# SOCIETY 5.0 AND ITS IMPACT ON AGRICULTURAL BUSINESS AND INNOVATION: A NEW PARADIGM FOR RURAL DEVELOPMENT

*Cariša Bešić[1], Dragan Ćoćkalo[2], Mihalj Bakator[3], Sanja Stanisavljev [4], Srđan Bogetić [5]*

**Corresponding author E-mail: mihalj.bakator@uns.ac.rs*

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ABSTRACT

This paper analyzes the impact of Society 5.0 on agricultural business and innovation, proposing a new paradigm for rural development. Society 5.0 represents the evolution beyond previous societal models, aiming to harmonize economic progress with solutions to social issues through the integration of cyberspace and physical space. Central to this model is the application of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), robotics, big data, and augmented reality. The study focuses on the significant changes within agricultural practices and business models. Through a review and analysis of current trends, the paper presents a theoretical framework The paper also proposes the Agricultural Business and Rural Development Potential (ABRDP) index as guide for future trends and potential outcomes in the agricultural domain, offering insights into optimistic, conservative, and pessimistic scenarios for rural development.

1 Cariša Bešić, Ph.D., Full Professor, University of Kragujevac, Faculty of technical science Čačak, 32000 Čačak, Svetog Save 65, Republic of Serbia, Phone: +381 60 369 96 96, E-mail: carisa.besic@sbb.rs, ORCID ID (https://orcid.org/0000-0001-5370-5328)

2 Dragan Ćoćkalo, Ph.D., Full Professor, University of Novi Sad, Technical faculty "Mihajlo Pupin" in Zrenjanin, 23000 Zrenjanin, Đure Đakovića bb, Republic of Serbia. Phone: +381 62 801 97 41, E-mail: dragan.cockalo@tfzr.rs, ORCID ID (http://orcid.org/0000-0003-2085-5420)

3 Mihalj Bakator, Ph.D., Teaching Assistant, University of Novi Sad, Technical faculty "Mihajlo Pupin" in Zrenjanin, 23000 Zrenjanin, Đure Đakovića bb, Republic of Serbia. Phone: +381 61/180-61-69, E-mail: mihalj.bakator@uns.ac.rs, ORCID ID (http://orcid.org/000-0001-8540-2460)

4 Sanja Stanisavljev, Ph.D., Assistant Professor, University of Novi Sad, Technical faculty "Mihajlo Pupin" in Zrenjanin, 23000 Zrenjanin, Đure Đakovića bb, Republic of Serbia, E-mail: sanja.stanisavljev@tfzr.rs, ORCID ID (https://orcid.org/0000-0003-3565-2597)

5 Srđan Bogetić, Ph.D., Professor of Vocational studies, Belgrade Business and Arts Academy of Applied Studies, 11000 Belgrade, Kraljice Marije 73, Republic of Serbia, E-mail: sbogetic@yahoo.com, ORCID ID (https://orcid.org/0000-0003-1855-0767)

## Introduction

Society 5.0, a concept originating from Japan, represents a vision of a new societal model. This concept goes beyond the previous societal stages of hunter-gatherer (Society 1.0), agrarian (Society 2.0), industrial (Society 3.0), and information (Society 4.0). Society 5.0 aims to balance economic advancement with the resolution of social problems through a system that highly integrates cyberspace and physical space (Narvaez Rojas et al., 2021).

In Society 5.0 the extensive use of advanced technologies such as the Internet of Things (IoT) (Huang et al., 2022), artificial intelligence (AI) (Bryndin, 2020), robotics (Nair et al., 2021)), big data (Foresti et al., 2020), and augmented reality (Kasinathan et al., 2022) is fundamental. These technologies are not just seen as tools for economic growth, but also as means to create a more inclusive, human-centered society. One of the key principles of Society 5.0 is the harmonization of technological advancement with human needs. Technological advancement also brings competitiveness that further positively influences economic growth (Bakator et al., 2019; Djordjevic et al., 2021a). Unlike the previous society models, which often prioritized economic growth over social welfare, Society 5.0 places a strong emphasis on using technology to improve quality of life for all individuals. This includes creating more efficient and sustainable cities, improving healthcare through technology, and ensuring equal access to information and services (Djalic et al., 2021). Society 5.0 also envisions a future where data and technology are used to create more responsive and effective governance. Governments in this model are expected to use big data and AI to better understand and respond to citizens' needs, leading to more personalized and efficient public services. This approach also encourages greater collaboration between the public and private sectors, fostering innovation and societal well-being (Djordjevic et al., 2021b).

