International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Sustainable Rice Fish Farming: A Case Study in the Kuttanad Region

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Abstract

Integrated rice farming is a sustainable agricultural practice that aims to optimise resource use, increase productivity, and reduce environmental impacts. This study focuses on the need for a sustainable farming method in Kuttanad region in Alappuzha , a low-lying, waterlogged region in Kerala. This region is situated below sea level and is highly prone to many natural calamities like floods and will result in huge crop failure. Hence, to increase the income and the biological habit of the area, the study investigates the sustainability of integrated rice fish farming in the study area. Thus, a sustainable farming methodology as Integrated rice-fishing culture is considered. A case study analysis of two farmland is used to reach the research objective. As well, in one farmland, paddy is cultivated twice a year and the other farmland practices rice cultivation in one half and fish farming in the other half of the year. Although, the profit of fish cultivation along with paddy and also through variables like crop yielding, labour inputs, output value, input cost, environmental impacts and social impacts are also analysed. As a result, the integrated rice farming system helps to maintain the water quality of the region, which is essential for the survival of the aquatic ecosystem. The system not only provides economic benefits to the farmers but also enhances the biodiversity and ecosystem services of the region.The findings suggest that the integrated rice farming system in Kuttanad is a successful example of sustainable agriculture, which can be adopted in other regions with similar ecological conditions**.**

Keywords: Punja Crop, Integrated Rice Fish Cultivation, Kuttanad Farming.

Introduction

Kuttanad, which was once known as the rice bowl of Kerala, is in danger due to the pollution of the soil and atmosphere.Kuttanad's biological habitat has been destroyed due to the wrong farming practices that have been going on for ages and Kuttanad has now become uninhabitable. Deadly diseases, the change in the chemical composition of the soil, the collapse of fisheries, which was another means of livelihood for the people of Kuttanad apart from rice cultivation, biological depletion, and the frequent floods are causing concern to the life here. When we search for the reason behind this, we arrive at the wrong farming method. Therefore, the combined farming method is best suited to the particular topography and climate of Kuttanad. It is imperative to promote organic farming and ensure the survival of species including humans. The agriculture sector should be recovered from the collapse and the traditional fishermen should be guaranteed their jobs. In these circumstances it is very much important to adopt a farming method that will help farmers in increasing their income as well as reviving the biological habitat of the area.

Aquaculture, also known as fish farming, is the farming of aquatic organisms such as fish, shellfish, and seaweed. It is a rapidly growing industry that plays a vital role in meeting the increasing demand for fish and other seafood products. In recent years, the integration of aquaculture with other forms of agriculture, such as paddy farming, has gained attention as a way to increase the productivity and sustainability of both systems. Rice-fish farming, also known as integrated rice-fish culture, involves the simultaneous cultivation of rice and fish in the same field or pond. This practice has been shown to increase yields, improve water management, and enhance overall biodiversity. However, the potential income-generating capabilities of this method have not been thoroughly researched. This research paper aims to examine the potential of integrating rice and fish farming as a means to generate greater income compared to traditional paddy cultivation alone. Through a case study analysis of farm lands in Kuttanad region that currently practices rice-fish farming, this paper aims to fill this research gap and provide insight into the change to come in the agricultural sector of Kuttanad, need for this sustainable farming method in the study area and the economic benefits of this method for small-scale farmers.

OBJECTIVES

- To identify the need for a sustainable farming method that is suitable for Kuttanad region.
- To analyze the effects of fish cultivation along with paddy in the study area.
- To draw a comparison between two times paddy cultivation and alternate cultivation of paddy and fish.

SCOPE AND IMPORTANCE OF THE STUDY

About 70% of the population depends on agriculture for their living and the main source of their income is from agriculture. But due to the change in climatic conditions and many other factors there is decline in the production. Many farmers therefore start shifting to other economic activities, thus causing a decline of the sector. Therefore in order to revive the agriculture sector, a farming pattern that is more attractive as well as profit yielding should be adopted. Also it is important to understand the benefits like change in income level of farmers by engaging in more than one type of farming. And agriculture is always a risky business. It depends on many factors like farm size, type of crops which are cultivated, climate, technologies used, government intervention etc. There is no certainty in the crop yield that is to be obtained from the farm land. Therefore it is important to move on to an efficient farming strategy which reduces risk as well as enhances productivity.

By adopting multiple cropping patterns like integrating fish farming, the farmers may be able to create an additional source of income other than from the traditional paddy cultivation. Nowadays, a decline of fisheries in water bodies is also observed due to the release of sewage into the water bodies. Thus this integration method may enhance the fisheries sector too. It is observed that the risk factor in fish farming is much lesser compared to that of paddy. Therefore there is a sure profit.

Above all, this method can be adopted to overcome the financial crisis of farmers to some extent and help in improving the living standards of farmers.

LITERATURE REVIEW

Integrated rice-fish farming is a sustainable agricultural system that combines the cultivation of rice and

fish in the same field. This literature review aims to provide an overview of the current state of research on the ecological benefits, economic viability,potential benefits,and challenges associated with integrated rice-fish farming.

The integration of rice and fish cultivation in the same field offers numerous potential benefits, including increased crop yields, improved water management and reduced use of fertilizers. Studies have shown that the integration of fish farming in rice fields can increase rice yields by 8-15% (Mishra and Mohanty 2004; Mohanty et al. 2004). However, the overall productivity from the farmlands is lower due to the low levels of inputs, lack of technical knowledge, aversion to risk based on natural calamities and other socio-economic factors such as poor credit facilities. (Ahmed, N., & Garnett, S. T. (2011). "Integrated rice-fish farming in Bangladesh: Meeting the challenges of food security.")Rice fish farming can be a solution for sustainable food production but it needs to be supported by adequate technical support, effective water management, and addressing socio-economic challenges to bring a positive impact.

