



Agroforestry development strategy through a food policy perspective for forest function restoration and local food security in Indonesian watersheds

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Received Date: May 17, 2025

Revised Date: June 7, 2025

Accepted Date: July 31, 2025

ABSTRACT

Background: Agroforestry, which integrates agricultural and forestry crops on the same land, offers significant potential to enhance food security while restoring forest functions. In Indonesia, many watersheds face degradation due to land conversion and deforestation, leading to reduced food availability and community welfare. Linking agroforestry to food policy is therefore critical to address both ecological and social challenges. **Methods:** This study employed a literature review with descriptive analysis, examining research and policy documents related to agroforestry, watershed management, and food security. **Findings:** The results indicate that agroforestry development improves land productivity, supports biodiversity, enhances environmental quality, and strengthens local food security. However, successful implementation requires policies that integrate agroforestry practices with food security programs at the national and regional levels. **Conclusion:** Agroforestry is an effective strategy for simultaneously restoring forest functions and improving food security in Indonesian watersheds. Policy integration and coordinated programs are necessary to ensure sustainability and maximize impact. **Novelty/Originality of this article:** This study highlights agroforestry not only as an ecological solution but also as a food policy strategy, emphasizing its dual role in environmental restoration and food system resilience in Indonesia.

KEYWORDS: agroforestry; food policy; food security; forest function; watershed area.

1. Introduction

Food security is now an increasingly urgent global issue, especially for developing countries such as Indonesia. With a continuously growing population, the challenge of meeting food needs is becoming increasingly complex. The ever-increasing demand for food has forced the government to take strategic measures, one of which is to launch a food estate program that involves converting forest land into large-scale agricultural land. However, this measure carries the risk of forest destruction, which could threaten the ecological, social, and economic sustainability of the program area. In facing these challenges, agroforestry has emerged as a solution that combines food crops and trees in a single land management system. With this approach, we can increase food security while restoring the vital functions of forests (Nair, 2012; Mulyana et al., 2017).

Indonesia's diverse geographical conditions have a profound impact on many aspects of life, one of which is the presence of highlands and mountain slopes in various regions.

Cite This Article:

Rahmawati, A. Z. (2025). Agroforestry development strategy through a food policy perspective for forest function restoration and local food security in Indonesian watersheds. *Jurnal Bisnis Kehutanan dan Lingkungan*, 3(1), 49-58. <https://doi.org/10.61511/jbkl.v3i1.2025.2298>

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However, forest and land degradation is a significant problem, mainly due to deforestation and land use change. According to a report from the FAO, the rate of deforestation in Indonesia has declined significantly in recent years, with the deforestation rate in 2020 being the lowest in more than 30 years (FAO, 2022). Nevertheless, Indonesia still faces the challenge of losing around 270,000 hectares of forest per year, which has an impact on the decline in biodiversity and increased soil erosion, particularly in Sumatra, Kalimantan, and Papua (Global Forest Watch, 2023). The high rate of deforestation has resulted in the loss of forests' function as a provider of food and other natural resources, including negative consequences for the environment, one of which is an increase in flooding in watersheds. Watersheds are very important areas for natural resource management because they function as ecosystem buffers and water providers for agriculture (Setyawan, 2010; Ministry of Forestry, 2011).

The latest policy currently in effect encourages the conversion of forests into food estates, which can accelerate forest destruction. Food estates are large-scale efforts to produce integrated food products, covering various sectors such as food crops, horticulture, plantations, livestock, and fisheries, which are managed within forest areas. In the 2020-2024 National Medium-Term Development Plan, food estates are one of the development priorities, especially in Sumatra and Sulawesi.

This policy also aims to attract foreign investors who will buy or lease large tracts of land in developing countries to produce food and biofuels for foreign markets, while anticipating a possible food crisis (Ito et al., 2014). The concept of establishing food estates was discussed in the World Development Report 2008 by the World Bank, which is closely related to global food security efforts. The report recommends the need for more investment and market freedom to achieve this goal (Ploeg, 2010). The development of food estates in Indonesia under a private management scheme is a response to this push. As an alternative, agroforestry systems could be a more sustainable solution, helping to maintain biodiversity balance and reduce the negative impacts of deforestation. Agroforestry combines forestry management with agriculture, aiming not only to increase agricultural yields but also to improve community welfare.

