
APPLICATION OF SUSTAINABLE AGRICULTURAL TECHNOLOGY TO INCREASE PRODUCTIVITY AND FOOD SECURITY

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ABSTRACT

Food security is an important global issue to overcome. The increasing world population and climate change bring new challenges to ensuring the availability of sufficient and nutritious Food. Sustainable agriculture offers solutions to increase productivity and Food security while preserving the environment. This research aims to evaluate the effectiveness and impact of implementing sustainable agricultural technology in increasing agricultural productivity and food security in an area or community. This study used qualitative research methods. The data collection technique in this research is a literature study. The data that has been collected is then analyzed in three stages, namely data reduction, data presentation, and conclusion. The research results show that sustainable agricultural technology can increase productivity and Food security. Farmers who apply sustainable agricultural technology generally produce higher yields and are more resistant to pests and disease. However, its implementation still needs challenges, such as limited access to technology and knowledge, high costs, and lack of policy support.

Keywords: Agricultural Technology, Productivity, Food Security.

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INTRODUCTION

Food is an essential need that every individual must fulfil. Food access is recognized as one of the human rights, as described in Article 27 of the 1945 Constitution and the 1996 Rome Declaration (Tampubolon, 2022). Food is often associated with rice in Indonesia as the dominant staple. Past events, such as the spike in rice prices during the 1997/1998 economic crisis, have demonstrated its profound impact on food security and caused social insecurity that threatened economic and national stability.

The government consistently strives to improve food security by increasing domestic production. This is becoming increasingly important for Indonesia, given the increasing population growth and widespread population distribution across the region (Arif et al., 2020). To ensure that the population's food needs are met, Indonesia must ensure sufficient and equitable food availability, both for direct consumption and for adequate national stocks by the needs of vast and dispersed logistics.

The definition of food security is also regulated in Law No. 18/2012 on Food, which explains that food security includes the availability of sufficient Food both in terms of quantity and quality, safe, diverse, nutritious, equitable, affordable, and by the religious values, beliefs, and culture of the community, enabling them to live healthy, active, and productive lives sustainably (Rijaya & Munandar, 2020).

Sustainable agriculture has become the go-to solution for improving productivity and food security without compromising environmental sustainability. The concept emphasizes agricultural practices that focus on the efficient use of natural resources, waste reduction, and ecosystem preservation. By adopting sustainable farming practices such as the use of organic fertilizers, natural pest and disease control, and crop rotation, farmers can increase their yields without harming the environment. In addition, this approach also encourages crop diversification so that people have access to a variety of nutritious and balanced foods.

Previous research (Sihombing, 2022) showed that appropriate and location-specific technology includes mapping of land capability and suitability, commodity ranking, farming analysis, optimization of land use, agrotechnology application, integrated agriculture, provision of agricultural production inputs, infrastructure improvement, empowerment assistance training, technology development, control of agricultural land conversion, and institutional arrangements. The application of this technology is positively correlated with food security, especially in farmer households, where farmers who apply technological innovations have a better level of food security than farmers who do not.

Another study (Abdullah & Vaulina, 2023) found that alternative agricultural technology innovations that can help improve food security in Indonesia through sustainable agriculture include vertical farming, biofortification technology, intelligent irrigation systems, soil-less agricultural cultivation, and big data technology. Then, several ways of optimizing agrarian spatial planning can help improve food security in Indonesia through sustainable agriculture, namely developing productive agricultural land, structuring agricultural areas, regulating agricultural land conversion, agribusiness integration, and production diversification.

The results of this study can strengthen the argument that sustainable agricultural practices are not only beneficial to agricultural productivity but can also promote environmental and social sustainability. The theoretical implications can help develop theories and concepts related to sustainable agriculture and support efforts to encourage wider adoption of such practices in various agricultural contexts. This research aims to evaluate the effectiveness and impact of sustainable agriculture technologies in improving agricultural productivity and food security in a region or community.

