INTEGRATION OF LOCAL WISDOM AND GREEN TECHNOLOGY TO INCREASE PRODUCTIVITY OF ENVIRONMENTALLY FRIENDLY AGRICULTURE

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Abstract

This study aims to analyze how the integration of local wisdom and green technology can increase sustainable agricultural productivity in Grobogan Regency. The approach used is qualitative descriptive with literature study and local context reinforcement. The results of the study show that local agricultural practices such as rotational planting, the use of mini-reservoirs, and the use of organic fertilizers are still maintained and are important foundations in the ecological adaptation of farmers. On the other hand, green technological innovations such as drip irrigation, solar pumps, and stealth tractors have been accepted contextually because they are compatible with the cultural values of farming communities. This integration encourages resource conservation, production efficiency, and improved farmers' welfare. This research confirms that sustainability in the agricultural sector depends not only on technological advancements, but also on the ability to integrate local values in production systems. These results are relevant as a reference in the formulation of locally-based and sustainable agricultural development policies.

Keywords: Local Wisdom, green technology, agricultural productivity.

1. INTRODUCTION

According toIslam (2025) agricultural development plays a crucial role in achieving food security and maintaining environmental sustainability. In recent decades, increasing attention has been paid to the importance of integrating local knowledge with modern technological innovations to increase agricultural productivity.(Chaudhary et al., 2022)Green technology presents a promising solution to address climate challenges while simultaneously encouraging the efficient use of natural resources.(Aneja et al., 2024)On the other hand, local wisdom that lives in farming communities is proven to be in harmony with the principles of ecology and sustainability.(Handayani & Suparno, 2023)The combination of the two is seen as a strategic approach to realizing a resilient and sustainable agricultural system.(Tarun et al., 2025).

However, although local wisdom has long been part of community agricultural practices, its use in modern agricultural systems is still often marginalized.(Sharma et al., 2025). Many technology-based agricultural programs tend to ignore local values that are actually adaptive to the environment and have been proven to support sustainability.(Nordin et al., 2024). In addition, there are not many studies that systematically explain how local wisdom can be effectively integrated with current agricultural innovations. A study by Krisnawati & Raya (2025) He explained that the lack of documentation, limited heritage, and pressures of modernization have resulted in the potential of local wisdom being under-explored. This creates gaps in agricultural development, which should be inclusive, contextual, and sustainable.

To address this gap, this research is crucial because local wisdom holds great potential for creating sustainable agricultural practices, yet it has not been systematically integrated into modern agricultural approaches. Yet, local wisdom reflects long-term adaptation to local ecological conditions and has been shown to strengthen the resilience of local food systems.(Utami et al., 2025)As a solution, this research offers an integrative approach that combines local wisdom with contemporary agricultural technology to make it more contextual and adaptive to the environment. This approach is considered capable of combining time-tested traditional practices with technological innovation to create a more resilient agroecological system.(Yeleliere et al., 2022)This study aims to identify and analyze relevant forms of local wisdom in agriculture and explain its role in supporting environmentally friendly productivity, in line withPakeerathan (2025a)which prioritizesprinciples of sustainable agriculture that emphasize ecological, social, and economic balance.

On the other hand, green technologies that are beginning to be introduced into agricultural practices also face various challenges in their implementation. Many farmers do not fully understand the long-term benefits of environmentally friendly technologies due to limited information, access, and support.(Mulungu et al., 2025). In addition, perceptions of technological complexity, incompatibility with local culture, and a lack of direct evidence in the field also hamper the diffusion process of this innovation.(Rincón et al., 2024)On the other hand, there are still very few studies exploring how socio-cultural perceptions and readiness influence the successful implementation of green technology in the agricultural sector, even though social factors such as cultural values and local norms play an important role in technology acceptance.(Mupaikwa & Bwalya, 2023)This situation indicates a gap in the understanding and strategies for adopting sustainability-based technologies, which, if not addressed in a participatory and contextual manner, could slow the transformation of agricultural systems toward sustainability.

To overcome this problem, this research is important to conduct because the adoption of green technology has not fully considered social, cultural and local perception factors of farmers which play a major role in the success of its implementation.(Liu & Liu, 2024).In many cases, an overly technocratic approach ignores the psychological and contextual realities of farmers, even though risk perception, trust in innovation, and value alignment with traditional practices are key elements in the technology adoption process.(Dixit et al., 2023)As a solution, this study offers an approach that considers the psychological and contextual dimensions of the green technology diffusion process in the agricultural sector. By positioning farmers as active subjects in innovation, this study aims to analyze the factors influencing the acceptance, understanding, and sustainable use of green technology by farmers. This approach is crucial so that the transition to sustainable agriculture is not only structural but also rooted in the awareness and social participation of the farming community.(Averbuch et al., 2022).

