

THE ROLE OF GREEN INNOVATIONS IN INCREASING THE EFFICIENCY OF AGRICULTURAL PRODUCTS

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Annotation

This article examines the importance of green innovations such as regenerative agriculture, AI, drone technology, and carbon farming in addressing the environmental crisis in the agrarian sector caused by water scarcity and soil degradation in the Republic. This scientific-analytical approach, based on the analysis of global and local experiences, numerically proves that the introduction of these innovations can reduce water consumption by up to 54%, pesticide use by up to 60%, and increase productivity by up to 31%. In addition to the mission of the mechanism to protect the environment, green innovations have the potential to increase farmer income and add billions of dollars to the national economy. These green innovations, in addition to being an ecological necessity, have the potential to increase farmer income and add billions of dollars to the country's economy. What is noteworthy is that this article also proposes a financially sound road-map for the widespread introduction of these technologies by 2030. To do this, relying on existing theoretical methodological research, we will try to systematize green innovations and identify the main patterns, for which it is necessary to understand it as an object in order to more deeply understand the role of green innovations.

Keywords

Soil degradation, green innovation, regenerative agriculture, ecology, artificial intelligence, carbon, climate change.

Introduction.

Currently, one of the key pillars of the economy and food security of the Republic of Uzbekistan is the sustainable development of the agricultural sector. However, in recent years, climate change, a sharp decrease in water resources and soil degradation have remained serious risk factors negatively affecting agricultural efficiency. According to the Food and Agriculture Organization of the United Nations (FAO), Uzbekistan's water resources are expected to decrease by 15% to 20% by 2030. In addition, as a consequence of the Aral Sea disaster, which was once the fourth largest lake in the world, approximately 2 million hectares of the Republic Land have become saline and unsuitable for agricultural use [6]. Looking at the data of the Ministry of Agriculture, at the same time agriculture consumes almost all of the water of the Republic [2]. Most concerning is that almost a third of these waters are being used ineffectively. This situation, combined with other challenges such as annual soil erosion reaching 5–7 tons per hectare and critically low levels of organic matter, is rendering the agricultural system increasingly unsustainable [12]. These indicators not only show that the agrarian system is highly vulnerable, but also prove that it is impossible for us to achieve sustainable profitability through traditional agricultural methods. Nevertheless, international experiments and achievements offer a source of optimism for Uzbekistan. Modern green innovations such as regenerative agriculture, artificial intelligence (AI), drone technologies and carbon farming not only save water consumption from 30 to 60 percent, but also create conditions to decrease the use of pesticides and herbicides by 25–50% [4,5]. Companies in food and agrarian orientation have already begun to stimulate such innovations. For instance, Nestlé planned to obtain 32% of its raw materials from the regenerative method by 2025, for which it spent USD 1.4 billion [8]. PepsiCo increased barley yields in Colombia by 36% (PepsiCo 2025). Facing the indicators in India and Uzbekistan, the CropIn AI system has reduced pesticide consumption by 58 percent in tens of thousands of hectares in these countries [10]. In Uzbekistan, Presidential Decree No. PQ-4477 (2019) and the “Strategy for the Transition to a Green Economy (2019–2030)” signal the beginning of nationwide implementation of green innovations [1]. Projects such as EU-AGRIN, FOLUR, green space are such early steps. These projects [11,13,15] showed positive results by increasing water savings by 40% on 50,000 hectares and productivity by 30%. However, it should be emphasized that these pilot projects have not yet been implemented on a large scale. Their economic feasibility and overall agro-efficiency therefore require further comprehensive analysis. For this reason, this article aims to prove that green innovation is not only the need for nature protection for agriculture in the Republic of Uzbekistan, but also the greatest potential for economic development by numbers, global and local experiences. In addition, the

study seeks to develop concrete, financially justified, and step-by-step recommendations for the large-scale implementation of these innovations across the Republic by 2030.

Literature Review.

