Development of green technologies in agriculture: investment opportunities and challenges

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Abstract . The article discusses the concept of a "green" economy, and also analyzes the concept of "green" bonds. The role of consumer demand as a factor in the development of the concept is assessed. Therefore, the development of green technologies in agriculture represents a necessary alternative to increase food production while minimizing the negative impact on the environment. In addition, green technologies in agriculture open up new opportunities for economic growth and development. Innovative approaches such as digitalization, the use of sensors and data analytics, and biotechnology can significantly improve the productivity and efficiency of agricultural production. This helps improve the competitiveness of agricultural enterprises and create new jobs. Thus, studying this topic allows us to identify the potential for the development of green technologies in agriculture, as well as develop strategies to overcome existing challenges and obstacles.

1 Introduction

Over time, technology has significantly influenced society, economies, and lifestyles, fostering advancements and facilitating the emergence of leisure classes. Notably, science has contributed various technological innovations, spanning from aircraft and automobiles to biotechnology and the internet, fundamentally altering human experiences and enhancing comfort.

In striving for improvement, societies often compare existing systems to hypothetical "ideal systems," conceptualized as perfect in every aspect. These idealized standards, such as ideal engines or switches, serve as benchmarks for enhancing practical devices or systems. Researchers continuously strive to refine practical technologies by aligning their characteristics with those of ideal models, thereby improving performance and quality.

The concept of an ideal technology model envisions a system capable of meeting all basic human needs while promoting luxurious comfort without adverse societal or environmental impacts. Such an ideal technology should elevate quality of life universally, fostering happiness and contentment for all. To delineate ideal technology system characteristics, a

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model incorporating input, output, environmental conditions, and system requirements is proposed

2 Materials and methods

This study attempts to develop our own model for assessing the impact of green technologies on the environment, as well as forecasting the reduction of greenhouse gas emissions, reduction of water and energy consumption, etc.

3 Results

Currently, the concept of a “green” economy and “green” technologies represents a paradigm shift towards sustainable development, including a fairly large number of elements and aimed at harmonizing economic growth in the context of environmental management.

At its core, the green economy paradigm embodies a shift from traditional growth models based on resource depletion and environmental degradation towards a regenerative economic model based on resource efficiency, ecosystem resilience and social inclusion .

Central to the idea of using a green economy is the idea of decoupling economic growth from environmental degradation, thereby exploring the possibilities of economic prosperity and environmental sustainability at the same time. This entails a fundamental reorientation of production and consumption patterns towards low-carbon , resource-efficient and environmentally friendly alternatives, thereby mitigating environmental impacts while increasing economic sustainability and competitiveness.

In the agricultural sector of the Russian Federation in recent years, green technologies are a set of tools and elements for the implementation of environmental programs, including a wide range of innovations aimed at increasing agricultural productivity while minimizing the impact on the environment.

In conclusion, we note that the implementation of investment opportunities for the development of green technologies in agriculture faces a number of huge challenges covering financial, technological, infrastructural, regulatory and socio-cultural aspects. Addressing these challenges requires a concerted, multi-stakeholder approach that includes policy reforms, technological innovation, capacity-building initiatives and public awareness campaigns, thereby creating an enabling environment that promotes the sustainable integration of green technologies into agricultural systems.

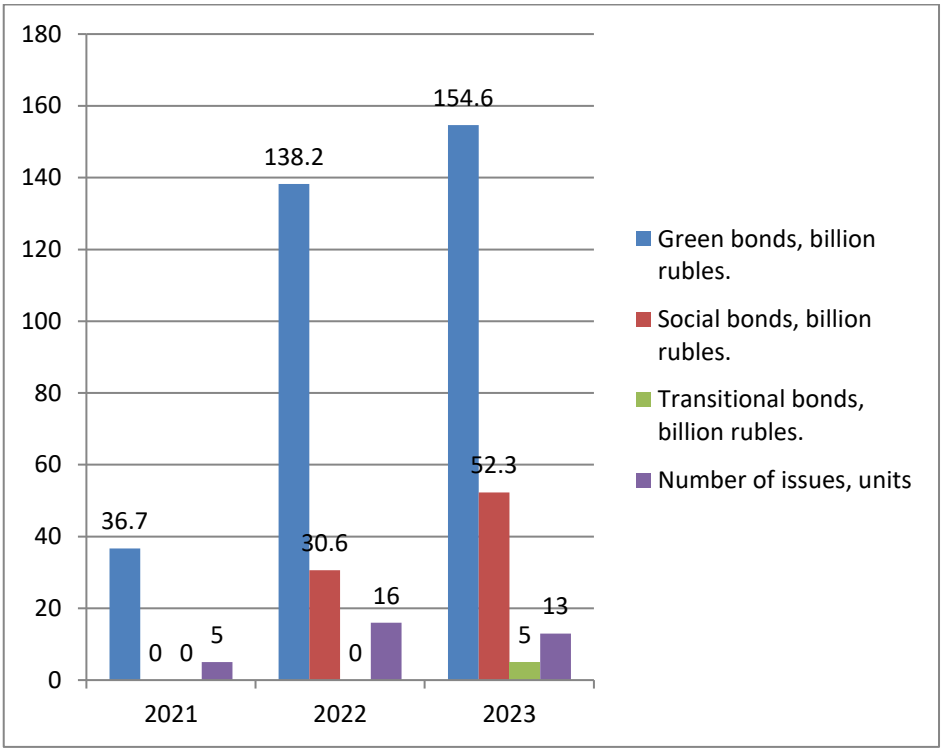

Fig. 1. Volume and number of bond issues in the format of sustainable development of Russian issuers 2021-2023, units. / billion rub

2023 showed even greater development in this direction - the size of issued "green" bonds increased by 10.6% and amounted to 154.6 billion rubles (Figure 1 - Volume and number of bond issues in the sustainable development format of Russian issuers 2020-2023. , units / billion rubles).