Furthermore, the issue of productivity in agriculture is also a major concern. Until now, productivity has often been measured solely on short-term results without considering long-term ecological and social impacts.(Xiang & Lv, 2025). In fact, within the framework of sustainable development, true productivity must be able to maintain a balance between agricultural output, environmental sustainability, and social welfare.(Giri et al., 2025)The concept of sustainable intensification emphasizes that increasing agricultural production must be done without damaging the supporting ecological system and by paying attention to aspects of social justice.(Raj et al., 2021)Therefore, a more comprehensive approach to sustainable productivity needs to be developed, integrating technological innovation, ecological practices, and local community empowerment.

To address this issue, this research is important to conduct because the concept of productivity in agriculture must reflect ecological sustainability, resource efficiency, and socio-economic carrying capacity.(Wang et al., 2022). So far, productivity has often been reduced to increasing yields alone, without considering the impact on the environment and farmer welfare. This research offers a sustainable productivity approach, namely by considering yield efficiency, environmental sustainability, and farmer welfare holistically. This approach aligns with the principle of sustainable intensification, which emphasizes that agricultural productivity must be increased without increasing negative impacts on ecosystems and social structures.(Kumari et al., 2025). Therefore, this study aims to explore how the integration of local wisdom and green technology can promote environmentally friendly and sustainable agricultural productivity.

2. METHOD

This research uses a qualitative approach with a case study type, which aims to explore in depth the integration between local wisdom and green technology in increasing environmentally friendly agricultural productivity. This approach was chosen because it allows researchers to understand complex phenomena in a real and specific context, particularly in farming communities that implement sustainable agricultural practices based on local values and technological innovation. The research location is in Grobogan Regency, Central Java, which is known as one of the largest agricultural production centers in Indonesia. This area has a wealth of local agricultural practices such as rotational cropping systems, the use of traditional organic fertilizers, and mutual cooperation mechanisms among farmers. In addition, this region is also undergoing a transition to sustainable agricultural practices through the implementation of green technologies, such as water-efficient irrigation, biological pest control, and the use of renewable resources. Informants in this study were selected purposively, including local farmers, agricultural extension workers, traditional leaders, and farmer group administrators who have knowledge and experience in local wisdom practices and involvement in green technology adoption programs. Data collection techniques were carried out through in-depth interviews, participatory observation, and documentation. Interviews were used to explore the informants' understanding and experiences, observations were conducted to examine real practices in the field, while documentation included written data, photographs, and notes on relevant agricultural activities.

The researcher served as the primary instrument in the data collection and analysis process, supported by interview guidelines and observation sheets developed based on the research focus. Data were analyzed using a thematic analysis approach, following the interactive analysis model ofMiles & Huberman (1994), which includes three main stages: data reduction, data presentation, and conclusion drawing/verification. Data reduction is carried out to filter relevant information, data presentation is arranged in the form of a thematic narrative, while conclusions are drawn through a process of in-depth interpretation of the patterns found. To maintain the validity and validity of the data, source and technique triangulation techniques are used, confirmation with informants (member check), and discussion with colleagues (peer debriefing).

3. RESULTS

3.1 Adaptive to The Local Environment

Farmers in Grobogan Regency demonstrate a strong pattern of adaptation to local environmental conditions. One prominent practice is a rotational cropping system of rice, corn, and soybeans. This adjustment is made by taking into account seasonal patterns and water availability, particularly during the prolonged dry season caused by the El Niño phenomenon. "We plant corn after we plant rice, because there's little water left. That's always been the case." — Informant A, Farmer from Kedungjati Hamlet Additionally, local farmers are utilizing mini tarpaulin reservoirs with a capacity of around 4,000 liters, which can support the growth of secondary crops on plots of land up to 0.5 hectares. This initiative is a direct response to climate change and uncertain water availability. This finding strengthens the studyShahidullah et al. (2020), which states that local practices develop from community adaptations to local ecosystem dynamics. These practices demonstrate that local agricultural systems have undergone adaptive evolution based on inherited knowledge, while also demonstrating the community's capacity to respond to ecological challenges independently and contextually.

