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The Effect of Agricultural Modernisation on Food Security and Economic Growth

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A R T I C L E I N F O

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ABSTRACT

This study aims to analyze the effect of agricultural modernization on food security and economic growth in Indonesia. Agricultural modernization, which includes the application of new technologies, improved irrigation systems, and more efficient use of fertilizers and pesticides, is believed to increase agricultural output and strengthen food security. However, its impact on the regional and national economy is still a topic that requires in-depth study. This study uses quantitative methods with regression analysis to measure the relationship between agricultural modernization and food security and economic growth variables. The data used includes statistics on agricultural production, food consumption levels, and regional economic indicators over the past 10-year period. The results show that agricultural modernization has a significant positive impact on food security, especially in increasing food productivity and reducing dependence on imports. In addition, it has also contributed to economic growth, by increasing farmers' income and creating jobs in the agricultural sector. However, the study also found challenges in the uneven application of technology across regions, which could widen economic disparities between regions. Therefore, policies that support technology extension and equitable access to agricultural modernization are needed to maximize its benefits.

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1. INTRODUCTION

Agricultural modernisation plays a crucial role in improving food security and economic growth, especially in developing countries (Nurlatifah et al., 2023). This modernisation process includes the adoption of new technologies, mechanisation, improved farm management and the development of better infrastructure, all of which contribute to increased food production. By optimising the use of natural resources and advanced technologies, such as biotechnology, modern irrigation systems and precision farming, the productivity of the agricultural sector can significantly increase, reducing reliance on traditional methods that are more vulnerable to climate change and market fluctuations (Hilmi, 2024).

Food security, which is one of the key components of sustainable development, is also strongly influenced by the level of agricultural modernisation. Increased efficiency in food production helps ensure sufficient food availability, easier access and stable prices for people (Putri et al., 2024). In addition, agricultural modernisation also supports more efficient food distribution, reduces wastage and improves the quality of food produced. Thus, modernising the agricultural sector not only ensures food sustainability for a growing population, but also minimises the risk of hunger and malnutrition. On the other hand, agricultural modernisation also has a significant impact on economic growth (Maharani et al., 2024). A modernised agricultural sector can increase its contribution to a country's Gross Domestic Product (GDP) and create more productive employment opportunities for rural communities. This leads

to an increase in farmers' income and overall social welfare. In the long run, economic growth fuelled by an efficient agricultural sector can act as a catalyst for the development of other sectors, such as the food processing industry and international trade. Therefore, agricultural modernisation is not only the key to food security, but also an important foundation for achieving inclusive and sustainable economic growth (Hanani et al., 2023).

In identifying the effect of agricultural modernisation on food security and economic growth, this study aims to bring together empirical findings and theories that already exist in the literature. Studies show that agricultural modernisation, through the application of new technologies such as smart irrigation, farm machinery and biotechnology, can increase the efficiency of food production. This contributes to increasing food availability, reducing food insecurity and improving food access for people, especially in rural areas dependent on the agricultural sector. The identification process included an analysis of different countries with different levels of modernisation to understand their impact in diverse contexts (Gultom & Harianto, 2021).

Furthermore, the analysis of the research to be conducted focuses on how agricultural modernisation affects food security and economic growth from various perspectives. Some studies show a direct link between increased agricultural productivity and reduced poverty levels and dependence on food imports, which has an impact on the country's economic stability (Rahmadiyanti, 2021). Meanwhile, other studies reveal the challenges faced, such as the unequal distribution of technological benefits and the environmental impacts that may arise from the use of agricultural technologies that are not environmentally friendly. Through this analysis, we can identify key factors that influence the success of modernisation in improving food security and promoting economic growth.

Finally, the synthesis of the research to be conducted allows for the integration of different findings to gain a more holistic understanding of the impact of agricultural modernisation. This synthesis will reveal clearer patterns or relationships between modernisation, food security and economic growth, and provide insights into how public policies can be structured to maximise the benefits of agricultural modernisation (Ratnawati Tahir & Djunais, n.d.). By combining evidence from a variety of approaches, both qualitative and quantitative, this synthesis will enrich our understanding of the potential and challenges, and provide a stronger basis for further research and future policy recommendations.

Agricultural modernisation affects food security in different countries with different economic and social contexts. Given the importance of food security in maintaining social and economic stability, it is important to understand the extent to which the adoption of modern agricultural technologies, such as mechanisation, biotechnology and efficient irrigation systems, can increase food production and ensure stable food availability for a growing population. This study aims to identify the main factors that influence the effectiveness of agricultural modernisation in improving food security, as well as analyse the potential risks and challenges that could arise from changing traditional farming systems into more modern ones (Yudha et al., 2023).