American ecologist and agroforestry specialist **Eric Toensmeyer** was the first to develop a comprehensive “menu” on carbon farming, including over 100 practical methods. He emphasized that each method can sequester 3–30 tons of carbon per hectare per year. Among these, the most potentially effective in Uzbekistan are planting wheat among pomegranate and almond trees, and planting alfalfa under walnut trees with sheep grazing. Studies indicate that these agroforestry systems can sequester 5–12 tons of carbon per hectare annually. In addition, these methods diversify production, allowing 3–5 different crops to be grown in the same area, thereby increasing the stability of the agricultural system. In contrast, traditional crops such as cotton or wheat hardly increase soil carbon, storing only 0–0.5 tons per hectare annually. However, integrating these crops with pistachio or walnut trees increases carbon sequestration by 15–30 times. These agroforestry systems also improve economic efficiency: one hectare can yield USD 1,000–5,000 per year, with an additional USD 100–300 from carbon storage incentives. Toensmeyer tested these methods in arid regions, including the deserts of Australia, Mexico, and India, and observed a 60% reduction in water use, demonstrating effectiveness even under drought conditions. In practical experiments on his own land, Toensmeyer planted over 1,000 species on just 400 m², producing 3 tons of fruits and vegetables annually while sequestering 20 tons of carbon. This shows that even small multi-layered gardens can provide ten times more ecological and economic benefits than conventional farming.

If all farmlands worldwide adopted Toensmeyer’s agroforestry systems, 10–25 billion tons of carbon could be sequestered annually, offsetting emissions from vehicles and airplanes. In Uzbekistan, adapting 4 million hectares to these methods could sequester 40–100 million tons of carbon per year, positioning the country among the largest “green lungs” globally.

Toensmeyer argues that replacing traditional crops with combinations of trees and livestock can increase yields and income while stabilizing the climate. This approach is particularly suitable for Uzbekistan’s saline and arid lands. **Rattan Lal**, a leading soil scientist, has demonstrated over the past 50 years that simple, effective ecological practices significantly benefit climate and agriculture. Lal emphasizes that soil is a natural carbon bank; by storing carbon in soil rather than releasing it into the atmosphere, global warming can be mitigated. Increasing soil organic matter by just 1% globally could sequester carbon emissions from factories,

vehicles, and airplanes. Proper management of one hectare can neutralize annual carbon emissions from 10–20 cars. Lal highlights three main principles: firstly, minimize or eliminate tillage; secondly, never leave land bare and maintain continuous plant cover; thirdly, return plant residues, manure, and compost to the soil. Adhering to these principles can double crop yields, halve water consumption, reduce fertilizer costs, and restore soil fertility within 10–20 years, sustaining it for up to a century. For Uzbekistan, Lal's research is highly relevant: saline and degraded lands around the Aral Sea can be restored by applying these principles over 25–30 years, re-establishing ecological and agricultural sustainability. **Allan Savory** developed the "Holistic Management" system, where livestock, such as sheep and cattle, graze in dense herds for short periods (2–3 days) and are then moved to another area, mimicking wild herd behavior. Results show that within 400–600 days, grass cover on one hectare of desert land can recover up to 90%. According to the Savory Institute, over 40 million hectares in more than 50 countries have been converted into green pastures, sequestering 3–10 tons of CO₂ per hectare annually. Savory states, "Animals are not the enemy of desertification; they are the strongest remedy." Experiments show that increasing livestock density tenfold with proper rotational grazing increases grass cover by 300–500%. Grazing animals consume grass, deposit manure, and trample the soil, improving seed-to-soil contact—a natural ecological process. Savory's research proves that combating desertification does not require billion-dollar projects or artificial forests; proper livestock management alone is sufficient. This cost-effective, rapid, and scientifically validated approach is directly applicable to Uzbekistan's 20 million hectares of pastureland.

Methodology.

This article provides its scientific basis with a multi-method research approach. At the initial stage, a comprehensive analysis of existing sources was carried out. This included a comprehensive study of official reports of international organizations such as FAO [6], UNDP [7], global companies such as Nestlé [8], PepsiCo [9], Cropin AI [10], John Deere, and the Ministry of Agriculture of Uzbekistan [2] for 2020–2025. These sources include not only fundamental works by influential scientists such as Rattan Lal [3], Eric Toensmeier [4], Allan Savory [5], but also the final technical reports of the EU-AGRIN [11], FOLUR [13], and Yashil Makon [15] projects. On this basis, a reliable theoretical basis was created in order to conduct a comparative analysis of global and local experiences. At the next stage, a case study method was used to connect theory with practice. In this regard, pilot projects implemented in Uzbekistan, in particular, the 50 thousand hectares of EU-AGRIN [11], the 10 thousand hectares of Cropin AI in the Fergana-Andijan region