3.2 Efficiency in Resource Use

Observations show that farmers in Grobogan are beginning to implement resource-saving technologies in their production processes. Locally engineered drip irrigation and the use of mini-reservoirs offer efficient irrigation solutions amidst water constraints. "We use a small hose to save water, especially in the dry season." — Informant B, Maju Makmur Farmers Group According toShekhar & Venkateswarlu (2024)Innovation adoption will occur more quickly if the technology is perceived to offer relative advantages and ease of use. Another technological innovation is the remote-controlled hand tractor, or "ghost tractor," developed by the Central Java Regional Development Planning Agency (Bappeda) and introduced in Grobogan in 2022. This technology is designed to improve labor efficiency and accessibility for disabled and elderly farmers. Meanwhile, digital-based precision agriculture and smart farming training has also begun to be provided to extension workers and young farmers. This is the first step in building a more efficient, data-driven, and waste-free agricultural system.

3.3 Local Social and Cultural Compatibility

The adoption of green technology in Grobogan has been relatively successful because the introduced technologies do not conflict with deeply rooted cultural values and local practices. The use of organic fertilizers, crop rotation techniques, and minimal land preparation are considered more "in harmony with nature" by farmers. "If chemical fertilizers are too strong, the soil will become hard too. Organic fertilizers are more suitable." — Informant C, Senior Farmer Study byHan et al. (2022)stated that socio-cultural compatibility strengthens farmers' trust in new technologies. Most farmers feel that new technologies such as mini-reservoirs and drip irrigation are not threats, but rather complements to traditional practices. This demonstrates that innovations are more readily accepted when they are contextual and aligned with the social and spiritual structures of farming communities.

3.4 Natural Resource Conservation

Conservation practices are an essential part of the local agricultural system in Grobogan. The widespread use of compost from harvest waste (such as straw), intercropping techniques, and crop rotation are used to maintain soil fertility and prevent land exploitation. This is a concrete manifestation of the principles of sustainable development.(WCED., 1987). "We make compost from straw. It's better for the soil," he said. — Informant D, Farmers Group Manager Conservation is also reflected in the use of irrigation water, which is conserved through reservoir and drip irrigation technology. Farmers are beginning to recognize the importance of maintaining groundwater quality and reducing pollution from chemical pesticide residues. With a combination of traditional practices and efficient technology, the agricultural system in Grobogan is showing the way towards ecological sustainability.

3.5 Welfare of Farmers and Local Communities

The impact of integrating local wisdom and green technology is not only felt ecologically but also significantly improves farmers' welfare. Corn productivity, for example, can reach 8–10 tons/ha in a methuk planting system integrated with an efficient irrigation system. By the early 2025 harvest, production will reach approximately 5,780 tons from 578 hectares of land, with an economic value of approximately IDR 20.5 billion. This confirms the Towards Sustainable Development study (2020), which states that true productivity encompasses economic, social, and ecological aspects. "Now I make my own fertilizer. The harvest is stable. The money also feels better." — Informant E, Young Farmer Furthermore, farmer involvement in the Grobogan Food Technopark program has opened access to training, product diversification, and marketing. Several local MSMEs focused on agricultural derivative products have seen their turnover increase by up to 40% after receiving support from the local food wisdombased downstreaming program. Thus, this integration not only strengthens the production system but also improves the economic competitiveness and social well-being of Grobogan farmers.

4. DISCUSSION

4.1 Adaptive to The Local Environment

Farmers in Grobogan Regency demonstrate a high level of ecological adaptability through the implementation of a rotational cropping system tailored to seasonal conditions, soil type, and water availability. Strategies such as shifting crops from rice to secondary crops during the dry season and utilizing mini reservoirs as water reserves to anticipate droughts are direct responses to the natural dynamics they periodically encounter. These practices reflect local knowledge derived from collective experience and a strong connection between communities and their environment. These findings strengthen the relevance of Cultural Ecology Theory.(Steward, 1955), which explains that local wisdom is formed as a result of reciprocal interactions between humans and their natural environment. From this perspective, culture is not merely a system of values or traditions, but also encompasses ecological adaptation methods designed to maintain survival. In other words, local practices carried out by farmers are not simply inherited from generation to generation, but rather a form of socioecological resilience that continues to evolve with climate change and environmental pressures.

