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Utilization of Black Soldier Fly (BSF) as Green Technology in Coconut Waste Management and Farmers' Economic Empowerment

Muhamad Farih[1], Ridha Taurisma Lajaria[2], Asri Djauhar[3], Grace Permatasari Tandipayuk[4]*

[1] Department of Digital Business, Universitas Sulawesi Tenggara, Indonesia
[2] Department of Entrepreneurship, Universitas Sulawesi Tenggara, Indonesia
[3] Department of Management, Universitas Sulawesi Tenggara, Indonesia
[4] Department of Marketing, Monash University Malaysia, Malaysia

[*]*e-mail: ridhataurisma.mm@gmail.com*

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Abstract: *This study aims to analyze farmers' perceptions, attitudes, and readiness to adopt the Black Soldier Fly (BSF) technology as an environmentally friendly innovation in coconut waste management in the Konawe Islands, Indonesia. A descriptive quantitative approach was used by surveying 45 coconut farmers in Pewalea village. Data were collected through structured questionnaires and analyzed using descriptive statistics with a Likert scale. The results indicate that 71.1% of farmers had never heard about BSF technology, while 77.8% expressed positive attitudes toward its implementation. A total of 55.6% were willing to adopt the technology if training and assistance were provided, and 64.4% identified access to capital as the main determinant of adoption. This study highlights the potential of BSF as a green innovation supporting circular economy practices and sustainable entrepreneurship in rural areas. The implication of this research is that the successful adoption of BSF technology requires integrated policies that strengthen farmers' access to training, financial support, and market networks, which in turn can enhance rural economic resilience and environmental sustainability.*

Keywords*: black soldier fly, green innovation, circular economy, sustainable entrepreneurship, waste valorization*

1. INTRODUCTION

Coconut waste produced from the coconut processing process in various production areas is generally left to accumulate without adequate handling. This accumulation causes environmental problems such as land pollution due to the decay of organic matter and the appearance of unpleasant odors that can disturb the comfort of the surrounding community. In addition, coconut waste left open has the potential to become a breeding ground for disease vectors, such as flies and other insects, which worsen environmental sanitary conditions. This problem is increasingly complex because coconut waste management is still not a priority in waste management strategies at the local level, especially in remote areas and lack of access to appropriate technology. In this context, Konawe Islands Regency is one of the coconut production areas that also experiences the problem of waste accumulation without effective treatment. Geographical conditions and limited technological facilities cause coconut waste to become a useless pile that continues to grow every harvest season.

Various studies have shown that conventional approaches in organic waste management have not been able to provide effective solutions to coconut-based waste. Coconut waste, especially its endosperms and fibers, belongs to the category of lignocellulose waste that is difficult to decompose naturally without the help of technological intervention or certain microorganisms (Pliantiangtam et al., 2024). In practice, traditional approaches such as open burning or hoarding only move the problem without solving it, even causing side effects such as air pollution and soil degradation. On the other hand, the current waste management theories and policies are still general and have not specifically answered the problem of coconut waste at the production community level. In fact, an environmentally friendly green technology-based approach is very necessary, not only to manage waste but also to generate added value for the community. Unfortunately, there have not been many academic studies that directly explore the linkage between green technology approaches and community-based coconut waste management specifically, especially in the context of remote areas such as the Konawe Islands. This inequality shows that there is a knowledge gap that needs to be bridged through applied research.

This study aims to explain the potential application of Black Soldier Fly (BSF) larvae as an appropriate technology in coconut waste management by local farmers in Konawe Islands Regency. BSF is a saprofag insect that is able to consume various types of organic waste, including coconut waste, and convert it into high-value biomass such as proteins and lipids (Muin, Alias, Nor, & Taufek, 2022). Dalam proses pengolahan ini, BSF tidak hanya membantu mengurangi volume limbah secara signifikan, tetapi juga menghasilkan larva yang dapat dimanfaatkan sebagai pakan ternak maupun sumber biodiesel (Wong et al., 2020). In addition, residues from this bioconversion process can be used as organic fertilizers, providing additional benefits to local agricultural ecosystems. By adopting this technology, local farmers are expected to obtain sustainable solutions to manage coconut waste economically and environmentally friendly. Therefore, it is important to conduct an in-depth study on the effectiveness and potential implementation of BSF technology in the local context of the Konawe Islands.

