлюють існуючі проблеми та їхній внесок у зниження продуктивності сільського господарства та підвищення вразливості до змін навколишнього середовища. Узагальнено, що вирішення досліджуваної проблеми потребує практичної взаємодії між державними органами та фермерами, спрямованої на надання необхідної інформації та ресурсів для адаптації до кліматоорієнтованих сільськогосподарських практик. Проаналізовано потенціал інноваційних технологій точного землеробства в контексті досліджуваної проблематики. Виявлено важливу проблему відсутності механізму обміну сільськогосподарськими знаннями між фермерами, оскільки їм складно визначити, де і від кого отримати досвід. Обґрунтовано, що інтеграція елементів сільськогосподарського дорадництва в середовище функціонування фермерських господарств має потенціал для суттєвого стимулювання позитивної динаміки розвитку сільського господарства. Такий підхід дозволить найбільш точно підібрати оптимізаційні заходи, які впливатимуть на економічну ефективність та екологічну результативність ведення сільського господарства. Практична цінність результатів дослідження полягає у можливості їх використання для пом'якшення процесу адаптації сільськогосподарського виробництва в країнах, що розвиваються, до неминучих змін клімату

► **Ключові слова:** ґрунт; практики землекористування; сприйняття; точне землеробство; сільськогосподарське консультування