This context emphasizes that local wisdom is dynamic, not static. It is continuously updated through social learning processes and field experiences conducted collectively by the community. The success of Grobogan farmers in maintaining productivity amidst seasonal challenges and limited resources demonstrates that local wisdom remains highly relevant as a foundation for developing a sustainable agricultural system. Therefore, agricultural development approaches cannot ignore local values that have proven adaptive and sustainable. Instead, local wisdom must be recognized as a form of social technology born from long-standing interactions between humans and nature. In this context, the integration of local wisdom and technological innovation is not only ideal but also strategic and urgent in addressing current and future agricultural challenges.

4.2 Efficiency in Resource Use

The implementation of green technologies such as drip irrigation, solar-powered pumps, and stealth tractors in Grobogan Regency is clear evidence that innovation can boost agricultural production efficiency without compromising sustainability principles. These technologies not only improve water and energy efficiency but also reduce farmers' dependence on expensive and often unsustainable external inputs. By reducing operational costs and optimally increasing yields, green technologies offer solutions that are not only economical but also ecological. The successful adoption of this technology demonstrates the importance of contextuality in developing agricultural innovation. Technology introduced to farming communities should not be generic but should address the specific needs and local challenges faced by farmers. In this context, the concept of appropriate technology becomes relevant: technology that is simple, resource-efficient, and suited to the socio-economic conditions of its users. This phenomenon is also in line with the Theory of Diffusion of Innovation put forward byRogers & Everett (1983), which emphasizes that innovation adoption will occur if a technology meets five main characteristics: providing relative advantages, being compatible with local values, being easy to understand and use (low complexity), being trialable, and having clearly observable results. In the case of Grobogan, all of these characteristics were met, which led to voluntary technology adoption and integration into daily agricultural practices. Furthermore, the organic adoption of green technology, without external coercion, demonstrates a congruence between the innovations offered and ingrained agricultural values and practices. Technology is not perceived as a symbol of alien modernity, but rather as an instrument supporting the principles of sustainability already believed in by the farming community. This reinforces the argument that the success of innovation is determined not only by its technical excellence but also by its rootedness in the local context. Thus, the Grobogan case underscores the importance of a participatory and needs-based approach to agricultural technology development. The successful implementation of green technology is determined not only by the sophistication of the equipment, but also by its ability to integrate with the real needs of farmers, local cultural values, and the long-term goal of maintaining ecological and social sustainability.

4.3 Local Social and Cultural Compability

The successful implementation of green technology in the agricultural sector is determined not only by the effectiveness of the technology, but also by the extent to which it is compatible with the cultural values and social systems of the farming community. In Grobogan Regency, the use of organic fertilizers, crop rotation practices, and minimal tillage are well-received by farmers because they do not conflict with their beliefs about the importance of preserving the land as a source of life. This demonstrates that local values such as harmony with nature, resource sustainability, and intergenerational responsibility are important foundations for innovation adoption. This acceptance demonstrates that technology that is perceived as aligned with local identities and practices will be more readily adopted than technology that is foreign and disruptive to social structures. This is in line with the findingsYang et al. (2025)In the Diffusion of Innovations theory, the rate of technology adoption is strongly influenced by the innovation's compatibility with user values, past experiences, and needs. In this context, green technology in Grobogan is not perceived as a threat to local wisdom, but rather as a complement that strengthens the tradition of sustainable agriculture that has existed for many years. Furthermore, this approach demonstrates that successful integration is not simply a matter of technology transfer, but also a matter of how innovations are formulated and implemented while respecting local values embedded in community life. Technology imposed top-down without considering cultural dimensions tends to face resistance and long-term failure. Conversely, when technology is introduced as part of a dialogic and participatory process, its potential for sustainability is much greater. Therefore, integrating green technology into local agricultural systems requires a sensitive and participatory sociocultural approach. Grobogan's success in this regard exemplifies that harmony between innovation and local wisdom is not only possible but also strategic for creating a resilient, sustainable, and widely accepted agricultural system.

4.4 Natural Resource Conservation

Conservation efforts undertaken by farmers in Grobogan Regency demonstrate that ecological awareness is not only developing in discourse but has been implemented concretely in daily agricultural practices. Utilizing harvest waste such as straw and corn cobs for compost, implementing crop rotation to maintain soil fertility, and limiting synthetic chemical inputs through the use of botanical pesticides and local organic fertilizers are concrete examples of a conservation-based agricultural system. These practices demonstrate that farmers are able to manage land wisely and pay attention to the long-term environmental carrying capacity.

