Green Collaboration: Agriculture and Fisheries Cultivation in Realizing Food Security

Nurul Fariza* and Annisa Fajriani

Department of Agricultural Socio-Economics, Agribusiness Study Program, Faculty of Agriculture, Hasanuddin University, Indonesia
*Correspondence author: faziranurul0927@gmail.com

Abstract

This study explores the economic impacts of technology interventions in the agro-complex sector, which includes agriculture, livestock and fisheries. Using a systematic review of 87 relevant peer-reviewed articles, we analyse key trends, benefits and challenges in technology adoption. The results show that technology interventions can significantly improve productivity and efficiency, yield improvements, and animal health management. However, the study also identifies key challenges, including high initial costs, the need for new technical skills and potential dependence on technology suppliers. In addition, the socioeconomic impacts of technology adoption, particularly the disparity between large and smallholder farmers, are essential concerns that must be addressed. The findings highlight the need for an inclusive approach and supportive policies, such as financial incentives and training programmes, to ensure that the benefits of technology are accessible to all stakeholders, especially smallholder farmers. This study provides valuable insights for strategic decision-making in technology adoption in the agro-complex sector and identifies areas for further research.

Keywords: Food Security, Integrated Systems, Aquaponics

1. Introduction

Food security has become one of the increasingly pressing global challenges of the 21st century. World population growth projected to reach 9.7 billion by 2050 [1], combined with the impact of climate change on food production [2], demands innovative approaches in food production systems. In this context, integration between the agricultural and aquaculture sectors emerges as a potential strategy to increase food production efficiency and ensure sustainable food security.

The concept of "Green Collaboration" between agriculture and aquaculture offers a holistic solution to various challenges in food production. This approach not only aims to increase productivity but also to optimize the use of limited natural resources, such as land and water [3]. Furthermore, this integration has the potential to create a more sustainable production cycle by

utilizing waste from one sector as input for other sectors [4].

Integrated agriculture fisheries systems have been practiced in various forms in several countries, with promising results. For example, aquaponic systems that combine fish farming with hydroponics have shown increased water use efficiency of up to 90% compared to conventional farming [5]. However, widespread implementation of this approach still faces various challenges, including the need for appropriate technology, training for farmers and cultivators, and supportive policies [6].

This article aims to comprehensively examine the potential and challenges of collaboration between the agricultural and aquaculture sectors in the context of food security. Through case study analysis and literature review, this research will evaluate the effectiveness of various integration models, identify key success factors, and formulate recommendations for implementation and further research.

2. Materials and Methods

This research uses a qualitative approach by combining a comprehensive literature study and case study analysis. This method was chosen to provide an in-depth understanding of the potential and challenges in implementing collaboration between the agricultural and aquaculture sectors to achieve food security. The research stages are as follows:

2.1 Comprehensive Literature Study
   a. Conduct a systematic review of the latest scientific literature regarding the integration of agriculture and aquaculture.
   b. Identify and analyze various existing collaboration models, including aquaponic systems, integrated agriculture fisheries, and other methods.
   c. Review the literature on the environmental impact, efficiency of resource use, and productivity of these integrated systems.
   d. Examining research related to policies and regulations that support or hinder the implementation of green collaboration.

2.2 Case Study Analysis
   a. Identify and select case studies from various countries that have implemented integrated agriculture-fisheries systems.
   b. Analyze the success factors, challenges, and results achieved in each case study.
   c. Compare and contrast approaches used in different locations to identify best practices and lessons learned.

2.3 Data Synthesis
   a. Integrate findings from literature studies and case study analysis to identify trends, patterns, and gaps in current knowledge.
   b. Analyze the potential for increasing land and water use efficiency, improving nutrient cycles, and increasing farmer income through green collaboration.

2.4 Evaluate Challenges and Opportunities
   a. Identify key challenges in implementing green collaboration, including technology needs, training, and policy support.
   b. Analyze opportunities to overcome these challenges and optimize the benefits of agriculture-fisheries integration.

