Economic assessment of fruit crop yields under transformation of agroplots in Panfilov district, Kyrgyz Republic

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Abstract: The object of the study is fruit and berry crops grown in Panfilov district of Chui oblast of the Kyrgyz Republic. The aim of the work is to conduct economic evaluation of yields of these crops under the conditions of transformation of plantation areas in the period from 2021 to 2024. In the process of the study, methods of statistical analysis were used, including comparison of gross harvest, area of fruit-bearing plantations and average yields for the main types of crops. Data on apple, pear, plum, cherry, cherry, cherry, apricot and peach were analysed. The results showed that despite the reduction in the area of plantations from 474 to 192 hectares, there is a steady increase in yields, which indicates an increase in the efficiency of land resources utilisation. The highest yields were achieved for apple and pear. It is revealed that the increase in productivity is associated with the optimisation of plantation structure, application of modern agrotechnical measures and possible improvement of varietal composition. It is concluded that it is necessary to take into account economic and agroecological factors when planning the fruit sector of the region. The obtained results can be used in the development of regional programmes on horticulture development and optimization of agro-production systems in conditions of limited land resources.

1 Introduction

Improving the efficiency of land resources utilisation and crop yields remains one of the priority tasks of the agricultural sector in the context of limited available land and increasing climatic changes. This problem is particularly relevant in regions with high agrarian potential, such as Panfilov district of Chui oblast of the Kyrgyz Republic, where the share of horticulture in the structure of agriculture is significant for food security and income of the local population [1].

Modern trends in agro-production management imply not only the expansion of areas, but also the increase of yield per unit area, which requires an objective assessment of yield in the conditions of transformation of the plantation structure. Decrease in the area of perennial fruit crops observed in recent years requires scientific analysis of its impact on

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gross yield and economic productivity. In the conditions of land reduction under fruit crops, it is especially important to assess how effective such purposeful management of cultivated areas becomes and how much it contributes to the sustainable development of the agricultural sector [2].

In this article the economic assessment of fruit and berry crops yield in Panfilov district for the period 2021-2024 is carried out. The aim of the work is to analyse the relationships between the area of plantations, gross yield and yield with a focus on identifying the factors that ensure productivity growth when the area is reduced. The results of the study are intended to contribute to the development of scientifically sound recommendations for optimising the structure of perennial plantations and improving the efficiency of horticulture in the conditions of transformation of agro-areas [3].

Despite the presence of a number of studies devoted to the issues of crop yields and gross harvest of agricultural crops, the aspect of economic evaluation of fruit and berry crops efficiency when changing the structure of agricultural areas remains insufficiently studied, especially in the regional context of Kyrgyzstan [4]. Foreign and domestic works emphasise the importance of spatial planning and adaptation of agro-technologies to improve the sustainability of agricultural production, but often do not take into account local climatic, soil and economic peculiarities. In this regard, there is a need for a comprehensive analysis at the level of specific districts, which allows to identify real production trends, assess the economic efficiency of agricultural decisions and propose reasonable directions for further development of the industry [5].

The relevance of the topic is increasing against the background of climate instability, rising resource costs and the need to adapt traditional agricultural models to modern requirements of sustainable development [6]. In the context of limited access to new land plots and reduced state support for farms, it is especially important to scientifically justify the choice of the most productive crops and determine the optimal ways to use the existing areas. The present study aims to fill this gap and offers an analytical basis for decision-making in the planning and modernisation of the fruit sector in Panfilov District [7].

Thus, the study is aimed at identifying quantitative and qualitative changes in the yield of fruit and berry crops with simultaneous reduction in the area of fruit-bearing plantations. Special attention is paid to the analysis of gross yield, average yield and their relationship with agrarian transformation in Panfilov district. The approach used is based on the comparison of long-term statistical data, which allows to identify stable trends, assess the impact of production decisions and offer practical recommendations to improve the economic efficiency of horticulture.