The article (Halwart, M. (1998)-provides more specific information on the practice of rice-fish farming, including the countries where it is more prevalent, the fish species used, and the techniques employed in this method of farming.The most significant countries in terms of rice-fish farming area are China, Egypt, Indonesia, and Thailand. Farmers select rice varieties based on their suitability for the local climate and consumer preferences, and modern varieties have led to an increase in yields. Common carp and Nile tilapia are the most widely used fish species. Integrated Pest Management techniques, such as using rice varieties resistant to pests and diseases, are used to manage pests in rice-fish farming. Further studies are needed to improve rice-fish farming systems considering socio-cultural and economic factors.

This method of farming is feasible too. The main finding was that rice-fish culture is feasible in the West African subregion. It was revealed that rice-fish farming can be implemented successfully in western Africa, due to the region's great infrastructure potential for irrigated rice culture. However, water management was identified as the most important factor for success in low-lying areas. The use of chemicals in rice farming was also noted as a potential issue, but integrated pest management techniques were being used in some countries to reduce the use of chemicals. Traditional extensive rice-fish farming was still practiced in some countries, while experiments on intensive or classic rice culture were being carried out in others. Rice-fish farming was seen as a potentially important technology for food security, but farmers expressed concerns about lack of technological knowledge and need for training, among other issues. Overall, farmers expressed a strong interest in this technology.

The study by (Ahmed, N., Zander, K. K., & Garnett, S. T. (2011) note that rice fish culture is cost effective and technically efficient, but faces challenges due to social, economic and environmental factors.The main challenges facing rice-fish farming include lack of technical knowledge, high production costs, water pollution, and the use of pesticides for rice crops. These issues can lead to increased fish mortality and make it difficult for farmers to prevent fish from escaping during floods. Additionally, rice farmers are often reluctant to adopt rice-fish farming due to risks and it is found that farmers most likely to be active in rice-fish farming are better off than those who grow only rice.

There is literature that describes the benefits and challenges of integrated fish farming in irrigation systems

and the factors that can influence the adoption of this farming method, particularly economic and social factors.

A study by Nourhosseini Niyaki S.A and Allahyari M.S (2011) highlights the factors such as influence of contact with extension agents in adoption of rice-fish farming, influence of family size, influence of participation in extension-education activities, influence of membership in social institutions, influence of farm workers etc. that can have an impact on this farming method. And problems faced by farmers include economic problems, food problems, losses of fish in rice-fish farming, problems of fish fingerlings, water problems, wildlife in rice-fish farming, lack of knowledge and expertise, lack of insurance, lack of O2, azolla problems in rice-fish farming, transportation problems of fish, lack of markets etc.Economic factors influencing the adoption of integrated rice fish farming such as yearly income from agricultural activities, average yield of rice production, yearly expenditure in rice farming, number of owned farm plots, farming systems, farm workers, accessibility to agricultural inputs, accessibility to financial resources, credits, investment etc.fish farming incomes etc

Studies have also shown that integrating fish farming in irrigation systems has benefits such as controlling diseases, enhancing incomes, and utilizing habitats created by irrigation and agriculture. A systems approach for integrating fish farming in irrigation systems has been proposed for Sri Lanka and has good potential for success. However, implementing fish farming in other components of irrigation systems is still experimental or has failed.These studies suggest that promoting IRFF requires a system approach that takes into account these factors and provides farmers with necessary knowledge and resources to succeed. It can increase adoption rates, and more attention should be given to promoting the technology to a large number of farmers.

Therefore the successful implementation of Integrated Rice-Fish Farming (IRFF) requires proper training and resources for farmers. The study by Sarma, H., Talukdar, R. K., & Mishra aimed to investigate the impact of training on the knowledge level of farmers, especially women farmers regarding Integrated Rice-Fish Farming (IRFF) practices. The study found that mass media exposure and the availability of a fish pond had a negative correlation with the knowledge level of trained farmers, suggesting that access to resources and practical experience are important factors in improving farmers' understanding of IRFF practices.

Similarly, Omidi-Najafabadi & Hosseini Kheshte Masjedi (2011) found that educational methods, such as holding field days and using Farmer Field Schools (FFS), are crucial for the efficient implementation of IRFF The research suggests that educational methods are the most important consideration for experts in this field and highlights the key role of agricultural extension in efficient implementation of Integrated Rice-Fish Farming. Efforts should be made to identify institutional mechanisms for disseminating fish farming information among farmers, involving both private and public sectors. Fisheries experts and extension agents should pay attention to socio-personal characteristics of farmers, particularly women who are less likely to adopt fish farming and make deliberate efforts to reach out to them.

Rice fish culture was also investigated as a way for rural development as well as poverty alleviation. Rice-fish culture is a low-cost and sustainable practice that can be used to alleviate poverty in rural areas of

Asia by providing high value protein food and minerals. This method reduces the use of fertilizer, pesticides, and herbicides in rice fields and increases farmers' additional income from fish sales, resulting in a net productivity that is higher than rice monoculture. The practice has been shown to increase rice yields by 25-30% and provide extra income to farmers. (SAIKIA, S. K., & DAS, D. N. (2008). Proper location-specific refinement of packages of practices, using locally available resources, can turn traditional rice-fish culture into a low-input self-supporting system and can be extended as a small-scale industry through extension and training programs for rural people.

