ECONOMIC ANALYSIS OF RICE BASED INTEGRATED FARMING SYSTEM MODELS IN KUTTANAD

By

NANDA BAIJU

(2019-11-145)

DEPARTMENT OF AGRICULTURAL ECONOMICS

COLLEGE OF AGRICULTURE

VELLANIKKARA, THRISSUR- 680 656

KERALA, INDIA

2021

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THESIS

Submitted in partial fulfillment of the

requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF AGRICULTURAL ECONOMICS

COLLEGE OF AGRICULTURE

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2021

DECLARATION

I, hereby declare that this thesis entitled **"Economic analysis of rice based Integrated Farming System models in Kuttanad"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"Economic analysis of rice based Integrated Farming System models in Kuttanad"** is a bonafide record of research work done independently by **Ms. Nanda Baiju (2019-11-145)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship, or associateship to her.

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ACKNOWLEDGEMENT

I humbly bow my head before ***God Almighty****, for giving me the strength, opportunity and will power to take up the study and complete it successfully.*

I express my sincere gratitude to my major advisor, ***Dr. A. Prema,*** *Professor and Head, Department of Agricultural Economics, College of Agriculture, Vellanikkara, and Chairperson of my advisory committee, for her valuable guidance, untiring patience, constant support and encouragement without which the thesis would not have been complete.*

I extent my deepest gratitude to ***Dr. Jacob John****, Professor (Agronomy) & Head, IFSRS Karamana, member of my advisory committee for the constant support and for providing me with the data necessary for the analysis.*

I also thank ***Dr. Anu Susan Sam*** *and* ***Dr. Hema.M****, members of my advisory committee for their valuable guidance, timely help and generous support throughout the completion of the thesis.*

I sincerely thank my teachers from the department of Agricultural economics, ***Dr. Anil Kuruvila****,* ***Dr. Chitra Parayil*** *and* ***Ms. Divya K.M*** *for their valuable suggestions and guidance throughout the period of the study.*

I express my heartiest gratitude to ***Dr. Devi V.S****, Assistant Professor (Agronomy), KVK, Kottayam and* ***Dr. Jacob.D****, Assistant Professor and Head, On Farm Research Centre, College of Agriculture, Vellayani for providing me with contact details of farmers and all support necessary for the research work.*

I am also indebted to the ***Agriculture officers*** *of the panchayats in the study area for providing me with the necessary information. I am extremely thankful to all the* ***farmer respondents*** *of Kuttanad for their wholehearted cooperation and sincere responses during the survey. I owe my special thanks to* ***Suresh chettan*** *and* ***Ravindran sir*** *for their timely support.*

I am extremely indebted to my dearest friend, ***Anila V.S*** *for her constant encouragement, ever willing help and for staying with me through thick and thin. I also sincerely thank my dear batch mates* ***Ankitha Thakur, Nithyakalpana****,* ***Akhil Reddy*** *and* ***Binu chechi****. I extent my indebtedness to my seniors* ***Femi Elizabeth*** *and* ***Apeksha K Rai*** *for their unrelenting help throughout the course work. I also thank* ***Shilpa chechi, Sreelekshmi chechi, Geethu chechi*** *and* ***Neetha chechi*** *for their constant support, help and motivation.*

I sincerely thank my dear friends ***Parvathy, Arya K.S, Athira, Greeshma. U*** *and dearest* ***Aswathy*** *for their support, love and constant encouragement.*

I also owe my heartfelt thanks to my juniors ***Vaishnav, Anupama, Midhuna*** *and* ***Manoj*** *for all the help, love and support.*

I wholeheartedly thank all the staff of ***College library, Central library*** *and the* ***Computer centre*** *for all the help extended to me during the period of the research.*

Above all, I would like to owe my sincere and heartfelt gratitude to my ***Achan, Amma, Amoomma, Chechi****,* ***Chettan,*** *and my* ***Kunjoos*** *for all the patience, love, prayers, support and encouragement without which this endeavour would not have been complete.*

Nanda Baiju

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

APPENDICES

ABBREVIATIONS USED

MSL	Mean Sea Level
MVP	Marginal Value Product
MFC	Marginal Factor Cost
AEU	Agro Ecological Unit
B-C	Benefit-Cost
C-D	Cobb-Douglas
NPW	Net Present Worth
IRR	Internal Rate of Returns
PD	Person Days

Introduction

1. Introduction

In any developing economy, in order to attain pro-poor growth and economic development, it is necessary that the agriculture sector flourishes, along with improvement in farmers' income. Fifty eight percent of the population in India is dependent on agriculture for livelihood. Of the total farmers in the country, 62 percent are marginal farmers and 19 percent are small farmers. Even though these two groups comprise 81 percent of the farming community, they possess only 36 percent of the operational land holdings. The average size of operational land holding in India has declined from 1.15 ha in 2010-11 to 1.08 ha in 2015-16 (GOI, 2016). Given the declining trend in the size of operational land holding in India, the scope for horizontal expansion is grim. With ever increasing population and decreasing operational holding size, vertical expansion is the only solution incorporating integration of appropriate subsidiary enterprises that require lesser space and time so as to ensure reasonable year-round income to the farm families.

The situation is not very different in Kerala where the average operational land holding has seen a decline from 0.22 ha in 2010-11 to 0.18 ha in 2015-16 (GOK, 2020). Recent statistics revealed that, cash crops like cashew, rubber, pepper, coconut, cardamom, tea and coffee account for majority of the total cropped area of the state (61.6 percent) and food crops like rice, tapioca, millets and pulses constituted only 9.88 percent (GOK, 2020). Even though rice is the staple food of the people of Kerala, the state's agriculture has traditionally been aligned towards perennial cash crops on account of their agronomic suitability and remunerative nature. Increase in input costs and wages unaccompanied by a similar increase in output price forced farmers to take up remunerative crops like coconut over rice which led to a drastic change in the land use pattern of Kerala. This shift from food crops to non-food crops eventually led Kerala dependent on other states for food grains.

The major food crop, rice is cultivated in 7.37 percent of the total cultivated area of the state (GOK, 2020). The production of rice in 2017-18 was 5.21 lakh tonnes which showed a decline of 11.7 percent compared to 2008-09 levels (GOK, 2018). Changes in land use and the cropping pattern of the state pose a huge threat to food security and sustainability. Sustained and concerted efforts from the part of the Government have resulted in increase in area under rice from 1.97 lakh ha during 2015-2016 to 1.98 lakh ha in 2019-20 (GOK, 2020). This is in contrast to the declining trend observed during the previous years. In addition, the percentage increase in rice production during the year 2019-20 was an all-time high of 12 percent compared to the 2010-11 levels (GOK, 2020). Despite the efforts, attaining self-sufficiency in food grain production is still a far reaching goal for the state. Hence, the requirement of a holistic approach to enhancing food grain production in the state without compromising on sustainability, ecological stability and economic viability is imperative.

Agro-ecological delineation based on climatic conditions, soil quality, topography etc. developed by FAO is an important tool to attain the optimum production potential of an area. India was divided into fifteen broad agro climatic zones by the Planning Commission during the eighth five-year plan based on this methodology. According to the classification, Kerala belongs to the twelfth zone which is the West coast plains and the Ghat region. In 2008, National Bureau of Soil Survey and Land Use Planning analysed the agro-ecology of Kerala state on the basis of climate, geomorphology, land use and soil variability which in turn resulted in the delineation of the state into five Agro-Ecological Zones and twenty-three Agro-Ecological Units (AEUs) (KAU, 2016). Out of the 23 AEUs, five are given the status of 'special AEUs' because of their soil and hydrological conditions in the coastal region and the unique management strategies required. One of the special agro-ecological units is Kuttanad (AEU 4), known as the rice bowl of Kerala which is geographically, socio-economically and culturally unique. Farmers in Kuttanad have been traditionally practising below Mean Sea Level (MSL) rice cultivation, one of its kind in India since 200 years. The region provides direct and indirect livelihood to 1.5-2 lakh people living within and in its vicinity. Kuttanad has been declared by the FAO as a Globally Important Agricultural Heritage System (GIAHS) in 2013 and has similarities to the Dutch polder system.

After the flood devastation of 2018, which severely affected Kuttanad, the Government of Kerala in its Post Disaster Needs Assessment identified several strategies to increase economic activity and build resilience in the agriculture sector in Kuttanad in line with the principles of ‘Build Back Better’ (GOK, 2019). Promoting Integrated Farming System (IFS) was one of the strategies put forth in the assessment. Under the ‘Jaivagriham’ project funded by the Rebuild Kerala initiative, farmers were given financial assistance to take up enterprises like dairy, poultry, aquaculture, duckery etc. along with crops to better utilize the space, time and energy and to ensure permanent income. In the ‘Subhiksha Keralam’ scheme launched by the Govt. of Kerala during the COVID-19 pandemic in 2020, promotion of Integrated Farming System was taken up as an important intervention. It was observed that augmenting farmers’ income through subsidiary enterprises can be a solution for addressing farmers’ distress. Since Kuttanad is an ecologically sensitive and risk prone AEU, and rice-based farming system being dominant in the region, integration of other field and horticultural crops, fish, dairy, poultry, duckery, buffalo, piggery and other income generating activities would be the right approach to ensure sustainable livelihoods for the small and marginal farmers.

Integrated Farming System (IFS) can be defined as a resource management strategy to achieve economic and sustained agricultural production, to meet diverse requirements of the farm household, while preserving the resource base and maintaining a high environmental quality. The farming system approach ensures sustained productivity while meeting the nutritional requirements of the farm family. In developing countries like India, Farming Systems research is considered as a potent tool for competent natural as well as human resource management (Behera, 2019). IFS ensures year-round income, employment generation, yield stability, optimum utilization of resources like farm residues and livestock waste and production of heterogenous farm products leading to a balanced diet for the farm family. IFS can lead to a considerable improvement in the standard of living of the farmers. Selection of enterprises that complement the agro-climatic situation and socio-economic condition of the farmer is the key to the success of IFS. As the income sources are diversified, IFS provides a buffer against price, trade and climate fluctuations (Kumar *et al.*, 2015).

It is in this context that the present study entitled “Economic analysis of rice based Integrated Farming System models in Kuttanad” was taken up with the objective to identify the different IFS models existing in Kuttanad and to analyse their profitability.