In the context of Society 5.0, agricultural business and innovation are undergoing a transformative phase, driven by the integration of advanced technologies and a shift towards more sustainable and efficient practices. This transformation is essential in addressing global challenges such as food security, climate change, and the need for sustainable resource management (Kusdiyantu et al., 2022; Ragazou et al., 2022; Rajnović et al., 2023). One of the most significant innovations in agriculture within Society 5.0 is the adoption of precision farming techniques (Raj et al., 2022). Another key area is the development of smart farming systems. These systems integrate various technologies to monitor and automate agricultural processes (Dhanaraju et al., 2022). For example, sensors can provide real-time data on soil moisture and nutrient levels, while AI algorithms can analyze this data to optimize irrigation and fertilization schedules. This level of automation not only improves efficiency but also reduces the need for manual labor, which is particularly beneficial in regions facing agricultural labor shortages. The development of technological solutions can further improve rural tourism and competitiveness of the agro-sector (Leković et al., 2020).

The current body of literature of agricultural business development is broad and includes various aspects and trends. This paper aims to expand the current body of literature by thoroughly analysing existing studies and available data across databases that track indicators in the domain of agriculture. The paper provides interesting insight into the agricultural business development potential of Serbia. Potential development scenarios are discussed. Additionally, suggestions and guidelines for improving the domestic agricultural business sector are noted.

The paper consists of five main sections. First, a brief introduction on the topic is presented. Next, the materials and methods are explained. Third, a theoretical background is given. Further, the results are presented as well as the potential scenarios of future development. After this, suggestions and guidelines for improvements are discussed. Finally, conclusions are drawn and ideas for future research are noted.

## Materials and methods

The study included the following main phases. **Phase 1:** Review of the existing literature was conducted and data an information was draw from a diverse array of sources including scholarly articles, conference proceedings, governmental reports, and statistical databases. In order to access publications and establish a solid theoretical foundation, the KoBSON service, a Serbian consortium for digital libraries, was used. Additional platforms and services included WoS, DOAJ, IEEE, Scopus, JSTOR, arhivX. **Phase 2:** Following the literature review, a theoretical framework was developed to guide the analysis of collected data. The research process also involved the formulation and testing of specific hypotheses related to the aims of the paper. These hypotheses were examined through the developed theoretical framework and ABRDP index, correlating macro-economic values, investments in agriculture, research and development expenditure, and environmental factors with the potential for agricultural business and rural development. The following hypotheses are proposed:

- $H_1$: Higher macro-economic values of agricultural production index, gross per capita agricultural production index, share in agricultural land use, and agriculture value added positively affect agricultural business and rural development potential.
- $H_2$: Higher credit to agriculture development and gross domestic value of agriculture positively affect agricultural business and rural development potential.
- $H_3$: Higher number of organizations that conduct R&D in agriculture, investments into agriculture, and research and development expenditure, positively affect agricultural business and rural development potential.
- $H_4$: Higher GDP, GDP per capita, and net salaries growth positively affect agricultural business and rural development potential.
- $H_5$: Higher temperature change of land and inflation rates negatively affect agricultural business and rural development potential.

**Phase 3:** The data analysis phase was multifaceted, employing deductive reasoning from the datasets, qualitative analysis through comparison with other studies, and the construction of a basic linear model. This model was developed for exploring potential future directions for sustainable agribusiness practices and understanding the relationship between technological advancements and rural development potential. A novel aspect of this research was the development of the Agricultural Business and Rural Development Potential (ABRDP) index. This index served as a quantitative measure of the impact of various factors on agricultural business and rural development. Indicators such as the agricultural production index, temperature change of land, credit to agriculture development, and GDP were identified and analyzed. The calculation of the ABRDP index, based on coefficients derived from these indicators, provided a unique metric for assessing future trends in the agricultural domain. **Phase 4:** In the final stage, the findings were synthesized to propose recommendations for advancing agribusiness practices in Serbia and beyond. Insights from the literature review, theoretical framework, and ABRDP index analysis were utilized to suggest practical and policy-oriented recommendations.