In summary, integrated rice-fish farming offers potential benefits such as increased crop yields and improved water management but faces challenges such as lack of technical knowledge, high production costs, water pollution and use of pesticides. The adoption of this method is influenced by socio-economic factors and the government can play a role in increasing its adoption by providing support and training to farmers, making low-interest credit available and addressing the challenges. Economic factors such as yearly income and expenditure in rice farming also play a role in the adoption of this method. Studies have also investigated the problems faced by farmers in implementing this method and the need for technical knowledge, low-interest credit and markets. This literature tried to explore the various studies conducted on integrated rice-fish farming and provide insight on the current understanding of the system.

METHODOLOGY

A case study is a useful research method for preliminary investigation.(Eisenhardt,1989). Given the exploratory nature of this method, an in depth case study is adopted to investigate the sustainability of integrated rice fish farming in the study area. Specifically this study tries to draw a comparison between the traditional paddy cultivation and integrated rice fish farming in Kuttanad region which is known as the ‘rice bowl’ of Kerala. As to provide a detailed exploration of the research objectives, two farmlands were chosen for the case study analysis to provide a rich description of context and deep insight into social and economic dynamics.

Research Framework

This methodology framework aims to provide a systematic approach to analyze and compare the performance of traditional ways of paddy cultivation and the integrated rice fish farming from a sustainable perspective. To meet the research objective, initially the need for a sustainable farming method in the study area is identified. The adoption of integrated rice fish farming as a sustainable alternative is explored and then compared with the traditional way of paddy cultivation in terms of crop yield, fish production,input costs, labour inputs, output value, environmental and social impacts. Finally the research framework aims to evaluate the challenges associated with this farming method and to provide recommendations for the adoption of integrated rice fish farming as a sustainable farming method. The results obtained from this analysis will help in making informed decisions for the adoption of this farming method in the study area.

Case Selection

Two farmlands were chosen based on their farming methods. One practices the traditional way of paddy cultivation ie. cultivating paddy two times a year and another that practices rice cultivation in one half and fish farming in the other half of the year. Almost 65% of the population is engaged in farming, mainly paddy cultivation and fish cultivation. Area occupied by the paddy is about 38% of the cropped area. The ‘punja’ paddy in Kuttanad and its unique collective-management in ‘padasekharam’ framework bear a

Kuttanadan socio-cultural stamp.This region is situated below sea level and is highly prone to many natural calamities like floods. This is the main reason why the farmers face huge crop failures in this region. The farmlands are selected from Kuttanad region, in Alappuzha district, Kerala. The farmlands are selected based on their location, size, and type of cultivation. The two farmlands are inherited by the owners and their land size matches the average land holding of the farmers in Kuttanad region. The farmland chosen for the integrated rice fish farming has been successful in this new agricultural practice for years. A purposive sampling strategy is used to select a representative sample of farmlands that practice single paddy cultivation and integrated rice fish farming.

Data Collection

Telephonic interviews with the farmers using a semi-structured questionnaire will be conducted. The interviews will be recorded, transcripted into textual material and will also take field notes. The questionnaire includes open-ended questions about the farmers' demographic characteristics, farming practices, yields, and challenges. Informed consent from the farmers before conducting the interviews is taken and the confidentiality of the farmers' information will be maintained, and their identities will not be disclosed in the research findings. The research findings will also be triangulated with other sources of data, such as government statistics or academic literature, to enhance the validity of the findings.

Data Analysis

The data collected from the interviews will be analyzed using qualitative content analysis. The analysis will focus on identifying themes related to the benefits and challenges of single paddy cultivation and integrated rice fish farming. The researcher will also conduct descriptive analysis to compare the yields and profitability of the two farming methods.

VARIABLES

Punja crop & Varsha crop

There are mainly two rice growing seasons in the study area.The punja crop is one which is grown in the summer season. It starts from December-January and extends up to March-January.The varsha crop which is also known as the second crop is grown in the autumn season. Its cropping season starts in May and extends up to September-October.

Crop yield

According to Fischer, R.A. (2015) 'Crop yield' is the weight of grain or other economic product, at some agreed standard moisture content, per unit of land area harvested per crop.'

Crop yield is measured in terms of the amount of rice produced per unit of land, or the total weight or volume of the rice harvest.

Fish production

Fish production is measured in terms of the number of fish produced, the weight of the fish, or the value of the fish in terms of market prices.In this study fish production is measured in terms of the total weight of fishes acquired in the farming.

Labour inputs

Labor input measures the time and effort required to cultivate and harvest the rice and fish, as well as the number of workers needed to carry out these tasks. Labour costs consist of the cost of human labour which includes the cost of hired human labour and imputed value of household labour and exchange labour, animal labour costs and costs of machine labour (Thomas, P. M. ,2002).

Input costs

Input costs include expenses related to seed, fertilizer, feed, and other materials used in the production process. In the case of agriculture, inputs are necessary investments in related machinery and fertilizers. The cost of "seed" and "labour" is also included.