The study also focusses on estimating the profitability of the rice based IFS model developed by Kerala Agricultural University at Integrated Farming System Research Station (IFSRS), Karamana. The constraints faced by the farmers in the adoption of the IFS models have also been analysed during the study.

The specific objectives of the study are:

1. Economic analysis of rice based IFS models existing in Kuttanad
2. Estimation of profitability of KAU recommended rice based IFS models for Kuttanad
3. Analysis of constraints faced by farmers in adoption of IFS models

1.1 Scope of the study

The economic analysis of the rice-based IFS models in the Kuttanad AEU gives an insight into the different IFS models identified in the study area, the level of integration, the inter relationship between the different enterprises and how integrating the enterprises have helped farmers to reduce their dependence on the market for different inputs, as resources get recycled within the system. The share of costs and returns of the different components have been studied in detail. The superiority of the KAU recommended model which could be replicated in the farmer's field have been analysed in the study. This research also tries to analyse the sustainability of the models along with assessing the resource use efficiency of rice under IFS. Constraints faced by the farmers in the study area that prevent them from diversifying their farm enterprises have also been studied under the final objective of the study.

1.2 Limitations of the study

The study is based on responses from 100 farmers in the Kottayam and Alappuzha districts of Kuttanad AEU and hence generalizations might not be quite accurate. The present study mainly uses the primary data collected from farmers through pre-tested structured interview schedule. Maintenance of field books is not seen among the farmers and hence, the required information was collected from their memory which could suffer from recall bias. However, the data was cross-checked to minimize the errors and misconception to the extent possible. The inadequacy of information and common limitations of statistical analysis might also have affected the study slightly. Apart from these limitations, this study also suffered from scanty availability of published literature, as previous research studies in the area were less. Another important constraint was imposed by the COVID-19 pandemic and the associated lockdown which put up some restrictions in conducting elaborate personal interviews with the farmers. Despite all these constraints, utmost care has been taken to make the study as objective as possible.

1.3 Presentation of the thesis

The thesis entitled "Economic analysis of rice based Integrated Farming System models in Kuttanad" is organized and presented in five chapters. The first chapter "introduction" presents a brief note on the theoretical background of the study, its relevance, objectives, scope and the major limitations. The second chapter "review of literature" intends to provide theoretical and empirical background of the study by reviewing previous studies related to the present research. Third chapter "methodology" is comprised of an overview of the study area, nature and sources of data, details of design of the study and various methods adopted for carrying out the research work and its analysis. The results and discussion based on the observations are presented in the fourth chapter "results and discussion". A brief summary of the overall results and the main findings of the study is presented in the fifth chapter "summary and conclusions".

Review of Literature

2. Review of Literature

A review of the past research studies help in the identification of conceptual and methodological issues pertinent to the study. This chapter gives a comprehensive review of the past works which has direct or indirect bearing on the objectives of the study. The review is presented under the following sub headings.

2.1 Integrated Farming System

2.2 Economic analysis of IFS

2.3 Resource use efficiency

2.4 Constraints in adoption of IFS

2.1 INTEGRATED FARMING SYSTEM (IFS)

According to Singh and Ratan (2009), IFS is an integrated group of components and practices that are performed in the field in a sustainable basis to increase productivity and the net farm income.

Farming systems for sustainable crop production intensification will offer a range of productivity, socio-economic and environmental benefits to producers and to society at large, including high and stable production and profitability; adaptation and reduced vulnerability to climate change; enhanced ecosystem functioning and services; and reduction in agriculture's greenhouse gas emissions and "carbon footprint" (FAO, 2011).

Selection of an IFS model depends on the agro-climatic and agro- ecological situation prevailing in that place. Based on soil type, rainfall and market demand, the Tamil Nadu Agricultural University (TNAU) has recommended models for different agro-climatic zones. Crop + Fishery + Poultry + Oyster mushroom, Rice-Gingelly-Maize, Rice-Soyabean-Sunflower + Polyculture fish rearing + Pigeon + Mushroom and Goat + fish + crop for the wetlands in the western zone, Crossbred milch animal + Biogas production + Mushroom for irrigated uplands in the western zone, Crop + Fodder + Silvipastoral trees + Thorn less Prosophis interplanted with Cenchrus grasses + Goatry in the rainfed areas of the western zone. The model recommended for rainfed areas of the

North- Western zone is Crop + Cows + Poultry + Milch animal + Goat + Mulberry /Sericulture. Cow + Poultry / Broiler is recommended in the hilly areas while Rice + Cow, Crop + Goat, Crop + duck and fish + mushroom are recommended in the Cauvery delta zone. Models suitable for the southern zone include Rice + fish + poultry in Periyar – Vaigai Command Area, Milch cow + fish rearing + rice-based cropping system in wetlands of Tirunelveli district, Crop + fruit tree + goat in rainfed black clay soil (TNAU, 2016).

Kumar *et al.* (2018) identified Integrated Farming Systems (IFS) as the possible solution to the ever increasing demand for food and for ensuring sustainability and livelihood security of small and marginal farmers.

Mukhlis (2018) identified that implementation of rice and cattle integration system could increase the use of family labour, reduce the use of inorganic fertilizers, reduce production costs, and can increase the income from rice farming and cattle business. It could also improve land fertility, water and air quality and create harmony between the socio-cultural environments of the local community, and be solution to climate change mitigation.

According to Singh *et al.* (2019), complementary enterprises in an IFS system increases productivity by two to four times over mono-cropping. It also ensures higher resource use efficiency, recycling of ecosystem services and is a climate smart technology for mitigating the negative impacts of extreme weather conditions.

The advantages of IFS include pooling and sharing of resources/inputs, efficient use of family labour, conservation, preservation and utilization of farm biomass including nonconventional feed and fodder resources, effective use of manure/animal waste, regulation of soil fertility and health, income and employment generation for many people and increase economic resources (Behera, 2019).

2.2 ECONOMIC ANALYSIS OF IFS

Shanat (2000) studied the economics of rice-fish sequential farming system and monocropping in Kuttanad. The Benefit-Cost ratio of monocropping of rice was found to be 1.08 while that of rice and fish separately in the integrated farming system was 1.44 and 1.3 respectively. The B-C ratio of the rice-fish sequential system was found to be 1.40.

Among the different IFS models studied by Channabasanna and Biradar (2007) in Karnataka, (Rice-fish (pit at the center of the field) – poultry (reared separately)) recorded maximum net returns of ₹62,977/ha/yr with a B-C ratio of 1.91. Rice-fish (pit at one side of the field)–poultry (shed on fish pit) followed with net returns of ₹49,303/ha/yr and B-C ratio of 1.73.

Comparison of the traditional farming and integrated farming in the Northern plains of India by Rai *et al*. (2013) showed that the average net returns obtained from conventional farming (rice-wheat) was ₹96,000, while that obtained from taking up poultry and vegetable cultivation was ₹2,71,000. Specialized IFS involving poultry, banana, gladiolus and vegetable cultivation yielded net returns of ₹6,13,000. It was also found that the input cost decrease by 25-35 percent in the IFS models, while it remained more or less the same in the traditional farming.

According to Deshmukh *et al*. (2013), integration of poultry, azolla cultivation, and vermicomposting to the traditional cultivation of red gram and Bengal gram in Bidar district of Karnataka increased the productivity as well as profitability of the farm. While, the net returns from the traditional cultivation was ₹63,700 per year, IFS resulted in a net returns of ₹1,53,200 per year. In the different components integrated into the system, production of worms for vermicomposting recorded the highest B-C ratio of 1:24 followed by dairy (1:14) which was due to increased milk yield from feeding azolla, followed by poultry (1:13), red gram cultivation (1:5.5) and vermicomposting (1:4.5). Bengal gram cultivation resulted in the lowest B-C ratio of 1:3.7 in the system.

IFS comprising of cotton, vegetables, vermicompost, goat rearing, poultry and cattle (bullocks, cow and calves) rearing in Raichur, Karnataka yielded a net returns of

₹2,27,398 at the end of third consecutive year with a B-C ratio of 4.63 and with 26.5 percent higher net returns compared to the traditional cultivation of cotton alone (Desai, 2015).

Crop, crop + dairy, crop + horticulture were identified as the major farming systems in Amravati district of Maharashtra. In case of crop farming system, cost A, cost B and cost C were ₹3,72,22, ₹51,950 and ₹59,873 respectively. In case of crop + dairy farming system, the corresponding values were ₹49,893, ₹72,695 and ₹80,219 respectively. Cost A, cost B and cost C of crop + horticulture farming system were ₹70,693, ₹96,311 and ₹1,04,534 respectively. The highest B-C ratio at cost A was recorded for crop + dairy farming system i.e. 2.50, followed by crop farming system (B-C ratio: 2.07), followed by crop + horticulture (orange) farming systems (B-C ratio: 1.99). At cost C, The B-C ratio (1.56) was observed highest in case of crop + dairy farming system, followed by crop + horticulture farming systems (B-C ratio: 1.35), followed by crop farming system (B-C ratio: 1.29). Hence, it was concluded that crop + dairy farming system was profitable than other two farming systems (Nagre *et al*., 2017).

Economic analysis of different IFSs in Sidlaghatta Taluk of Chikkaballapura district in Karnataka revealed that crop (1.9 acres) + dairy (4 cows) + sericulture (100 DFL) was most profitable with a B-C ratio of 1:2.04 for small farmers. Whereas, crop (2.95 acres) + dairy (3 cows) + sericulture (200 DFL) was most profitable for medium farmers with B-C ratio of 1:1.89 and for large farmers, crop (7.39 acres) + small ruminants (9 nos) + sericulture (180 DFL) was most profitable with a B-C ratio of 1: 1.82. (Nataraja, 2016).

The economic analysis of different IFS adopted by small and marginal farmers in Adilabad district of Telengana state revealed that the returns per rupee was highest for Paddy+ Sericulture+ Poultry (1.89) followed by Paddy-Paddy + Tomato + Goat + Poultry (1.78), Paddy+ Dairy+ Moriculture (1.72) and Paddy-Paddy + Tomato + Cotton + Goat + Poultry (1.70) (Srinika *et al*., 2017)

Singh *et al*. (2017) studied integration of fish and water chestnut in fox nut cultivation in the field and pond conditions in Darbhanga district of Bihar. In the field conditions, fox nut cultivation alone resulted in a net returns of ₹88,368/ha. Fox nut-water chestnut cultivation resulted in maximum net returns of ₹1,56,436/ha followed by fox nut + fish (₹1,21,520/ha), fox nut-rice (₹1,16,322/ha). In the pond system, cultivation of water chestnut alone resulted in a net returns of ₹57,960/ha. Fox nut + fish-water chestnut resulted in highest net returns of ₹1,26,505/ha followed by fox nut-water chestnut (₹1,07,660/ha) and fox nut + fish (₹1,02,635/ha). The highest B-C ratio of 1.79 was recorded for the fox nut-water chestnut combination in the field condition. The study concluded that integration of fish or water chestnut into fox nut farming ensured a sustainable livelihood to the fox nut farmers of Bihar.