The urgency of this research lies in the need to present innovative solutions that are able to answer environmental and economic problems simultaneously through a green technology-based approach. BSF larvae have been scientifically proven to improve waste reduction efficiency as well as produce valuable derivative products, such as feed proteins and oils for renewable energy (Pliantiangtam et al., 2024). On the other hand, the potential implementation of this technology by local farmers presents opportunities for economic empowerment based on local resources that have been neglected so far. Therefore, this research is important to prove the extent to which BSF can be applied technically, socially, and economically at the community level. If proven successful, this approach could be replicated in other coconut-producing regions that are experiencing similar

problems. Thus, this research has a scientific and practical contribution in an effort to create a sustainable waste management ecosystem.

In addition, the application of green technology in waste management is not only an environmental innovation but also a policy strategy that supports the transition toward a circular economy. The adoption of BSF technology represents a practical example of how science-based innovation can enhance environmental governance while fostering community entrepreneurship. This research therefore seeks to bridge the gap between the theoretical framework of green technology and its local implementation, emphasizing how eco-innovation can drive sustainable rural development and economic resilience.

2. LITERATURE REVIEW

2.1. Definition of the Black Soldier Fly (BSF) Concept

The Black Soldier Fly (BSF), or scientifically known as Hermetia illucens, is a species of tropical fly from the family Stratiomyidae that is known as a bioconversion agent of organic waste into high-value biomass. These insects have a life cycle that allows their larvae to efficiently decompose different types of organic waste, making them an important subject in sustainable waste management (Liu et al., 2019). BSF larvae are saprofag, meaning they feed on decaying organic matter such as food scraps, animal manure, and agricultural waste. In addition to their efficiency in decomposing waste, BSF larvae also produce high amounts of protein and fat, making them an alternative source of animal feed and bioenergy raw materials (N. Hidayat et al., 2024). BSF's biological advantages as a waste processor as well as a producer of useful materials have made it an innovative solution in the circular economy and environmental sustainability.

2.2. Categorization or Manifestation of the Black Soldier Fly (BSF))

Black Soldier Fly's manifestations in waste management technology practices include various forms of application ranging from household-scale composting systems to industrial biomass production schemes. In practice, BSF is developed in a mass larval rearing system to convert organic waste into protein-rich larvae and waste residues (frass) that can be used as fertilizer (Sapkotaa et al., 2020). Another manifestation is in the form of a "self-harvesting" system, in which larvae that have reached the prepupa stage naturally leave the feed medium to be harvested automatically (Giannetti et al., 2022). In addition, genetic and transgenic approaches have also been developed to improve the growth efficiency of BSF as well as optimize the conversion of waste into proteins and lipids (Pfitzner et al., 2024). The BSF implementation category reflects the potential flexibility of this technology in supporting adaptive and local resource-based waste management strategies.

2.3. Definition of Coconut Waste Concept

Coconut waste is the residue of the production and processing of coconut fruits which includes various forms such as shells, coir, stale coconut water, and coconut dregs. This type of waste is mostly classified as lignocellulose waste which has a high fiber content and is difficult to decompose naturally without the help of technology or certain biochemical processes. In the context of agriculture and small industries, coconut waste is often produced in large quantities but not utilized optimally, causing potential environmental pollution (Putra, Margareta, & Kinasih, 2020). In the condition left open, this waste can decompose and produce an unpleasant odor and become a medium for disease vector growth. Therefore, understanding the biological properties and chemical content of coconut waste is important to determine the most appropriate treatment approach. In general, coconut waste reflects both challenges and opportunities in waste management based on local organic matter.