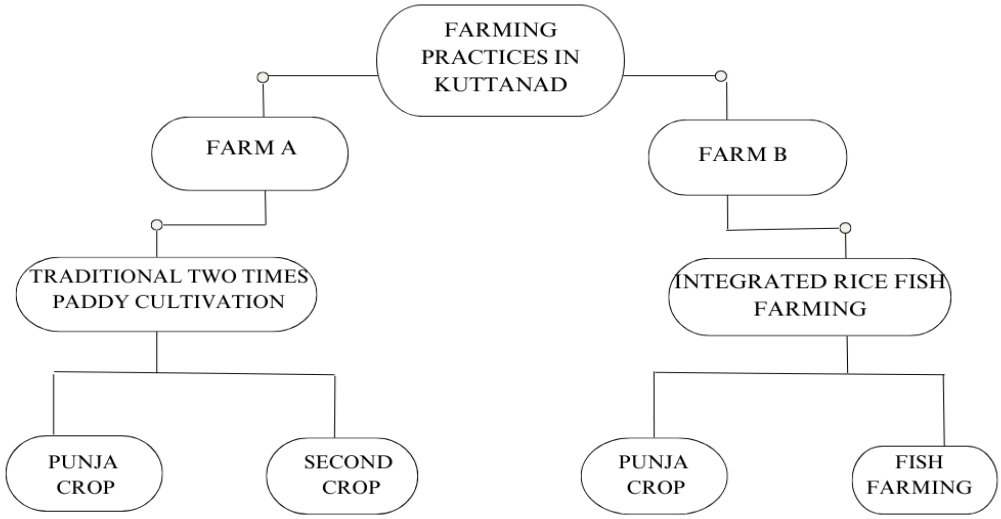
Output value

Output value is measured in terms of the revenue generated from the sale of the rice and fish, or the profit margin released from the sale of these products. It is measured by multiplying the per acre productivity and the price of crops per quintal.

Environmental impacts

Environmental impact is the measure of water use, greenhouse gas emissions, effect of chemical fertilizers and other impacts.Agriculture puts pressure on natural resources and degrades water and soil, so more attention needs to be paid to the environmental impact of agriculture.

Fig 1: Framework of case study analysis



Authors own compilation.

ANALYSIS AND FINDINGS

The economic feasibility of integrated rice and fish farming is analyzed by using qualitative methods in which the two farming methods are compared in terms of total investment, total costs, technology used, harvesting method, total revenue and environmental impact.

LOCATION AND AREA

The two farmlands are located in the villages named Chennithala and Edathua in Kuttanad region, Alappuzha. It has a tropical climate with hot and humid summers and abundant rainy seasons. The average literacy rate in the district is 88.21%. The average annual precipitation in this area is 2965.4 mm.The highest temperature was between 28.80c and 32.70c and the lowest temperature was between 25.50c and 22.60c. The main occupation of the people is farming followed by fisheries. Paddy is the main crop grown in the region which covers a vast area of agricultural land of about 1.5 lakh acres. The area of the farmland has different rock types such as sand and silt. The geomorphology of the area is an alluvial plain. Kuttanad

is a low lying area which is situated below the dea level. The major portion is covered by laterite and alluvial soil. The Achankovil river and Pampa river are the two major water reservoirs in the area.
This research will be crucial in identifying the strengths and weaknesses of the agricultural practices in the area and suggesting measures for improving crop production and revenue.
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CASE I

TRADITIONAL PADDY CULTIVATION

In a 7 acre of farmland located in Chennithala village of Kuttanad region, Alappuzha traditional, two-times paddy cultivation is carried out for over 30 years. The 7-acre land which is inherited as a family property where he cultivates both the cropping seasons, Punja and Varsha crop is investigated.

Punja crop

The farming procedure in the farmland begins in the first week of December, where the land is plowed using a tractor. Next, the seed is sowed in the farmland, with 40 kg of seed sowed in 1 acre of land. After 15 days, herbicides are sprayed to destroy the weeds, followed by the application of fertilizers such as postrates, urea, and potash after 20 days as the crop grows.
The same set of fertilizers is applied again after 40 days. By the end of the third month, the farmland is ready for harvest, which is mainly done using machines that are rented. It takes about 2 days to complete the harvest, and the farmer expects a yield of about 20 quintals in the Punja season.The farming is always profitable in this season.

Varsha Crop

The farmer cultivates paddy for the second time in the year from May to October. The farming method is the same as that of the ‘punja’ crop. The process comprises the construction of ring bunds, ploughing, sowing,weeding,fertilizing etc.The harvesting season starts from the middle of september. The ‘varsha’ crop is a high risk in the region. The success of crops is really uncertain because of the chance of abnormal rainfall and floods in the region which will cause overflowing and breaking of bunds. Unexpected heavy rains after sowing raise the water level in ‘padasekharams’ and destroy the sprouting seeds necessitating a second time sowing. But still the farmer is forced to do it because it is not good for the land to be in an uncultivated state and the ‘padashekharam’ the farmer community will collectively decide to carry out the farming inorder to save the residents near the farmlands from their houses getting abandoned due to the effect of flood.

COST COMPONENTS

MATERIAL COST

The material costs comprise the cost of seeds and the cost of fertilizers, pesticides, weedicides etc.

Cost of Seeds

One of the significant cost components in paddy cultivation is the cost of seeds. In this particular farmland, seeds of various varieties, such as Bhadra MO 5 and Asha MO 5, are purchased during the previous crop season. For sowing in one acre of land, 40 kg of seeds are required, and the cost of 1 kg of seed is ₹40. Thus, the total cost of seeds required for one acre of land is about ₹1600. Considering this farmland's area to be 7 acres, the total cost of seeds for cultivation would be approximately ₹11200. It is worth noting that seed quality is a crucial factor that can significantly affect the crop yield, and hence, farmers choose high-quality seeds.

Cost of Weedicides, Fertilizers and Pesticides

The farmer in this farmland uses chemical fertilizers, weedicides, and pesticides for paddy cultivation. After sowing the seeds, weedicides are applied to the farmland within 15 days, which costs ₹260 per acre. In addition, fertilizers such as 50 kg of phosphate costing ₹1800, 20 kg of urea costing ₹350, and 20 kg of potash costing ₹700 are applied after 20 days. The same set of fertilizers is applied again after 40 days. The total cost of fertilizers per acre of land is about ₹5700, and for the entire 7-acre farmland, it will be around ₹39,900.

LABOUR COSTS

Labour costs mainly include the human labour costs and machine labour costs. No animals are used for any farming activity in this farmland.