Consequently, based on the results of the analysis of the above Figure 1, we can conclude that currently agriculture, from the point of view of the development of innovative technologies, including the use of "green" technologies, is experiencing a rapid leap in its development. In this regard, it must be said that agriculture in the Russian Federation is achieving certain successes from a strategic point of view, since green technologies are necessary for the effective development of the agro-industrial sector of our country. We believe that green technologies will over time displace even more different outdated and traditional approaches to the implementation of agricultural production.

It is for this reason that the introduction of green technological solutions in the development of agriculture in the Russian Federation solves a large number of different problems. Among the green technologies known in 2024 are zero tillage, organic farming and the use of environmentally friendly electrical energy technology.

4 Discussion

The agricultural sector has undergone significant transformations over time to meet the increasing food demands of the expanding global population. According to projections by the Food and Agriculture Organization (FAO) of the United Nations, the world's population is expected to reach 9.7 billion by 2050, necessitating a 70% increase in food production. Challenges such as diminishing agricultural land and water resources, alongside the impacts

of climate change, exacerbate this issue. Moreover, achieving higher food production levels without causing environmental harm poses a significant challenge.

However, emerging technologies offer the potential to revolutionize agriculture, enabling more efficient and sustainable food production practices. The integration of advanced technologies such as precision agriculture, the Internet of Things (IoT), robotics, genetic engineering, and controlled environment agriculture holds promise for the future of farming. These technologies empower farmers to optimize their operations, enhance productivity, and contribute to the development of resilient and sustainable food systems.

The evolving landscape of agricultural research is characterized by the incorporation of these emerging technologies, presenting a substantial opportunity to address the sector's challenges. By harnessing the potential of these technologies, agricultural research can pave the way for a more efficient, resilient, and environmentally friendly future of farming. This approach ensures global food security while promoting sustainable agricultural systems.

Agricultural Robotics:

Robotics encompasses a diverse field of engineering and science dedicated to designing, building, and operating robots, along with the associated computer systems for their control and data processing. In agriculture, robots and drones are finding new applications such as weed control, cloud seeding, seed planting, harvesting, environmental monitoring, and soil analysis. These tasks are facilitated through various platforms including satellites, aerial vehicles like unmanned aerial vehicles (UAVs), and ground-based vehicles like unmanned ground vehicles (UGVs), such as field robots or commercially available off-highway vehicles.

Genomic Technologies/Nutrigenomics:

Genomic technologies involve manipulating and analyzing genomic information to drive advancements in crop breeding. Tools like genome editing enable precise modifications to native genes, enhancing traits such as nutritional value, disease resistance, and yield. Marker-assisted selection and CRISPR-Cas9 gene editing methods have revolutionized crop breeding practices, allowing for the development of improved crop varieties.

Blockchain in Agriculture:

Blockchain technology provides a decentralized ledger of accounts and transactions, offering a reliable source of truth for agricultural data such as farm information, inventories, and contracts. This transparency within the agricultural supply chain facilitates traceability of products, ensuring consumers have access to information regarding product origin, quality, and production methods. By promoting transparency and trust, blockchain enhances fair trade practices and improves supply chain management efficiency.

Artificial Intelligence (AI) and Machine Learning (ML):

AI and ML technologies empower automation in farming operations by mimicking human cognitive abilities to perform complex tasks like decision-making, data analysis, and language translation. Machine learning algorithms are trained with data sets to develop models capable of tasks such as planting, harvesting, and sorting crops. These technologies utilize data from sensors, cameras, and machine vision systems to execute tasks accurately and efficiently, driving productivity and optimization in agriculture.

Bioinformatics:

Bioinformatics applies computational methods to biological data, playing a pivotal role in agricultural research. It enables scientists to analyze large-scale genomic and biological datasets, leading to advancements in crop improvement, livestock breeding, disease management, and sustainable agriculture. Through techniques like transcriptomics and proteomics, researchers gain insights into gene expression patterns, protein interactions, and metabolic pathways, informing innovative strategies for crop enhancement and management.

5 Conclusion

The development and adoption of emerging agricultural technologies are still in their infancy. To effectively integrate these technologies into the agricultural sector, pilot testing and scientific validation are essential. Scientific institutions play a crucial role in conducting these tests to determine the scope and opportunities for adopting these technologies to enhance food and nutritional security. However, it is imperative that this process aligns with sustainable development goals (SDGs) and prioritizes environmental preservation.

Moreover, comprehensive training programs are necessary to equip farmers with the knowledge and skills required to adopt these technologies successfully. By providing farmers with proper training, they can maximize their profits while minimizing damage to natural resources and the ecosystem. This holistic approach ensures that the adoption of emerging technologies in agriculture contributes to sustainable development and addresses the challenges of food security and environmental conservation.

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