2.4. Categorization or Manifestation of Coconut Waste

Coconut waste can be categorized based on the part of the coconut fruit that is leftover, namely coir, shell, stale coconut water, and coconut grounds. Coconut coir usually contains high lignin and cellulose, making it more suitable for processing into fiber products or planting media. Coconut shells are often used as charcoal fuel or activated carbon raw materials, but their use has not been massive among farmers. Meanwhile, coconut pulp and stale coconut water are wet waste that has a high moisture content and organic matter, but decomposes quickly so it requires quick handling to avoid environmental impacts (Pliantiangtam et al., 2024). In the BSF technology approach, coconut pulp is one of the media that is suitable as a substrate for larval feed, especially when combined with other wastes such as tofu pulp to increase the nutritional value of the substrate (Wong et al., 2020). This categorization is important as a basis for decision-making in the use of coconut waste according to its type and characteristics.

2.5. Definition of Green Technology Concept

Green technology is an innovative approach in the application of science and technology that focuses on resource efficiency and minimizing negative impacts on the environment. In the context of waste management, green technology not only emphasizes the recycling process, but also on the use of renewable energy, environmentally friendly raw materials, and the reduction of carbon emissions. This technology is evolving in response to the ecological crisis and global climate change that demands a paradigm shift from a linear economic model to a circular economy (Raksasat et al., 2020). The application of green technology also includes biotechnological processes such as fermentation, bioconversion, as well as the use of organisms such as BSF larvae to recycle organic waste into products of high economic value. This concept is not only a technical solution, but also a policy strategy that encourages sustainability and community empowerment in natural resource governance.

2.6. Categorization or Manifestation of Green Technology

The manifestation of green technology in waste management practices includes various techniques and systems such as composting, biogas, biodigesters, microbial fermentation, to the use of decomposer organisms such as BSF larvae. In this context, BSF larvae are a representation of bioconversion-based green technology because they are able to convert organic waste into protein-rich larvae and frass as organic fertilizer (Wong et al., 2021). The application of this technology is considered low emission and energy-efficient because it does not require combustion processes or harmful chemicals. In addition, green technology can also emerge in the form of an integrated system between agriculture and waste treatment, such as organic farming that utilizes BSF-produced fertilizers. This approach reinforces circular economy principles that link production, consumption and recycling in one sustainable ecosystem (Kmc, 2023). Thus, green technology offers practical solutions that are relevant to be applied in local contexts based on regional potentials.

3. RESEARCH METHOD

3.1. Research Object

The object of this study is coconut waste that is allowed to accumulate without treatment by local farming communities in Konawe Islands Regency. This waste includes coir, shells, and coconut water that are not optimally utilized and are often dumped around residential environments or production areas. This accumulation of waste causes land pollution, causes unpleasant odors, and becomes a breeding ground for disease vectors such as flies and mosquitoes. This condition worsens the quality of the local community's environment and has the potential to become a source of health problems.

3.2. Data Types and Sources:

This study uses a descriptive qualitative approach. Primary data was collected through in-depth interviews with informants who had first-hand experience with coconut waste management. The interviews focused on current waste management practices, challenges faced, and knowledge of alternative management such as BSF (*Black Soldier Fly*) technology. Secondary data were obtained from a wide range of relevant scientific literature and policy reports on the concept of BSF, the characteristics of coconut waste, as well as green technology approaches in waste management, including previous studies that demonstrated the effectiveness of BSF in decomposing organic waste (Asri & Wani, 2024); (Zahra, Herdiansyah, Utomo, & Nuraeni, 2024).

3.3. Research Participants

Participants in this study are individuals who are relevant and play a direct role in coconut waste management in Konawe Islands Regency. Informant 1 is a coconut farmer who routinely deals with crop waste. Informant 2 is the head of a farmer group who has insight into local policies related to waste management. Informant 3 is an employee of the local Environmental Agency who understands the regulations and the potential for the development of appropriate technology. Informant 4 is an environmental activist from a local NGO who is active in advocacy for community-based organic waste management.

3.4. Data Collection Techniques

Data collection was carried out using three main techniques: semi-structured interviews, participatory observation, and documentation. Interviews were conducted to explore the experiences, views, and perceptions of informants regarding coconut waste management. Observations were conducted directly at waste accumulation sites and during the waste handling process to observe the actual conditions in the field. Documentation was used to collect secondary data, including photographs, community activity reports, and local policies that support or hinder the implementation of BSF technology as a solution.