## Theoretical background on Society 5.0, sustainable development, and agribusiness

Rural development in the context of agricultural business encompasses a multi-approach aimed at improving the economic, social, and environmental well-being of rural communities. This development is particularly significant as agriculture remains a primary source of livelihood for a large portion of the global rural population (Jeločnik et al., 2023; Pavlova, 2022). Economically, rural development focuses on diversifying agricultural activities and increasing productivity (Tamsah & Yusriadi, 2022). Socially, rural development initiatives aim to improve the quality of life in rural areas (Khan et al., 2022). This includes ensuring access to essential services like healthcare, education, and connectivity (Ge et al., 2023; Tiwari, 2023). (Empowering local communities, especially women and marginalized groups, through education and skill development is important (Zikargae et al., 2022). These efforts help in creating a more inclusive rural workforce, thereby fostering a sense of community and belonging.

Environmental sustainability is another significant aspect of rural development (Koul et al., 2022). Sustainable agricultural practices such as organic farming, conservation agriculture, and efficient water management are encouraged to preserve natural resources (Wanniarachchi & Sarukkalige, 2022). Such practices help in mitigating the impacts of climate change and maintaining ecological balance, which is vital for the long-term sustainability of rural areas (Bwambale et al., 2022). Infrastructure development is also integral to rural progress (Hussain et al., 2022). Improving transportation networks, storage facilities, and market access enables farmers to reach broader markets (Kaiser & Barstow, 2022). Additionally, access to renewable energy sources can transform rural living, making it more sustainable and less reliant on traditional, often environmentally harmful, energy sources (Rahman et al., 2022).

Innovations are not only reshaping agriculture but also play an important role in promoting rural development (Mahdad et al., 2022; 2Vrabcová & Urbancová, 2023), One of the key technologies in modern agriculture is the Internet of Things (IoT). IoT devices, such as soil sensors and climate monitoring equipment, provide real-time data on environmental conditions. This data enables farmers to make informed decisions about irrigation, fertilization, and pest control, leading to more efficient resource use and higher crop yields (Rehman et al., 2022). Additionally, IoT technologies facilitate precision agriculture, which optimizes field-level management with regard to crop farming (Pallathadka et al., 2023). Artificial Intelligence (AI) and Machine Learning (ML) are also revolutionizing agricultural practices Shaikh et al., 2022). AI-driven analytics can predict weather patterns, analyze crop health, and even automate tasks such as harvesting. This not only increases efficiency but also helps in mitigating risks associated with farming, such as unpredictable weather conditions. AI can also support decision-making processes, improving the overall productivity and sustainability of agricultural systems (Sood et al., 2022).

Drone technology is an innovative tool that transfors agriculture. Drones can be used for a range of tasks, from aerial surveillance of crops to the precise application of pesticides and fertilizers (Rejeb et al., 2022). Blockchain technology holds promise for ensuring transparency and traceability in the agricultural supply chain. It can be used to track the road of produce from farm to consumer, ensuring food safety and quality (Sajja et al., 2023). This increased transparency can lead to better market access for rural farmers and fairer pricing.

In addition, technological advancements can address some of the significant challenges faced by rural areas, such as labor shortages and limited access to markets (Cock et al., 2022). For instance, automated farming equipment can compensate for the lack of agricultural labor (Takeshima, 2024), and e-commerce platforms can connect rural farmers directly with consumers, bypassing traditional, often less efficient, supply chains (Liu et al., 2023).

The development of advanced biotechnologies include genetically modified crops that are more resistant to pests and diseases, require fewer chemical inputs, and can withstand extreme weather conditions (Das et al., 2023). Additionally, advancements in gene editing, such as CRISPR technology, offer the potential to rapidly develop crops with desired traits, such as improved nutritional value or reduced need for water and fertilizers (Aman Mohammadi et al., 2023). These technologies not only increase crop yields but also help in conserving biodiversity and adapting to climate change.