Integrated rice-fish-poultry farming in Cuddalore, Villupuram, Nagapattinam and Thiruvannamalai districts of Tamil Nadu increased net returns per household by ₹33,000/ha/yr for two crops and ₹50,500/ha/yr for three crops. Integrated rice-fish-vegetable farming in Lakhimpur, Kokrajhar and Karbi Anglong districts of Assam resulted in a net economic benefit of ₹29,000 per household per annum (Srivastava, 2018).

According to the study conducted by Ranjith *et al*., (2019) among Pokkali rice-prawn farmers in Ernakulam district of Kerala, cost of cultivation of Pokkali rice alone was ₹1,27,525 per ha while that of Pokkali rice-prawn system was ₹2,39,505 per ha. Pokkali rice cultivation alone resulted in a loss of ₹62,864 per ha. But, cultivating prawns in the next season yielded a profit of ₹3,43,879 for every hectare cultivated. The B-C ratio of the system was 2.17 which indicated that the farmer got 2.17 rupees in return to every rupee invested in the Pokkali rice-prawn system.

Upon studying the impact of IFS on reducing cost of cultivation and increasing income of farmers in Chatra district of Jharkhand, Saroj (2019) found out that integration of fruit plants, vegetable, piggery, dairy, poultry and composite fish farming in 5 acres of field crop resulted in an annual net income of ₹5,94,431 which was 686 percent more than that of conventional farming system.

Sabu (2020) studied the different IFS models in Kuttanad and identified that the most profitable integrated farming system model in the region was Coconut+ Banana+

Dairy cow+ Poultry+ Goat with a Benefit-Cost ratio of 2.86 followed by rice based Rice+ Fish model with a Benefit- Cost ratio of 2.63. The other models identified were Coconut+ Banana+ Poultry (B-C ratio: 2.27), Coconut+ Banana+ Cow (B-C ratio 2.17), Coconut+ Poultry+ Cow (B-C ratio 1.24), Coconut+ Banana+ Goat (B-C ratio 1.51), Coconut+ Banana+ Poultry+ Cow (B-C ratio 2.30), Coconut+ Banana+ Poultry+ Goat (B-C ratio 2.10), Coconut+ Banana+ Poultry+ Goat+ Cow (B-C ratio 2.86).

2.3 RESOURCE USE EFFICIENCY

Mohandas (1994) analysed the resource use efficiency of rice production in Kuttanad and indicated that there was a positive and significant contribution of machine labour, human labour and fertiliser towards the gross income of the paddy farmers in the area.

According to Saijyoti (2005), labour cost and seed cost were the major determinants of gross returns in the case of conventional paddy farmers of Kuttanad in Kerala. The expenditure on chemical inputs was having a negative effect though it was statistically insignificant. It was also found out that IPM technology had a strong positive influence on the profitability of paddy. The study concluded that IPM farmers had better resource utilization than the non-IPM counterparts.

Majumder *et al*. (2009) analysed the productivity and resource use efficiency of Boro rice production in Bhola district of Bangladesh. The Marginal value product (MVP) for seedling and insecticide was found to be positive and greater than one for owner operators which indicated that the opportunity for increasing production by increasing the use of these two resources were high. For cash tenants on other hand, MVP was positive and greater than one for seeds, fertilizers as well as insecticides. In the case of crop share tenant operator, seeds and insecticides were the inputs which showed highest use efficiency. In all the three cases human labour was found to have MVP less than one which indicated the need to limit the use of the resource.

Singh (2018) studied the resource use efficiency of Integrated Farming Systems of Banswara district of Rajastan. In the rainfed situation, it was found that the resources for production- seeds, fertilizers, manure, bullock labour and machine labour were underutilized and in the irrigated condition, inputs like seed and human labour were found to have high resource use efficiency since the ratio of MVP to Marginal Factor Cost (MFC) was found to be greater than one. In the case of dairy, green fodder and concentrates were found to have high efficiency. The study revealed that there was scope for reorganising resources so as to attain better production efficiencies.

According to Dhakal *et al*. (2019), resource use efficiency ratio less than one was observed for inputs like manure and labour which indicated they were over utilized in the rice production system in Chitwan district of Nepal. On the other hand, the efficiency ratio greater than one was observed for seed, fertilizer, machinery, bullocks, pesticides and transportation indicating they were underutilized in the study area.

Konja *et al*. (2019) estimated the resource use efficiency of rice cultivation in the Tolon district in the northern region of Ghana. The study revealed that land size, quantity of weedicides and fertilizers have a positive effect on the output. Weedicides, fertilizer and seeds were found to be over utilized in the production process as the ratio of MVP to MFC was less than one. It was concluded that the rate of use of these inputs have to be reduced to improve productivity.

2.4 CONSTRAINTS IN ADOPTION OF IFS MODELS

According to Lightfoot and Minnick (1991), main constraints in adoption of IFS in Philippines and Ghana were the long transition period to integrated systems, labour shortage, lack of secure land rights and disincentives to adopting integrated farming resulting from government subsidies, credit for fertilizers and herbicides.

Lack of labour and timely availability of animal feed were the major constraints in adoption of IFS in Northern Cameroon (Ngmabeki *et al*., 1992).

While studying the economics of paddy cum prawn culture in the Pokkali lands of Ernakulam district, Vijaya, (1998) identified that the major constraints faced by the farmers were non-availability of labour during peak season, submergence of fields, non availability of prawn fingerlings during season, high input cost and soil salinity and acidity.

Constraints to the adoption of integrated crop-livestock system in the US corn belt region as observed by Sulc and Tracy (2007) include the tradition of single enterprise farming existing in the region, ease of management and government support programmes that favour large-scale mono cropping over diversified farming, higher managerial and labour input required for diversified farms, lack of appreciation and understanding among farmers for system-level performance and limited incentives for greater diversity and environmental conservation in production systems.

Constraints limiting the efficiency of different farming sub systems in Chittorgarh and Rajsamand districts situated in the Agro climatic Zone-IV A in Rajasthan were identified by Singh *et al.* (2013). Non-availability of seeds of newly developed high yielding varieties followed by imbalanced use of fertilizer were observed as the major constraints in enhancing the crop productivity under crop production component. In the animal husbandry component, lack of crossbred and exotic breeds of animals, lack of artificial insemination and medical facilities for cattle and improper maintenance, balance feeding and lack of organized co-operative societies were identified as the major constraints. Lack of availability of improved good planting material suitable for local conditions, imbalanced use of fertilizers and lack of knowledge of improved package of practices were the major constraints in the horticulture sub component.

John and Nimisha (2014) identified the absence of reliable output market as the major constraint faced by small and marginal farmers of homestead based IFS in Southern Kerala.

Constraint analysis of maize farmers in Mahbubnagar district of Andhra Pradesh by Devi *et al*. (2016) using Garrett ranking technique identified small farm holdings and limited resource availability with farmers as the most important constraint. This was followed by climate extreme conditions resulting in drought/excess water associated with increased incidence of diseases/pests, cultivation in Kharif mainly under rain-fed conditions on marginal lands with inadequacy in irrigation, limited adoption of improved production-protection technology and deficiencies in the production and distribution system of quality seed.

Srinika *et al.* (2017) did a constraint analysis in adoption of IFS by small and marginal farmers in Adilabad district of Telengana. Lack of training facilities was identified as a major constraint by small and marginal farmers. Severe market price fluctuation was identified as one of the major constraints by 93.33 percent of the small farmers and 86.66 percent of the marginal farmers. Nearly 78 percent of small farmers and 88 percent of marginal farmers expressed lack of credit facilities as one of the major constraints in adoption of IFS models.

Constraints in adoption of IFS faced by farmers in the Brahmaputra valley of Assam as determined by Debahash *et al.* (2019) were social problems, disease and pest incidence, financial constraints and lack of knowledge and skill.

According to Pandey *et al.* (2019), 54.44 percent of farmers in the Vindhyan plateau of Madhya Pradesh faced some constraints in adopting IFS. Financial constraints were ranked first followed by marketing constraints, situational constraints, production constraints and extension constraints. Under financial constraints, 83.33 percent farmers ranked lack of required finance as the most important constraint. Under marketing constraints, 88.89 percent of farmers ranked fluctuations in market price as the most important marketing constraint confronted by them. Uneven distribution of rainfall was ranked as the most important situational constraint by 88.89 percent of the farmers. Non availability of quality seed, planting materials/breeds/species were ranked first under the production constraints by 66.67 percent of the farmers. Under the extension constraints, non- availability of clinical services for livestock was the most important problem faced by 55.56 percent of the farmers.

Problems faced by the Pokkali-prawn farmers in Kerala was analysed by Ranjith *et al.* (2019) using Garrett ranking technique. Major constraints in the production process were identified as labour shortage and high wage rates. Problems in mechanization, perishability of prawns and market price fluctuations were other important constraints faced by the farmers.

Onoh *et al.* (2020) identified inadequate water supply to rice- fish farms, scarcity of inputs, dearth of information, and lack of finance as the major constraints to the level of use of integrated rice- fish farming in Ebonyi state of Nigeria.

Literature reviews on the topic could identify a gap in studies related to economics of IFS and rice based IFS in particular. Even though the resource use efficiency has been studied widely for monoculture systems, no studies could be observed in the case of integrated systems. Scanty literature on the economic sustainability of the IFS models and its system economic efficiency has also been noted. Economic analysis of rice based IFS models developed by KAU has also not been done, which also has been taken up as an objective in the study.

Methodology

3. Methodology

Research is the systematic approach towards purposeful investigation and for successful conduct of a research study an appropriate research design is a pre-requisite. Research methodology is a way to systematically solve the research problem. It discusses the various steps adopted to study the research problem along with the logic behind them. This chapter discusses in detail about the study area, concepts, sampling procedure and analytical tools adopted in the study under the following sub divisions.