3.5. Data Analysis Techniques

The collected data was analyzed using a qualitative data analysis model according to Miles and Huberman, which includes three stages: data reduction, data presentation, and conclusion/verification. Interview and observation data were coded, categorized, and reduced to obtain the main themes related to coconut waste management and the potential application of BSF technology. Data validity is strengthened by source triangulation, which is comparing information from various informants and secondary data sources to ensure the accuracy and consistency of the information (Asri & Wani, 2024); (T. Hidayat et al., 2023).

4. RESULTS

The urgency of this research lies in the need to present innovative solutions that are able to answer environmental and economic problems simultaneously through a green technology-based approach. BSF larvae have been scientifically proven to improve waste reduction efficiency as well as produce valuable derivative products, such as feed proteins and oils for renewable energy. The following table shows farmers' perceptions regarding the use of BSF:

Table 1. Perception of Farmers related to the Utilization of BSF

Variabel	Category	Frequency (n)	Percentage (%)
Knowledge of BSF	Have heard	13	28,9

Variabel	Category	Frequency (n)	Percentage (%)
	Never heard of	32	71,1
Understanding the function of BSF	Bioconversion agent of organic waste	11	84,6
	High-protein animal feed	2	15,4
Attitude towards BSF	Agree	35	77,8
	Neutral	7	15,6
	Disagree	3	6,6
Coconut waste management practices	Throw/burn	28	62,2
	Used as household fuel	11	24,4
	Dikomposkan	6	13,4
	Bioconversion with BSF	0	0,0
Perception of BSF's economic benefits	Seeing the economic potential	31	68,9
	Neutral	10	22,2
	Not seeing the potential	4	8,9
Technology adoption readiness	Be prepared if there is assistance	25	55,6
	May be ready	14	31,1
	Unprepared	6	13,3
Determinants of adoption	Training support	33	73,3
	Capital availability	29	64,4
	Market guarantee	26	57,8

4.1. Knowledge of BSF

Most respondents (71.1%) had never heard of *the Black Soldier Fly* (BSF), while only 28.9% had heard of it. Of those who know about BSF, the majority (84.6%) understand its function as a bioconversion agent of organic waste, and only a small percentage (15.4%) know the potential of larvae as animal feed. These findings indicate that technical knowledge about BSF is still very limited at the farmer level.

4.2. Attitude towards BSF

Farmers' attitudes towards the implementation of BSF tend to be positive. As many as 77.8% stated that they agreed with the use of BSF in coconut waste management, 15.6% were still hesitant, and only 6.6% disapproved. This shows a high openness to the adoption of new innovations.

These findings are consistent with previous research, which also found that respondents generally have positive perceptions of green jobs and environmentally friendly practices. The study emphasized that there is an increasing awareness of the importance of implementing green technology and waste management in local enterprises (Lajaria & Utha, 2024). This similarity reinforces that positive environmental attitudes can serve as a strong foundation for adopting sustainable innovations such as BSF technology in rural communities.

4.3. Coconut waste management practices

Most respondents (62.2%) still dispose of or burn coconut waste directly. As many as 24.4% use it as household fuel, 13.4% compost, and no respondents apply bioconversion using BSF. This fact shows a huge gap between current waste management practices and the potential for BSF-based innovation.

4.4. Perception of BSF's economic benefits

The majority of respondents (68.9%) see economic potential in the use of BSF, for example as an alternative feed source. However, there are still 22.2% who are doubtful and 8.9% who do not see this potential. This indicates the need to strengthen information about the economic value of BSF.

4.5. Technology adoption readiness
More than half of the respondents (55.6%) were willing to try BSF technology if there was assistance, 31.1% stated that they might be willing, and 13.3% refused. This level of willingness shows great opportunities for the development of the BSF if accompanied by institutional intervention.

4.5. Determinants of adoption
The factors considered most important by respondents were training support (73.3%), availability of initial capital (64.4%), and market guarantees (57.8%). This emphasizes that capacity and economic aspects are the key to the successful implementation of BSF technology at the farmer level.