Human labour costs

Human labour plays a major role in the paddy cultivation process, and the farmer in this farmland relies entirely on hired labour for their operations. The labour is required for various activities such as land preparation, leveling, removing weeds, moving crops to land if there is no land nearby, construction or repair of bunds, sowing, manuring, spraying pesticides and fertilizers.

The current daily wage for sowing and spraying fertilizers and pesticides is about Rs. 1000 per person. Additionally, it costs about Rs. 4000 to carry and load 2 quintals of harvested crops. On average, the farmer spends about Rs. 7600 per acre as human labor costs. It is found that more than half of all labour is harvesting, followed by field preparation for sowing.

Therefore, it is evident that human labour costs are a significant expense for the farmer. Since the labour is hired, the costs vary depending on the availability of labour and the demand. Additionally, factors such as the size of the farm and the complexity of the operations will also impact the labour costs.

Machine labour

In this farmland, machine labour is utilized for various activities such as dewatering, ploughing, threshing and winnowing. For dewatering the farmland, high-power electric pumps are utilised, and this expense is mostly covered by the government. Tractors are used for ploughing the farmland, and the farmer incurs a cost of Rs. 1000 per acre for hiring them. During the harvesting season, threshing machines are hired by the farmer to carry out both threshing and winnowing. The rent for the machine for 1.5 hours is approximately Rs. 3000. For this 7-acre farmland, the total cost for hiring the threshing machines will be around Rs. 21,000.

Other Expenses

It has been discovered that the labour costs for the second crop are notably higher than those for the first crop. This is due to the fact that the second crop is cultivated during the monsoon season, which necessitates additional expenditures for constructing and repairing bunds to safeguard the farmland from waterlogging. Additionally, there is a higher risk of weed growth during this season, necessitating additional expenses for weed removal. As a result, more human labour is required, and as demand for labour is high during this season, workers typically demand higher wages.

In addition to material and labour costs, farming in the study area will cost many things, such as land tax, purchase of agricultural equipment such as baskets, maintenance costs, food for workers and other incentives for farmers. Additionally, all farmers share the costs of repairing ring bunds and dewatering, based on the size of the area they cultivate. On average, these expenses amount to around Rs. 5000.

PRODUCTIVITY AND VALUE OF PRODUCT

The average expected productivity of the farmland is about 20 quintals minimum per acre. It will vary depending on climatic conditions and the quality of the seeds. The harvested crop is collected by Kerala Civil Supply Corporation through various modern rice mills and the minimum support price fixed by Kerala government is Rs.2820 per quintal. Therefore the average value of product per acre is estimated to be Rs.56,500.

These modern rice mills that collect the harvested crops from farmers provide them with a Paddy Receipt Sheet(PRS) that will ensure the payment for crops through their bank accounts.

PROFITABILITY

The per-acre gross profit of the sample farmers in the study area was calculated by deducting the average production costs from the value of the product.(Thomas,P.M.,2002). It was found that the cost incurred by the farmer for producing 1 quintal of paddy was Rs. 958. The mean gross profit per acre earned by the farmers for the Punja crop was estimated to be Rs. 32,240, resulting in a total profit of Rs. 2,60,680 for the 7-acre farmland. Moreover, the economic feasibility of the paddy crops was analyzed without taking into account the opportunity cost of the paddy field in the study area, which was deemed insignificant.

CHALLENGES OF THE SECOND CROP FARMING

The farmer in this region cultivates paddy in both the Punja and Varsha crop seasons, with the latter season beginning in June.The whole process of farming is same as that of the punja crop cultivation. However, the expenses incurred during the Varsha crop are much higher due to the higher water pressure in the area. The farmer must use motors to control the water flow, which increases input costs. Additionally, this season is highly prone to floods, and there is a higher chance of breaches in the bunds surrounding the farmland. As a result, the farmer must build and repair bunds that can resist flooded water entering the farmland. Due to the rainy season, the chance of weed growth is also doubled, requiring additional herbicide treatments to protect the crops, which must be carried out at the correct timings. However, the available labor at that time demands higher wages, which adds to the total expenses, increasing them by approximately 25% compared to the Punja crop. Moreover, the farmer is forced to contribute his own resources to protect the bunds as a whole.

After incurring all these expenses, the yield from the Varsha crop is highly uncertain. Floods occur almost every year during this season, and if the water level is above normal, the breaches in the bunds may cause a significant crop failure. Even if the floods do not affect the farmland that much, there are other problems during the time of harvest. In some areas of the farmland, it may not be possible to harvest the crop using machines because of the risk of the machine getting stuck in the farmland. These areas have to be harvested manually, which is highly labor-intensive and time-consuming. After harvesting, the harvested crops cannot be left for a long time and must be transported promptly, as the monsoon may cause the rice to crack.

Furthermore, the Varsha crop yields much less compared to the Punja crop, with the average yield being decreased. As a result, the farmer may incur significant losses, and the profit may not be enough to cover the expenses for the next farming season. Therefore, a sustainable farming method is necessary to adopt, which can yield the farmer a good profit with lesser costs and, most importantly, one that can withstand the effects of floods.

ENVIRONMENTAL IMPACTS

The practice of two times paddy cultivation in a year has several environmental impacts. Firstly, the use of chemical fertilisers is increased with the increased frequency of farming.“It is recommended to apply pesticides and fertilisers thrice in Punja farming, but I can confirm that the repeated application of urea, potash, and phosphate can cause the chemicals to accumulate in the soil and water." stated the respondent. . The accumulation of these chemicals in the water system can lead to water pollution, which can have harmful effects on aquatic life and can also contaminate the water used for human consumption.

Secondly, the excessive use of water for irrigation purposes can lead to the depletion of groundwater levels. This is a serious environmental issue as groundwater is a valuable resource that is required for various purposes, such as drinking water, agricultural purposes, and industrial use. The depletion of groundwater can lead to water scarcity, which can have significant socio-economic impacts.

