Agroecological and green agriculture practices for sustainable agricultural development in Kyrgyzstan

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This article provides information on how agroecology and green agriculture can help address local challenges faced by farmers and agricultural enterprises in Kyrgyzstan, ensuring a balance between economic efficiency, environmental sustainability, and social equity. It compares the concepts of agroecological approaches and the principles of green agriculture.

***Keywords:** Agriculture, agroecology, green agriculture, sustainable agriculture, climate change adaptation, land and water resources*

INTRODUCTION

Kyrgyzstan is a mountainous country where agriculture holds a high development priority and makes a significant contribution to the national economy, faces main global challenges such as land degradation and declining soil fertility on arable lands, overexploitation and degradation of pastures, water scarcity for irrigation, and climate change, etc. These issues negatively impact crop productivity and livestock productivity, environmental conditions, social well-being, and farmers' incomes. In this context, understanding and adopting the principles of agroecology and green agriculture play a vital role in ensuring the sustainable development of the country's agricultural sector, mitigating environmental risks, and adapting to climate change.

Agriculture in Kyrgyzstan is not only an economic activity but also a way of life for a significant part of the population (over 60%). It serves as a key social factor shaping the development of rural areas, where nearly one-third of the country's population resides (in seven provinces). Unfavorable weather conditions, environmental pollution, and poor land reclamation in some regions are among the factors that limit the full utilization of the country's agro-climatic, water and land resources. In addition, seed production remains one of the most critical and problematic areas in the republic. In the livestock sector, inadequate progress in breeding practices presents a major issue. Moreover, fragmented small-scale farming with outdated technologies continues to negatively affect the development of agriculture (National Statistical Committee of the KR, 2020).

All these challenges, as well as several other issues, pose important tasks for the government, academic sector, non-governmental organizations and international development partners. These include the need to promote sustainable agricultural practices, particularly the development and adoption of sustainable agriculture, best practices in green agriculture, and agroecological principles.

The term *"agroecology"* emerged in the early 20th century. Among the first Russian ecologists was Andrey Bolotov (1738-1833), a scientist who focused on urban and agricultural ecology (Ilichev).

Agroecology as a scientific area was first mentioned in a 1920 report by the Italian Academy of the Lincei. Significant contributions to the development of agroecology were made by the authors of monographs titled "Agricultural Ecology" - the Italian scientist G.Azzi and the German scientist W.Tischler (Chernikov, 2022).

In Russia, this term was first used by agronomist Vasily Benzin in 1928 to describe the application of ecological methods in agricultural crop research (Science, 2019).

In Kyrgyzstan, agroecology began forming as a scientific and educational discipline in the late 1990s, combining agricultural, ecological, agronomic, agrometeorological, and land management knowledge, etc. Initially developed as

a course at the Kyrgyz Agrarian Academy (KNAU), it later evolved into a full-fledged specialty, as well as becoming part of agricultural ecology research, including pasture monitoring, water and land resource improvement, and cultivation of drought-resistant crops, etc.

Significant contributors to agroecology in Kyrgyzstan include scientists from the Kyrgyz National Agrarian University such as Prof. N.Karabaev (soil ecology), Prof. A.Asanaliev (soil and water conservation technologies), Dr. T.Semenova (pasture ecology, agroecology), Prof. B.Saipov (climate change, land reclamation, and agriculture), Dr. N.Yakovleva (agroforestry), among others. These scientists contributed to developing scientific approaches to pasture ecology, lend melioration, agroforestry, environmental aspects of livestock production, sustainable land use, and environmental safety in agriculture, etc.

Since the 2010s, educational programs integrating agroecology principles have actively developed in Kyrgyzstan. The Kyrgyz Agrarian University introduced an international master's program in agroecology focused on interdisciplinary approaches, including ecology, agronomy, economics, and food security. This initiative has been crucial in training a new generation of specialists capable of applying systems thinking to agriculture and natural resource management.