METHOD

This research uses qualitative research methods. According to (Moleong, 2017), qualitative research refers to a study that aims to comprehensively understand phenomena related to what is experienced by research subjects, such as behaviour, perceptions, motivations, actions, and other aspects. This research describes the phenomenon using words and language in a natural context or by actual conditions and using various natural methods. The data collection technique in this research is a literature study. A literature study is a method that includes searching, selecting, and analyzing various sources of information published previously related to the research topic. Data that is relevant and related to the research problem is obtained from books, scientific journals, articles, research reports, official documents, and other documented sources. The type of data used in this research is secondary research obtained from Google Scholar. The data that has been collected is then analyzed in three stages, namely data reduction, data presentation, and conclusion drawing.

RESULTS AND DISCUSSION

The agricultural sector is still a vital part of Indonesia's national development. The country has a large land area, providing opportunities for people to depend on the agricultural sector for their livelihoods. However, it is essential to note that the agrarian or agricultural sector is a source of livelihood for the population and a key driver of economic growth (Kusumaningrum, 2019). Agriculture in Indonesia provides Food for the people and contributes significantly to the national economy. Various agricultural subsectors, such as food crop agriculture, plantations, livestock, and fisheries, positively impact the Indonesian economy.

The role of the agricultural sector in the economy of a country or region can be seen from several perspectives. First, the agricultural sector's contribution to Gross Domestic Product (GDP) or Gross Regional Domestic Product (GRDP) reflects how much the sector contributes to economic value. Second, the agricultural sector provides significant employment opportunities for the community, making it one of the primary sources of employment. Third, the ability of the agricultural sector to provide a diverse diet influences people's consumption patterns and nutrition. Fourth, the agricultural sector also supports the development of upstream and downstream industries by providing raw materials and serving as a market for industrial products. Fifth, exporting agricultural products contributes to foreign exchange (Isbah & Iyan, 2016).

The role of the agricultural sector in a country is so significant that it is essential to ensure that agricultural productivity remains high. Agricultural productivity refers to the total amount produced per unit area harvested in a given period, such as a semester or quarter. This productivity measurement is usually done in kilograms per hectare (Kg/Ha). In agricultural economics, productivity is the ratio between the expected yield at harvest time and the costs incurred to achieve that yield. In other words, agricultural productivity reflects the efficiency of the agricultural effort. This efficiency is closely related to achieving desired yields at minimal cost. When the yield obtained at harvest time exceeds the production costs incurred, the farm is considered productive or efficient (Rahman & Octaviani, 2021).

Improving agricultural productivity has become a significant focus of efforts to strengthen food security and address the challenges of rapid population growth. One of the approaches adopted is sustainable agriculture, which emphasizes farming practices that aim to increase production and consider resource use efficiency, environmental conservation, and long-term sustainability (Siregar, 2023). Experts suggest that sustainable agriculture is essential because Food is relevant for the present and future generations.

There are problems currently faced by farmers in Indonesia, including weather instability that affects crop productivity, lack of knowledge about agricultural technology, difficulty in adopting new technological developments as the majority of farmers have low education levels, and lack of adequate arrangements in the distribution of agricultural products (KANISA, 2023). In the face of these challenges, humans need to continue to develop, and one of the solutions to this problem is to apply innovative agricultural technology. The application of innovative technologies in agriculture has a crucial role in increasing the productivity of agricultural businesses, which in turn can improve the welfare of life and strengthen food security. This can be achieved through the development of farming patterns that are based on the principles of sustainable agriculture (Sihombing, 2022).

Sustainable agriculture is a concept that is inseparable from the use of technology. Sustainable agriculture has three main aspects: social, economic, and ecological. This technology must have the

ability to increase the added value, competitiveness, and profitability of agricultural products (Kuntariningsih & Mariyono, 2014). Development in the agricultural sector is significant, especially in the industrial era 4.0, which features automated machines connected to the internet. The agricultural sector must adapt to 4.0 technology to meet the needs of a growing population by implementing the concept of agriculture 4.0, where it is expected that the agricultural sector will actively use digital technology in its development process (KANISA, 2023).