Another area of innovation is in the field of robotics and automation (Pearson et al., 2022). Autonomous tractors, drones, and robotic harvesters are becoming increasingly sophisticated and capable of performing complex agricultural tasks. These technologies can significantly reduce labor costs and increase precision in farming operations  For example, robotic systems can be programmed to selectively harvest ripe fruits, thereby reducing waste and improving the quality of produce.

Vertical farming and urban agriculture are also emerging as innovative approaches in agricultural business (Lubna et al., 2022; Siregar et al., 2022). They require less land and water than traditional agriculture and can reduce the carbon footprint associated with transporting food into urban areas. This approach is particularly promising for growing high-value crops like herbs and leafy greens in urban settings (Jeager et al., 2022).

The future of agricultural business is likely to be shaped by a diverse innovations. From biotechnology and robotics to AI, blockchain, and renewable energy, these advancements hold the potential to transform agricultural practices, making them more efficient, sustainable, and profitable.

## Results

Based on the analysed literature, the framework for agricultural business and rural development potential is outlined through a dozen of indicators. These indicators don't necessarily confirm causation when it comes to agricultural business development, but provides a significant insight into future potential trends in the agricultural domain. The Agricultural Business and Rural Development (ABRDP) indicators are presented in Table 1. The base year was 2018 for indicators where applicable.

**Table 1.** Agricultural Business and Rural Development Potential (ABRDP) indicators

| Indicator | Label | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Agricultural production index | API | 107.59 | 107.75 | 110.88 | 104.28 | 98.31 | N/A |
| Gross per capita agricultural production index | GPAP | 108.81 | 109.46 | 113.29 | 107.44 | 102.35 | N/A |
| Share in agricultural land use (%) | SALU | 39.61 | 39.56 | 41.41 | 41.44 | 42.05 | N/A |
| Temperature change of land (°C) | TCL | 2.317 | 2.087 | 1.816 | 1.594 | 1.938 | N/A |
| Credit to agriculture development (millions of euros) | CTAG | 2794.46 | 2668.61 | 2943.23 | 3583.02 | 3869.87 | N/A |
| GDP (billions of euros) | GDP | 44.07 | 45.90 | 46.42 | 54.90 | 55.30 | 56.84 |
| GDP per capita (euros) | GDPC | 6309 | 6610 | 6727 | 8031 | 8297 | 9831 |
| Net salaries growth (%) | NETS | 4.5 | 8.5 | 3.7 | 8.8 | 9.64 | 13.76 |
| Inflation rates (%) | INFL | 1.96 | 1.90 | 1.58 | 4.09 | 11.98 | 7.6 |

| Indicator | Label | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Gross domestic value – Agriculture (%) | GDVAG | 1.9 | 2.2 | 2.0 | 2.1 | 2.3 | 2.2 |
| Organizations that conduct R&D in agriculture | RDAG | 33 | 33 | 32 | 32 | 33 | 33 |
| Country investment into agriculture (in millions of euros) | CIAG | 2794.46 | 2668.61 | 2943.23 | 3583.02 | 3869.87 | N/A |
| Research and development expenditure (% of GDP) | RDE | 0.92 | 0.89 | 0.91 | 0.99 | 1.01 | 1.03 |
| Agriculture value added (% of GDP) | AGVD | 6.34 | 5.95 | 6.34 | 6.29 | 6.46 | 6.88 est. |

Sources: (FAO, 2024; RZSS, 2024; The World Bank, 2024)

Currently, there are no indicators regarding biotechnology application, AI technology application, drone application, IoT solutions, and blockchain solutions in Serbia's agriculture. Therefore, the ABRDP index doesn't include these as there is no empirical data over time on these indicators. However, the suggestions and guidelines are indeed considering the advanced agricultural technology applications and these are appropriately noted.

The values from Table 1. are converted to coefficients for easier calculation of the Agricultural Business and Rural Development Potential (ABRDP) indicators. Where there was no data (N/A) the coefficient was taken from the year before. The other coefficients are calculated on a compared-to-max-value ratio. More precisely, the largest/most favorable values are converted into 100, while the others are proportionally less.