Alongside academic development, agroecological principles are increasingly implemented through rural communities and local farming initiatives, and climate adaptation strategies. With support from international organizations (FAO, WFP, GIZ, IFAD, JICA, and others), various projects were implemented in Kyrgyzstan, focusing on ecosystem-based management of pastures, forests, land, water resources, etc.

In addition to environmental aspects of agriculture, climate change, and sustainable use of natural resources, the implementation of green agriculture practices, as part of the green economy, has gained relevance.

The term *"green agriculture"* does not have a single attributed author, but its dissemination is associated with international organizations such as FAO (United Nations Food and Agricultural Organization) and UNEP (United Nations Environment Programme).

In 2008, UNEP launched the Green Economy Initiative, aimed at supporting governments in transitioning to a low-carbon, resource-efficient, and socially inclusive economy. One of its five priority areas was agricultural energy, including renewable energy use and sustainable biomass (UNEP, 2025).

In 2022, FAO launched its Green Agriculture Initiative through the Regional Office for Europe and Central Asia (Kyrgyzstan joined this initiative in 2025). This initiative promotes sustainable agricultural practices and supports countries transitioning to a green economy. According to the FAO Regional Technical Platform on green agriculture (FAO, 2025) it involves rational management of natural resources, biodiversity, and ecosystem services to create sustainable, productive, and resilient agroecosystems capable of addressing present and future challenges (FAO, 2025).

Overall, the concept of green agriculture focuses on environmentally safe farming methods such as reducing carbon emissions, sustainably using natural resources, and incorporating renewable energy sources. In other words, green agriculture can be defined as an integrated system of sustainable farming that combines productivity and competitiveness with environmental protection, restoration of natural capital, greenhouse gas reduction, and climate change adaptation.

According to D.Zholboldueva and co-authors (2024), during the period 2010–2020, the development of agriculture in the Kyrgyz Republic demonstrated certain positive trends and improvements in sectoral reproductive indicators, partly due to the application of agroecological approaches, resource-efficient technologies, and other sustainable agricultural practices (Zholboldueva et al., 2024).

The goal of this study is to analyze the farming practices currently applied in Kyrgyzstan and to highlight the role of agroecology and green agriculture in ensuring sustainable development of the country’s agricultural production.

MATERIALS AND METHODS

This study is based on a qualitative synthesis of secondary data and practical field experience. The research involved a comprehensive review of scientific and methodological literature, policy documents (National Sustainable Development Strategy, Concept for Organic Agriculture Development, and climate adaptation frameworks), and relevant legal acts on land use and environmental protection.

Project reports and technical documents from initiatives implemented between 2010 and 2024 (e.g., by FAO, GEF, WFP, UNDP and USAID) provided additional empirical insights. Field-level knowledge was complemented by semi-structured interviews with local experts, including scientists, cooperative members, farmers, and NGO

representatives, to validate findings and incorporate practical perspectives.

RESULTS AND DISCUSSION

As outlined above, in recent decades, agriculture has faced the urgent need to transition toward more sustainable and environmentally friendly production methods. This has led to the development of approaches such as agroecology and green agriculture. These two concepts share common goals, such as reducing environmental impacts and increasing the resilience of agricultural systems but differ in their methods, principles, and areas of focus.

All these initiatives and approaches that fall under the broader umbrella of sustainable agriculture are a set of principles and practices aimed at preventing harm to people, animals, and the environment in food production. Rather than extracting value from natural systems, sustainable agriculture maintains and enhances ecosystem functions both within and beyond farm boundaries (Shtebner and Yerlygina, 2023).

Sustainable Agriculture and Good Agricultural Practices: Green agriculture, Digital agriculture, Conservation Agriculture, Bioeconomic in agriculture, Ecosystem Services Agriculture, Agrobiodiversity, Precision agriculture, Agroecology, Climate Smart Agriculture, Organic agriculture, Integrated Water Resources Management, Low carbon agriculture, Agrobiotechnology, Regenerative agriculture.

As noted by FAO (2017), sustainable agricultural development requires integration and synergy across sectors, as well as a combination of social, economic, and environmental aspects. Sustainable methods and production technologies are based on synergies between the supply-production chain and natural resources.