3.1 Study area

3.2 Sampling procedure

3.3 Nature and sources of data

3.4 Analytical tools

3.1 Study Area

The study was undertaken in Kuttanad, known as the rice bowl of Kerala. Kuttanad belongs to the special AEU 4. It covers three districts of Kerala namely, Alappuzha, Kottayam and Pathanamthitta. In this section an attempt is made to detail the physiography, geography, climatic factors, land utilization pattern and cropping pattern of Kerala state, along with that of Kuttanad (AEU 4).

3.1.1 Kerala

Situated in the South-Western Malabar Coast of India, Kerala is known as God's own country. According to 2011 census, Kerala has a population of 3.33 crores which accounts to about 2 percent of India's population, with a population density of 860 persons per square kilometer. The state has a sex ratio of 1,084 females for every 1,000 males. Despite being a small state lying at the southern coastal region of the country, it has significant achievements in global socio-economic and health arena. With a life expectancy at birth of 75.2 years and literacy rate of 94 percent, the state is at par with those of developed countries with regard to human development.

3.1.1.1 Location

The state lies between 08°17'30" and 12°47'40" North latitude and 74°27'47" and 77°37'12" East longitudes. With a total area of about 38,863 square kilometer, Kerala is bordered by Karnataka to the north and northeast, Tamil Nadu to the east and south, and the Arabian Sea to the west.

3.1.1.2 Land utilization pattern

The land utilization pattern of Kerala is presented in Table 3.1. The table reveals that the total cropped area accounted to 66.38 percent of the total geographical area of the state. The total cultivable wasteland of the state was 99810 ha which accounted for 2.57 percent of the total geographical area of the state.

Table 3.1 Land utilization pattern of Kerala

Category	Area (ha)	Percentage to total geographical area
Total cropped area	2586452	66.38
Net cropped area	2026064	52.13
Cropping intensity	126	-
Land put to non-agricultural uses	455897	11.73
Current Fallow	57387	1.48
Fallow other than current fallow	46931	1.21
Cultivable waste land	99810	2.57
Area sown more than once	539284	13.88
Marshy land	11	0
Still water	100160	2.58
Water logged area	3077	0.08
Social forestry	2679	0.07
Barren and uncultivable land	10619	0.27

Land under miscellaneous tree crops	2143	0.06
Forest	1081509	27.83
Permanent pastures and other grazing land	0	0
Total geographical area	3886287	100

Source: Agricultural Statistics 2019-20, Department of Economics and Statistics, Government of Kerala.

3.1.1.3 Cropping pattern

The cropping pattern of Kerala presented in Table 3.2 indicated that about 29 percent of the total cropped area is under the cultivation of oil seeds which include coconut, groundnut, sesamum and few other minor crops, of which the highest area falls under the cultivation of coconut.

Table 3.2 Cropping pattern of Kerala

Crop	Area (ha)	Percentage to total cropped area
Rice	198180	7.66
Other cereals and millets	669	0.03
Pulse	2260	0.09
Sugar crop	2823	0.11
Spices and Condiments	261373	10.11
Fresh fruits	331132	12.8
Dry fruits	39898	1.54
Tapioca	62070	2.4
Tubers	15656	0.61
Vegetables	41053	1.59
Oil seeds	763343	29.51
Fibers, Drugs and Narcotics	422	0.02

Plantation crop	687227	26.57
Other non-food crops	180346	6.97
Total cropped area	2586452	100

Source: Agricultural Statistics 2019-20, Department of Economics and Statistics, Government of Kerala

3.1.1.4 Agro-ecological units of Kerala

Based on climatic variability, landform and soils, twenty-three agro-ecological units have been delineated for Kerala State. In order to facilitate materialising of development plans, spatial bounding limits of Agro-ecological Units (AEUs) have been set as the administrative boundaries of local self governments. Table 3.3 gives the area covered by the different agro-ecological units.

Table 3.3 Agro-ecological units of Kerala

Agro-ecological units (AEU)		Area(ha)	Percentage to total geographical area
AEU 1	Southern coastal plain	56782	1.46
AEU 2	Northern coastal plain	122970	3.16
AEU 3	Onattukara sandy plain	67447	1.74
AEU 4	Kuttanad	126931	3.27
AEU 5	Pokkali lands	39765	1.02
AEU 6	Kole lands	71142	1.83
AEU 7	Kaipad lands	24209	0.62
AEU 8	Southern laterites	38727	1.02
AEU 9	South central laterites	365932	9.42
AEU 10	North central laterites	171469	4.41
AEU 11	Northern laterites	460257	12.36
AEU 12	Southern and central foothills	315893	8.13
AEU 13	Northern foothills	144181	3.71

AEU 14	Southern high hills	672675	17.31
AEU 15	Northern high hills	528434	13.60
AEU 16	Kumily high hills	150984	3.81
AEU 17	Marayur hills	28968	0.75
AEU 18	Attappady hills	8872	0.23
AEU 19	Attappady dry hills	18495	0.48
AEU 20	Wayanad Central plateau	74471	1.92
AEU 21	Wayanad eastern plateau	70325	1.81
AEU 22	Palakkad central plain	112957	2.91
AEU 23	Palakkad eastern plain	47049	1.21

Source: Package of Practices Recommendations: Crops, KAU, 2016

Out of the 23 AEUs, five units have been identified to have special soil and hydrological conditions in the coastal zone. These special zones require specific management strategies. The five special AEUs are Kuttanad, Onattukara sandy plain, Pokkali lands, Kaipad lands and Kole lands. The present study was undertaken in one of the special AEUs- Kuttanad, a major rice tract of Kerala. Department of Agriculture and Farmer’s Welfare, Government of Kerala has been giving thrust for AEU based farming since 2020. Fig. 1 shows the AEU map of Kerala.

3.1.2 Kuttanad

3.1.2.1 Location

Located between North latitudes 90̊ 8’ and 90̊ 52’ and East longitudes 760̊ 19’ and 760̊ 44’, Kuttanad lies 0.5-2.5m below the Mean Sea Level (MSL) making it the only system in India which favours rice production below MSL. Kuttanad is bordered by Kaduthuruthy - Vaikom road in the north, Kaduthuruthy -Kottayam - Mavelikkara railway line in the east, Mavelikkara - Haripad - Thottapally road in the south and Thottapally - Alappuzha-Thaneermukkom road in the west. The west flowing rivers- Manimala, Achenkoil, Muvattupuzha, Meenachil and Pamba confluence into the

Vembanad Lake here, thus contributing to the fertility of the region. Location near the equator, ideal temperature, high rainfall and solar radiation throughout the year renders Kuttanad wetland system unique. Kuttanad covers an area of 1,26,931 ha which accounts for 3.27 percent of the total geographical area of the state spread over sixty-nine panchayats of Alappuzha (41.3 percent), Kottayam (27.08 percent) and Pathanamthitta (3.39 percent) districts forming an important part of Vembanad wetland system.

3.1.2.2 Climate

Kuttanad has a tropical humid monsoon type climate with a mean annual temperature of 27.6° C and a mean annual rainfall of 2746.1 mm. The winds have seasonal direction of North- West during monsoon and speeds attain 45-55 km/hr. The humidity is 70-80 percent due to closeness to the Arabian Sea. Probability of annual moderate drought is very low in the area. The probability of two adjacent weeks receiving more than 20 mm rainfall was found to be high in the region from mid-April to November end.

3.1.2.3 Soil

The soil type of the Kuttanad is hydromorphic with potential acid-sulphate sediments underlying it. Based on the different soil types, Kuttanad has been classified into:

a) Kayal lands: These are rice fields reclaimed from the Vembanad Lake and lies 1-2 m below the MSL. The soils are highly saline in this region.
b) Karappadam: This region has the specificity of lying near to the waterways and rivers. The soil of Karappadam is often replenished by the silt deposits that are carried by the rivers.
c) Kari: The Kari soils are the most acidic and saline and has high amount of partially decayed organic matter and pyrites.