**Table 2.** Coefficients for the Agricultural Business and Rural Development Potential (ABRDP) index

| Coefficients | Label | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Agricultural production index | API | 97.03 | 97.18 | 110.88 | 94.05 | 98.31 | 98.31 |
| Gross per capita agricultural production coefficient | GPAP | 96.05 | 96.62 | 100 | 94.84 | 90.34 | 90.34 |
| Share in agricultural land usage coefficient | SALU | 94.20 | 94.08 | 98.48 | 98.55 | 100 | 100 |
| Temperature change of land coefficient | TCL | 54.64 | 69.07 | 86.07 | 100 | 78.41 | 78.41 |

| Coefficients | Label | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Credit to agriculture development coefficient | CTAG | 72.21 | 68.96 | 76.07 | 92.61 | 100 | 100 |
| GDP coefficient | GDP | 77.53 | 80.75 | 81.67 | 96.59 | 97.29 | 100 |
| GDP per capita coefficient | GDPC | 64.17 | 67.24 | 68.43 | 81.69 | 84.40 | 100 |
| Net salaries growth coefficient | NETS | 32.7 | 61.77 | 26.89 | 63.95 | 70.06 | 100 |
| Inflation rates coefficient | INFL | 75.95 | 79.74 | 100 | 1.00 | 1.00 | 1.00 |
| Gross domestic value – Agriculture coefficient | GDVAG | 82.61 | 95.65 | 86.86 | 91.30 | 100 | 100 |
| Organizations that conduct R&D in agriculture coefficient | RDAG | 100 | 100 | 96.97 | 96.97 | 100 | 100 |
| Country investment into agriculture coefficient | CIAG | 72.21 | 68.96 | 76.07 | 92.61 | 100 | 100 |
| Research and development expenditure coefficient | RDE | 91.09 | 88.11 | 90.10 | 98.02 | 100 | 100 |
| Agriculture value added coefficient | AGVD | 98.45 | 92.39 | 98.46 | 97.67 | 100 | 100 |

*Sources:* Authors

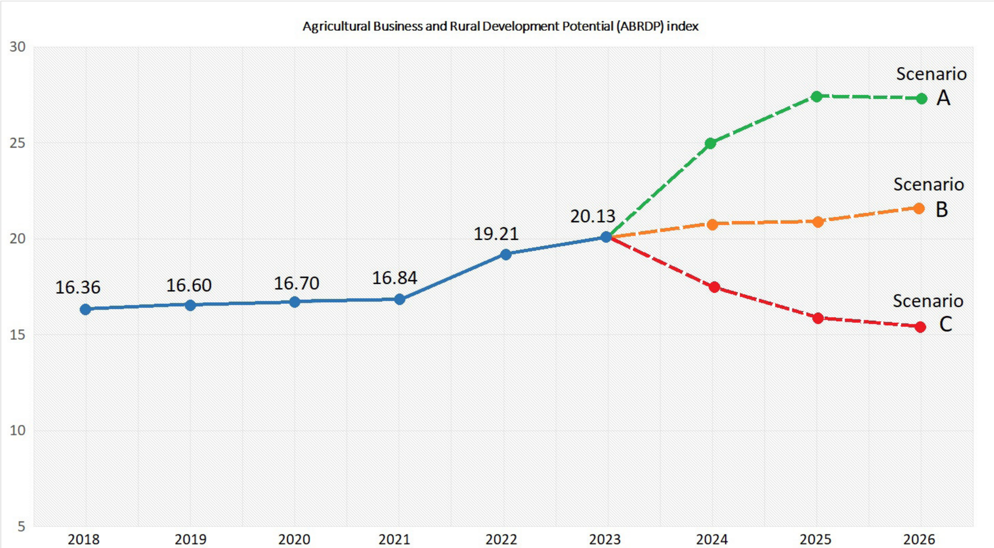
The Agricultural Business and Rural Development Potential (ABRDP) index calculation is based on the following equation:

