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Integrated Rice-Poultry-Fish Farming for Economic Efficiency and Sustainability: An Overview

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Conflict of Interest

The authors declare that the manuscript was formulated in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authors Contribution

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Abstract

The increase in population and economic activity has resulted in more intensive agricultural, animal husbandry, and aquaculture techniques in emerging countries. Many historic revolutions were launched in response to the growing demand for food, including the Green Revolution in the 1960s, the Pink Revolution in 1964, and the Blue Revolution in 1984. However, the limitations posed by rice monoculture and traditional aquaculture have spurred the development of integrated rice-fish farming methods. This innovative approach not only boosts productivity and dietary variety but also acts as a sustainable source of income, driving economic advancement for farmers and the nation. Integrated rice-fish farming emerges as a pivotal transition, meeting food demands while ensuring ecological sustainability amidst population growth and economic activities. In the context of integrated fish-livestock farming, the utilization of cost-effective fish feed and organic manures derived from livestock waste substantially reduces expenses linked to fish feed and chemical fertilizers. This highlights the economic efficiency of the integrated farming system, which delivers high yields at minimal costs. Incorporating organic manures alongside organic pest control in rice cultivation exemplifies a sustainable approach, resulting in increased crop productivity and enhanced soil fertility.

KEYWORDS

Integrated Farming System, Rice Cultivation, Fish Farming, Poultry Farming

INTRODUCTION:

An integrated agricultural system is a sustainable agricultural model that includes livestock, crops, fish, poultry, trees, farm crops, and other mutually beneficial systems. It works on the principle that there is no waste, and what might be considered waste in one component becomes valuable input to other system parts. The Integrated Farming System (IFS) approach is widely acknowledged as a highly effective method for boosting the profitability of farming systems, particularly beneficial for small and marginal farmers aiming to enhance the productivity of their agricultural ventures. Various factors have contributed to the recent slowdown in agricultural production and a decline in factor productivity. These include the depletion of natural resources, an increase in both biotic and abiotic stresses, and a low rate of seed replacement. Furthermore, ecosystem damage has prompted the indiscriminate use of pesticides and fungicides, leading to alterations in soil microbial dynamics. To overcome these challenges, the systems approach to agriculture has become widely recognized and accepted as a valuable tool for the wise use of resources and their cumulative impacts to create sustainable production systems. Integrated farming systems (IFS) integrate a variety of conservation practices to achieve profitable results and maintain consistently high production levels. At the same time, we are working to promote environmental conservation and mitigate the negative effects of intensive farming. The promise of IFS lies in its potential to improve food security, nutritional content, and the overall livelihoods and incomes of farmers. It also serves as a strategy to mitigate the risk of complete crop destruction in monoculture areas exposed to biotic factors such as weather uncertainty or pests. Almost half of the world's population eats rice on a daily basis, making it one of the three major food crops. Worldwide, rice is grown on 165.25 million hectares, with annual production reaching 519.5 million tons (FAO, 2022). As highlighted by Fujisaka et al. (1994), long-term rice cultivation without proper crop management practices and low system productivity results in various nutritional deficiencies. Moreover, the sustained cultivation practices resulted in the degradation of soil physical properties, leading to a decline in both crop yield and urea productivity. Therefore, integrated agricultural systems not only promote diversification but also promote synergies between components, thereby improving both production and productivity. The integrated approach to agriculture is represented by the integrated farming of rice, fish and poultry. Farmers are changing their agricultural practices to create healthy ecosystems where every element counts. There is a symbiotic relationship between the fish pond and the chicken coop, complementing the surrounding landscape and supporting the rice fields that form the farm's foundation.