1.1. Literature review

Agroforestry is one effective approach to addressing land degradation. This approach combines agricultural and forestry practices to restore ecosystem functions, improve soil fertility, and increase water retention. Pantera et al., (2021) state that based on recent research, the widespread application of agroforestry principles and practices can be a key way for the global food sector to achieve more sustainable methods of food and fiber production, providing economic benefits for farmers and environmental benefits for communities.

For example, agroforestry systems can increase the organic carbon content in soil and microbial diversity, which is important for soil fertility and nutrient cycling (Fahad et al., 2022; Chatterjee et al., 2022). Other studies show that agroforestry, through a combination of trees and crops, can reduce soil erosion rates and increase water availability in degraded areas (FAO, 2023). Practices such as the use of cover crops and nitrogen-fixing trees have also been shown to increase nitrogen content in the soil, which contributes to increased crop productivity (Gusli et al., 2020). In addition, agroforestry also contributes to food security. For example, traditional home gardens provide 20% more food variety than commercial gardens, while commercial gardens can provide up to five times more income (Duffy et al., 2021).

The ideal condition expected from the implementation of agroforestry is the achievement of a balance between agricultural production and forest conservation. This balance can be achieved through the implementation of a sustainable agroforestry system. This not only supports environmental conservation but also improves the welfare of local communities. In addition, rehabilitation of critical watersheds using agroforestry systems can ensure sustainable water availability and prevent soil erosion, thereby providing long-

term benefits for the ecosystem as a whole (FAO, 2023; Global Forest Watch, 2023). Agroforestry has been proven to provide many benefits, including increased land productivity, reduced erosion, and increased biodiversity (Mishra et al., 2017; Jacobi, 2016). Several studies show that agroforestry can increase farmers' income and food security (Wanderi et al., 2019; Nurdjannah, 2004). However, the implementation of agroforestry is often hampered by unsupportive policies and a lack of knowledge among farmers (Rahman, 2018; Gai, 2020).

Food policy in Indonesia has a background that is closely related to the need for sufficient and equitable food availability for all citizens. In the early days of independence, Indonesia faced major challenges in achieving food security, especially in meeting the demand for staple foods, namely rice. Over time, Indonesia's food policy has evolved, with a primary focus on increasing domestic food production. The Green Revolution policy achieved self-sufficiency in 1984-1985 but lasted less than a decade until the 1998 Asian Economic Crisis (Patunru & Ilman, 2020). The policy proved effective initially, but over time various problems arose that required more comprehensive policy adjustments. As times changed and challenges became more complex, Indonesia's food policy underwent various revisions to remain relevant to the needs of the people and the ever-evolving global conditions.

According to the FAO (2006), food security has four main dimensions. First, sufficient and quality food availability according to needs. Second, food access, which refers to the right of individuals to have sufficient resources to obtain nutritious food. Third, food utilization, which includes healthy eating patterns, access to clean water, good sanitation, and health services to achieve optimal nutrition. Fourth, food stability, which guarantees sufficient access to food for individuals or households at all times. In Indonesia, the concept of food security is outlined in Regulation of the Minister of Environment and Forestry No. 24 of 2020, which defines food security as the fulfillment of food for the country down to the individual level, including sufficient, safe, nutritious, diverse, equitable, affordable, and in accordance with the religious values, beliefs, and culture of the community, to support a healthy, active, and productive life in a sustainable manner. A sustainable food security system must prioritize a cradle-to-cradle approach and be closed-loop, with the aim of increasing efficiency and reducing resource waste.

Indonesia has established a national food policy that focuses on achieving food security and equitable distribution. This policy is not limited to increasing food production, but also includes the provision of affordable food and fair distribution for all levels of society. One of the important regulations in food management is Law No. 18 of 2012 concerning Food, which regulates food diversity, adequate food availability, and protection of the food rights of every citizen. According to Hadi (2015), this law underlines the importance of food management based on sustainability, social justice, and the right to obtain nutritious food. This policy also emphasizes the need to reduce Indonesia's dependence on food imports, which often disrupts domestic food price stability and availability.