Furthermore, the excessive use of machinery for farming can also have negative environmental impacts. The use of tractors, threshing machines, and other heavy machinery can lead to soil compaction, which can reduce the soil's ability to absorb water and nutrients. The heavy machinery can also damage the soil structure, making it more vulnerable to erosion.

Overall, the two times paddy cultivation in a year can have significant environmental impacts, including water pollution, groundwater depletion, and soil degradation. Therefore, it is essential to consider these impacts while evaluating the economic viability of this farming practice.

CASE II

INTEGRATED RICE FISH FARMING

The case study focuses on Mr. Babu Joseph, a 67-year-old farmer who owns a 7-acre farmland that was inherited as family property.He has a college education and has been involved in farming for over 50 years. His main source of income is from agriculture. Mr. Babu Joseph has implemented an innovative farming method by incorporating fish farming in his land after the main farming 'punja'seasons.

Earlier, Mr. Babu Joseph used to carry out farming in a traditional manner, where paddy was grown in both the farming seasons. The first season started from December and lasted until March, which was called the Punja crop. The second season started from June and continued until October, during which rice was cultivated in both seasons.This method has been followed for the last 4 years and was successful too.

Mr. Babu Joseph adopted integrated rice and fish cultivation in his farmland due to the failure of the second crop in traditional farming methods. The Kuttanad region where the farmland is located is situated below sea level, making it highly prone to floods. The subsequent floods result in the salinization of water and breach of bunds, leading to massive crop failures. Restoring the farmland to a cultivable form after such floods would require significant investments. As a result, farmers like Mr. Babu Joseph were forced to shift to more productive and less costly farming practices like integrated rice and fish cultivation.

After the Punja crop is harvested in March-April, the farmer, Mr. Babu Joseph, starts preparing the land for fish farming. He carried out fish farming during the time when he used to do the second crop earlier.

Special Techniques

Integrated rice farming system requires some special techniques and tools that are not needed in conventional farming. Some of them are:

Fishnets are used to fence the fish enclosures. These nets should be strong and durable enough to withstand the currents and the weight of the fish and also protect the fish from moving out during the floods.Small

boats are used to move around the paddock to feed the fish during the different phases of growth. These boats should be able to navigate shallow waters.

In the fish enclosures, the oxygen level should be maintained at an optimum level for the growth of fish. For that purpose, Aerators are used to pump oxygen into the water to ensure the survival and growth of the fish. The fish require specialised feed during the different phases of growth. The feed should be formulated to provide the right balance of nutrients required for the growth and development of the fish. Natural feed such as tapioca powder, oil cake etc are given to the fish with respect to their size and growth. And when it is time to harvest the fish, traps are used to capture them. These traps should be designed to prevent the fish from escaping and should be easy to remove from the water.

Farming Phases

The fish farming process involves four distinct phases.

In the first phase, Mr. Joseph keeps the fish fry in a separate nursery and feeds them special rations twice a day. After a month, the fry are released into specially fenced enclosures, entering the second stage of growth. In the second phase, the fish fry are given a slightly larger feed produced by Godrej Company, which is purchased from the public market at Rs 8.5 per kg.

During the third phase, the fish fry grow to about three inches in size and are given fish food of slightly larger size once a day, along with cooked chicken intestines, tapioca powder, and oil cake. The fish are fed twice a day by going around the paddock in a small boat.The fourth phase lasts for three to five months, during which only chicken waste is fed to the fish, leading to their complete growth and weight gain. After five months, fish weighing between 750 grams to 2 kg are caught for sale.

Different varieties of fish were used in the fish farming like Catla, Red bellied piranha, Green chromide, Knife fish etc. These fish varieties are fast growing types that can be easily cultured. These varieties also have a high market demand due to its taste and nutritious value.

Harvesting

In the integrated farming of rice and fish, the fish harvest process is a crucial aspect of the farming cycle and is quite different from that of paddy. In the case of paddy, the crop is harvested by cutting the entire plant and then threshing to remove the grains by using machines. However, in the case of fish, the harvest process involves catching the mature fish from the enclosure using nets or traps.

Unlike paddy, where the entire crop is harvested at one time, the fish harvest is staggered over a period of several months, depending on the growth rate of the fish. This means that the farmer needs to keep track of the growth and maturity of the fish and harvest them accordingly.It involves several steps.

Firstly, the farmer needs to drain the water from the pond or enclosure where the fish were grown. Once the water level decreases, the fish become easy to catch.

Secondly, the farmer uses a seine net to catch the fish. Seine net is a large fishing net that is dragged through the water.Thirdly, the fish caught in the net are sorted and separated based on their size and weight. This process is essential because the fish are sold based on their weight, and the price varies according to their size.Then the fish are washed and cleaned to remove any dirt, scales or impurities on their skin.Finally, the fish are transported to the wholesale and retail market or sold directly to the buyers. The transport process is critical because the fish need to be kept fresh and alive until they reach their destination.

In the case of fish, the harvest is processed immediately after catching to prevent spoilage.

ECONOMIC VIABILITY OF FISH FARMING

COST COMPONENTS

The cost components for fish farming in the study area include material, labour costs and additional expenses. Material costs include the purchase of fish fry from a private nursery, installation of aerators in fish ponds, and procurement of various equipment such as motors, pumps, weighing machines, and pipes, which amounts to Rs. 1,93,950. Fish feed costs about Rs. 25,000, and human labour costs for fish field preparation, feeding, and fishing at a daily wage of Rs. 1000 per person come to Rs. 59,250. Additional expenses include current charges, vehicle fare, marketing expenses, office expenses, and expenses on refreshments for labourers, amounting to Rs. 30,906. Overall, the cost components involved in fish farming include materials, labour, and additional expenses, which add up to a total expense of approximately 3,28,500.