[10], the 12 thousand hectares of drone projects in Khorezm and Karakalpakstan, and the FOLUR (Food Systems, Land Resources Management and Restoration) [13] project, which includes 350 thousand hectares of sustainable management, were selected. The results of these projects were studied based on specific numerical indicators. In parallel, a SWOT analysis was conducted to systematically identify the problems and opportunities in the implementation of green innovations. To emphasize the importance and objectivity of the analysis process, a comparative method based on statistical data was used. By comparing the results on a global scale and the indicators achieved in Uzbekistan, similarities and differences were scientifically substantiated.

Research methodology.

The methodological proposals, scientifically based recommendations and conclusions developed in the research results are explained by the possibility of using special scientific abstraction, analysis and synthesis, induction and deduction, dedicated to improving the foundations of organizational economic mechanisms of green innovative activities in the field of services in the production of agricultural products.

Analysis and results.

The above-mentioned achievements have become possible due to the special attention paid by the head of our state to increasing the efficiency of green innovation and innovative research activities in the agricultural sector, as well as the widespread introduction of scientific results into production.

One of the main indicators of the level of development of any country is the competitiveness of its education and science systems. These factors determine the innovative nature of the economy, therefore, in developed countries, great importance is attached to the continuous development of these areas. This requires not only constant investment in science and education, but also the correct organization of their structure, which should be flexible in relation to new tasks and meet modern requirements. In other words, education and science systems must be able to adapt to new economic, social, technological problems. In addition, non-linear and contingent factors play an important role in the process of innovative activity, since in the field of organizational and economic innovations, a single innovation may follow several independent development pathways. For example, in the process under consideration, the 50-year work of the American soil scientist Rattan Lal plays an indispensable role in the current global application of green innovations. According to the scientist's well-founded calculations, if the organic matter of the soil is increased by just 1%, there is a strong possibility of

fully compensating for global emissions [3]. It is gratifying that this idea has not only remained on paper, but has also laid the foundation for the “4 per 1000” initiative and has become a global movement. R. Lal’s experiments substantiate the multifunctionality of the soil, that is, it is not only a place for growing crops, but also the largest carbon sink. Based on this experience, methods such as no-till, cover crops, and organic residue return to the soil have become the standard worldwide. In order to put Ratton Lal’s theory into practice, Eric Toensmeier cataloged more than 100 permanent crop and agroforestry methods in his book “The Carbon Farming Solution” [4]. Interestingly, Toensmeier notes that replacing permanent crops, especially cotton and wheat, with trees such as pomegranates, almonds, and pistachios, can store a huge amount of carbon in the soil, up to 30 times more [4]. In addition, this method saves almost two-thirds of the water. The scientist’s experiments have been tested on millions of hectares, from the Australian deserts to the tropical forests of Costa Rica. As a result, regenerative methods have been proven to increase farmers’ income by 3-5 times. Toensmeier’s methods were adapted to deserts by Zimbabwean scientist Allan Savory. He converted 40 million hectares of desert into grasslands and demonstrated that sheep and cattle can perform functions similar to mechanical soil disturbance through controlled grazing practices [5]. In this case, the livestock would eat the grass, and the grazing residues would act as fertilizer and break up the soil, leading to new growth. Allan Savory’s integrated management approach has increased soil carbon storage from 3 to 10 tons per hectare [5]. In addition to these indicators, farmers have been able to increase livestock numbers by 30 to 50 percent. Remarkably, the combined scientific basis of Lal, Toensmeier, and Savory has inspired some of the world’s largest companies. This trend is illustrated by Nestlé, which launched a USD 1.4 billion program in 2020 [8]. As a result, by 2025, the company will have grown almost a third of its ingredients regeneratively. They have released a new variety for Nescafé coffee called “Star 4” that has increased climate resilience by 50%. Moving on to more recent results, PepsiCo has increased yields by 36% through a barley pilot project in Colombia [9]. Not only this achievement, the company has also begun work on creating a global map of regenerative agriculture by 2026 in partnership with National Geographic. Various platforms have been developed to bring this scientific basis to farmers, one of which is Cropin AI. This platform uses satellite imagery to monitor each hectare of land individually, providing information on which areas need spraying, irrigation, and other needs. The results of the trial conducted on 12 million hectares of land in India show that the project is effective. This system reduced pesticide use by 58% and increased yields by 31% [10]. These experiments prove that green innovations are no longer just dry theory, but have

become a multi-billion dollar business and the primary way of doing business for millions of farmers.