In addition, in facing global challenges, Indonesia's food policy also aims to strengthen the agricultural sector based on local food security. As suggested by Syamsudin and Hermawan (2020), the government is trying to reduce dependence on imports, such as rice and corn, by promoting local food diversity as an alternative solution. This is important considering that food security does not only depend on the availability of rice, but also on the utilization of various natural resources available in Indonesia.

Food security is a central theme in Indonesia's food policy. Food security not only covers food availability, but also involves equitable distribution and affordable access to food for all levels of society. In this case, the government plays a very strategic role in creating a safe and sustainable food system.

One of the important policies announced by the government is the National Medium-Term Development Plan/*Rencana Pembangunan Jangka Menengah Nasional* (RPJMN), which emphasizes efforts to strengthen food security by increasing domestic food production capacity and managing food distribution more efficiently and evenly. Ginting (2020) states that the Food Security Agency of the Ministry of Agriculture has a central role

in ensuring sufficient food availability and distributing it to various regions, especially in areas that often experience difficulties in accessing sufficient food.

However, the biggest challenge faced in this effort is Indonesia's dependence on imports of certain foodstuffs, such as soybeans and corn, which often cause food price fluctuations that are detrimental to the community. As stated by Suryadi and Sutrisno (2018), policies to reduce dependence on food imports require concrete steps, including diversification of local food sources and increased agricultural productivity.

Although Indonesia's food policies continue to evolve, major challenges remain, particularly those related to dependence on imports and uneven food distribution. Indonesia still faces difficulties in distributing food evenly, especially in areas that are difficult to reach by existing food distribution infrastructure. Arifin (2019) emphasizes that although the government has developed various programs to improve food distribution, logistical problems and inadequate infrastructure remain major obstacles. In addition, climate change and natural disasters are also factors that often disrupt food production in Indonesia.

Therefore, sustainable food policies must consider adaptation to climate change and potential natural disasters so that food security can be properly maintained. In this case, the development of environmentally friendly agricultural technology based on local food diversity is one of the solutions that needs to be implemented more widely. Sulaeman (2020) states that local food diversity, such as sorghum, cassava, and corn, can be an alternative that is more resistant to climate change and more environmentally friendly, thereby reducing dependence on rice.

In recent years, Indonesia's food policy has increasingly focused on the diversity of local food sources and the use of technology to improve the food distribution system. The government encourages the use of digitalization in food distribution to improve market efficiency and transparency. Sulaeman (2020) also reveals that by utilizing technology, food distribution can be carried out more quickly and accurately, especially to reduce waste and food price inequality in the market. Food policies based on food diversity and the use of technology are expected to reduce dependence on imported food, strengthen local food security, and create a more equitable and sustainable food system.

However, the implementation of this policy is often not integrated with forest management policies, resulting in conflicts between food needs and forest conservation (Prakoso, 2016; ADB, 2009). Therefore, despite the significant challenges that remain, Indonesia's food policy shows a positive direction for facing the changing times and creating a more resilient food system. This paper will review Indonesia's food policy in line with these objectives through agroforestry strategies that support the SDGs from an ecosystem, socio-cultural, and economic perspective.

2. Methods

The research was conducted by collecting various literature related to the Indonesian food perspective model. The method used was a literature review, which is the process of reading various literature collected from various sources, including journals, books, and government reports relevant to the research theme. Analysis was carried out to identify agroforestry development strategies that could be integrated with food policy.

The data collection procedure began with an initial screening stage, in which all studies found from the initial search were evaluated to determine their relevance to the relationship between food security and agroforestry. Studies that were deemed irrelevant were removed from the list. Next, studies that passed the initial screening stage were read thoroughly to ensure their suitability with the inclusion and exclusion criteria. Relevant data from the selected studies were extracted using a prepared data extraction form, which included information on study design, methodology, results and discussion, and conclusions.