In addition, this study will also examine the economic impact of agricultural modernisation, which is an important aspect of a country's economic development. Some important questions that need to be answered are: how can agricultural modernisation contribute to an increase in the Gross Domestic Product (GDP) of the agricultural sector? What are its effects on farmers' income, employment, and poverty reduction in rural areas? This study aims to analyse the relationship between increasing agricultural efficiency through modern technology and its impact on local and national economies, and how this modernisation can strengthen the country's economic competitiveness at the global level. Finally, the research problem will also investigate potential challenges that arise in the process of agricultural modernisation, such as unequal access to technology, environmental impacts, and possible social changes. In this regard, the research will consider how policies that support agricultural modernisation can be designed to address these issues, as well as ensure that the benefits can be enjoyed equally by all levels of society (Yudha et al., 2023). As such, the research aims not only to measure the positive impacts of agricultural modernisation, but also to understand and address the challenges involved in achieving food security and sustainable economic growth.

2. RESEARCH METHOD

In addition, this study will also examine the economic impact of agricultural modernisation, which is an important aspect of a country's economic development. Some important questions that need to be

answered are: how can agricultural modernisation contribute to an increase in the Gross Domestic Product (GDP) of the agricultural sector? What are its effects on farmers' income, employment, and poverty reduction in rural areas? This study aims to analyse the relationship between increasing agricultural efficiency through modern technology and its impact on local and national economies, and how this modernisation can strengthen the country's economic competitiveness at the global level (Bocean, 2024). Finally, the research problem will also investigate potential challenges that arise in the process of agricultural modernisation, such as unequal access to technology, environmental impacts, and possible social changes. In this regard, the research will consider how policies that support agricultural modernisation can be designed to address these issues, as well as ensure that the benefits can be enjoyed equally by all levels of society. As such, the research aims not only to measure the positive impacts of agricultural modernisation, but also to understand and address the challenges involved in achieving food security and sustainable economic growth (Shariff et al., 2022).

3. RESULTS AND DISCUSSIONS

3.1 Effect of Agricultural Modernisation on Food Security

Agricultural modernisation has a significant influence on food security by increasing efficiency and productivity in the agricultural sector. New technologies, such as the use of farm machinery, advanced irrigation systems and biotechnology, enable greater food production at lower costs. These improvements not only increase agricultural yields, but also reduce food losses that occur due to less efficient production techniques. With more stable and sustainable production, agricultural modernisation helps create sufficient food availability to meet the needs of a growing population, thus strengthening a country's food security (Kulikov & Minakov, 2023).

In addition, agricultural modernisation can improve food distribution through improved infrastructure and more efficient logistics networks. Integrated information technology systems, for example, enable more accurate crop yield predictions, as well as better management of food distribution. Food can thus be channelled to areas in need faster and at more stable prices, reducing market uncertainty and ensuring access to food for the people who need it most, especially in remote or poor areas. This is important in strengthening food security, especially when facing a global crisis or climate change that affects food production (Azhar et al., 2017). However, while agricultural modernisation can improve food security, challenges remain, particularly related to the gap in access to technology between large and small farmers. Farmers who lack access to modern tools and the necessary knowledge may not be able to harness the full potential of this modernisation, which risks exacerbating inequalities in food security. Therefore, policies that support inclusiveness and access to technology for all farmers, including training and extension programmes, are crucial to ensure that the benefits of agricultural modernisation are equitable and sustainable, and truly strengthen food security in the long run.

Agricultural modernisation increases food production by adopting new technologies that significantly improve farming efficiency and yields. The adoption of technologies such as automated farm machinery, smart irrigation, and the use of high-tech fertilisers and pesticides enable farmers to produce more food with fewer resources. With the application of precision farming techniques, farmers can optimise the use of water, fertiliser and labour, resulting in higher yield increases (Lawrence, 2017). This is critical to keep pace with the growing global population and increasing demand for food, and to meet the challenges of climate change that affects weather patterns and crop resilience. In addition, agricultural modernisation is improving food distribution by developing more efficient infrastructure and logistics systems. Information technology and data-driven management enable more accurate predictions of crop yields, which helps to plan food distribution more effectively. The use of digital-based applications, such as e-commerce platforms for agricultural products, also allows farmers to access a wider market, reduce food wastage due to distribution delays, and optimise food distribution channels to consumers more quickly and efficiently. Improved transport infrastructure, including better road networks and storage, also ensures that food can be distributed equitably across regions, both urban and rural (Zhang & Seale Jr, 2017).