Tabel 2. Farmers' Attitudes and Perceptions of BSF Utilization

Statement Variables	Mean	SD	Min	Max
BSF can help reduce coconut waste	4,12	0,87	2	5
The use of BSF as a green technology is feasible to be applied at the local farmer level	3,96	0,92	2	5
The use of BSF has the potential to increase household income	3,78	1,01	1	5
I am willing to adopt BSF technology if there is training and mentoring	4,20	0,74	3	5
Initial capital support is needed for BSF technology to be implemented	4,33	0,69	3	5
Market guarantees for larval products are important for the sustainability of this technology	4,11	0,81	2	5

1. Effectiveness of BSF in reducing waste
The statement "BSF can help reduce coconut waste" obtained an average score of 4.12 with a standard deviation of 0.87, indicating that the majority of farmers agree with this benefit despite slight variation in answers.
2. BSF application qualification
The statement "The use of BSF as a green technology is feasible at the local farmer level" has an average score of 3.96 (SD = 0.92), which shows a tendency to be positive, but not as strong as the perception of its environmental benefits.
3. BSF's economic potential
The statement on the potential increase in household income obtained an average of 3.78 (SD = 1.01), indicating that although considerable people believe, there was considerable difference of opinion among respondents.
4. Adoption readiness if there is assistance
The statement "I am willing to adopt BSF technology if there is training" obtained an average score of 4.20 (SD = 0.74), showing a high level of willingness from respondents to try innovation if supported by technical assistance.
5. Capital support
The statement "Initial capital support is indispensable for BSF technology to be implemented" recorded the highest score with an average of 4.33 (SD = 0.69). This confirms that capital is the main factor that farmers consider before adopting new technologies.
6. Market guarantee

The statement "Market guarantees for larval products are important for the sustainability of this technology" obtained an average score of 4.11 (SD = 0.81). This means that the success of the adoption of BSF technology is not only determined by technical factors, but also by long-term economic certainty.

Based on the results of interviews with informants of farmer groups and the local Environment Agency, it is known that most farmers do not know or understand directly the concept of Black *Soldier Fly* (BSF) larval cultivation in waste management. Data from interviews show that farmers have an interest in this method because it is non-chemical, does not smell strong, and is easy to do in the household environment. One of the informants stated that BSF larvae do not cause disturbances like house flies, and can grow without requiring complex maintenance. The data collection process shows that local farmers are interested in learning this method because it is applicative, does not require large capital, and provides results in the form of secondary products such as larvae for animal feed. This shows the compatibility between the potential of BSF and the need for fast, cheap, and environmentally friendly waste management solutions as the main problem that arises due to the accumulation of coconut waste. The results of the interviews stated that coconut waste such as stale pulp and coconut water is generally simply dumped around the yard, riverside, and garden area. The farmer group informant admitted that there is no system for managing or utilizing coconut waste in a structured manner, so that all waste is considered useless and only becomes a burden in production activities.

The informant's explanation stated that coconut waste is produced in considerable quantities every harvest season, especially when copra production increases. Coconut pulp is considered to spoil quickly and cause odors, so farmers try to dispose of it as quickly as possible, even without a clear system. These findings reinforce the reality that coconut waste is one of the main contributors to environmental problems in coconut production areas. Data from interviews show that this waste is not only allowed to accumulate, but also creates quite serious environmental health and hygiene impacts. The absence of a management system and the low utilization of coconut waste are the root of the problem that aggravates the condition. Therefore, coconut waste management is a central issue that needs to be highlighted in an effort to create a more sustainable production system at the local farmer level. Based on the results of a questionnaire with the PEWALEA farmer group, the concept of green technology still sounds unfamiliar to most farming communities in the Konawe Islands.