FISH PRODUCTION YIELD AND PROFITABILITY

A successful production of fish was reported in the farmland. After 5 months, fish weighing between 750g to 2kg were caught for sale by traders, who bought the juveniles at a rate of Rs. 85 to Rs. 90 per kg. The cost incurred by the farmer for catching fish was Rs. 3 per kg, while the total costs for the entire farming procedure were approximately Rs. 3,28,500. The total yield of fish obtained was 10,550 kg, which generated a revenue of Rs. 8,59,581 for the farmer. Thus, the profit derived from fish farming in the farmland was estimated to be approximately Rs. 5,30,081.

SALES AT A GLANCE AS ON 2019 FISH FARMING

Table No.1: Fish Sale and Revenue Analysis

	Sales in Kg	Average Rate in Rs.	Revenue in Rs.
Retail Sale	2366.5	128	3,02,912
Wholesale	8184	68	5,56,810
Market Sale	41.4	103	4270
Total	10550.9	81.47	8,59,581

Computed by the researcher.

The table shows the sales of fish in kg along with the average rate in Rs per kg and the corresponding revenue in Rs for retail sale, wholesale, and market sale. The total sales were 10,550.9 kg, with an average rate of Rs. 81.47 per kg, resulting in a total revenue of Rs. 8,59,581. The highest revenue was generated from wholesale sales, which accounted for 64.6% of the total revenue. Retail sales accounted for 35.2% of the total revenue, while the revenue from market sales was relatively low, accounting for only 0.5% of the total revenue. Overall, the sales of fishes were profitable for the farmers, as they generated a significant amount of revenue.

SUBSEQUENT PADDY FARMING

After fish farming, silt accumulates to a thickness of about 2 inches, along with fish excreta and other wastes, when farm water stagnates. There is no need to plough the land with a tractor after fish farming as it is a land where the fishes can penetrate. Because 200 kg of clams at the rate of 2 quintals per acre

changes the acidity of the agricultural land. Then after 5 days of loading the water, the water will be unloaded. Weed will grow. Re-watering kills weeds. Then the farmland is made suitable for sowing the seeds. Seed is sown here using a seed drum. Using a seed drum requires less seed than usual. That is, where 45 kg per acre is required, 25 kg is sufficient when using seed drums. Using the seed drum makes weeding easier. Due to good ventilation between the rice plants, the attack of pests will be less. Thus the farming will further continue.

It is observed that the subsequent 'punja' crop cultivation in the farmland after fish farming resulted in an increase in average crop productivity. This increase can be attributed to the natural manure provided by the fish excreta, which improved soil fertility and made the land more suitable for crop cultivation. Also this method of farming significantly reduces the use of chemicals and fertilisers.. On average, an additional 25 quintals of crop were harvested in the subsequent paddy cultivation after fish farming, resulting in an increase in average productivity from 20 quintals to 23 quintals per acre. The estimated additional revenue earned by the farmer from the paddy cultivation after fish farming is around Rs. 70,000. This suggests that fish farming has a positive effect on subsequent crop productivity and can improve the overall profitability of farming in the study area.

ENVIRONMENTAL IMPACTS

Integrated rice-fish farming has several environmental benefits. Firstly, the soil becomes more fertile due to the natural manure produced by the fish, which eliminates the need for chemical fertilisers. The fish feed used in this type of farming is usually organic, which further reduces the use of chemicals in the farming process. Additionally, the use of pesticides is reduced because the fish help to control the growth of harmful weeds and pests. This means that the soil and water sources in the farmland are less contaminated, leading to better quality of produce and reduced health risks for the farmers and consumers.Moreover, the integration of fish farming in rice cultivation helps to increase the productivity of the farmland. Additionally, rice fish farming can increase the biodiversity of the ecosystem as it creates a good environment for aquatic organisms. Overall, it has a positive impact on the environment by reducing the use of harmful chemicals, increasing soil fertility, and promoting biodiversity.

SUMMARY FINDINGS

- Fish cultivation instead of the traditional 'varsha' crop cultivation reduces the chance of farm failure due to the effects of flood and it is highly profitable. It enables the farmer to earn an additional income of Rs. 5,30,000 on an average from the fish farming and an additional profit of Rs.70,000 from the subsequent paddy farming.
- The paddy cultivation carried out after the fish farming yields higher productivity because the fish excreta will become a natural manure for paddy.
- This method of farming is environmentally friendly as the fish feed is mostly organic and the subsequent paddy cultivation requires only much less fertilisers compared to that of the traditional paddy cultivation method.

SUGGESTIONS

As Kuttanad is a water-centric ecosystem, an integrated approach should be given importance for the future of the region. Integrated rice and fish cultivation is one such approach that can be adopted to

increase the productivity of the land while reducing the dependence on chemical fertilisers and pesticides.This will lead to sustainable development and help in the conservation of the ecosystem.

A good market market value for fish should also be maintained so that farmers can get a good price for their produce. This is by establishing direct links between farmers and consumers. By eliminating intermediaries, farmers can sell their products at a higher price and consumers can get fresh, high quality produce. This can be done through community supported agriculture programs, online sales platforms, and through collaboration with local restaurants and chefs.

Other income and employment-generating programs should also be coordinated with rice and fish cultivation to maximise the benefits. The programs can be related to activities such as tourism, handicrafts, and small-scale industries etc. thereby creating job opportunities for the local community. This will help in generating additional income for the farmers and also reduce their dependence on rice cultivation..