ABRDP = [(API+GPAP+SALU+AGVD)*25+ (CTAG+GDVAG)*15+ +(RDAG+CIAG+RDE)*20+ (GDP+GDPC+NETS)*10- (TCL+INFL)*20]/1000

The ABRDP index is calculated based on the assumption of linear influences of the analyzed indicators. The ABRDP index is not addressing causation, but rather provides a basis for discussion and indication for future trends in this domain. Based on the equation and the coefficients from Table 2. the following ABRDP indexes are calculated: $ABRDP_{2018}$=16.36; $ABRDP_{2019}$=16.60; $ABRDP_{2020}$=16.70; $ABRDP_{2021}$=16.84; $ABRDP_{2022}$=19.21; $ABRDP_{2023}$=20.13.

Future trends based on the calculated ABRDP indexes are presented on Figure 1.

**Figure1.** ABRDP values and potential future outcomes (scenarios)




*Sources:* Authors

From 2018 to 2023, there is an observed increase in the ABRDP index, suggesting that factors influencing agricultural business and rural development are improving. Specifically, the index rises from 16.36 in 2018 to 20.13 in 2023. This growth trajectory is indicative of positive developments in the agricultural sector. This can further be positively influenced through the integration of advanced technologies and sustainable practices aligned with Society 5.0 principles, as discussed in the document. The graph projects three future scenarios:

Scenario A (green line) is the most optimistic, where the ABRDP index continues to rise sharply after 2023. This scenario would likely result from the successful optimization of renewable water sources, the application of new technologies and innovations in the agriculture sector, supportive government policies, improved standards of living, increased GDP, and reduced poverty risk.

Scenario B (orange line) represents a more conservative forecast, with the ABRDP index showing a plateau after 2023. This scenario might reflect a situation where economic and social indicators experience little to no change due to factors such as global economic crises, indicating a stagnation in the rate of sustainable development within the agricultural sector.

Scenario C (red line) is the pessimistic forecast, where the ABRDP index starts to decline after 2023. This could be the result of negative factors such as overexploitation of natural resources, ineffective water management, and the absence of strategic solutions for reversing unsustainable agribusiness processes, leading to a decrease in GDP.

The graph serves as a visual representation of the potential outcomes for agricultural business and rural development, dependent on how various economic, environmental, and social indicators evolve in the context of Society 5.0's impact on the agricultural sector.

## Discussion

Data analytics can provide insights into optimal planting times, soil health, and crop selection based on current production and yield data. This leads to better-informed decisions that can increase crop productivity. The transition from traditional farming practices to precision agriculture, utilizing IoT devices, allows for more efficient use of resources like water and fertilizers, tailored to the specific needs of different crop areas, thereby improving yields and reducing environmental impact. The economic realities of rural farming, such as market access and farmer incomes, are significantly impacted by digital platforms. E-commerce enables direct farmer-to-consumer sales, potentially increasing profits and reducing the dependency on middlemen. Current levels of resource use and environmental impact can be mitigated through sustainable practices. The adoption of organic farming and renewable energy sources reduces the carbon footprint and promotes the sustainable use of natural resources.

The introduction of automation and robotics in agriculture can lead to economic growth in rural areas by increasing efficiency and productivity. This can create new jobs in technology maintenance and management, contributing to the local economy. Smart governance can facilitate the development of modern infrastructure in rural areas. Policies that encourage investment in transportation and storage facilities can improve market access for farmers, thereby improving the overall agricultural value chain. The social dynamics of rural areas, including employment rates and community involvement in agriculture, are closely linked to education and skills development. Providing advanced training and education in modern agricultural techniques can empower local communities, leading to increased participation and innovation in agriculture. Practices that promote environmental sustainability in agriculture also have a positive impact on the social well-being of rural communities. Sustainable farming practices ensure long-term food security and preserve the natural resources that these communities depend on. The development of infrastructure directly influences economic growth in rural areas. Improved roads, better storage facilities, and access to markets facilitate the movement of goods and services, making agriculture more profitable and sustainable.

Advancements in technology and sustainable practices not only improve agricultural productivity but also have far-reaching implications for economic growth, environmental sustainability, and the social well-being of rural communities. These interactions highlight the transformative potential of integrating modern technologies into the agricultural sector within the broader framework of Society 5.0.