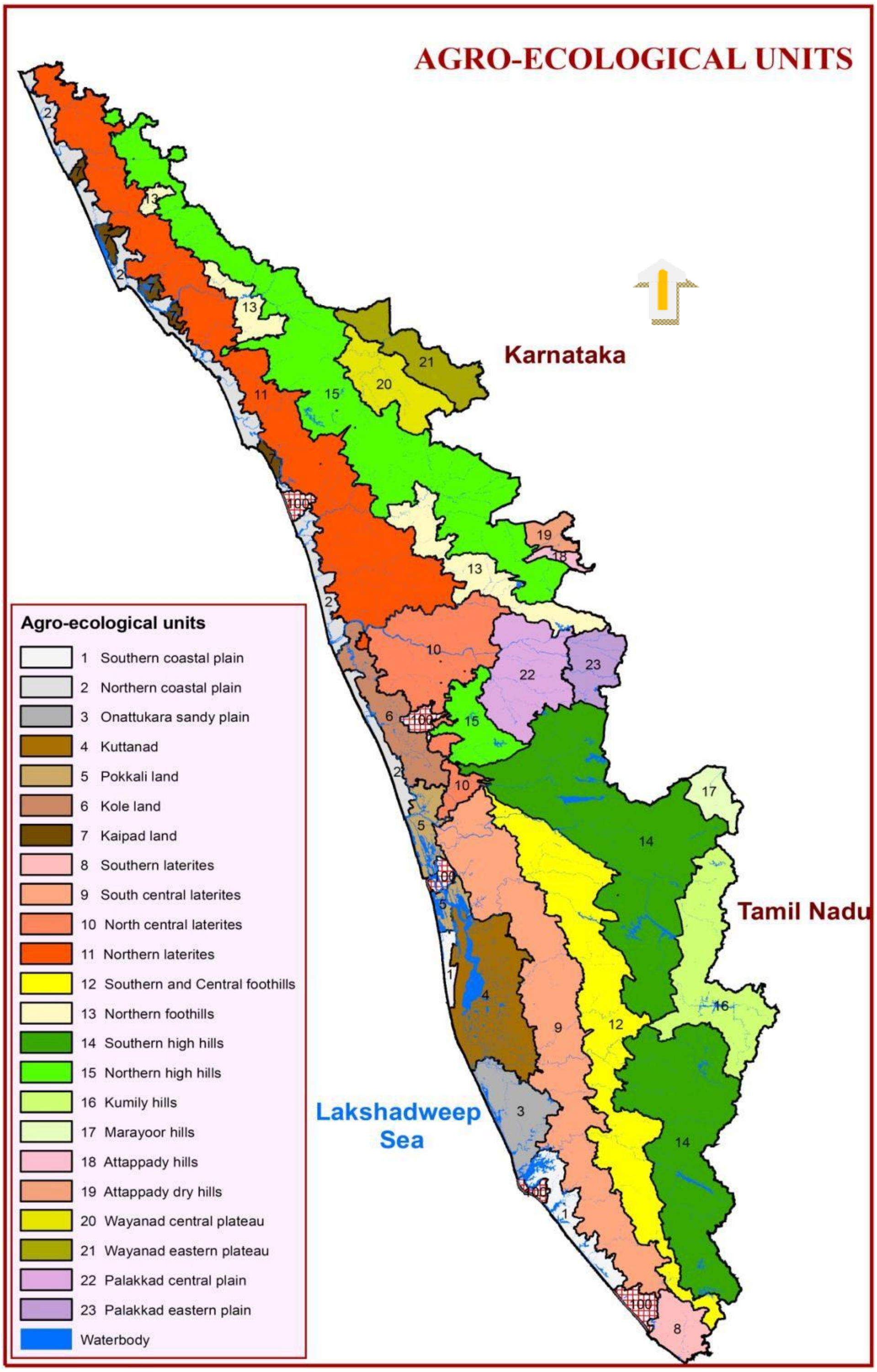

Fig. 1 Agro-ecological units of Kerala

3.1.2.4 Cropping pattern

The cropping pattern of Kuttanad (AEU 4) is given in Table 3.4. Rice is the most important crop which accounts for 40 percent of the total geographical area of Kuttanad. This is followed by coconut (31.53 percent), fruit crops that include jack, mango, banana, plantain, pineapple and papaya (13.57 percent), spices (4.79 percent) and tapioca (3.32 percent). Other important crops include vegetables and plantation crops like cocoa and cashew.

Table 3.4 Cropping pattern of Kuttanad

Particulars	Area (ha)	Percentage to total cropped area
Paddy	46332	40.39
Coconut	36170	31.53
Spices	5489	4.79
Fruit crops	15569	13.57
Plantation crops	1974	1.72
Tapioca	3810	3.32
Other tuber crops	943	0.82
Fibres, drugs and narcotics	13	0.01
Fodder crops	248	0.22
Green manure crops	718	0.63
Medicinal plants	82	0.07
Vegetables	3308	2.88
Sugar crops	45	0.04
Total cropped area	114700	100

Source: Agricultural Statistics 2019-20, Department of Economics and Statistics, Government of Kerala.

3.1.2.5 Kuttanad Wetland Ecosystem

Kuttanad forms a part of the Vembanad Wetland Ecosystem which is included in the list of wetlands of international importance by the Ramsar Convention. It is the second largest Ramsar site in India and the Govt. of India has brought the system under the National Wetlands Conservation Programme. Kuttanad offers a plethora of ecosystem services which include acting as a repository for monsoon flood flows, rich flora and fauna, providing direct and indirect livelihood to thousands of people and serving as a major destination for international and domestic tourism. Owing to the ingenious and traditional rice cultivation practices followed by the farmers of Kuttanad, often entitled ‘adventurous’, the FAO declared Kuttanad as a Globally Important Agricultural Heritage System (GIAHS) in 2013. According to FAO (2013), the unique system of farming in Kuttanad is an essential tool to combat climate change impacts in the coastal areas and to tackle the various soil and flood related issues in agriculture. Apart from agriculture, tourism is also a prominent economic activity in Kuttanad.

Alexander *et al*. (2010) recorded 130 plant species, 67 phytoplankton species and 7 species of zooplanktons with a population density of 3157 phytoplankton units per litre and 256 zooplankton units per litre in the Kuttanad wetlands. Narayanan *et al*. (2011) identified 225 taxa of birds out of which 38 percent were migrant birds. Fifty five percent of them were found to breed in the area. Endemic germplasm of banana, spices, tuber crops, medicinal plants and minor fruit crops have been identified from Kuttanad. Apart from that, 26 genotypes of indigenous mango and several genotypes of jack have also been identified. Local breeds of ducks, *Chara* and *Chemballi*, *Kuttanadan* buffalo, *Vechur* cow, *Kuttanadan* prawns (*Macrobrachioum rosenbergii*), Pearl spot (*Etroplus suratensis*), and black clam (*Villorita cyprinoides*) are considered as biodiversity icons of Kuttanad (Padmakumar, 2013). Endangered fish species like the endemic carp of Central Travancore (*Labeo dussumieri)*, golden catfish (*Horobagrus brachysoma*), river catfish (*Wallago attu*), Travancore catfish (*Clarias dussumeirri*) and the spotted murrel add to the richness of fish diversity of Kuttanad. Though Kuttanad is known for its ingenious cultivation practices, biodiversity and its sanctity, farmers in Kuttanad have been in severe distress for the past five decades (Ashtamoorthy, 2013).

Kuttanad is divided into specific zones based on the geo morphology, level of salt water intrusion, flood risk, soil fertility and cropping pattern. These zones are- Upper Kuttanad, Purakkad Kari, Lower Kuttanad, Kayal Lands, North Kuttanad and Vaikom Kari. Fig. 2 shows the map of Kuttanad with demarcation of different zones. Rice cultivation is carried out mainly in the *puncha* season *i.e*., from October-November to February-March. An additional crop of rice is also taken up by some farmers from April-May to September-October (KAU, 2016). Various State Governments over the years have intervened in several ways to make Kuttanad a rice centric economy (Padmakumar, 2013). One of the earliest projects was the Kuttanad Development Scheme which resulted in the construction of Thottappally spillway in 1951 for speedy discharge of flood waters into the Arabian Sea, the Thanneermukkom bund in 1955 to prevent salt water intrusion during the summer season and the construction of Alappuzha-Changanacherry bund road in 1957. Although the construction of the spillway and the bund targeted to extend the cropping season of rice and to increase the cropping intensity, it resulted in unexpected counterproductive consequences. Even though the scheme was aimed at the goodwill of the farmers, poor management, unscientific construction and technical delays led to it aggravating the distress of farmers in Kuttanad (Ashtamoorthy, 2013). Unscientific use of fertilizers and pesticides and resultant eutrophication has led to explosive growth of aquatic weeds like *Salvinia* and *Eicchornia* in the wetlands of Kuttanad. This eventually led to blockage of canals, improper drainage, increased soil acidity and deteriorated quality of drinking water. Lately, increased occurrence of water borne diseases and water pollution due to a boom in the tourism industry have been reported as pressing issues in Kuttanad (Jacob *et al*., 2018). Shift in the cropping pattern of the area from food crops to cash crops like coconut have also had severe negative impact on the Kuttanad wetland ecosystem. Losses in rice cultivation due to frequent bund breaches caused by heavy rainfall and flooding have mounted the distress of the farmers in Kuttanad in the recent times.

Prof. M. S. Swaminathan Research Foundation (2007) while discussing the measures to mitigate agrarian distress of Kuttanad farmers suggested improvement in productivity, profitability and sustainability of small and marginal farmer household with eco restoration as a medium to long term strategy. Based on the report, the Government of Kerala in 2010 launched the Kuttanad Package which was a set of formal recommendations to mitigate the agrarian distress in Kuttanad.

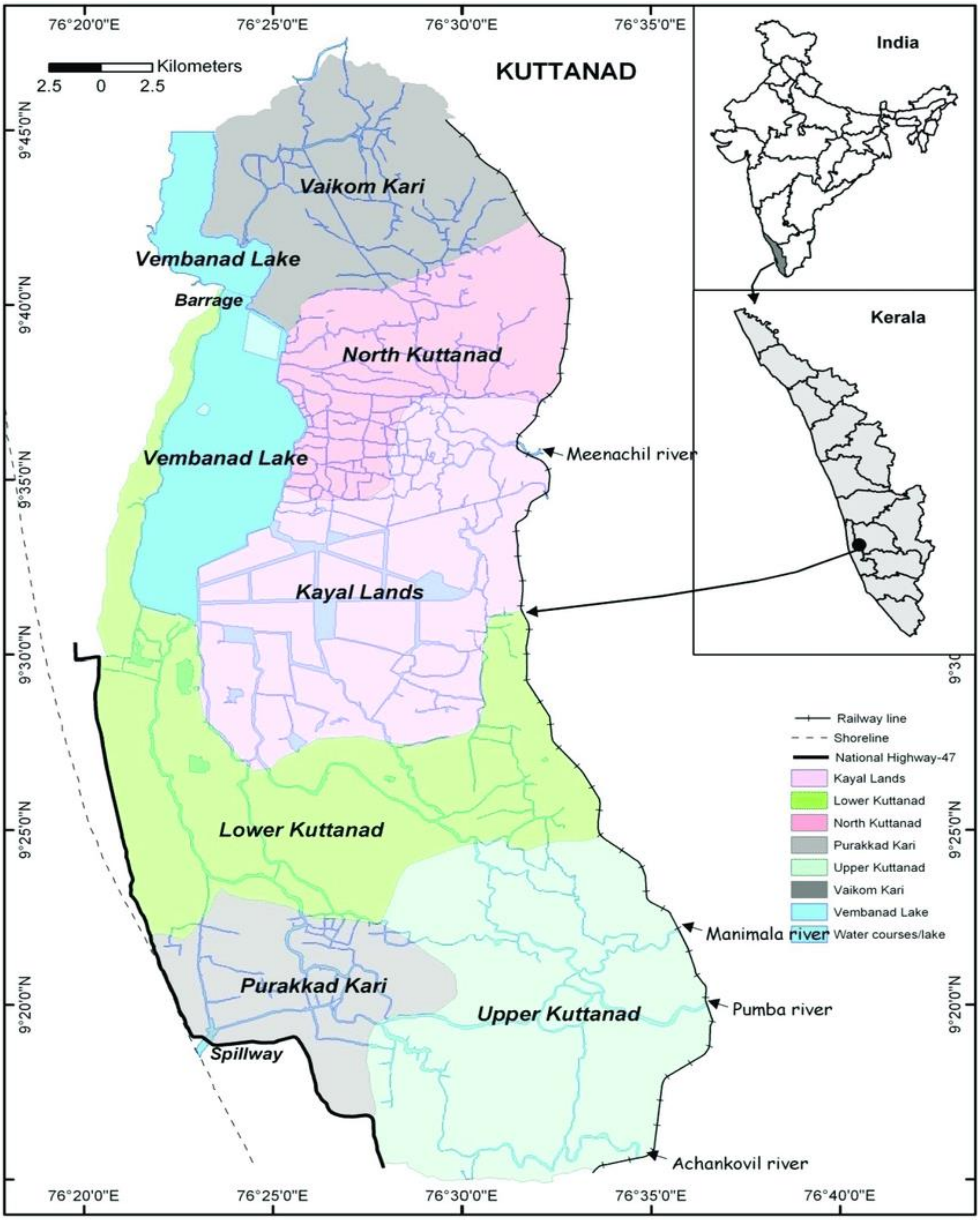

Fig. 2 Map of the study area

3.1.3 Selected districts in the study area

3.1.3.1 Kottayam District

3.1.3.1.1 Location

Located between 9°15' and 10° 21' North Latitudes and between 76° 22' and 77° 25' East Longitudes, Kottayam district covers a land area of 2208 sq km. It is flanked by Pathanamathitta district on the south, Alappuzha district on the west, Ernakulam district on the north and Idukki district on the eastern side. Total population of Kottayam is 19,74,551 persons (GOI, 2012). Kottayam District has a high literacy rate of 96.40 percent while that of Kerala state is 93.91 percent. Sex ratio of the district is 1040 females per 1000 males.