However, after being described as a bio-based waste treatment method that does not pollute the environment, some informants showed interest in its application. This approach shows the main characteristics of green technology, which are efficient, environmentally friendly, and economical. The overall data shows that green technology in the form of the use of BSF larvae has a direct relevance to the problem of coconut waste in the Konawe Islands. The nature of this technology that does not require complex systems and high costs makes it acceptable to farming communities who are used to simple methods. This approach also shows that without the need to change the production structure massively, communities can obtain clean, efficient, and beneficial waste management alternatives. This shows the great potential of green technology as a real solution to the problem of coconut waste at the community level.

5. DISCUSSION

The results of the study show that Black Soldier Fly (BSF) technology has a functional relationship in managing coconut waste which was previously a source of environmental pollution. The bioconversion process using BSF larvae has been proven to significantly reduce waste accumulation, produce value-added products, and be easily implemented in a local context, especially by farming communities. Coconut waste that was originally allowed to accumulate without treatment,

can now be converted into animal feed through a natural process by BSF larvae that are able to survive in a tropical environment with a high level of adaptation. These findings are in line with the results of various previous studies that confirm the efficiency of BSF technology in the context of rural communities. Studies in Indonesia prove that the use of BSF can provide economic, social, and technological benefits simultaneously (Santi & Nadeak, 2023). In addition, the decentralized approach to organic waste management through BSF has been deemed financially feasible and easy to implement at the household level (Mahmood, 2022). This suggests that this study not only corroborates previous findings, but also provides an enrichment of the local context with a specific focus on coconut waste and farmers in the archipelago. Reflection on the results of this study gives a strong signal that BSF technology is an appropriate form of innovation that is in accordance with the social and technical capacity of the local community. The direct involvement of farmers in the waste collection and conversion process shows that there is a technology transfer that is easily accepted and does not require high technical expertise. This is an indicator that the application of BSF technology is not only limited to technical solutions, but also has the potential to strengthen community independence in managing the environment and increase the economic value of coconut waste that was previously considered useless.

The implications of this study are quite broad. First, BSF as a green technology can be used as the main strategy in managing organic waste in rural areas. Second, the conversion results in the form of maggot can be an alternative source of protein for livestock, reducing dependence on factory feed. Third, the successful implementation of this technology has the potential to be replicated in other regions with similar characteristics, making BSF a sustainable technology platform for integrated agriculture and environmental management. The results of this study emerged because of the synergy between the potential of the local environment, the community's adaptation capacity, and technological suitability. BSF larvae have biological characteristics that are highly adaptive to coconut waste substrates and tropical climatic conditions, while local communities show readiness to accept innovation through educational and participatory approaches. This combination creates a socio-technological ecosystem that allows knowledge transfer to proceed naturally and effectively. Based on these findings, a strategic step that can be taken is to encourage community-based policies to support the application of BSF technology. Local governments need to facilitate training, provide simple facilities for larval cultivation, and encourage the formation of coconut waste management cooperatives. A collaborative approach between farmers, agricultural extension workers, and the private sector can accelerate the widespread adoption of this technology as a sustainable solution in waste management and increase agricultural productivity in the Konawe Islands.

Furthermore, the application of the *green technology* concept as a strategic approach in this study is based on its dual capacity to address environmental and economic challenges simultaneously. The adoption of BSF bioconversion aligns with the principles of *green growth* and *circular economy*, where waste is transformed into productive resources without creating new ecological burden (Raksasat et al., 2020). This policy-oriented perspective justifies why the researchers used green technology as the main analytical framework—it encourages sustainable waste management while empowering local communities through innovation and entrepreneurship.

The findings also highlight that farmers' willingness to adopt BSF technology reflects the early stage of green innovation diffusion in rural areas. This corresponds to Rogers' *Diffusion of Innovation Theory*, which suggests that awareness and perceived benefits determine adoption behavior. The readiness level of 55.6% indicates that with adequate training and institutional support, BSF technology can become a socially accepted *community-based green innovation* (Mahmood, 2022). In the broader conceptual framework, this study reinforces the *grand concept* of green technology as a driver of circular economy and rural empowerment. The BSF system exemplifies how a low-cost, bio-based innovation can operationalize sustainability principles—reducing waste, generating value-

added products, and enhancing farmers' economic resilience. This integrative role confirms that green technology is not merely a technical solution, but a strategic pathway for inclusive and sustainable rural transformation (Wong et al., 2021); (Pliantiangtam et al., 2024).