All approaches listed above (Fig. 1) can be seen as independent practices in agriculture, but they also fall within the overall framework of Good Agricultural Practices (GAP), which, according to FAO, are defined as practices that ensure environmental, economic, and social sustainability in farming processes that lead to the production of safe and quality food and non-food agricultural products (FAO, 2025).

In recent years, farmers in several regions of Kyrgyzstan have actively begun to adopt various agroecological methods, both with the support of international development projects and advisory services, as well as on their own initiative. These methods are aimed at restoring degraded lands, conserving biodiversity, own production of organic fertilizers, utilizing traditional knowledge, use of solar panels and biogas plants, and enhancing food security, etc.

Research conducted within the framework of the FAO project (Peeters et al., 2018), including field studies, analysis of secondary documents, and interviews with stakeholders, revealed significant potential for the development of agroecological approaches in Kyrgyzstan. Current agricultural practices with a limited use of synthetic fertilizers and pesticides for more than 20 years, low-intensity soil works, and diversity of crops including legume-based temporary grasslands, integration of crop and livestock, and family farming are some characteristics that make possible to actively develop this approach in Kyrgyzstan. The existing difficulties and gaps associated with the lack of specialists, knowledge and experience, and appropriate regulatory framework, are challenges and at the same time opportunities for the governmental and agricultural sectors (Peeters, et al., 2018).

Examples of the agroecological principles implementation in Kyrgyzstan (Fig. 2):

- ***Agricultural Conservation:*** Maintaining permanent soil cover, minimal soil disturbance, and plant diversity on farmer's fields. In 2014, FAO launched the “Farmer Field Schools” project on conservation agriculture. In 2017, FAO-SEC in Turkey published a Training guide for extension agents and farmers in Eastern Europe and Central Asia (Corsi and Muminjanov, 2017).
- ***Organic Agriculture:*** Adoption of a national concept and legislation in 2019 and 2023; work by the “BIO KG” Organic Movement Federation; 12,749 hectares certified as organic; over 1,000 farmers involved; more than 20 organic aimaks created.
- ***Traditional knowledge:*** Practices include natural livestock feeding, yurt construction and decoration, preparation of healthy nomadic foods, seed saving of local varieties, and more. Legislation to protect traditional knowledge was passed; working of the PF "Rural Development Found"; created a network of local agrobiodiversity keepers by the PF "ADI", etc.
- ***Pasture restoration:*** A National Pasture Development Program (2024–2029) has been adopted. Pasture committees are now established as municipal enterprises under Aiyl aimaks. Scientific research is being conducted by the Kyrgyz Research Institute of Livestock and Pastures; projects are being implemented by the PF "Camp Alatoo", etc.