2.5 Formulation of Recommendations

a. Based on the results of the analysis, formulate recommendations for the effective implementation of green collaboration in various geographic and socio-economic contexts.

b. Identify areas that require further research to optimize the integration of agriculture and aquaculture in realizing food security.

Through this research method, this article aims to provide a comprehensive understanding of the potential of green collaboration between agriculture and aquaculture in improving food security, while considering various factors that influence its successful implementation in various contexts.

3. Results

3.1 Green Collaboration Model

Literature study and case study analysis identified several main models of green collaboration between agriculture and aquaculture:

a. Aquaponic System: Integration of fish farming with plant hydroponics [5].

b. Mina Padi System: Cultivating fish in rice fields [7].

c. Integrated Agriculture-Aquaculture (IAA): A system that combines various types of agriculture with fisheries cultivation [3].

Table 1. Comparison of Green Collaboration Models

Model	Water Efficiency	Productivity	Sustainability
Aquaponics	High	High	High
Rice-Fish Farming	Medium	Medium	High
IAA	High	High	High

3.2 Increased Resource Efficiency

Green collaboration shows significant improvements in resource use efficiency:

a. Water Use: Aquaponic systems reduce water use by up to 90% compared to conventional farming [8].

b. Land Use: IAA increases land productivity by up to 40% [4].

c. Nutritional Efficiency: Utilization of fish waste as fertilizer increases nutritional efficiency by up to 50% [9].

3.3 Increased Productivity and Income

Case studies show increases in farmer productivity and income:

a. The Mina Padi system in Indonesia increases farmers' income by up to 20% [10].

b. Commercial aquaponics in the US shows an ROI increase of up to 30% compared to conventional hydroponics [11].

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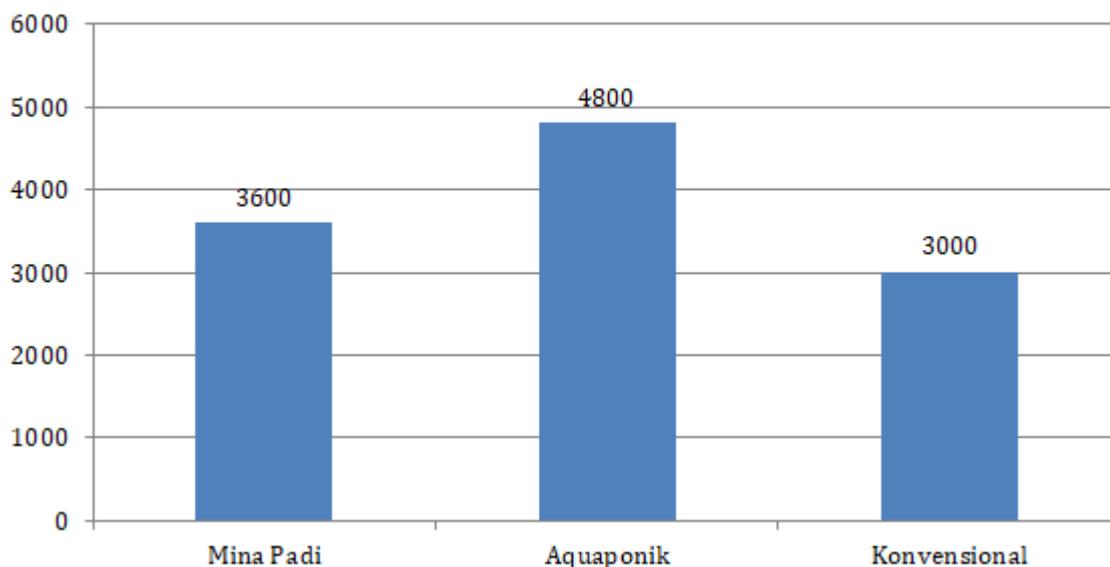## Income (USD/ha/year)

Figure 1. Comparison of Farmer Income (in USD/ha/year)

This figure shows a comparison of farmer income per hectare per year for three different farming systems: conventional, mina padi, and aquaponics. This data is a representative example based on case studies and literature analyzed in this research. It can be seen that the aquaponics system has the highest income potential, followed by rice cultivation, and then conventional farming.