To maintain the environmental stability of Kuttanad, there should be proper farming practices that can survive floods. Flood-resistant crops should be promoted, and farmers should be trained on techniques such as water management, land preparation, and planting methods. Bio-fences, mangroves, and fish stocks should be kept in abundance to reduce the impact of floods and improve the overall ecosystem.

Organic farming should be encouraged as it helps in maintaining the natural chemical composition of the soil, improves water quality, and reduces other negative impacts on the environment. This will also help in reducing the use of chemicals which can be harmful to the environment and human health. Farmers can be trained in organic farming techniques such as integrating fish farming in the paddy lands and incentives can be provided to those who adopt such practices.

Shifting cultivation should be encouraged as it will help in the regeneration of soil fertility and maintain biodiversity. This will also help in reducing soil erosion and nutrient depletion. Development of climate-friendly seeds, soil testing, mechanisation, and organic fertilisation should be encouraged to maintain water quality. Soil testing should be done to determine the nutrient content and pH level of the soil. This will help farmers to determine the type and quantity of fertilisers needed for optimal crop growth. Mechanisation should be promoted to reduce the labour-intensive nature of farming. This will help to increase efficiency and productivity, while also reducing the cost of production.

Juvenile rearing centres should be established to help in the conservation of fish species and to ensure a constant supply of fish seedlings.. This will also help in the sustainable management of fisheries, reduce overfishing and ensure a steady supply of fish for consumption and sale.

Fish farming should also be started in all possible ponds to promote sustainable aquaculture practices. This will also help in reducing the pressure on natural fish stocks.

Water hyacinth and other harmful water plants to fish farming should be removed immediately to reduce the negative impact on the ecosystem.

The intervention by the government is critical for the success of any farming system. Provision of subsidies and financial assistance to farmers, establishing a well functioning supply chain network for fish and rice, including proper storage and transportation facilities etc. can help the farmers to sell their produce at a fair price. Interest-free loans should also be ensured to experimenters in this sector to encourage integrated farming practices. This will help in promoting sustainable agriculture and fisheries practices and lead to the overall development of the region.

CONCLUSION

The study showed that the adoption of fish farming alongside paddy cultivation has the potential to

increase the overall productivity and profitability of farmland. A potential farming strategy that involves the rotation of rice and fish cultivation in paddy fields after the harvest of the "puncha" crop can lead to an increase in paddy field fertility and boost productivity by 30-40%. Implementing this method can significantly reduce weeding expenses and eliminate the need for ploughing since the fish in the culture act as natural weed controllers and maintain soil aeration.(Thomas, P. M.,2002). The natural manure produced by fish excreta and reduced use of pesticides and fertilizers in fish farming contributed to the increase in crop productivity during the subsequent paddy cultivation. The revenue generated from the fish farming and paddy cultivation, along with the reduced cost of pesticides and fertilizers, resulted in an overall increase in profitability for the farmers. However, the study also highlighted the potential negative environmental impacts of excessive use of fertilizers and discharge of toxic materials into the water reservoir. Thus, proper management and sustainable practices should be implemented to mitigate any negative effects on the environment.

As stated by Shyamasundaran Nair, Board of Health, "Aquaculture along with traditional farming can be developed as a good strategy to manage crops, increase profits and maintain ecological balance". If the cultivation is locally profitable, the government may stop giving subsidies, production incentives and other benefits to farmers. The savings from these projects can be allocated to critical infrastructure projects in the region. Overall, the findings of this study suggest that fish farming combined with rice cultivation can be a profitable and profitable agriculture that can improve food security in the study area and thereby improve the health of farmers.

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APPENDIX

Questionnaire:

Personal Details

1. Age: What is the age of the farmer?
2. Educational Qualification: What is the educational background of the farmer?
3. How many years of schooling did they have?
4. Land Ownership: How did the farmer acquire the land they are farming on? Is it inherited from their family or is it purchased?
5. Experience: How long have the farmers been into the farming activity?
6. Land Size: What is the size of the land that the farmer cultivates? Is it a small plot or a large farm?
7. Other Sources of Income: Does the farmer have any other sources of income besides farming? Do they have any businesses or jobs that they pursue in addition to farming?

Socio Economic Background

1. How the farming was carried out before in the farmland annually.
2. How do you know about this integrated rice fish farming?
3. What is the background and rationale for adopting rice-fish farming in the farmlands?Why is there a shift from the traditional way of paddy cultivation to the rice-fish farming in the farmland.
4. How long has this method of farming been followed in the area?
5. How is integrated cultivation implemented in terms of the area and proportion of rice and fish farming?
6. What are the different varieties of fish that are commonly used in rice-fish farming, and how are they selected?

Comparison Between The Traditional Way of Paddy Cultivation and Integrated Rice Fish Farming.

1. What are the benefits of intercropping rice and fish?In what ways does fish farming benefit the subsequent rice farming?

2. How does the harvesting process differ between rice and fish in an integrated cultivation system?
3. Are there any special techniques or tools required for integrated rice-fish farming that are not needed for conventional farming?
4. How does this method of farming benefit the environment?

Economic and Financial Aspects

1. What is the expected investment required for fish farming and rice farming, respectively?
2. Is there any economic benefit to this method of farming?
3. How does the production cycle of rice and fish in an integrated system affect the timing and amount of revenue generated?
4. How does the market demand for rice and fish affect the economic viability of integrated rice-fish farming?
5. Does the government provide any financial assistance or subsidies for this method of farming?

Challenges and Obstacles

1. What are the potential risks or uncertainties that could impact the profitability of integrated rice-fish farming, such as weather events or market fluctuations?
2. How do local residents respond to this type of farming? Do farmers face any resistance or objections from them?

Recommendations

1. What role does education and training play in promoting the adoption of integrated rice-fish farming among farmers and communities?
2. What suggestions would farmers give to attract others to this farming method