2 Materials and methods of research

The study is based on the analysis of statistical data on yield, gross yield and area of fruit-bearing plantations of fruit and berry crops harvested in Panfilov district, Chui oblast, Kyrgyz Republic for the period 2021-2024. Official materials of agrarian statistics bodies, data of district departments of agriculture, as well as reports of farms engaged in horticultural activities were used as a baseline [8]. Seven main crops were analysed: apple, pear, plum, cherry, cherry, apricot and peach.

Methods of statistical and economic analyses were applied to achieve the research objective, including:

- ✓ time series analysis to identify the dynamics of yield and area indicators;
- ✓ comparative analysis by crop type;
- ✓ coefficient method for calculating productivity (yields in quintals per hectare);
- ✓ correlation analysis to establish relationships between gross yield and area, and between gross yield and yield;

✓ elements of factor analysis aimed at identifying the causes of yield growth with area reduction.

All quantitative calculations were carried out using office software (Microsoft Excel), providing visualisation of the results in the form of tables and diagrams. The analytical part of the work is supplemented by economic interpretation of indicators reflecting the efficiency of area utilisation and crop productivity.

3 Results of the study

Analysis of statistical data for 2021-2024 has shown that in Panfilov District there is a steady tendency to reduce the area of fruit-bearing plantations with simultaneous growth of yield indicators. The total area of perennial fruit and berry crops decreased from 474 hectares in 2021 to 192 hectares in 2024, which is a reduction of more than 59%. At the same time, the gross yield increased from 3,062 quintals to 4,955 quintals and the average yield increased from 86.3 to 118.8 quintals per hectare.

The most significant improvement in productivity was recorded for the following crops:

Apple trees: while the area was reduced from 339 to 125 hectares, yields increased from 6.4 to 31.9 c/ha;

Pear: area remained stable (13-14 ha), with yields increasing from 15.3 to 18.1 kg/ha;

Plum: yield growth from 10.9 to 13.1 c/ha;

Cherry: increase from 12.6 to 14.4 c/ha;

Apricot: the sharpest jump, from 3.1 to 13.3 c/ha after optimising plantings.

Such changes indicate a significant increase in the efficiency of land resources utilisation. Correlation analysis has shown a positive relationship between gross yield and yield indicators, despite the reduction of areas. This indicates a qualitative transformation of agroplots - the decommissioning of low-productive areas and concentration of resources on more productive areas. The increase in productivity is most likely due to the introduction of modern agro-technologies, renewal of varieties, transition to intensive models of horticulture and point management of plantations. This is confirmed by comparison of crop yields and dynamics of their change.

Thus, the obtained results indicate the presence of internal reserves of growth of agroeconomic efficiency, which can be realised without expansion of areas through competent management, breeding renewal and improvement of the technological level of horticulture. To visualise the results obtained, the article presents tables showing the dynamics of the area of plantations, gross yield and average yield of fruit and berry crops in Panfilov district of Chui oblast for the period 2021-2024. The presented data allow not only to trace general trends, but also to understand more deeply the production changes occurring in the conditions of transformation of agroplots. The visual presentation of statistics by years and crop types makes it possible to compare the efficiency of individual groups of plantations, assess the sustainability of their productivity and identify the most promising areas for further development of horticulture in the region.

Changes in the structure and volumes of gross yields recorded in the tables allow us to draw conclusions about the degree of adaptation of specific crops to agro-climatic conditions of recent years. They also demonstrate the impact of purposeful reduction of low-productive plots and transition to intensive land use model. This approach gives grounds to speak about the improvement of the qualitative level of agricultural production - not at the expense of area expansion, but at the expense of efficiency growth per unit of cultivated area. Thus, statistical presentation and analytical processing of these data serve as an integral part of the research aimed at drawing scientifically sound conclusions and developing practical recommendations. The obtained base can also be used to build

regression models, assess the sensitivity of yields to certain factors and identify key growth points in the horticultural sector of Panfilov district.