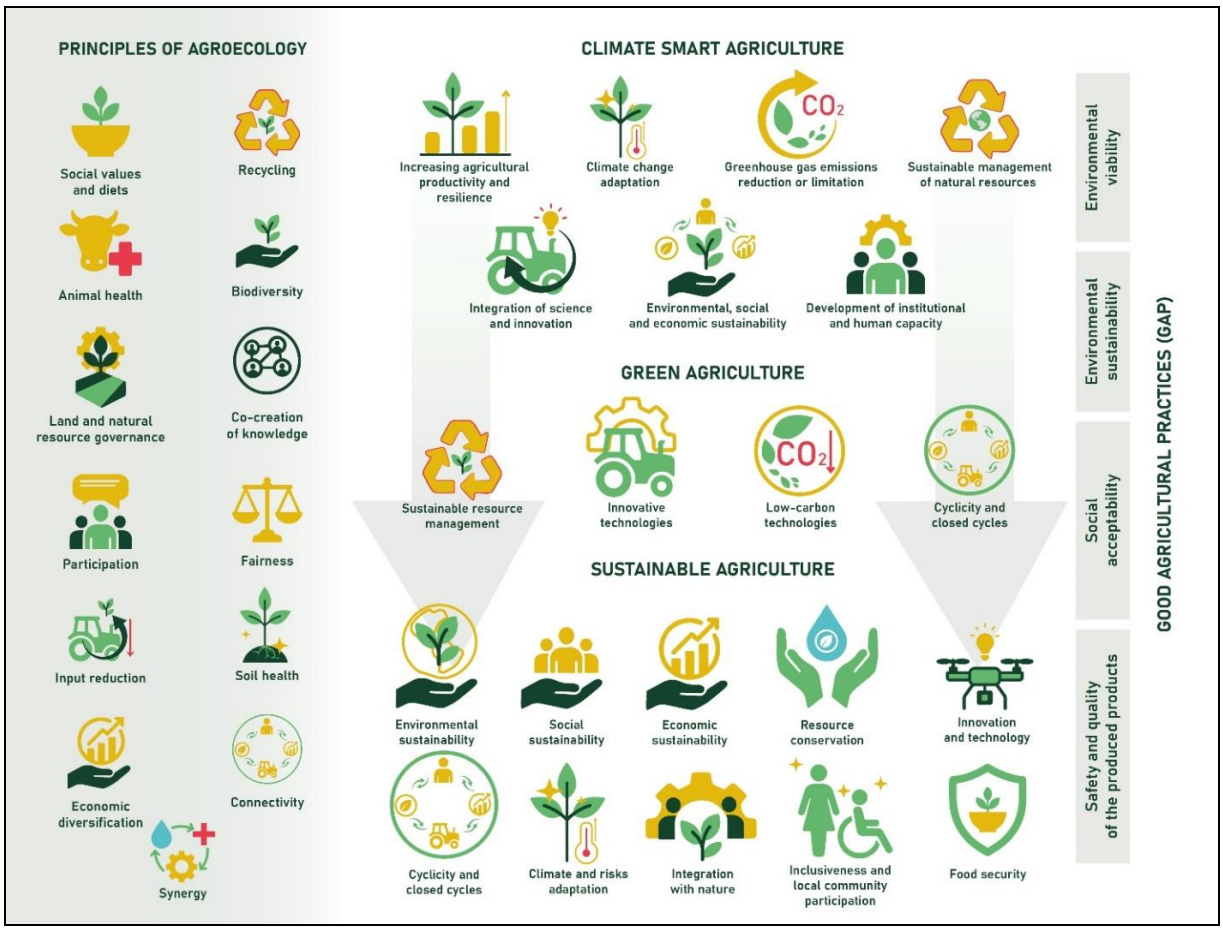


Fig. 1. Principles of agroecology, climate-smart agriculture, green agriculture, and sustainable agriculture as elements of Good Agricultural Practices in Kyrgyzstan (developed by the authors)

- ***Integrated Pest Management:*** Development of mobile applications like "IPM Tomato" and "BioControl"; agro-handbooks on biological pest control in various crops; implementation of IPM (Integrated Pest Management) by PA "AgroLead" and other organizations; beneficial insect production by the "Bai Dyikan" cooperative and State bio-factory.
- ***Agroforestry:*** A guide on agroforestry was published by WFP (2018) and GIZ (2022); the Kyrgyz Association of Forest and Land Users is active in this field; agroforestry was included in the Forest Code and national forestry concepts.
- ***Alternative fodders:*** Hydroponic feed cultivation; practical seminars conducted by the Department of Breeding, Pastures, and Feed in Issyk-Kul, Naryn, and Talas regions; testing of natural mineral feed additives like glauconite by Kyrgyz Research Institute of Livestock and Pastures, etc.
- ***Organic Fertilizers:*** Vermicompost production by farms in north and south of Kyrgyzstan; training and distribution in liquid, dry, and granulated forms; composting supported by JICA, etc.

In the context of Kyrgyzstan, the use of green technologies has become an important step toward sustainable development either. In recent years, various initiatives have emerged in the country aimed at introducing innovative and low-carbon solutions, such as drip irrigation, renewable energy use, digital agriculture, conservation and resource-saving farming, etc.