LIMITATIONS OF MONO-CROPPING RICE:

Constraints with Rice Monocropping Poor crop management techniques are frequently coupled with continuous rice cultivation with low system productivity, which leads to a variety of nutrient shortages, deterioration of the physical qualities of the soil, and decreased yield and element production. The soil undergoes alternating aerobic and anaerobic conditions during rice cultivation. This causes a variety of physical and electrochemical alterations that lead to a notable loss of nitrogen (N) through denitrification and leaching. Furthermore, it's possible that aerobic denitrification, especially through nitrate, is more common and significant than previously believed, particularly in soils that experience periodic wet and dry conditions (Ponnamperuma, 1972). Furthermore, considerable nitrogen sequestration into stable lignin compounds made from leftover plant residues is linked to rice systems

that are often flooded. When cultivating aerobic crops like wheat or corn, crop rotation is very crucial. The numerous advantages of integrated fish, poultry, and rice systems are discussed in this article, along with how they help farmers become more productive and sustainable. It contributes significantly to the breakdown of nitrogen sequestration. In order to increase production per unit of input, utilize land and water resources efficiently, promote sustainable agricultural growth, and enhance the environment, it is imperative to diversify and fortify rice growing methods (Hedge et al., 2003). Integrated agricultural techniques enhance productivity and production by encouraging component synergy in addition to diversification.

A HOLISTIC FARMING APPROACH:

Beyond their role as fundamental dietary elements, rice and fish play a pivotal role in nurturing the nutritional health of farmers. Fish, renowned for its abundance of proteins, vitamins, micronutrients, and fatty acids, contributes significantly to this nutritional profile. Incorporating ducks, cattle, poultry, and horticulture into rice-fish farms introduces a diverse array of nourishing food items, encompassing eggs, meat, milk, yoghurt, and seasonal vegetables. This comprehensive integration augments farmers' financial well-being and advocates for a more health-conscious dietary lifestyle (Nayak et al., 2018; Poonam et al., 2019).

(Fig. 1) After the cultivation of rice, by-products like rice straw and husk serve various crucial roles in households, ranging from electricity generation to providing fodder for cattle, constructing roofs, and acting as a source of energy for cooking. Consequently, the concurrent cultivation of rice and fish not only generates livelihood prospects but also enhances social standing, especially by empowering women through expanded employment opportunities.

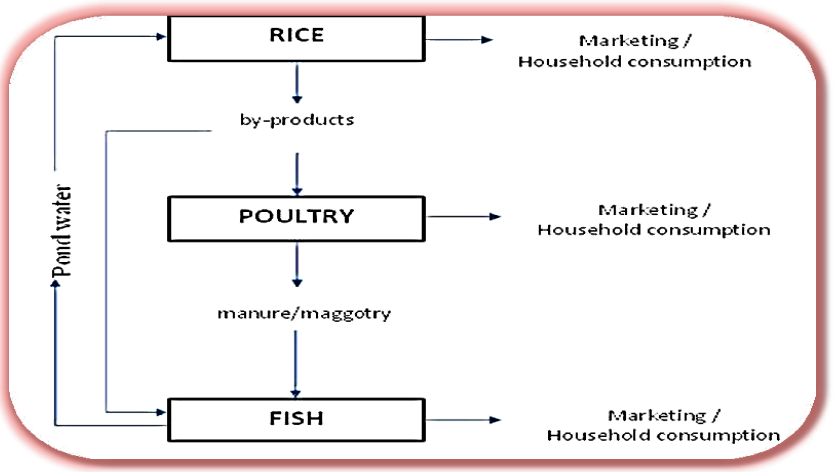

Fig. 1: Holistic farming approach (Source: Oben et al. 2015)

NUMEROUS BENEFITS OF THE RICE-FISH-POULTRY INTEGRATED SYSTEM:

The integration of the rice-fish system has been identified as a profitable technology, with increased adoption leading to higher household income, enhanced labour absorption, and improved liquidity. The significant advantages of rice-fish culture extend to environmental sustainability, system biodiversity, farm diversification, and household nutrition. In rice-poultry integration, around 500-600 poultry birds can supply enough litter to manure one hectare of waste area in the fish pond, offering multiple benefits.