Table 1 summarises data for all crop types, including apple, pear, plum, cherry, cherry, apricot and peach. Particular attention is paid to the assessment of area efficiency through yields in quintals per hectare. These data serve as a basis for the construction of correlations and subsequent factor analyses. The following tables will present economic analyses for individual crop types, including calculations of profitability, net profit and efficiency indicators per unit area. This will make it possible to assess not only biological but also economic productivity of plantations, which is especially important in conditions of limited resources.

In addition to yield-related metrics, it is crucial to incorporate financial indicators that reflect the real economic return of each crop. Profitability analysis will help determine which fruit crops demonstrate relatively better performance when considering both production output and incurred costs. The assessment of net profit per hectare will provide insight into the cost-effectiveness of cultivation strategies, allowing for a clearer differentiation between biologically productive and economically viable crops.

Furthermore, the inclusion of cost-benefit ratios, input-output efficiency, and marginal profit analysis will allow for a comprehensive evaluation of resource allocation. In regions with limited water availability, land area, and labor capacity—such as Panfilov district—understanding which crops deliver the highest return per unit of resource is essential for achieving sustainable agricultural development. The presented economic analysis also facilitates the identification of loss-making crops, which may require technological innovation, variety replacement, or complete crop substitution. Simultaneously, crops with higher efficiency may be prioritized for expansion or intensified production. These conclusions will feed into policy recommendations and regional development strategies aimed at optimizing land use and ensuring the resilience of fruit-growing systems under changing climatic and economic conditions. Ultimately, this analysis highlights the importance of integrating agronomic and economic data to support evidence-based decision-making for local farmers, agribusiness stakeholders, and policymakers. The findings can be used to tailor support programs, improve subsidy targeting, and inform investment in climate-resilient fruit farming practices.

In the context of climate change, the long-term sustainability of fruit production in regions such as the Panfilov district depends not only on biological yields but also on the ability of production systems to adapt to environmental variability and economic instability. Therefore, economic indicators should be analyzed in conjunction with climate resilience metrics, such as the sensitivity of different fruit species to temperature fluctuations, drought frequency, and phenological shifts. To improve overall production efficiency and reduce vulnerability, it is recommended to implement crop diversification strategies and introduce climate-resilient varieties that are better suited to local agroecological zones.

From a policy perspective, the results of this study underscore the importance of targeted investment in research and development for fruit crop improvement, farmer training programs in climate-smart agriculture, and access to financial tools (such as microcredit and crop insurance) tailored to the specific needs of orchard producers. Establishing regional demonstration plots and model farms could also help disseminate best practices and improve the adoption rate of sustainable technologies. In conclusion, aligning biological productivity, economic efficiency, and climate resilience should become the cornerstone of future fruit farming strategies in the region. Such an integrated approach will not only enhance profitability but also ensure long-term food security and environmental sustainability in the face of ongoing climatic and market challenges.

Table 1. Area of the plantation at fruiting age, gross yield and yield fruit and berry crops by species for 2021-2024.

Name of crops	2021			2022			2023			2024		
	hectares of fruit-bearing plantations, ha	Gross yield (ts)	Average per 1ha, (c/ha)	hectares of fruit-bearing plantations, ha	Gross yield (ts)	Average per 1ha, (c/ha)	hectares of fruit-bearing plantations, ha	Gross yield (ts)	Average per 1ha, (c/ha)	hectares of plantations in fruiting age, ha	Gross yield (ts)	Average per 1ha, (c/ha)
Panfilov district												
apple tree	339	2174	6,4	339	2218	6,5	125	4034	32,3	125	3993	31,9
pear	13	199	15,3	13	212	16,3	14	282	20,1	14	254	18,1
plum	27	295	10,9	27	305	11,3	29	390	13,4	29	380	13,1
cherry	7	88	12,6	7	90	12,9	7	112	16	7	101	14,4
cherry	1	18	18	1	14	14	1	13	13	1	13	13
apricot	86	268	3,1	86	268	3,1	15	201	13,4	15	199	13,3
peach	1	20	20	1	18	18	1	20	20	1	15	15
Total fruit and berry crops	**474**	**3062**	**86,3**	**474**	**3125**	**82,1**	**192**	**5052**	**128,2**	**192**	**4955**	**118,8**