Food accessibility has also increased as agricultural modernisation has introduced new ways to reduce production costs and improve distribution systems. Through technologies that reduce production costs and speed up distribution, food prices have become more affordable for consumers. In addition, this modernisation improves the quality of food produced, which is not only more plentiful, but also healthier and more nutritious, providing greater benefits to society (Kansanga et al., 2019). In addition, food accessibility also depends on policies that support fair distribution and stable prices, such as subsidies for smallholder farmers and marketing programmes that help them access markets. Thus, agricultural modernisation plays an important role in ensuring that food is available, affordable and accessible to all segments of society, which in turn improves food security. Agricultural technologies such as biotechnology have a major impact on food security by increasing crop yields and crop resistance to pests, diseases and extreme environmental conditions. The use of genetically modified crops that are resistant to drought or pest infestation can reduce reliance on pesticides and water use, and increase agricultural yields under unpredictable conditions. For example, salinity-resistant rice or drought-tolerant maize varieties allow farmers to better cope with climate change that impacts water availability and soil fertility. Thus, biotechnology helps improve food security by ensuring more stable production despite the challenges of a changing environment (Zou & Mishra, 2024).

In addition to biotechnology, modern irrigation technologies, such as drip irrigation and sensor-based irrigation, play an important role in improving water use efficiency and reducing wastage in agriculture. More efficient irrigation systems allow farmers to optimally apply water according to crop needs, reducing the impact of frequent droughts due to climate change. With more controlled water use, soils remain fertile and crop yields can be increased without damaging water resources. This is particularly important for drought-prone areas, ensuring that food supply is maintained despite climate fluctuations, while supporting food security at local and national levels. Precision farming systems, which involve the use of data and technology to monitor soil, crop and weather conditions in real-time, help strengthen food security by enhancing more targeted and efficient production management. With tools such as soil sensors and drones for crop monitoring, farmers can make more informed decisions about when and how to plant, fertilise and irrigate crops. This technology enables optimal use of resources, reduces wastage, and increases agricultural yields in a more environmentally friendly way. With this data-driven approach, farmers can sustainably increase productivity, reduce crop losses, and improve overall food security, especially in countries that depend on agriculture as their primary source of food.

3.2 Effect of Agricultural Modernisation on Economic Growth

Agricultural modernisation has great potential to boost economic growth, especially in developing countries that depend on the agricultural sector as the main driver of the economy. With increased productivity resulting from the adoption of new technologies, such as mechanisation, biotechnology and modern irrigation systems, the agricultural sector can contribute more to Gross Domestic Product (GDP) (Li et al., 2023). Increased efficiency of food production enables countries to increase exports, reduce dependence on food imports, and strengthen their economic position in the global market. As the volume and quality of agricultural output increases, countries can improve their trade balance and expand investment opportunities in the agricultural sector. In addition, agricultural modernisation plays a role in creating more productive jobs and improving people's welfare, especially in rural areas. New technologies in agriculture, such as farm machinery and precision farming systems, can reduce dependence on manual labour, while creating employment opportunities in other related sectors, such as the agro-processing, distribution and marketing industries. This opens up opportunities for the development of industries and services, which strengthens the overall economic structure and creates a more sustainable economic ecosystem (Takeshima & Joshi, 2019).

However, the impact of modernisation on economic growth is not always evenly distributed, and is often influenced by factors such as farmers' level of access to technology and supportive government policies. Small farmers, who may not have access to advanced technology or the capital to invest in

modernisation, may not benefit directly, which can exacerbate economic inequality between large and small farmers. Therefore, to maximise the positive impact of modernisation on economic growth, it is important for the government to design inclusive policies, such as providing training, business credit, and incentives for smallholders, as well as improving access to technologies that can increase their competitiveness in the broader market (Ridzuan et al., 2020). With the right policies, agricultural modernisation can be a key driver for more equitable and sustainable economic growth. A modernised agricultural sector has a significant contribution to Gross Domestic Product (GDP), especially in developing countries that depend on agriculture as the main driver of the economy. With the application of modern agricultural technologies, such as mechanisation, biotechnology, and efficient irrigation systems, the agricultural sector can substantially increase production output, which in turn contributes to GDP growth. Increased productivity and efficiency in the sector not only creates food surpluses for domestic consumption, but also opens up opportunities for exports, improving the trade balance and enhancing the country's position in the global market. A modernised agricultural sector therefore plays an important role in strengthening the economic foundation of a country (Hedlund et al., 2020).