Table 1.1

Ecological and Economic Efficiency of Innovative Agricultural Services and Regenerative Approaches

Scientist Organization	Core Methodology	Water Conservation	Yield Growth	Reduction in Pesticide Use	Carbon Sequestration (t/ha/year)
Rattan Lal	No-tillage farming + cover crops	50-60 %	+25-40 %	-70-80 %	3-8
Eric Toensmeier	Perennial crops + agroforestry	60 %	+30-50 %	-80 %	8-30
Allan Savory	Rotational grazing (holistic management)	40-50 %	+30-50 %	-50-70 %	3-10
Nestlé	Regenerative supply chains	40 %	+30 %	-50 %	5-12
PepsiCo	Barley-based pilot project	35-45 %	+36 %	-60 %	4-8
Cropin AI	Satellite monitoring + AI	50-60 %	+31 %	-58 %	3-7

Source: Analysis of global indicators of green agrarian innovations[3, 4, 5, 8, 9, 10]

Each new research initiative or corporate project presented in the table demonstrates its effectiveness in agro-innovation through high levels of water conservation, yield improvement, reduction in pesticide use, and carbon sequestration. In this context, Uzbekistan can also be regarded as part of the global chain of experience and has the potential to adapt these innovations across millions of hectares of agricultural land.

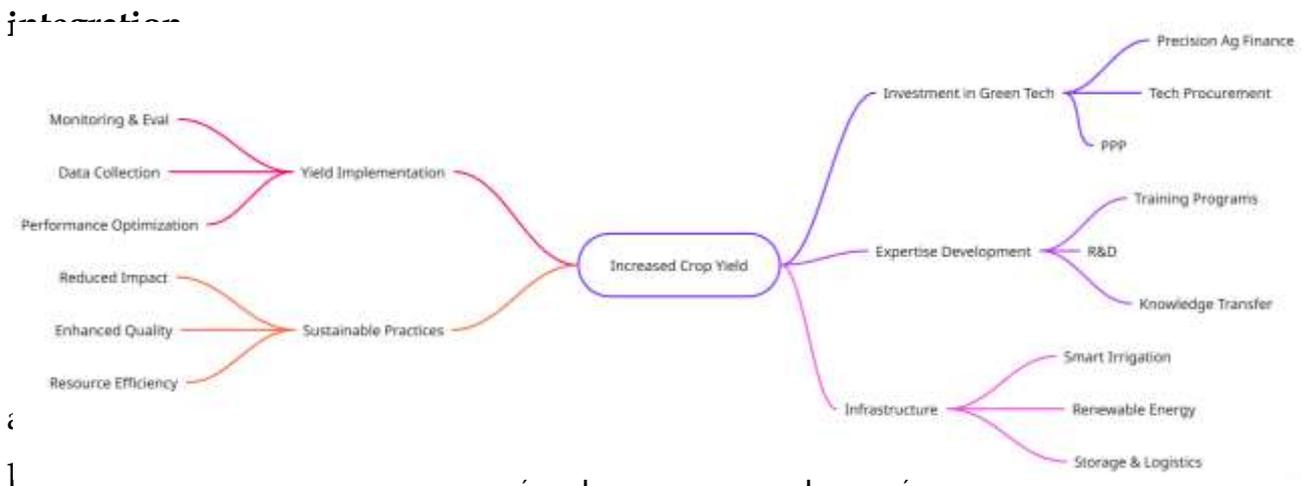
Conclusions and recommendations

The process of introducing green innovations in agricultural production and their effective management should be carried out on the basis of a phased approach. This process begins with creating conditions for the formation of new green agro-services that save resources, reduce negative environmental impact, and serve sustainable production based on intellectual initiatives and environmentally friendly innovations. At the next stage, attracting green investments and organizing financial mechanisms, followed by ecological and economic expertise of the proposed innovative solutions, are of great importance. The final stage involves the formation of green infrastructure facilities, including the introduction of

environmentally friendly technologies, renewable energy sources, and digital monitoring systems.