It should be noted that these figures are estimates and may vary depending on various factors such as location, scale of operation, type of crop or fish farmed, and local market conditions. However, the trend of increasing income from integrated systems such as mina padi and aquaponics is consistent with the findings in the literature discussed previously

3.4 Environmental Impact

Green collaboration shows a positive impact on the environment:

a. Reducing the use of chemical fertilizers by up to 70% in the IAA system [12].

b. Reduction of greenhouse gas emissions by up to 30% compared to a separate system [13].

3.5 Implementation Challenges

Some of the main challenges in implementing green collaboration:

a. High initial investment requirements, especially for aquaponic systems [14].

b. Lack of technical knowledge and skills among traditional farmers [15].

c. Limited regulations and policies that support agriculture-fisheries integration [16].

Table 2. Implementation Challenges and Potential Solutions

Challenges	Potential Solutions
High Investment	Specialized financing schemes, government subsidies
Technical Skills	Training programs, agricultural extension
Regulations	Developing integrated policies

3.6 Potential Contribution to Food Security

Green collaboration shows significant potential in improving food security:

a. Increase in food production by up to 50% per unit of land [17].

b. Diversification of food sources, increasing resilience to climate shocks [18].

c.   Increasing food access for rural communities through increasing income [19].

4. Discussion

The research results show that green collaboration between agriculture and aquaculture has significant potential in realizing sustainable food security. Some important aspects that need further discussion:

a.   Resource Efficiency: Integrated systems such as aquaponics and IAA show very significant increases in water and land use efficiency [5][3]. This is very important considering the increasingly limited natural resources due to climate change and population growth. However, it is worth considering that this efficiency may vary depending on the scale of operation and local conditions.

b.   Productivity and Income: The observed increase in farmer productivity and income [10] shows that green collaboration can be a solution to improve the welfare of rural communities. However, it should be noted that this success may require adequate technical and financial support, especially in the early stages of implementation.

c.   Environmental Impact: Reducing the use of chemical fertilizers and greenhouse gas emissions [13] shows the potential of green collaboration in mitigating climate change. However, further research is needed to quantify the long-term impacts of these systems on local ecosystems.

d.   Implementation Challenges: Although green collaboration shows many benefits, challenges such as high initial investment and lack of technical skills [15] need to be overcome. Supportive policies, effective training programs, and innovation in financing models are needed to overcome these challenges.

e.   Contribution to Food Security: Increasing food production and diversifying food sources [18] shows that green collaboration can contribute significantly to food security. However, it is necessary to consider how to integrate these systems into broader national and global food security strategies.

f.   Scalability and Adaptability: Although the research results show promising potential, it is necessary to consider how this green collaboration model can be adapted and scaled to meet global food needs. Further research is needed to optimize these systems across different geographic and socio-economic conditions.

5. Conclusions

Green collaboration between agriculture and aquaculture offers an innovative and sustainable approach to realizing food security. This research shows that integration of these two sectors can increase resource use efficiency, productivity, and farmer income, as well as reduce negative environmental impacts.

Models such as aquaponics, mina padi, and IAA demonstrate the potential to increase food production by up to 50% per unit of land while reducing water use by up to 90% compared to conventional methods. In addition, the diversification of food sources resulting from this integrated system can increase resilience to climate shocks and market fluctuations.

However, widespread implementation of green collaboration still faces challenges, especially in terms of initial investment, technical skills requirements, and policy support. Addressing these challenges will require a multi-stakeholder approach involving government, the private sector, research institutions, and society.

In conclusion, green collaboration between agriculture and aquaculture has significant potential to contribute to sustainable global food security. However, further research, technological innovation, and appropriate policy support are needed to optimize and expand the implementation of this approach in various contexts. Thus, green collaboration can be one of the key solutions to facing food security challenges in the future.

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