3.1.3.1.2 Agro-ecological units in the district

Kottayam District has been delineated into three AEUs *viz*., Kuttanad (AEU 4), South Central Laterites (AEU 9) and Southern and Central Foot Hills (AEU 12). The percentage share of each AEU in the total geographical area of the district is given in Table 3.5. Nearly 36 percent of the geographical area of Kottayam district lies in AEU 9, 33.76 percent in AEU 12 and the least area *i.e*., 30.32 percent lies in AEU 4. AEU map of the district is depicted in Fig. 2.

Table 3.5 AEUs in Kottayam

AEU	Area (sq km)	Percentage share of each AEU
AEU 4 Kuttanad	646.48	30.32
AEU 9 South central laterites	765.89	35.92
AEU 12 Southern and central foothills	719.89	33.76
Total area	**2132.26**	**100**

Source: NBSS & LUP, 2001

3.1.3.2 Alappuzha District

3.1.3.2.1 Location

The district is located between North Latitudes – 9° 05′ and 9° 54′ and East Longitudes – 76° 17′ 30″ and 76° 40′, bound by Ernakulam district in the North, Kottayam district and Pathanamthitta District in the East, Kollam District in the South and the Arabian Sea in the West. The district has a total population of 2,127,789 persons. The sex ratio is 1100 females per 1000 males.

3.1.3.2.2 Agro-ecological units in the district

Alappuzha District is delineated into five AEUs *viz*. Southern Coastal Plains (AEU 1), Onattukara Sandy Plain (AEU 3), Kuttanad (AEU 4), Pokkali Lands (AEU 5) and Southern Central Laterite (AEU 9).The percentage share of each AEU in the total geographical area of the district is given in Table 3.6. Out of the total geographical area of Alappuzha district, 50.72 percent lies in AEU 4, 32.92 percent in AEU 3, 7.83 percent in AEU 1, 5.63 percent in AEU 9 and 2.9 percent in AEU 5. AEU map of the district is given in Fig. 3.

Table 3.6 AEUs in Alappuzha

AEU	Area (sq km)	Percentage share of each AEU
AEU 1 Southern Coastal Plain	110.66	7.83
AEU 3 Onattukara Sandy Plain	465.52	32.92
AEU 4 Kuttanad	717.26	50.72
AEU 5 Pokkali Lands	40.99	2.9
AEU 9 Southern Central Laterite	79.6	5.63
Total	**1414.03**	**100**

Source: NBSS & LUP, 2001

3.2 Sampling Procedure

In the first stage, out of the three districts that make up Kuttanad AEU, Alappuzha and Kottayam districts were chosen, as the two districts had the maximum share of land area under Kuttanad AEU. From the two districts, a block each was selected based on the maximum area under rice. From the two blocks, five panchayats were purposively sampled based on the criteria of having maximum area under rice. Out of the ten panchayats, 100 farmers practising IFS were purposively sampled for the study. The secondary data for the study was collected from the Integrated Farming System Research Institute of Kerala Agricultural University located at Karamana, Thiruvananthapuram.

3.3 Nature and Sources of Data

The study made use of both primary as well as secondary data for analysis for reaching at meaningful conclusions for the specific objectives of the study. The primary data was collected from the 100 farmers spread across 10 panchayats of Kottayam and Alappuzha Districts of Kuttanad. Pre-tested, structured interview schedule was prepared and used to elicit the necessary information from the respondents. The restrictions imposed by the COVID-19 pandemic constrained the data collection by personal interview to 40 sample farmers and the response of the remaining 60 farmers were collected through telephonic interview. Information collected included socio-economic profile of the sample farmers, various enterprises in the farm, cultivation practices, input and output quantities and prices. Ranking of constraints faced by the farmers in adopting IFS models were also done. The secondary data on the inputs, establishment costs, output *etc*. pertaining to the IFS model developed by IFSRS, for a period of nine years was collected for analysing profitability.

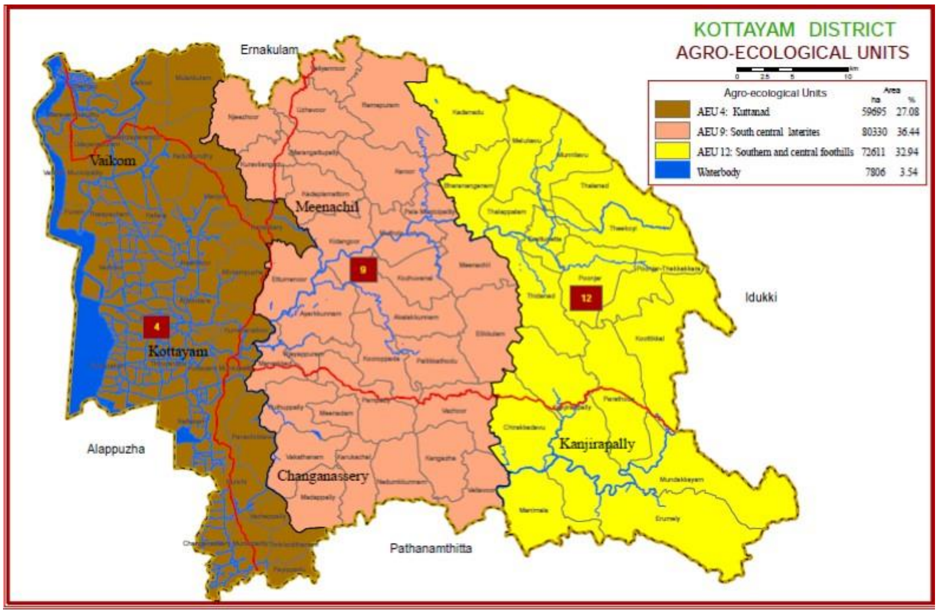

Fig. 3 AEU Map of Kottayam

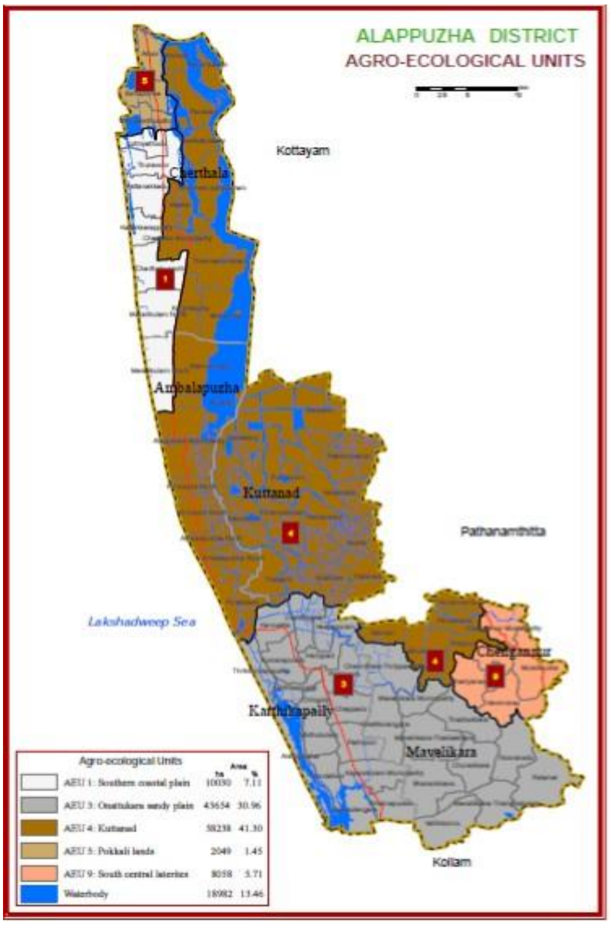

Fig.4 AEU Map of Alappuzha

3.4 Analytical tools

The primary and secondary data collected were analysed using specific tools so as to attain the objectives of the study. Microsoft Excel was used for analysing the collected data.