3. Results and Discussion

3.1 Agroforestry development strategy

Agroforestry development in watersheds requires a comprehensive approach to policy assessment, which includes three main strategies. First, improving farmers' knowledge and skills through training and extension on effective agroforestry techniques is essential to increase farmer participation in this system (Limi et al., 2018; Septiana, 2018). Second, policy support integrated with food security programs must be implemented to create optimal synergy between natural resource management and meeting the food needs of the community (Prakoso, 2016; ADB, 2009). Third, the development of adequate infrastructure, including market accessibility for agroforestry products, needs to be considered so that farmers can market their agricultural products efficiently and increase their income (Ministry of Agriculture, 2020). By integrating these three strategies in policy assessment, it is hoped that the development of agroforestry in watersheds can provide sustainable benefits for food security and environmental preservation.

3.2 Impact on food security

The implementation of agroforestry in watersheds can improve local food security through food source diversification. To solve food problems in a sustainable manner, it is necessary to promote solutions that are environmentally non-degrading, technically appropriate, economically viable, and socially acceptable (FAO, 1988). Agroforestry allows farmers to grow various types of crops, thereby reducing dependence on a single commodity (Mulyana et al., 2017; Nair, 2012). Diversification of food sources through agroforestry strategies is an integrative approach that combines woody plants with food crops, livestock, or other components on a single plot of land. This approach not only increases land productivity but also plays a role in environmental conservation and improving farmers' welfare.

3.2.1 Benefits of agroforestry in food source diversification

Agroforestry systems provide significant benefits in improving farmers' welfare and preserving the environment. In terms of increasing income, agroforestry allows farmers to grow various commodities on one plot of land, such as cocoa beans, fruits, and other products. This diversification not only increases farmers' income, but also reduces the risk of dependence on a single commodity that is vulnerable to price fluctuations or climate change. By growing various types of crops, such as rice, vegetables, and fruit trees, farmers can meet diverse nutritional needs and reduce dependence on a single commodity (Wanderi et al., 2019; Nair, 2012). In addition, this diversification also reduces the risk of crop failure due to climate change or pest attacks, thereby increasing overall food security (Zulkarnain & Rahman, 2019).

Agroforestry also contributes to community food security by introducing various types of food crops other than rice and corn, such as cassava, gembili, ganyong, hanjeli, and mung beans, which can be grown under the canopy of timber and fruit trees. Although its implementation is still in the development stage, this food diversification effort shows great potential in strengthening local food security. This statement is also reinforced by Jacobi (2016), who states that from an economic perspective, agroforestry can increase farmers' income through the sale of various products such as vegetables, fruits, and wood, which can increase income by up to 30% compared to conventional farming systems (Jacobi, 2016).

From an ecological perspective, agroforestry also plays a role in environmental conservation by supporting sustainable land management. The integration of woody plants with food crops can prevent forest land conversion, maintain soil fertility, and reduce erosion. Thus, agroforestry not only supports farmers' welfare, but also plays a role in preserving ecosystems and natural resource sustainability. Agroforestry practices

contribute to improving soil and environmental quality by improving soil structure and reducing erosion (Mulyana et al., 2017). Thus, the development of agroforestry not only supports food diversification but also maintains environmental sustainability, making it an important strategy in achieving ecologically, economically, and socially sustainable food security.

3.2.2 Implementation of agroforestry in Indonesia

Food policy based on an environmental science perspective means adhering to the basic ecological principles of diversity, interconnection, interdependence, harmony, and sustainability of each component of the food system (Habib, 2024). Although not yet optimal, this step demonstrates the potential of agroforestry in food diversification. In addition, in South Sulawesi, a local crop-based agroforestry system has been implemented in the Forest Management Unit area. This approach not only increases the food security of communities living near forests but also preserves the function of the forest without changing it.

The application of payments for ecosystem services in agroforestry systems Environmental Services Payments in Indonesia are an important mechanism that provides compensation to individuals or communities who play a role in protecting and preserving the environment. In the context of natural resource management, IJL is becoming increasingly relevant given the environmental challenges faced, such as deforestation, pollution, and climate change. Regulations governing IJL in Indonesia include Law No. 32 of 2009 concerning Environmental Protection and Management, Law No. 41 of 1999 concerning Forestry, and Government Regulation No. 46 of 2016 concerning Guidelines for the Implementation of Environmental Services. These regulations provide a clear legal basis for the implementation of IJL, including procedures for identification, determination of parties involved, negotiation, and monitoring. According to Chandler (2003), there are five main activities in RUPES research and development, including:

Table 1. Main activities in RUPES research and development

No	Key Activities in RUPES Research and Development	Description/Example
1	Environmental service measurement	Identifying and evaluating benefits and obstacles in implementation, for example reforestation in Lake Singkarak.
2	Development of compensation mechanisms	Creating mechanisms such as land rights, water taxes, reforestation, and direct payments for environmental services.
3	Supporting a conducive environment	Overcoming obstacles such as lack of political, legal, and financial support to improve implementation.
4	Raising public awareness	Promoting the value of environmental services through national and international forums.
5	Building partnerships	Establishing strong collaboration between researchers and stakeholders to formulate and mediate environmental service agreements.

(Chandler, 2003)

One example of successful PES implementation in Indonesia is the RUPES (Rewarding Upland Poor for Environmental Services) Program. This program aims to reward upland communities in Asia, including Indonesia, for the environmental services they provide. In the Sumberjaya area of Lampung, farmers are given incentives to protect forests and manage land sustainably. Through collaboration between the government, NGOs, and local communities, RUPES demonstrates the great potential of IJL mechanisms in improving community welfare while preserving the environment.

Although regulations and programs such as RUPES have provided a clear framework for the implementation of IJL, challenges in implementation and public awareness still need to be addressed. There is a need to increase public awareness and education about IJL so that people understand the importance of their role in protecting the environment. In

addition, strengthening cooperation between the government, the community, and the private sector is also very important to ensure the success of the IJL program. Further research is needed to evaluate the effectiveness and impact of existing IJL programs so that the necessary improvements can be made.

3.2.3. Challenges and recommendations

Biogeophysical conditions such as rainfall patterns and soil health further influence the success of the program, requiring tailored approaches for effective implementation. Payments for ecosystem services programs involve various risks, covering multiple dimensions. These risks include market uncertainty, internal factors within the program, deficiencies in program design, and environmental challenges. Market risks, such as delays in credit payments, hamper the financial cycle of the program. Other factors, such as farmer commitment, unfair benefit sharing, and labor displacement, contribute to the risk of program sustainability. The success of the program is further threatened by poor program design, inadequate conservation measures, and the impacts of climate change. Ultimately, understanding and addressing these obstacles is essential to fully realizing the benefits of payments for ecosystem services in agroforestry.

Agroforestry strategies offer a range of benefits, but in practice, challenges such as farmers' lack of knowledge about effective and efficient agroforestry systems and limited market access for diversified products remain evident. Therefore, a comprehensive strategy is needed, including policy support, stakeholder engagement, and fair compensation, along with collaborative efforts from the government, non-governmental organizations, and communities. Overall, agroforestry strategies have great potential for diversifying food sources, increasing farmers' incomes, and conserving the environment. Agroforestry systems can improve soil quality and increase fertility, which has a positive impact on agricultural productivity (Wanderi et al., 2019; Jacobi, 2016). Traditional agroforestry systems also have the opportunity to be developed, scaled up, and mainstreamed in building food security, and even further in realizing food sovereignty and the welfare of rural communities. Building farmers' awareness of the risks of agricultural practices, both from an economic and environmental perspective, through a generic and location-specific approach can build holistic awareness.

4. Conclusions

The development of agroforestry through a food policy perspective is an effective strategy for restoring forest functions and improving local food security in Indonesian watersheds. Policies that support agroforestry need to be integrated with food security programs to achieve optimal results. Further research is needed to evaluate the implementation of this strategy in various regions of Indonesia.

Acknowledgement

The author would like to extend heartfelt thanks to the reviewers for their constructive feedback and thoughtful suggestions, which significantly enhanced the quality of this manuscript. Appreciation is also given to all those who provided support and encouragement throughout the development of this work.

Author Contribution

This study was entirely conducted by A.Z.R., who took full responsibility for the research design, data acquisition, analysis, interpretation of results, and drafting of the manuscript.

Funding

This research did not receive funding from anywhere.

Ethical Review Board Statement

Not available.

Informed Consent Statement

Not available.

Data Availability Statement

Not available.

Conflicts of Interest

The author declare no conflict of interest.

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