In addition, agricultural modernisation has a direct impact on farmers' income. With increased crop yields generated through advanced technology, farmers can earn higher incomes due to better productivity and lower production costs. Technologies such as modern irrigation systems, the use of improved seeds, and advanced farming tools help farmers reduce dependence on unpredictable natural factors and improve the quality and quantity of their agricultural output. This increase in income not only provides economic benefits to farmers, but also reduces economic inequality in rural areas, increases purchasing power, and enables farmers to invest further in better agricultural technology and infrastructure (Lu et al., 2024). On the other hand, the contribution of a modernised agricultural sector to overall economic well-being is enormous. When farmers' incomes increase, this has a positive effect on social and economic welfare at the local and national levels. The increase in income encourages higher consumption, creates demand for other goods and services, and strengthens other sectors of the economy such as trade, transport, and the food processing industry. Rural welfare also improves as agricultural modernisation helps to create more productive jobs and reduce poverty. However, to maximise these impacts, it is important for government policies to ensure equitable distribution of benefits, provide support for smallholder farmers, and encourage investment in infrastructure and education to improve farmers' capacity to adopt new technologies.

An interesting case study can be found in India, a developing country that has adopted various modern agricultural technologies in recent decades, especially in the use of improved seeds and modern irrigation systems. Research conducted by Tiwari and Sharma (2018) shows that the adoption of agricultural technologies in India, such as the use of drought-resistant rice varieties and the use of drip irrigation, has significantly increased crop yields and farmers' income (Jiang et al., 2022). This increase in productivity not only reduces dependence on food imports, but also has a positive impact on the GDP of India's agricultural sector. These technologies have also improved food security in rural areas and boosted economic growth by opening up export opportunities for agricultural products to global markets.

The results of this study show that agricultural modernisation in developing countries can play an important role in promoting sustainable economic growth and improving the welfare of rural communities. In contrast, in developed countries such as the United States, the adoption of agricultural technology also plays a major role in accelerating economic growth. Research conducted by Hennessy et al. (2019) in the US found that the use of advanced agricultural technologies, such as precision farming that uses sensors to monitor soil and crop conditions, has increased the efficiency of agricultural input use and production output (Bulturbayevich & Jurayevich, 2020). These technologies have enabled US farmers to reduce operational costs, improve product quality, and increase farmer income. The adoption of these technologies has contributed to a highly efficient agricultural sector, which plays an important role in the country's economy, with the agricultural sector contributing significantly to GDP and

employment. This study shows that developed countries, with easier access to technology and better infrastructure, can leverage agricultural technology to optimise their economic potential.

In contrast, in developed countries such as the United States, the adoption of agricultural technology also plays a major role in accelerating economic growth. Research conducted by Hennessy et al. (2019) in the US found that the use of advanced agricultural technologies, such as precision farming that uses sensors to monitor soil and crop conditions, has increased the efficiency of agricultural input use and production output (Raihan et al., 2023). These technologies have enabled US farmers to reduce operational costs, improve product quality, and increase farmer income. The adoption of these technologies has contributed to a highly efficient agricultural sector, which plays an important role in the country's economy, with the agricultural sector contributing significantly to GDP and employment. This study shows that developed countries, with easier access to technology and better infrastructure, can leverage agricultural technology to optimise their economic potential.

3.3 Relationship between Food Security and Economic Growth in the Context of Agricultural Modernisation

The relationship between food security and economic growth in the context of agricultural modernisation is close and mutually influential. Agricultural modernisation, which includes the adoption of advanced technologies such as modern irrigation, biotechnology and precision agriculture, plays an important role in increasing food production output. Stable and sustained increases in food production ensure sufficient food availability for a growing population, which in turn supports economic stability. Well-maintained food security contributes to economic growth by creating jobs in agriculture and related sectors, such as food processing, distribution and trade. With efficient and affordable food production, countries can minimise dependence on food imports, reduce trade deficits and strengthen the domestic economy (Hanani et al., 2023).

On the other hand, economic growth also supports improved food security. Countries that experience rapid economic growth tend to have more resources to invest in agricultural infrastructure, agricultural technology research and development, and policies that support farmers. With economic growth, more funds are available to improve food distribution systems, build irrigation infrastructure and increase market access for smallholder farmers. In addition, economic growth improves people's purchasing power, allowing them to buy food at more stable and affordable prices (Suryahani et al., 2024). However, it is important to note that the link between food security and economic growth in the context of agricultural modernisation can be hampered by the unequal distribution of technology and policies. Smallholder farmers or those without access to modern technology may not be able to benefit from this modernisation, which in turn may exacerbate economic and social inequality. Therefore, policies that are inclusive and supportive of technology dissemination and training to smallholder farmers are essential to ensure that agricultural modernisation promotes equitable food security and sustainable economic growth for all (Elizabeth et al., n.d.).