Figure 1.1

Strategic roadmap for increasing crop yield through green innovation



branch highlights specific actionable components—such as Public-Private Partnerships (PPP), Knowledge Transfer, and Smart Irrigation—that collectively drive sustainable yield implementation and resource efficiency.

As a management model aimed at ensuring the consistent implementation of these stages, a model of digital agro-platforms supporting green innovations in the agricultural sector is proposed. This model allows farms to order environmentally friendly equipment rental, organic seeds and fertilizers, green financing, sustainable marketing, and “green logistics” services online through special Internet-based platforms. This approach allows reducing costs by increasing the speed of production processes, eliminating territorial restrictions, and ensuring the efficiency of resource use. At the same time, the effectiveness of digital agro-platforms is directly related to the level of development of the Internet infrastructure, information security, and the reliability of data in environmental monitoring, and these factors are manifested as the main limitations. In international experience, the “AgroStar” platform in India is recognized as a successful model in the application of green innovations, while in Uzbekistan, the improvement of the “Agroplatform” project aimed at green innovations management and its implementation in pilot regions will serve to ensure the environmentally sustainable development of the agricultural sector. In addition, a hybrid (integrated) model is also widely used. This approach combines several organizational methods. For example, a cluster system can operate within an agro-technopark built on the basis of PPP, and this system can be connected to a digital platform. Such a model allows you to use the positive aspects of each approach and increases the ability to quickly adapt to market demand. However, its main

limitation is the complexity of management and the need for multilateral agreements. Thus, when organizing innovative agro-services, it is necessary to deeply analyze the advantages and limitations of each model, adapt them to the specialization, economic potential and level of infrastructure of the territory. Practical experience in Uzbekistan shows that there is an opportunity to achieve high efficiency by integrating several models. The proposed proposals for the formation of innovative services take into account the differentiation of individual elements of innovative development and can be applied both at the republican and regional levels, since they are based on a theoretical and methodological basis for managing innovative processes in the economy.

REFERENCES:

1. **Administration of the President of the Republic of Uzbekistan.** (2019). Resolution No. PQ-4477. Official website of the President of the Republic of Uzbekistan.
2. **Ministry of Agriculture of the Republic of Uzbekistan.** (2025). Agricultural Statistics of Uzbekistan. Tashkent: Ministry Publication.
3. **Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan.** (2025). Report on the Results of the “Yashil Makon” Project. Tashkent: Ministry Publication.
4. **Lal, R.** (2020). Soil organic matter content and crop yield. Journal of Soil and Water Conservation.
5. Toensmeier, E. (2024). The Carbon Farming Solution. Chelsea Green Publishing.
6. Savory, A. (2024). Holistic Management. Island Press.
7. FAO. (2024). The State of Food and Agriculture. Rome: FAO.
8. UNDP. (2024). Human Development Report. New York: UNDP.
9. Nestlé. (2025). Regenerative Agriculture Report. Nestlé Global.
10. PepsiCo. (2025). Food for Tomorrow Initiative. PepsiCo Inc.
11. Cropin AI. (2025). Annual Report on AI in Agriculture. Cropin Technology.
12. EU-AGRIN. (2025). Project Final Report. European Union.
13. **Institute of Soil Science and Agrochemical Research.** (2024). Soil Degradation Report. Tashkent.
14. FOLUR. (2025). Project Outcomes Report. FAO.
15. **Abramov, S. I.** (2000). Investment. Moscow: Center for Economics and Marketing. 440 p.

16. **Abdusattorova, Kh. M.** (2011). Innovation Strategy. Textbook. Tashkent: Tashkent State University of Economics. 278 p.

17. **Djuraeva, D. D.** (2019). The role of enhancing human potential and innovative activity in the development of the national economy. Scientific Bulletin of Bukhara State University, No. 4, pp. 309–316. (10.00.00, № 1).