The following examples of green agriculture practices already implemented in Kyrgyzstan contribute to increased productivity, improved environmental conditions, and enhanced food security while minimizing negative impacts on natural resources and the climate. Special attention is also paid to technologies that reduce methane and other greenhouse gas emissions in agriculture.

Examples of the green agriculture principles implementation in Kyrgyzstan include (Fig.3):

- ***No-Till technology:*** FAO initiated farmer field schools in 2014 on conservation agriculture. These approaches are now piloted in the south of the country under GIZ and WFP projects.

Revival of local vegetable varieties at the farm level, PF "ADI", 2015

Establishment of "Organic Aimaks" by PF "BIO KG", 2024

Release of beneficial insects in the fields of Chuy Region, "Bai Dyikan" Cooperative, 2024

Cultivation of hydroponic fodder by the Agricultural Cooperative "Bio Sevis," 2025

In-Vitro Laboratory (virus-free raspberry cultivation), KNAU, 2024

Production of biohumus in Osh, Cooperative "Asan Ata Biogumus," 2024

Support to the development of agroforestry (fruit orchards and beekeeping), WFP Projects, 2019

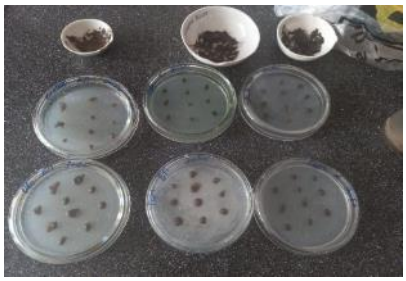
Underground storage of organic potatoes in Chong-Alai, "Zher Bashy" Cooperative, 2024

Establishment of experimental plots by Kyrgyz Research Institute of Livestock and Pastures on the pastures of Cholpon AO, 2021

Production of packaged green fodder – portioned silage, Cooperative "Bermet Farm", 2023

Cultivation of drought-resistant crops – sorghum, PA "Xpert Agro", 2023

Environmentally friendly mineral feed additive "glauconite" in animal feeding, Kyrgyz Research Institute of Livestock and Pastures, 2020



Soil decontamination from pesticide by using soil bacteria, FAO / Manas Kyrgyz-Turkish University, 2024

Conservation Agricultural technologies (CA), FAO, GIZ, WFP, PF "AgroLead" projects in Kyrgyzstan, 2014–2024

Farmer Field Schools (FFS) and the activities of extension services, FAO, NGOs, and RAS (Rural Advisory Services), 1994–2025

Fig. 2. Examples of the implementation of agroecological and organic agriculture practices in the Kyrgyz Republic (1999-2025)

Biogas plant at the agricultural enterprise “Novy Put”, Novopavlovka village, "Fluid" LLC, 2014

Solar dryer equipment for drying fruits, vegetables, kuruts, etc., CREED, 2024

Production of building blocks from rice husks, PE “Taabaldiev”, 2024

Use of agro-drones and small aircraft for agricultural purposes in Issyk-Ata district, 2024

Smart greenhouses in Chui region, Greenhous.kg, 2024

Collection and export of frozen horse placenta, “AgroExportService” LLC, 2018

Cricket farming for the production of cookies, protein, bars, and others, PE “Asanbekov”, 2022

Plastic recycling for the production of granules, irrigation hoses, and others PE "Masiraliev", 2024

Use of modern agricultural machinery for precision seeding – minimal soil impact, FAO, 2014

Use of solar panels on remote pastures, UNDP Project, 2014

Creation of artificial glaciers for pasture irrigation, FAO Project, 2025

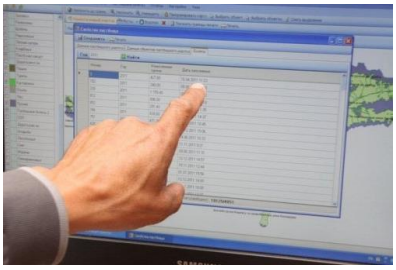
Underground manure storage – clean and odorless, Cooperative “Bermet Farm”, 202