Innovations combining agricultural practices with technology are Precision agriculture, precision farming, and digital farming. These three terms refer to agricultural systems that use technology to monitor crop needs and growth precisely and automatically. The application of this technology is believed to increase crop productivity by 300%, reduce water consumption by 50%, and save fertilizer use by 70% compared to conventional methods. This system can be applied to various types of land, weather conditions, and topography (Saraan & Rambe, 2023). In research conducted by (Sihombing, 2022), the application of innovative technology in designing agricultural systems is seen in several aspects:

1. Tillage

Tillage technology includes the application of ameliorants to improve soil fertility and reduce greenhouse gas emissions. Amelioration can be done using various materials such as dolomite, kaptan, zeolite, manure, and husk ash. In addition, efficient fertilization technology is applied by applying organic matter during tillage for quality and optimal yields.

2. Balanced fertilization

Balanced fertilization involves using SRF plus compound fertilizer that combines inorganic fertilizers, organic fertilizers, and biofertilizers. This aims to provide a balanced plant fertilizer and maintain soil fertility.

3. Drip irrigation

Drip irrigation is a method of applying water by dripping water through pipes around the plants. This method results in efficient water use as only part of the root zone is wetted. However, the added water can be absorbed quickly in low soil moisture conditions. Drip irrigation can be differentiated based on the type of water dripping, such as seeping, dripping, or gushing through holes in the lateral pipes.

4. Pest and disease control

Technological innovations include using environmentally friendly pesticides such as biopesticides or biological pesticides. These pesticides can control plant pest organisms but break down faster and have low toxicity to animals. Some biological pesticides developed include vegetable pesticides from neem seeds or leaves, brotowali, tegari, sambiloto, and tobacco stem waste.

Research (Febrianti et al., 2021) added that progress in agriculture can be achieved through technology that leads to innovations. Mobile technology is one of the developments in agricultural technology that farmers can utilize. Mobile technology is one of the latest agricultural innovations that allows farmers to access information quickly. Farmers can obtain information about agricultural commodities through mobile technology and available information services. This helps farmers save time in finding information such as seed prices, crop area, harvest predictions, and other matters related to agricultural activities. In addition, mobile technology also allows farmers to estimate prices in the market more accurately because the difference between field conditions and the data obtained is similar.

Applying sustainable agriculture technology has significant benefits in improving productivity and food security. Compared to conventional agriculture, sustainable agriculture uses less water and energy, improves soil nutrient balance, reduces production costs, increases community participation, and is environmentally friendly. This proves sustainable agriculture can provide better results without sacrificing environmental sustainability (Rosalina, 2022). Farmers who adopt sustainable agricultural technologies generally achieve greater yields and crops more resistant to pests and diseases. So, sustainable agricultural technology has a positive impact on increasing agricultural productivity. It plays a vital role in supporting food security.

Innovations in agricultural technology are primarily aimed at simplifying farming processes. However, their implementation depends on the ability of farmers to adopt these innovations. However, several challenges are faced in implementing these innovations, such as limited access to technology and knowledge. In the current era of modernization, many people still need to fully optimize available facilities due to a need for knowledge and information. Despite advances in agricultural technology, farmland management could be more effective, causing problems to be identified (Savira et al., 2020).

To address the first challenge, the limited knowledge of farmers, the government must provide training and mentoring to use the technology effectively and sustainably. This education and training can be provided through extension services by individuals with an education in the field. Field extension officers are vital in introducing agricultural technology innovations to farmers. Their role is not only limited to introducing technology to farmers but also involves increasing the capacity of farmers to be independent in running their agricultural businesses (Fatchiya & Amanah, 2016). With proper counselling and mentoring, farmers can understand and implement technology effectively, thereby increasing the productivity and sustainability of their farms.