Table 2 reflects the dynamics of changes in the area of fruit-bearing plantations of the main types of fruit and berry crops in Panfilov district of Chui oblast for the period from 2021 to 2024. The table shows that for the specified period there were significant structural changes in the distribution of areas between crops, which indicates the processes of transformation of agro-production systems. The most significant reduction of area is observed for apple - from 339 hectares in 2021-2022 to 125 hectares in 2023-2024, which is a decrease of more than 63%. A similar trend is seen for apricot, which decreased from 86 to 15 hectares. These changes may be due to renewal of plantings, decommissioning of low-yielding areas or concentration of resources on more profitable crops. At the same time, the areas of cherry, cherry and peach remained stable throughout the period, indicating that the structure of these plantations remained the same. There was a slight increase in pear from 13 to 14 hectares in 2023, and plum from 27 to 29 hectares.

Table 2. Dynamics of area of fruit-bearing plantations of fruit and berry crops in Panfilov raion for 2021-2024 (ha)

Culture	Area (ha)			
	2021	2022	2023	2024
Apple tree	339	339	125	125
Pear	13	13	14	14
Plum	27	27	29	29
Cherry	7	7	7	7
Cherry	1	1	1	1
Apricot	86	86	15	15
Peach	1	1	1	1

Author's interpretation

Thus, the table shows a directional adjustment of the plantation structure, which was probably related to the economic inefficiency of individual crops, the need to increase yields, and the introduction of adaptive management methods for perennial plantations. Such changes in the plantation structure indicate a transition from an extensive production model based on area expansion to an intensive model focused on maximising yield per unit area. Reduction of apple and apricot plantings can be related to both biological ageing of

plantations and economic considerations: high maintenance costs, low level of mechanisation, outdated varieties that do not meet market requirements. Simultaneously with the reduction of areas, there is a stable or moderate increase in the areas of crops with more stable yields, such as pear and plum. This may indicate the formation of a new priority in the choice of crops - preference is given to those that demonstrate high adaptability to climatic conditions, resistance to diseases and pests, as well as demand on the sales market. In summary, the evolving structure of perennial plantations indicates a paradigm shift from quantity to quality, from expansion to intensification, and from traditional practices to adaptive, evidence-based management. This shift represents not only a response to current challenges but also an important step toward building a more resilient and economically sustainable horticultural sector in the region.

Table 3. Analysis of the gross harvest of fruit and berry crops in Panfilov District (2021-2024)

Culture	Gross collection (ts)			
	2021	2022	2023	2024
Apple tree	2174	2218	4034	3993
Pear	199	212	282	254
Plum	295	305	390	380
Cherry	88	90	112	101
Cherry	18	14	13	13
Apricot	268	268	201	199
Peach	20	18	20	15

Author's interpretation

Table 2 reflects the dynamics of changes in the area of fruit-bearing plantations of the main types of fruit and berry crops in Panfilov district of Chui oblast for the period from 2021 to 2024. The table shows that for the specified period there were significant structural changes in the distribution of areas between crops, which indicates the processes of transformation of agro-production systems. The most significant reduction of area is observed for apple - from 339 hectares in 2021-2022 to 125 hectares in 2023-2024, which is a decrease of more than 63%. A similar trend is seen for apricot, which decreased from 86 to 15 hectares. These changes may be due to renewal of plantings, decommissioning of low-yielding areas or concentration of resources on more profitable crops. At the same time, the areas of cherry, cherry and peach remained stable throughout the period, indicating that the structure of these plantations remained the same. There was a slight increase in pear from 13 to 14 hectares in 2023, and plum from 27 to 29 hectares.