Increased Dietary Standards:

Employing fish and poultry within rice fields enhances nutritional levels, particularly addressing the

animal protein needs of impoverished rural households. Fish holds a multifaceted significance for humanity, serving both primary and secondary functions. It's most important point is that it serves as an essential food source, providing high-quality protein essential to the diet of humans and livestock. Recognized as one of the most cost-effective sources of animal protein worldwide, fish is widely consumed due to its balanced amino acid composition, which is important for rapid human growth (Carballo, Van Ecr, Schie, Tonvan, Hibbrands, and Odey, 2018). The nutritional advantages offered by poultry products, encompassing vital components such as animal proteins, minerals, fat-soluble vitamins, carbohydrates, pigments, fluids, and cholesterol, underscore their significant position as a primary food source on a global scale (Dilger, Schroeder, and Moseley, 2016)

Weed Control:

Uncontrolled agricultural methods and intensive food production present considerable environmental risks. The integration of rice and fish farming offers a sustainable agricultural strategy. Fish activity within rice fields contributes to the reduction of weed proliferation, facilitating efficient weed management (Halwart and Gupta, 2004; Nayak et al., 2018; Wan et al., 2019). Research conducted by Nayak et al. (2020) and Poonam et al. (2019) demonstrated a notable decrease in weed presence in rice-fish cultivation compared to rice monoculture.

Pest Management:

The presence of fish in rice fields is crucial for pest management as they feed on phytoplankton and zooplankton, thus enhancing disease resilience and decreasing the necessity for pesticides (Nayak et al., 2018; Matteson, 2000; Xie et al., 2011). Research has also indicated a noteworthy decline in pest populations in rice-fish cultivation compared to rice monoculture (Nayak et al., 2020; Poonam et al., 2019)

Soil Fertility:

Fish living in rice fields help improve soil fertility by regulating the growth of plankton and bacteria. Additionally, fishmeal, rich in phosphorus and nitrogen, increases soil fertility, promotes nutrient recycling, and reduces the need for fertilizers (Nayak et al., 2018) Including livestock, such as ducks and chickens, in rice-fish cocultures improves soil fertility and resilience by adding organic matter.

Cost Reduction:

Combining fish and poultry in integrated farming systems reduces costs. Poultry manure provides cheap fish food, and organic animal manure provides fertilizer for ponds. This reduces the overall costs associated with fish feed and chemical fertilizers. Srivastava et al., (1999).

Greenhouse gas emissions:

Moreover, rice-fish co-culture reduces N2O greenhouse gas emissions by 9% compared to rice monoculture, but methane emissions are relatively higher. Strategic selection of fish species combined with rice cultivation can mitigate these environmental impacts Datta et al. (2009); Bhattacharyya et al. (2013).

Obstacles:

A significant barrier hindering the advancement of rice, fish, and poultry farming lies in the substantial upfront investment necessary for infrastructure development. This challenge is particularly daunting due to the prevalent economic disadvantage among a significant portion of farmers in India, who typically possess small or marginal land holdings. The initial financial requirements pose a significant obstacle

that often overwhelms these farmers. However, addressing this issue requires substantial government support. Initiatives such as constructing initial infrastructure, providing training, raising awareness among small and marginal farmers, and facilitating easy access to credit to establish suitable market connections for rural farmers can enhance the viability and accessibility of integrated agricultural approaches.

CONCLUSION

Integrated farming has proven to be a superior and cost-effective approach compared to individual enterprises focusing only on rice, poultry, or fish production. The synergistic effect of this agricultural method, through various uses of the products produced as feed, fertilizer and as a source of additional income, significantly increases food production and ensures self-sufficiency for farmers. Beyond economic benefits, this comprehensive strategy plays a key role in strengthening women's social status and capabilities by expanding employment opportunities. The integrated agricultural model is a holistic approach to agriculture, emphasizing not only increased food production but also the efficient use of resources for wider social and economic benefits. It represents a promising paradigm for improving the resilience and prosperity of agricultural communities, with implications for various aspects such as economic efficiency, profitability, improved livelihoods, social empowerment, and sustainable use of resources.

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