3.4.1 Economic Analysis of IFS models

3.4.1.1 Cost concepts

Cost concepts as given by Raju and Rao (1990) were used so as to assess the different costs involved in the production process. The different cost items included under each cost concept are given below.

i) Cost A_1

It is the actual paid out cost for the owner cultivator that is the cash expenditure which includes the following cost items:

a. Wages of hired human labour

Human labour was mostly hired in the study area by the farmers. The wages were at the rate of Rs. 1000 per day for males and Rs.500 per day for the females. Labour was hired for different cultivation practices of rice like cleaning of bund prior to sowing, application of lime, manure and fertilizers, application of weedicides and insecticides, weeding, packing and bagging of produce, bundling and transportation of straw. Labour was hired for milking, green fodder collection, feeding of cattle and cowshed maintenance while hired labour was rarely used in poultry. For fisheries and duckery subcomponents, harvesting of fish and foraging of birds were respectively the major activities that demanded hired human labour. Banana and fodder cultivation also requires hired human labour mainly for planting, intercultural operations and harvesting. The total cost associated with hiring of labour for different enterprises has been jointly accounted for.

b. Charges of hired machinery

Machine labour was hired for activities like preparation of land, sowing, harvesting, and bundling of straw. Machines like tractor, tiller, drum seeder, combine harvester and baler were used for the different activities respectively. Apart from these, milking machine was used by some of the dairy farmers. The hiring charges varied among different activities. The average charges were ₹2000 per hour for land preparation using tractors, ₹1750 per hour for the same using tillers and ₹2250 per hour for harvesting using combine harvestor and ₹45 per bundle of straw in the case of baler.

c. Market rate of manures and fertilizers

This includes the costs involved in the purchase of manure and fertilizers for the cultivation of rice, banana and fodder grass. The cost of manure and fertilizers as required for the different enterprises were jointly accounted.

d. Market value for seeds

The costs involved in purchase of seeds of rice, slips of fodder grass and suckers for banana cultivation are included under this head *i.e.,* The joint cost of seeds included the cost of rice seeds, slips of fodder grass as well as suckers for banana cultivation.

e. Market value of chicks, ducklings and fingerlings

Costs involved in the purchase of chicks, ducklings and fingerlings at the prevailing market prices.

f. Market value for feed

This included the costs involved in the purchase of feed for cattle, poultry, duckery as well as fish.

g. Imputed value of manure

The market value of farm produced manure is estimated under this head. The farm produced manure was mainly used for rice cultivation.

h. Imputed value of straw

The market value of farm produced straw is considered. The value of farm produced straw was imputed as it was utilized within the farm as feed for cattle in the case of farmers with dairy as a subsidiary enterprise.

i. Imputed value of grains (as feed)

This included the market value of farm produced grains used as feed for poultry.

j. Market value of plant protection chemicals

Costs of pesticides and herbicides used in the cultivation process were estimated under this. This included the cost of weedicides applied in the rice field before sowing and the pesticides used in rice and banana.

k. Land revenue

This constituted the prevailing land revenue of the study area which was ₹200 per acre including the farmer's welfare fund as collected by the Department of Revenue, Government of Kerala.

l. Depreciation

The depreciation on farm implements and sprayers along with that of farm buildings like poultry shed, cattle shed and storage structures and depreciation on cattle were computed using straight line method. This method assumes that the assets are used more or less to the same extent every year and therefore equal amounts of costs on account of their use can be charged every year.

$$\text{Depreciation} = \frac{\text{Original cost} - \text{Junk value}}{\text{Expected life of the asset}}$$

m. Interest on working capital

The interest on working capital was calculated at the interest rate of 10.25 percent which is the prevailing interest rate of scheduled commercial banks in the study area.

n. Miscellaneous expenses

The miscellaneous expenses included the transportation cost as well as the veterinary expenses incurred.

ii) Cost A_2

$$\text{Cost } A_2 = \text{Cost } A_1 + \text{Rent paid for leased in land}$$

It is the sum of Cost A1 and the rent paid for land that was leased in by the farmers. The land was leased in for a period of one year at the rate of ₹18000 per acre per year.

iii) Cost B

$$\text{Cost B} = \text{Cost } A_2 + \text{Interest on fixed capital excluding land} + \text{rental value of owned land}$$

If the amount invested in purchase of land would have been put in some other long term enterprise or in a bank, it would have yielded some returns or interest. But due to the investment of the amount in the purchase of land, the farmer has to sacrifice returns or interest that he would have otherwise gained. This loss is considered as cost and is estimated under rental value of owned land. The hypothetical interest that the capital invested in farm business would have earned if invested alternatively is also considered as cost. Rental value of owned land and interest on fixed capital represent imputed costs which are added to Cost A_2 to get Cost B. The rental value of land was fixed at ₹18,000 per acre and fixed capital included sprayers, cattle, poultry shed, nets and cattle shed.

iv) Cost C

$$\text{Cost B} + \text{imputed value of family labour}$$

It is the total cost of production which includes all cost items, actual as well as imputed. The value of family labour is imputed and added to Cost B.

3.4.1.2 Farm efficiency measures

Income measures are used as the measures of efficiency in the study. Different income measures are associated with different cost concepts. The profits at the different cost levels provide different measures of returns to the cultivator.

i. **Gross income**

It is the total value of the main product and the by-products of the farm.

ii. **Farm business income**

It is the profit at Cost A_2. It provides an estimate of returns to the farmer for his investment and profit.

Farm business income = Gross income - Cost A_2

iii. **Family labour income**

It is the estimate of the returns of the farmer for his labour and profit. It is the profit at Cost B.

Family labour income = Gross income – Cost B

iv. **Farm investment income**

Farm investment income = Farm business income – imputed value of family labour

v. **Net income**

It is the profit at Cost C and estimates the returns to the farmer purely of profit.

Net income = Gross income - Cost C

3.4.1.3 Benefit-Cost Ratio

It is the ratio of gross return to the cost of cultivation. This serves as a measure to indicate whether the costs incurred commensurate with the returns obtained. A Benefit-Cost ratio of greater than one is considered profitable. This has been worked out at Cost A_1, Cost A_2, Cost B, and Cost C.

3.4.1.4 Cobb- Douglas production function

Resource use efficiency for rice under Integrated Farming System and was analysed using the Cobb-Douglas production function. Input factors that were significant were identified by running a log-linear regression analysis. Following this, the resource use efficiency of those resources having a significant contribution to the production process were analysed. For this, the ratio of Marginal Physical Product to the Marginal Factor Cost was calculated. The process is elucidated below:

Production function analysis of Rice

$$\mathbf{Y = A\ X1^{b1}\ X2^{b2}\ X3^{b3}\ X4^{b4}\ X5^{b5}\ X6^{b6}\ X7^{b7}\ e^{\mu i}}$$

Where,

A = Intercept

Y = Total returns from paddy cultivation (₹)

X_1 = Area under paddy cultivation (ha)

X_2 = Value of seed (₹)

X_3 = Value of fertilizers (₹)

X_4 = Cost of plant protection chemicals (₹)

X_5 = Cost of liming materials (₹)

X_6 = Cost of human labour (₹)

X_7 = Cost of machine labour (₹)

μ_i= Stochastic disturbance term

e = Napier base, *i.e.*, 2.718

b_1, b_2,.....b_7 = production elasticities of respective inputs

This Cobb-Douglas function was estimated using ordinary least square (OLS) approach after converting it into log-linear form. The estimable form of the equation is given below:

$$\mathbf{lnY = lna + b_1\, lnX_1 + b_2\, lnX_2 + b_3\, lnX_3 + b_4\, lnx_4 + b_5\, lnX_5 + b_6\, lnX_6 + b_7\, lnX_7 + \mu_i}$$

The coefficients that represent the production elasticities of the respective inputs were tested for statistical significance by using 't'test. A rational farmer always aims at profit maximization and hence, it is important to allocate resources consistent with their respective marginal contributions in monetary terms. Allocative efficiency measures the degree to which it is accomplished. If the marginal contribution of one unit of input is found to be greater than the price of the input, then the farmer is said to have allocated the resources efficiently and there is further scope for allocating more units of that particular input. If the marginal contribution is negative, then the farmer is said to be using the input excessively so that the fixed resources become no longer responsive to the variable input applied. Allocative efficiency (AE) is determined by calculating the ratio of the Marginal Value Product (MVP) to the Marginal Factor Cost (MFC), *i.e*.

$$\mathbf{AE = \frac{MVP}{MFC}}$$

$$MVP = MPP_i \times P_y$$

Where,

MVP = Marginal value product

MPP_i = Marginal physical product of the i^{th} input

P_y = Price of output

$$MPP_i = b_i \times \frac{Y_i}{X_i}$$

Where,

b_i = Elasticity coefficient of the i^{th} independent variable

Y_i = Geometric mean of the output, and

X_i = Geometric mean of the i^{th} input

3.4.1.5 Sustainability Value Index

In order to analyse the economic sustainability of the existing farming system models in Kuttanad, Sustainability Value Index (Bohra and Kumar, 2015) was calculated using the formula:

$$\textbf{Sustainability Value Index } (SVI_i) = \frac{NRi - SDi}{MNR}$$

Where,

NR_i = net returns obtained under i^{th} model

SD_i = standard deviation of net returns of i^{th} model

MNR = maximum net returns attained under any model

3.4.1.6 System Economic Efficiency

The primary aim of an integrated farming system is to ensure sustained livelihood to the farmers practicing the different models. System economic efficiency is defined as the ratio of the net returns obtained under the various IFS models during a year to the total number of days in a year (Kumar *et al.*, 2018).

$$\textbf{System Economic Efficiency} = \frac{\textbf{Net Returns}}{\textbf{365}}$$

3.4.1.7 Employment generation

Employment generation in the IFS models was assessed using Person Days per year.

3.4.2 Estimating profitability of KAU recommended rice based IFS model

3.4.2.1 Net Present Worth

Net Present Worth (NPW) is defined as the present worth of the cash flow stream. NPW is calculated by discounting the cash flows at the opportunity cost of capital. A project is financially feasible if the NPW turns out a positive value. NPW is estimated using the following equation:

$$NPW = \frac{P1}{(1+i)^{t1}} + \frac{P2}{(1+i)^{t2}} + \ldots\ldots + \frac{Pn}{(1+i)^{tn}} - C$$

Where,

P_1 = Net cash flow of first year

P_n = Net cash flow of nth year

i = Discount rate

C = Initial cost of the investment

3.4.2.2 Benefit- Cost Ratio

It is the ratio of present worth of benefits to present worth of costs, discounted at the opportunity cost of capital. A B-C ratio of greater than one is considered feasible for a project. The formula given below depicts the estimation of B-C ratio.

$$\text{B-C Ratio} = \frac{\sum_{t=1}^{n} \frac{Bt}{(1+r)^{t}}}{\sum_{t=1}^{n} \frac{Ct}{(1+r)^{t}}}$$