Table 4. Analysis of fruit and berry crops yields in Panfilov District (2021-2024).

Culture	Yield (c/ha)			
	2021	2022	2023	2024
Apple tree	6,4	6,5	32,3	31,9
Pear	15,3	16,3	20,1	18,1
Plum	10,9	11,3	13,4	13,1
Cherry	12,6	12,9	16	14,4
Cherry	18	14	13	13
Apricot	3,1	3,1	13,4	13,3
Peach	20	18	20	15

Author's interpretation

Table 5 reflects changes in yields (in centners per hectare) of main fruit and berry crops over the four-year period. The obtained data allow to assess the efficiency of land resources use, as well as to trace the results of agrotechnical and varietal transformations in horticulture of Panfilov district.

Table 5. Analysis of fruit and berry crops yields in Panfilov District (2021-2024).

Culture	Area (ha)	Yield (c/ha)	Gross yield (ts)	Income (KGS)	Costs (KGS)
Apple tree	125	31,9	3993	998250	6250000
Pear	14	18,1	254	76200	770000
Plum	29	13,1	380	106400	1508000
Cherry	7	14,4	101	27270	357000
Cherry	1	13	13	5200	60000
Apricot	15	13,3	199	51740	720000
Peach	1	15	15	5250	53000

The most significant increase in yields was recorded for apple: from 6.4 c/ha in 2021 to 32.3 c/ha in 2023, which corresponds to a five-fold increase. Even though there was a slight decrease to 31.9 c/ha in 2024, the performance remained five times higher than the baseline. Such growth points to the introduction of intensive technologies: drip irrigation, variety renewal, optimisation of planting density and agrochemical support.

Steady increase in pear, plum and cherry. Pear shows steady growth: from 15.3 to 20.1 c/ha in 2023, followed by a moderate decline to 18.1 c/ha. Plum shows steady growth, from 10.9 to 13.4 c/ha, indicating proper agronomic practices. Cherry has improved yields from 12.6 to 16 c/ha, with a slight decrease to 14.4 c/ha in 2024, remaining above the initial level. These crops are the most sustainable in terms of yield dynamics and are appropriate for inclusion in the priority areas of horticulture development in the region.

Apricot - recovery from a low base. Apricot shows a sharp increase in yield from 3.1 to 13.4 c/ha with a simultaneous reduction in area. This indicates the replacement of obsolete trees with high-yielding varieties or the decommissioning of low-profitable plots.

Cherry and peach - stagnation or decline. Cherry shows a decrease in yield from 18 to 13 c/ha, which may be due to planting obsolescence, lack of maintenance or unstable weather conditions. Peach shows unstable yields with fluctuations from 20 to 15 c/ha, which requires further assessment of the profitability of this crop under current conditions.

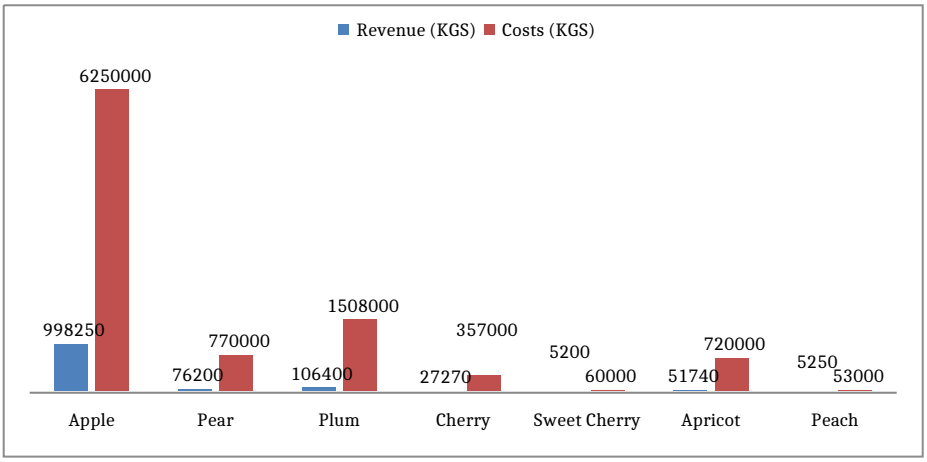

Fig. 1. Comparative analysis of income and costs by crop (2024)