One of the other constraints is the high costs associated with farm modernization. Agricultural modernization requires farmers to incur significant costs to start their farming business. All of this requires considerable funds, in contrast to previous farming systems. All these expenses are required to implement new technologies in agriculture for farmers (Rinardi et al., 2019). To overcome the high-cost constraints associated with agricultural modernization, the government can facilitate access to affordable financing for farmers. One way this can be done is by private and Islamic banks providing credit to farmers. Financing generally refers to the funding used to support planned investments by themselves or other parties (Rahayu, 2015).

Such financing aims to increase agricultural productivity, allowing farmers to increase their production power. In other words, access to finance allows farmers to expand their farming businesses by obtaining the necessary funds to implement new technologies and modernization in farming practices. This will help reduce the cost burden borne by farmers themselves and facilitate the development of more sustainable and productive agriculture. Researchers have found that providing credit to farmers positively impacts agricultural production output per hectare after receiving financing. Agricultural finance, whether in the form of conventional credit or otherwise, has contributed significantly to the rural economy by providing capital to farmers to make new investments or adopt new agricultural technologies (Basyariah, 2022).

Another constraint in applying technology in agriculture is the lack of policy support that can encourage the adoption of sustainable agricultural technologies. To address this, the government must develop policies supporting the transition towards sustainable agriculture. According to (Arifin

et al., 2023), government policies should be designed to incentivize and support farmers. Hence, they are more likely to adopt sustainable agricultural practices. One way this can be done is by providing financial incentives or subsidies to farmers who implement sustainable practices. This can help offset the initial investment costs required to implement new technologies in agriculture. In addition, creating and expanding markets for sustainable and organic products is also very important. This can be done through marketing support and certification programs that promote these products to consumers. Following increased demand and higher prices for sustainable products, farmers will earn greater profits, which in turn will encourage them to adopt sustainable farming practices more widely.

Based on these findings, the use of sustainable agricultural technologies has the potential to improve agricultural productivity and food security. These positive impacts are crucial for advancing the agricultural sector in Indonesia. Nonetheless, several constraints still need to be addressed for these benefits to be fully realized. Focusing on the challenges faced in implementing sustainable agricultural technologies is essential to ensure that the positive potential of such technologies can be optimally realized, thereby making a significant contribution to the country's economic growth.

CONCLUSION

The implementation of sustainable agricultural technologies has a positive impact on productivity and food security. Farmers who adopt these technologies tend to obtain more abundant yields and are more resilient to pest and disease attacks. However, despite its significant benefits, implementing sustainable agricultural technologies is still faced with various challenges. Among these are limited access to the necessary technology and knowledge, high implementation costs, and a need for more policy support from relevant parties. These challenges must be considered to expand the implementation of sustainable agricultural technologies to maximize their potential and sustainably increase productivity and food security.

REFERENCES

- Abdillah, F., & Vaulina, S. (2023). Menuju pertanian berkelanjutan: akselerasi inovasi dan optimalisasi tata ruang agraria untuk meningkatkan ketahanan pangan. *Prosiding Seminar Nasional Fakultas Pertanian UNS*, 7(1), 987–996.
- Arif, S., Isdijoso, W., Fatah, A. R., & Tamyis, A. R. (2020). Tinjauan Strategis Ketahanan Pangan dan Gizi di Indonesia. *Jakarta: SMERU Research Institute*.
- Arifin, Z., Suparwata, D. O., Rijal, S., & Ramlan, W. (2023). Revitalisasi Ekonomi Pedesaan melalui Pertanian Berkelanjutan dan Agroekologi. *Jurnal Multidisiplin West Science*, 2(09), 761–769.
- Basyariah, N. (2022). Pembiayaan Sektor Pertanian: Mendukung Visi Negara Ketahanan Pangan Dan Pusat Industri Halal Global. *Youth & Islamic Economic Journal*, 3(01s), 1–11.
- Fatchiya, A., & Amanah, S. (2016). Penerapan inovasi teknologi pertanian dan hubungannya dengan ketahanan pangan rumah tangga petani. *Jurnal Penyuluhan*, 12(2), 190–197.
- Febrianti, V. P., Permata, T. A., Humairoh, M., Putri, O. M., Amelia, L., Fatimah, S., & Khastini, R. O. (2021). Analisis Pengaruh Perkembangan Teknologi Pertanian di Era Revolusi Industri 4.0 Terhadap Hasil Produksi Padi. *Jurnal Pengolahan Pangan*, 6(2), 54–60.
- Isbah, U., & Iyan, R. Y. (2016). Analisis peran sektor pertanian dalam perekonomian dan kesempatan kerja di Provinsi Riau. *Jurnal Sosial Ekonomi Pembangunan*, 7(19), 45–54.
- KANISA, I. D. (2023). *PENGARUH REVOLUSI INDUSTRI 4.0 DALAM MENCAPAI KETAHANAN PANGAN DAN MENDUKUNG PERTANIAN BERKELANJUTAN*.