Based on the analysed literature and calculated ABRDP index, the hypotheses are assessed as follows:

- $H_1$: Higher macro-economic values of agricultural production index, gross per capita agricultural production index, share in agricultural land use, and agriculture value added positively affect agricultural business and rural development potential **is failed to be rejected.**
- $H_2$: Higher credit to agriculture development and gross domestic value of agriculture positively affect agricultural business and rural development potential **is failed to be rejected.**
- $H_3$: Higher number of organizations that conduct R&D in agriculture, investments into agriculture, and research and development expenditure, positively affect agricultural business and rural development potential **is failed to be rejected.**
- $H_4$: Higher GDP, GDP per capita, and net salaries growth positively affect agricultural business and rural development potential **is failed to be rejected.**
- $H_5$: Higher temperature change of land and inflation rates negatively affect agricultural business and rural development potential **is failed to be rejected.**

Based on the analysed literature about the integration of Society 5.0 innovations in agricultural business and their impact on rural development, here are suggestions and guidelines to improve both sectors:

- Implement precision agriculture that encourages the adoption of IoT, AI, and GPS technology to optimize resource use and increase crop yields.
- Develop infrastructure to support the use of drones, autonomous tractors, and robotic harvesters to reduce labor costs and improve efficiency.
- Encourage practices that minimize environmental impact, such as organic farming and conservation agriculture.
- Support the transition to sustainable energy sources like solar, wind, and biomass to power agricultural operations.
- Leverage big data to make informed decisions regarding crop selection, pest control, and weather predictions.
- Use climate data and predictive modeling to prepare for and mitigate the impacts of climate change on agriculture.
- Create and support online platforms for farmers to directly sell their produce, reducing reliance on middlemen.
- Develop financial products tailored to the agricultural sector to help farmers invest in new technologies and practices.
- Provide educational programs and workshops on the latest agricultural technologies and practices.

- Ensure that rural populations have the skills to utilize digital tools and platforms effectively.
- Build and maintain roads, and invest in storage facilities to reduce post-harvest losses.
- Invest in broadband infrastructure to ensure rural areas have reliable internet access.
- Foster partnerships between academic institutions, tech companies, and agricultural businesses to drive innovation.
- Allocate resources to research on crop improvement, sustainable practices, and climate adaptation strategies.
- Craft policies that support sustainable farming, technology adoption, and rural development.
- Encourage collaboration between government entities and private companies to fund and implement rural development projects.

By implementing these strategies and actions, rural development and agricultural business can be significantly improved, aligning with the principles of Society 5.0. These suggestions aim to create a sustainable, efficient, and inclusive agricultural sector that supports the broader goals of economic growth, environmental sustainability, and social well-being in rural communities.

## Conclusion

The exploration of Society 5.0's impact on agricultural business and innovation provides a comprehensive understanding of how advanced technologies and sustainable practices are pivotal in reshaping rural development. This study elucidates the transformative potential that lies in the integration of cyberspace and physical space, with a particular focus on the agricultural sector. This shift is not only essential for addressing pressing global challenges such as food security and climate change but also aligns with the overarching goals of Society 5.0 to balance economic advancement with social welfare.

The findings from this research underscore the importance of innovations. Moreover, the study introduces the Agricultural Business and Rural Development Potential (ABRDP) index as a tool for assessing future trends and potential outcomes, highlighting a positive trajectory for agricultural development under the influence of Society 5.0.

Future studies could delve deeper into the social implications of integrating advanced technologies in agriculture, particularly in terms of labor dynamics and rural-urban migration patterns. Additionally, there is a need for more empirical research on the scalability of innovative farming practices and their economic viability across different regions and farming systems. Investigating the role of policy and governance in facilitating or hindering the transition to a Society 5.0-aligned agricultural model could also provide valuable insights. Lastly, exploring the potential of emerging technologies not extensively covered in this study, such as nanotechnology and advanced genetic engineering, could uncover new opportunities for improving agricultural productivity and sustainability.

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### Conflict of interests

The authors declare no conflict of interest.

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