Construction of ponds for irrigation water collection, WFP Project, 2019

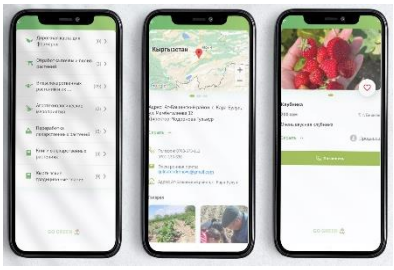
АТН ПОЛИС С/Х ЖИВОТНЫЕ АТН ПОЛИС УРОЖАЙ С/Х КУЛЬТУР

Agro-insurance, WFP Project and insurance company “ATN Polis”, 2013

Continued Fig. 3



Automated system “Electronic Pasture Committee” UNDP Project / PF "Camp Alatoo", 2013



Mobile application for farmers and potential buyers “Birlik,” RDF “Go Green” Project, 2023

Open Kyrgyz Data Cube (satellite imagery for pasture and climate condition analysis), SIBELIUS Project, 2021

Use of electric fencing on a goat farm, PE "Egemberdieva", 2023

Use of water meters and water sluices for measuring water inflow on main and internal channels (on farmers' fields), Kyrgyz Research Institute of Irrigation, 2025

Drip irrigation in Batken region, UNDP Project, 2020

Fig. 3. Examples of the climate-smart agriculture and green agriculture methods implementation in the Kyrgyz Republic (2013-2025)

- ***Efficient use of irrigation water:*** In response to water shortages, especially in the southern regions, farmers began implementing drip irrigation systems (UNDP), constructing mini-reservoirs for irrigation water collection (WFP), etc.
- ***Alternative irrigation sources:*** Artificial glaciers have been created for irrigating agricultural lands during summer (FAO has supported seven such glaciers and published a guide for their construction); mini-reservoirs and other water collection systems are also used.
- ***Renewable energy in agriculture:*** Some farms use solar panels to power water pumps, irrigation systems, and drying cabinets. The center for renewable energy and energy efficiency (CREED) promotes solar thermal and photovoltaic systems, biogas plants, micro-hydropower stations, wind energy, and energy efficiency projects [14].
- ***Low-Carbon technologies:*** Some farms are minimizing carbon emissions through energy from biomass (e.g., biogas installations), replacing chemical fertilizers with organic vermicompost, and reusing rice husk waste to produce eco-friendly building materials.
- ***Agricultural waste recycling:*** Examples include eco-bricks from rice husk waste (“Eco Panel” boards), freezing and exporting horse placenta, processing sheep wool, drying and preserving fruits and vegetables, and more.
- ***Cold storage facilities with modern technologies:*** Use of ozone-safe refrigerants (e.g., R404A, R507) and energy-efficient cooling systems that reduce carbon footprints and minimize emissions of harmful substances, etc.

Currently, the Kyrgyz Republic has several legislation documents potentially aimed at the development of agroecology, green agriculture, and sustainable agriculture, including Water Code of the Kyrgyz Republic, Land Code of the Kyrgyz Republic; Law "On the Development of Agriculture"; Law "On Environmental Protection"; Law "On Organic Production," etc.

The existing institutional framework ensures interaction between various state, international, scientific, and non-governmental organizations for the implementation of sustainable agriculture policies, including agroecological practices, as well as natural resource management in the context of climate change and environmental protection.

Since the concepts and application of the terms *"agroecology"* and *"green agriculture"* are

relatively new for Kyrgyzstan, there is a significant potential for scientific research, attracting experts, training specialists, updating or supplementing regulatory legal acts, developing recommendations, and implementing innovative technologies, among other activities.