- Kuntariningsih, A., & Mariyono, J. (2014). Adopsi teknologi pertanian untuk pembangunan pedesaan: Sebuah kajian sosiologis. *Agriekonomika*, 3(2), 180–191.
- Kusumaningrum, S. I. (2019). Pemanfaatan sektor pertanian sebagai penunjang pertumbuhan perekonomian Indonesia. *Transaksi*, 11(1), 80–89.
- Moleong, L. J. (2017). Metode penelitian kualitatif, Bandung: PT. *Remaja Rosda Karya*, 17.
- Rahayu, L. (2015). Aksesibilitas petani bawang merah terhadap lembaga keuangan mikro sebagai sumber pembiayaan. *AGRARIS: Journal of Agribusiness and Rural Development Research*, 1(1), 52–60.
- Rahman, A., & Octaviani, E. (2021). Analisis produktivitas tenaga kerja sektor pertanian dan kemiskinan di Indonesia. *Seminar Nasional Variansi (Venue Artikulasi-Riset, Inovasi, Resonansi-Teori, Dan Aplikasi Statistika)*, 2020, 39–48.
- Rinardi, H., Masrurroh, N. N., Maulany, N. N., & Rochwulaningsih, Y. (2019). Dampak revolusi hijau dan modernisasi teknologi pertanian: studi kasus pada budi daya pertanian bawang merah di Kabupaten Brebes. *Jurnal Sejarah Citra Lekha*, 4(2), 125–136.
- Rosalina, D. I. (2022). Penerapan dalam Pembangunan Pertanian Modern Di Indonesia yang Sehat, Ramah Lingkungan dan Berkelanjutan. *SEMAGRI*, 3(1).
- Saraan, M. I. K., & Rambe, R. F. A. K. (2023). Kebijakan Pengembangan Inovasi Teknologi Pertanian Presisi di Provinsi Sumatera Utara. *Jurnal Kajian Agraria Dan Kedaulatan Pangan (JKAKP)*, 2(1), 1–5.
- Savira, R. P., Firdaus, J. E., Rochmanila, K., Saputra, R. D., Zukhri, Z., & Cahyono, A. B. (2020). eduFarm: Aplikasi Petani Milenial untuk Meningkatkan Produktivitas di Bidang Pertanian. *Automata*, 1(2).
- Sihombing, Y. (2022). Penerapan Inovasi Teknologi Pertanian Berbasis Sistem Usaha Pertanian Inovatif Mendukung Ketahanan Pangan. *Proceedings Series on Physical & Formal Sciences*, 4, 439–445.
- Siregar, M. A. R. (2023). *Peningkatan Produktivitas Pertanian Melalui Penerapan Sistem Pertanian Terpadu*.
- Tampubolon, N. (2022). *Tanggung Jawab Negara Terhadap Jaminan Kesehatan dalam Perspektif Hak Asasi Manusia*.



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