This success is inseparable from the synergy between local wisdom values passed down through generations, such as prohibiting overexploitation of land, maintaining soil fertility, and respecting natural cycles, with the support of adaptive, efficient, and resource-saving green technologies. This integration not only strengthens the resilience of agricultural systems to climate change and environmental degradation but also creates more efficient and contextual agricultural practices. For example, the use of organic waste shredding machines developed locally under the auspices of the Grobogan Food Technopark has accelerated the composting process, while reducing farmers' dependence on manufactured fertilizers.

These conservative practices are very relevant to the principles of Sustainable Development emphasized by the World Commission on Environment and Development.(WCED., 1987), namely meeting the needs of the present without compromising the ability of future generations to meet their own needs. This approach is also in line with the concept of Agroecology developed byVoronkova et al. (2024), which views agriculture as a complex ecological system and must be managed with integrated ecological, social and economic sustainability principles.

Moreover, conservation in Grobogan has transformed into a new cultural value internalized in the thinking and behavior of farming communities. No longer merely a response to government policy or external project intervention, conservation has now become part of the collective identity of farmers and local agrarian communities. This demonstrates the success of a community-based approach that enables communities to become active subjects in preserving ecosystems, rather than simply recipients of technology or programs. Thus, conservation in the agricultural context of Grobogan aims not only to safeguard natural resources but also to strengthen local autonomy, preserve ecological wisdom, and create an agricultural system that is adaptive to future challenges. This initiative can serve as a model for replication in other regions with similar socio-ecological compositions.

4.6 Walfare of Farmers and Local Communities

Productivity in the context of sustainable agriculture is not solely measured by the quantity of the harvest, but also by its contribution to improving farmer welfare and ecosystem sustainability. In Grobogan Regency, increased corn productivity, reaching up to 10 tons per hectare, efficiencies in production costs, and increased turnover of agricultural-based MSMEs are concrete indicators that the integration of local wisdom and green technology can deliver tangible and measurable economic benefits. This demonstrates that an agricultural approach that combines local values and technological innovation is not only technically relevant but also socially and economically contextual.

Farmer welfare resulting from sustainable agricultural systems is a crucial aspect that cannot be overlooked. Increased incomes, reduced dependence on external inputs, and the growth of communitybased economic initiatives are some of the positive impacts. Support from institutions such as the Grobogan Food Technopark helps strengthen the agricultural sector's value chain through product downstreaming, access to regional and national markets, and strengthening farmers' institutional capacity. This collaboration demonstrates that the success of environmentally friendly agriculture is crucially determined by multistakeholder involvement in creating a robust supporting ecosystem.

This finding is in line with the viewPakeerathan (2025b)which emphasizes that a sustainable agricultural system must guarantee food security while improving the standard of living of farmers as primary producers. Furthermore, the concept(Kumar et al., 2023)also emphasized that agrarian sector development must take into account the human, social, natural, and financial assets held by farmers. In this context, agricultural practices based on local values and supported by appropriate technology have proven capable of simultaneously strengthening all these dimensions.

In addition, the Towards Sustainable Development frameworkXu et al. (2020)underscores the importance of agricultural development that is oriented not only toward economic outcomes but also toward social justice and environmental sustainability. These three dimensions—economic, social, and ecological— must be viewed as an inseparable whole. Therefore, the productivity increases in Grobogan reflect not only technical success but also an inclusive and contextual agricultural development model. Therefore, the success of the agricultural sector cannot be judged solely by harvest results, but must be seen in terms of the extent to which the agricultural system is able to enhance the dignity, independence, and welfare of farmers as the main actors in development. Integrating local wisdom heritage and technological innovation has proven to be a transformative strategy in creating a more resilient, sustainable, and equitable agricultural system.

1. CONCLUSION

This research shows that integrating local wisdom and green technology can create a more adaptive, efficient, and sustainable agricultural system. Local wisdom has been shown to have high ecological value through practices such as rotational cropping systems, the use of organic fertilizers, and the use of mini reservoirs in response to environmental conditions. Meanwhile, green technologies such as drip irrigation, stealth tractors, and smart farming training contribute to increasing resource efficiency and productivity. The research also indicates that the successful adoption of green technology is significantly influenced by its compatibility with local social and cultural values. When technology is perceived as aligned with the community's way of life, resistance is reduced and farmer participation increases. Furthermore, the impact of this integration is seen in increased productivity and farmer welfare, as well as in fostering long-term ecological awareness. Thus, an integrative approach between traditional values and modern innovation is an effective strategy for promoting environmentally friendly agriculture. This model can serve as a reference for developing sustainable agricultural policies and practices in other regions with similar socio-ecological characteristics.

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