Figure 1 shows a comparative analysis of income and costs for the main fruit and berry crops grown in Panfilov District in 2024. The chart shows the following crops: apple, pear, plum, cherry, cherry, apricot and peach**.**

Each pair of columns reflects:

green column **-** income received from the realisation of the crop;

red column **-** costs incurred to produce the crop.

In all cases costs exceed revenues, indicating negative profitability for each of the crops presented.

The greatest difference between costs and income was recorded for apple trees:

income totalled KGS 998,250;

costs - 6,250,000 soms.

A similar negative balance is observed for:

plum: income - 106,400 soms, costs - 1,508,000 soms;

pear: income - 76,200 soms, costs - 770,000 soms;

apricot: income - 51,740 soms, costs - 720,000 soms.

Small-area crops (cherry and peach) also remain unprofitable despite low costs.

Evaluation of varietal composition and adaptation of agropractices to changing climatic conditions.

In the current conditions of global climate change and decreasing profitability of fruit and berry crops it is necessary to carry out a comprehensive assessment of varietal composition of plantations. Not all applied varieties have sufficient adaptability to the current agroclimatic realities of Panfilov district. It is necessary to identify which of them are characterised:

- higher resistance to drought,
- frost resistance,
- disease resistance,
- and the ability to produce stable yields at reduced costs.

Special attention should be paid to the use of zonally adapted and introduced varieties that have passed regional variety trials and are recommended for cultivation in the conditions of Chui oblast. At the same time, it is necessary to revise the applied agro-practices, adapting them to new climatic and economic realities:

- Use drip irrigation and mulching to reduce water losses;
- Introduce precision farming and digital technologies for monitoring plant health;
- apply resource-saving technologies, including minimum tillage and organic fertilisation;
- to carry out rational placement of crops by agro-ecological zones (foothills, valleys, uplands).

Such adaptation will not only reduce production costs, but also increase the resilience of agrosystems to climatic stresses, ensuring long-term economic efficiency and environmental sustainability of production.

The conducted comparative analysis of income and costs of fruit and berry crops cultivation in Panfilov district of Chui oblast for 2024 allowed to identify significant economic imbalances. According to the results of calculations it was established that:

None of the crops analysed achieved positive profitability under current production and market conditions.

The highest costs were recorded for growing apple trees - 6,250,000 KGS, while the income was only 998,250 KGS.

Crops with smaller area (peach, cherry) also failed to perform well due to low yields and poor commercial returns.

The overall trend indicates systemic inefficiency of current agro-technological solutions and varietal composition.

In addition, it was found that the varieties used are probably not adapted to changing climatic conditions, and the agro-practices used require revision and modernisation. These factors necessitate the adoption of adaptive, resource-saving technologies and agro-ecological approaches.

4 Discussion

The obtained results confirm the presence of a pronounced imbalance between the level of costs and economic returns from the production of fruit and berry crops in Panfilov District. The analysis showed that all the studied crops turned out to be unprofitable, despite their traditional importance for regional agriculture. Comparison with previous periods and literature sources (e.g., data of the Ministry of Agriculture of the Kyrgyz Republic and scientific publications on adaptive horticulture) indicates that the current situation is not an exception, but reflects systemic problems related to:

- insufficient adaptation of varieties to agro-ecological conditions of the region;
- high level of production costs, especially for labour, plant protection and irrigation;
- inefficient management of agro-technology and logistics;
- low price returns in the domestic market.