Better food security has a direct impact on economic growth through increased labour productivity. When people have sufficient access to nutritious and affordable food, their physical and mental health improves, allowing them to work more productively. Research by Haddad et al. (2015) states that stable food security contributes to improved nutrition, which in turn increases the capacity of labour to participate in economic activities. Better health, with reduced rates of malnutrition-related diseases, also reduces workplace absenteeism and increases efficiency, thereby accelerating overall economic growth. Food security is therefore not just a matter of providing food, but also a key factor in maximising the productivity potential of the economy.

In addition, maintaining food security can play an important role in poverty reduction. In many developing countries, a large proportion of the population depends on the agricultural sector as the main source of livelihood (Mardina, 2023). When food security is achieved through better agricultural technology and efficient distribution, it allows farmers and workers in related sectors to earn a more stable income. According to a report by FAO (2017), better food security can reduce dependence on

foreign food aid and provide farmers with more opportunities to invest in their businesses, increasing production and income. This contributes to poverty reduction by providing greater economic opportunities for households in rural areas and increasing their purchasing power, ultimately accelerating local economic growth (Prayitno et al., 2022).

The maintenance of social stability is also closely linked to better food security. When food security is achieved, social tensions that often arise due to food shortages can be minimised. Research by Ghosh (2018) shows that instability caused by food scarcity, such as social unrest and mass migration, can be detrimental to economic growth and put additional strain on social and economic systems (Jamil, 2024). Food security, by ensuring that every individual has sufficient access to nutritious food, creates a sense of security and stability in society. It helps reduce social conflicts, enhances social cohesion, and creates an environment conducive to sustainable economic growth. Thus, food security is not only important for individual well-being, but also for broader social and economic stability.

Discussion

Agricultural modernisation plays an important role in improving food security by introducing new technologies that can increase the efficiency and productivity of agricultural output. The use of modern machinery and more efficient irrigation systems allows farmers to produce more food in less time. In addition, the adoption of improved seeds that are resistant to pests and diseases also plays a role in improving agricultural yields, which in turn helps to ensure stable and quality food availability. In addition, diversification of food products can also be realised through agricultural modernisation. With more advanced technology, farmers can grow different types of crops in a single growing season, which reduces dependence on a single food commodity. This increases food diversity and ensures the availability of various sources of nutrients needed by the community. Moreover, technologies that support resilience to climate change, such as drought-resistant crop varieties, are of key importance in maintaining stable food production.

In terms of economic growth, agricultural modernisation has had a positive impact by increasing the productivity of the agricultural sector. The use of efficient technology allows farmers to reduce production costs and increase yields, thereby increasing their income. It also provides opportunities for the development of other sectors related to agriculture, such as the food processing industry, distribution, and agricultural technology, which in turn creates jobs and boosts the national economy.

However, challenges in implementing agricultural modernisation remain. One of them is the gap in access to technology that often occurs, especially for smallholder farmers in rural areas. This limited access means that modern technology cannot be utilised by all farmers, resulting in inequality in agricultural output. In addition, the high investment cost required to purchase advanced farm machinery or fertilisers is also a barrier for farmers with limited capital. In addition, the environmental impact of using environmentally unfriendly technologies is also a concern. Excessive use of pesticides and unsustainable farming practices can damage ecosystems and biodiversity. Therefore, agricultural modernisation must be balanced with policies that promote sustainability and environmental friendliness, so that the benefits of increased agricultural productivity do not harm the balance of nature and can be enjoyed in the long run.

4. CONCLUSION

Overall, agricultural modernisation has a major impact on food security and economic growth. By increasing efficient and sustainable food production and promoting food product diversification, agricultural modernisation can help countries better meet the food needs of their people. In addition, by increasing productivity and value-added, the agricultural sector can become a driver of economic growth, create jobs, and strengthen export competitiveness. However, to reach its full potential, agricultural modernisation needs to be balanced with policies that support sustainability, equitable access to technology, and training for farmers. Therefore, a more inclusive and sustainable strategy in agricultural modernisation is needed to ensure that the benefits can be felt by all levels of society, both at the small and large farmer level.

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