CONCLUSIONS AND RECOMMENDATIONS

1. Sustainable agriculture is a broader concept encompassing ecological, economic, and social aspects. It includes but is not limited to agroecology and green agriculture and forms part of Good Agricultural Practices (GAP). Both approaches contribute to the resilience of agroecosystems and support national food security, which is crucial for achieving sustainable development amid climate change and growing food demand.
2. Strengthening the material, technical, and scientific base for agroecology and green agriculture in key research institutions will ensure the development and adaptation of innovative technologies, the conduct of applied research, and the training of qualified scientific personnel to implement sustainable practices in Kyrgyzstan's agricultural sector.
3. Raising awareness, conducting practical training, and knowledge exchange will help farmers not only adapt to climate and economic challenges but also improve production efficiency, preserve natural resources, and ensure the long-term sustainability of the agricultural sector.

REFERENCES

Agroecology as a science, movement, and practice. November 11, 2019. URL: https://dzen.ru/a/Xce1tG6LfmHAW44M (in Russian)

Analytical Note by the National Statistical Committee of the Kyrgyz Republic: "Features and Prospects of Agricultural Development in the Kyrgyz Republic". Bishkek: 2020.

Center for the Development of Renewable Energy and Energy Efficiency – a one-stop center for information, consultations, and other services in the field of renewable energy and energy efficiency in Kyrgyzstan. Website Green Energy KG. URL: https://www.greenenergy.kg/index.php?dispatch=companies.view&company_id=3

Chernikov V. Agroecology. Great Russian Encyclopedia. URL: https://bigenc.ru/c/agroekologiia-5c18fb (in Russian)

Corsi S., Muminjanov H. (2019) Conservation Agriculture: Training guide for extension agents and farmers in Eastern Europe and Central Asia. Ankara.

FAO Good Agricultural Practices. URL: https://www.fao.org/world-banana-forum/activities/good-practices/good-agricultural-practices

FAO Regional Technical Platform on Green Agriculture (2025) URL: https://www.fao.org/platforms/green-agriculture/ru (in Russian)

FAO Strategic Framework on Increasing the Sustainability of Food Production and Agriculture (2017) URL: https://openknowledge.fao.org/server/api/core/bitstreams/8f588a18-17e2-4dc0-840e-6cc340949a70/content

Ilichev V. History of Science: A.Bolotov – the founder of urban and agroecology. URL: https://bio.1sept.ru/view_article.php?ID=200602405 (in Russian).

Peeters A., Semenova T. et al. (2018) Report: Identification of agroecological farming and other agroecology-related activities in Kyrgyzstan. Agroecology Europe (AEEU), Brussels, November 2018.

Shtebner S., Yerlygina E. (2023) Sustainable Agriculture. *Bulletin of Science and Practice*, **9 (2):** 117-122; URL: https://cyberleninka.ru/article/n/ustoychivoe-selskoe-hozyaystvo (in Russian).

UN Environment programme. Green economy URL: https://www.unep.org/explore-topics/resource-efficiency/what-we-do/policy-and-strategy/green-economy

Zholbolduyeva D., Askarova A., Murzaliyeva E., Omurzakova U. (2024) Analysis of the current state and characteristics of agriculture in the Kyrgyz Republic. *International Journal of Humanities and Natural Sciences, Economic Sciences,* **1-4 (88):** 94-98.

Qırğızıstanda dayanıqlı kənd təsərrüfatının inkişafı üçün aqroekoloji və yaşıl kənd təsərrüfatı praktikaları

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Bu məqalədə aqroekologiya və yaşıl kənd təsərrüfatının Qırğızıstanda fermerlərin və kənd təsərrüfatı müəssisələrinin üzləşdiyi yerli problemlərin həllinə necə töhfə verə biləcəyi, iqtisadi səmərəlilik, ekoloji dayanıqlılıq və sosial ədalət arasında balansın necə təmin oluna biləcəyi haqqında məlumat verilir. Məqalədə aqroekoloji yanaşmaların konsepsiyası ilə yaşıl kənd təsərrüfatının prinsipləri müqayisə olunur.

Açar sözlər: *Kənd təsərrüfatı, aqroekologiya, yaşıl kənd təsərrüfatı, dayanıqlı kənd təsərrüfatı, iqlim dəyişməsinə uyğunlaşma, torpaq və su resursları*

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