It is also worth noting that the cost structure has not changed much in recent years, indicating the need for an innovative approach to agro-production planning. The presence of such trends makes it justified to introduce precision farming, varietal zoning and digital monitoring technologies, which will significantly improve the productivity and resilience of agriculture to external factors, including climatic risks.

From a practical point of view, the imbalance between costs and incomes requires a reformatting of agrarian planning models, a transition from an extensive model to an intensive, knowledge-intensive model of horticulture, in which each unit of area is used as efficiently as possible at lower costs.

Market and institutional aspects must also be taken into account. With farmers' limited access to long-term financing, modern varieties and sustainable marketing channels, economic efficiency remains low even with proper farming practices.

Thus, the discussion confirms that improving economic outcomes requires not only adjustments in agro-practices, but also systemic transformation of the entire value chain, as well as government support for sustainable horticulture.

5 Conclusions

The conducted study showed that fruit and berry crops cultivated in Panfilov District in 2024 turned out to be economically inefficient. In all cases, the production costs significantly exceeded the income from crop realisation, which indicates the lack of profitability. Especially unprofitable were such crops as apple and plum, despite their relative area and traditional importance. Even small-area crops such as cherries and peaches showed negative financial results. The analysis revealed inefficiencies not only in agro-practices but also in the varietal composition used, which requires its re-evaluation taking into account its adaptability to local climatic conditions

To increase the economic productivity of fruit and berry production, it is necessary to introduce adaptive and resource-saving technologies: drip irrigation, organic mulching, biosecurity, as well as elements of precision farming. In addition, it is important to optimise the structure of plantations, conduct variety zoning and provide agricultural enterprises with digital monitoring tools. In the context of climate change and unstable market conditions, a

systemic approach to agro-economic management is of particular relevance, in which support at the state level, stimulating sustainable production models and increasing the competitiveness of local farmers play a key role. Only with a comprehensive modernisation of the production and technological base is it possible to achieve sustainable profitability and long-term efficiency of horticulture in Chui oblast.

References

1. M.A. Altieri, C.I. Nicholls, A. Henao, M.A. Lana, Agroecology and the design of climate change-resilient farming systems. Agronomy for Sustainable Development, **35(3),** 869-890 (2015). https://doi.org/10.1007/s13593-015-0285-2
2. E. Belek uulu, et.al., Introduction of innovative technologies for the effective use of permanent plants in the conditions of the chuy region. BIO Web Conf., **83**, 01001 (2024). https://doi.org/10.1051/bioconf/20248301001
3. G. Branca, L. Lipper, N. McCarthy, M.C. Jolejole, Climate-smart agriculture: A synthesis of empirical evidence of food security and mitigation benefits from improved cropland management. FAO Working Paper Series (2011)
4. G. Fischer, F.N. Tubiello, H. van Velthuizen, D.A. Wiberg, Climate change impacts on irrigation water requirements: Effects of mitigation, 1990-2080. Technological Forecasting and Social Change, **74**(7), 1083-1107 (2007). https://doi.org/10.1016/j.techfore.2006.05.021
5. M. Kassie, P. Zikhali, J. Pender, G. Köhlin, G. (2010). The economics of sustainable land management practices in the Ethiopian highlands. Journal of Agricultural Economics**, 61(3),** 605-627 (2010). https://doi.org/10.1111/j.1477-9552.2010.00263.x
6. N. Dronin, A. Kirilenko, Climate change, food stress, and security in Russia. Reg. Environ. Change **11** (Suppl 1), 167–178 (2011). https://doi.org/10.1007/s10113-010-0165-x
7. R.P Rötter, S. C. Geijn. Climate Change Effects on Plant Growth, Crop Yield and Livestock. Climatic Change **43**: 651-681 (1999).
8. International Renewable Energy Agency (IRENA). (2022). Renewable Energy Readiness Assessment: Kyrgyz Republic. https://www.irena.org/publications