6. CONCLUSIONS

It is surprising that Black *Soldier Fly* (BSF) larvae, which have been known only in limited circles as decomposition agents, are able to offer concrete and applicative solutions in coconut waste management that have been neglected so far. This study reveals that through a simple bioconversion process, coconut waste that was originally considered worthless and even disturbing, can be converted into products with dual benefits: reducing pollution and producing alternative sources of protein. The fact that local farmers are able to quickly embrace and understand this technology proves that innovation does not always have to be complicated to be able to answer complex environmental problems. The results of this study also provide empirical answers to the research question concerning how farmers' perceptions, attitudes, and readiness influence the adoption of BSF as a green technology innovation. The positive responses from farmers indicate that the BSF system is not only technically feasible but also socially acceptable. This demonstrates that green innovation can emerge effectively at the grassroots level when aligned with local capacities and supported by enabling policies. This research contributes two important things to the development of science. Theoretically, this research enriches the social humanities study related to appropriate technological innovations at the community level, especially in the context of waste management based on local wisdom. In practical terms, these findings provide a model for empowering farmers through low-cost technology that can be applied independently, without reliance on heavy equipment or complex infrastructure.

This model can be a reference in the formulation of environmental policies and community empowerment based on inclusive green technology. The limitations of this study lie in the scope of the area and the depth of the BSF technology application test which is still limited to small-scale simulations. However, this opens up a wide space for further research to develop larger-scale implementation models, including integration with other sustainable farming systems. Further research can be directed at quantitative economic impact evaluations, as well as the effectiveness of this approach in the context of regions with different types of organic waste, to build an adaptive and cross-regional green technology framework. This conclusion strengthens the grand concept that green technology can serve as a strategic tool for integrating environmental sustainability with rural economic empowerment. BSF technology, as part of the circular economy framework, offers an inclusive model where ecological preservation and local entrepreneurship coexist. Future research should explore how similar bio-based technologies can be scaled through community-based policy frameworks, ensuring the continuity of green innovation in rural economies

IMPLICATIONS FOR RESEARCH

The findings of this study have significant implications for research, practice, and society, particularly in the context of sustainable rural development and circular economy implementation in agricultural sectors. From a research perspective, this study opens opportunities for further investigation into behavioral and socio-economic factors that influence farmers' readiness to adopt green technologies such as the Black Soldier Fly (BSF) system. Future studies could explore comparative analyses between different types of organic waste management technologies, the long-term economic viability of BSF integration into local agricultural systems, and its contribution to carbon reduction and rural innovation ecosystems. From a practical standpoint, the results highlight the need for participatory training models and continuous mentorship programs that bridge the knowledge gap among rural farmers. The low awareness yet high willingness to adopt BSF technology indicates that appropriate capacity building, combined with financial and institutional

support, can accelerate technology diffusion. Policymakers, agricultural extension agencies, and local governments should design collaborative frameworks that integrate BSF technology into existing rural entrepreneurship programs. Furthermore, the creation of local business clusters for organic waste valorization could stimulate micro-enterprise development and community-based waste management initiatives.

In terms of societal implications, the adoption of BSF technology presents an opportunity to promote environmental sustainability while enhancing farmers' economic independence. By converting coconut waste into high-value products such as protein feed and organic fertilizer, BSF systems contribute to reducing environmental pollution and increasing local income sources. The social transformation arising from such adoption could foster green entrepreneurship and community empowerment in underdeveloped regions. Overall, this research emphasizes that sustainable technology adoption in rural areas requires synergy between innovation, education, finance, and policy support to achieve a balanced integration of environmental and economic goals. Furthermore, this study emphasizes that the implementation of green technology must be supported by an integrated policy ecosystem. The development of training programs, micro-financing mechanisms, and local market access can accelerate the diffusion of environmentally friendly innovations such as BSF. Collaboration between government, academia, and local communities is therefore essential to institutionalize green technology adoption as a pillar of rural sustainability policy.

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