Where,

B_t = Benefit of the t^{th} year

C_t = Cost of the t^{th} year

r = Discount rate

t = 1......n years

n = total no. of years of the enterprise

3.4.2.3 Internal Rate of Return

Internal rate of returns is a tool used to analyse the actual rate of return from different projects. It gives the marginal efficiency of capital or yield on the investment made. It is the discount rate at which the present values of the net cash flows are equal to zero, i.e., NPW=0. In other words, it is the discount rate at which net present worth of costs is equal to the net present worth of the benefits. The IRR for the KAU recommended rice-based IFS model is calculated for a period of five years. The minimum discount rate is taken to be 10.25 percent i.e., the prevailing interest rate for working capital in scheduled commercial banks. Symbolically, IRR can be represented as,

$$\mathbf{NPW} = \sum_{t=1}^{n} \frac{(Bt-Ct)}{(1+r)^{t}} = 0$$

Where,

B_t = Benefit of the t^{th} year

C_t = Cost of the t^{th} year

r = Discount rate

t = 1......n years

n = total no. of years of the enterprise

Upon calculating the IRR, an arbitrary discount rate is assumed and an NPW for the same is worked out. The process is continued to reach a discount rate where the NPW turns out to be negative. To obtain the exact IRR, interpolation method is followed using the formula:

$$\text{IRR} = [\text{Lower DR}] + [\text{Difference between the two DRs}] \times \left[\frac{\text{PW of the cash flow at LDR}}{\text{Absolute difference between the PWs of the cash flows at the two DRs}} \right]$$

Where,

LDR- Lower Discount Rate

DR- Discount Rate

PW- Present Worth

3.4.3 Analysis of constraints in adoption of rice based IFS models

3.4.3.1 Garrett ranking technique

Garrett's ranking technique was employed to analyse the constraints faced by the farmers with regard to the adoption of various IFS models. The major constraints faced by the farmers were identified during the pilot survey. These constraints were presented to the sample farmers who were asked to rank the constraints according to their perceived importance. The ranks were then converted into percent position by the following formula:

$$\text{Percent position} = \frac{100 \text{ x } (\text{Rij} - 0.5)}{\text{Nj}}$$

Where,

R_{ij} = Ranking given to the i^{th} attribute by the j^{th} individual

N_j = Number of attributes ranked by the j^{th} individual.

These percentages were then converted into scores on a scale of 100 points referring to the table given by Garrett and Woodworth (1969). For each factor, the scores of the various respondents were added, from which total value of scores and mean value of scores were calculated. The mean score values were later arranged in the descending order. The factor having the highest mean value is considered to be the most important factor and thus was given the rank one and the others followed in order.

3.4.3.2 Kendall's Coefficient of Concordance

Kendall's W statistic, called the Coefficient of Concordance was employed to assess agreement between different respondents in ranking the different constraints.

Kendall's coefficient of concordance (W) is calculated as

$$W = \frac{12S}{p^2(n^3 - n) - pT}$$

Where,

n = the number of objects

p = the number of judges

T = the correction factor for tied ranks

$$S' = \sum_{i=1}^{n} R_i^2 = SSR$$

$$T = \sum_{k=1}^{m} (t_k^3 - t_k)$$

Where,

'S' = the sum of squares from row sums of ranks R_i

m = the number of groups

t_k = the number of tied ranks in each (k) of m groups.

Kendall’s W statistic ranges from 0 to 1. Zero shows there is absolutely no agreement between respondents, while 1 shows perfect agreement. Higher the value of Kendall's W statistic, the stronger is the association. Usually, Kendall's coefficients of 0.9 or higher are considered to be very good.

Results and Discussion

4. Results and Discussion

The present study entitled 'Economic analysis of rice-based Integrated Farming System models in Kuttanad' was conducted in parts of Kottayam and Alappuzha districts of Kerala falling under the AEU 4, Kuttanad. The objectives of the study were analysing the economics of rice based IFS models existing in Kuttanad, estimating profitability of KAU recommended rice based IFS models for Kuttanad and analysing the constraints involved in adoption of IFS models. IFS models existing in the rice based system was identified through the primary survey of 100 farmers. The results of the study are discussed under sections as given below:

4.1 Rice cultivation in Kuttanad

4.2 Socio-economic profile of the sample farmers

4.3 Economic analysis of rice based IFS models in Kuttanad

4.4 Profitability analysis of KAU recommended rice based IFS model

4.5 Constraints in adoption of rice based IFS models in Kuttanad

4.1 Rice cultivation in Kuttanad

Rice production in Kuttanad accounts for about 36.5 percent of Kerala's total rice production. Rice cultivation takes place in the 'kayal' lands which are reclaimed from the Vembanad Lake. During *puncha* cultivation, the fields are first drained off water and ploughed following which the bunds are strengthened to prevent breaches. The seeds are then broadcasted. Farmers cultivate medium duration variety, Uma (MO 16), having a duration of 120 days. Machine labour is hired by the farmers for activities like ploughing and harvesting. Balers are also used in the area for collection of straw after harvest. Human labour is hired for activities like broadcasting of seeds, applying manure and fertilizers, spraying of weedicides and pesticides and for other activities like weeding, cleaning of bunds, loading and unloading of the harvested grains and straw. The harvested grains are procured by the Civil Supplies Department of the Govt. of Kerala at Rs.27.48 per kg for the year 2020. The rice fields of Kuttanad are organized into *padashekharams*, a collection of rice fields contiguously situated within a common outer bund and with all or some of the agricultural operations like pumping, sowing, harvesting *etc.* done jointly by all the owners.

4.2 Socio-economic profile of the sample farmers

An understanding on the socio-economic status of the sample respondents gives an idea about the background information on the lives as well as the rural farming scenario. The distribution of sample respondents with respect to age, gender, family size, education, occupation, land holding, annual income and experience in farming is presented in Table 4.1.

Table 4.1 Socio-economic profile of the sample farmers (n=100)

Sl. No.	Characteristic	Classification						Mean
1	Gender	Male	Female					NA
		89	11					
2	Age (yrs)	<30	30-40	40-50	50-60	>60		52
		5	7	25	36	27		
3	Family size (No.)	Up to 2	3-5	>5				3
		10	68	22				
4	Education	Up to Secondary	Higher secondary	Degree/Diploma				NA
		35	40	25				
5	Experience in farming (yrs)	<5	5-10	10-15	15-20	>20		15
		11	17	31	19	22		
6	Occupation	Agriculture	Self-employed	Others				NA
		79	17	4				
7	Annual income (lakh ₹)	<1	1-2	2-3	3-4	4-5	>5	2,82,612
		8	25	27	21	7	12	

NA: Not Applicable

4.2.1 Age

Age wise distribution of the sample respondents as furnished in the Table 4.1 shows that the maximum number of farmers belonged to the age group 50-60 years (36 percent) and 27 percent of the sample farmers were aged above 60 years. The next category having the highest number of farmers was the age group 40-50 years (25 percent). Only 7 respondents belonged to the age group 30-40 years and 5 respondents were below 30 years of age. This is a sign of reluctance of the younger generation to take up agriculture as their primary source of income. The classification also reflects on the fact that more aged and experienced farmers were willing to integrate multiple enterprises along with rice cultivation. The mean age of the sample farmers in the study area was 52 years. The results are in line with the average age of Indian farmer reported as 52 years (Mahapatra, 2019).

4.2.2 Gender

Gender wise distribution of the sample respondents reveals that 89 percent of the respondents were males. Only 11 percent of the total respondents were females.

4.2.3 Family size

Majority of the respondents (68 percent) had 3-5 members in their families. The classification shows that 22 percent of the sample respondents had more than five members in their families. Only 10 percent of the respondents had up to two family members. The average number of family members was 3 in the study area.

4.2.4 Education

Majority of the farmers (40 percent) had higher secondary level of education and 35 percent of the farmers had education up to secondary level. Twenty five percent of the farmers had either a degree or diploma.

4.2.5 Experience in farming

The average number of years of farming experience of the sample farmers in the study area was 15 years. Thirty one percent of the farmers had 10-15 years of experience in farming followed by 22 percent of the farmers who had more than 20 years of experience. While 19 percent had 15-20 years of experience, 17 percent had 5-10 years of farming experience. Only 11 percent of the farmers had less than 5 years of farming experience.

4.2.6 Occupation

Seventy nine percent of the respondents had agriculture as their primary occupation/ source of income. Seventeen percent of the sample respondents were self-employed. They were involved in some other means of living other than agriculture. This mainly included small businesses. Four of the respondents were either government or private sector employees.

4.2.7 Annual income

The total income of the sample farmer for the reference year from various sources indicates his annual income. The average annual income of the respondents in the study area was ₹2,82,612. Most farmers (27 percent) had an income range of ₹2-3 lakh. One fourth of the respondents had income between ₹1-2 lakh and 21 percent had annual income between ₹3-4 lakh. Twelve farmers had an annual income of more than ₹5 lakh. Just 8 percent of the sample farmers had an annual income of less than ₹1 lakh.

4.2.8 Wetland area

Maximum number of farmers (33 percent) had a total wetland area of 2-4 ha. This was followed by 30 percent of farmers having a wetland area of 1-2 ha. Two farmers owned more than 10 ha of wetland. Twenty seven percent of the respondents had wetland area of less than 1 ha. Total wetland area is the sum of owned wetland and leased in wetland. Farmers also practised lease land farming in the study area. The rental value of land varied from ₹37,500 per ha to ₹50,000 per ha in the study area. The average wetland holding size in the study area was 1.8 ha. Twenty-five farmers in the sample practiced lease land farming. The average area of land leased in among these respondents was 1.4 ha. The Table 4.2 gives the distribution of farmers based on total wetland area.

Table 4.2 Distribution of farmers based on wetland area

Category	Total wetland area (ha)	No. of farmers	Percentage
Marginal	<1	27	27
Small	1-2	30	30
Semi-medium	2-4	33	33
Medium	4-10	8	8
Large	>10	2	2
Total		100	100

4.2.9 Farm loan

Among the sample respondents, 24 percent had availed farm loans from institutional lending agencies, mostly from commercial banks. Most farmers had availed loans from the State Bank of India, Canara bank and Cooperative banks. Majority of the farmers who availed loan were holders of Kisan Credit Card (KCC) and hence the loan was availed at an effective interest rate of 4 percent. Average credit availed by a farm household was ₹1,35,000.

4.2.10 Training on IFS

Thirty seven percent of the total sample farmers had attended at least one training on IFS. The trainings have been conducted by the Krishi Vigyan Kendras in the districts and Rice Research Station, Moncompu, Alappuzha.

4.3 Economic analysis of rice based IFS models in Kuttanad

4.3.1 Existing rice based IFS models in Kuttanad

The choice of the different subcomponents of an IFS model depends on the topographical characters, input and labour availability, the economic condition of the farmers and the farmers' perception regarding the utility of IFS (Nair *et al.*, 2019). The farming systems in AEU 4 were mainly rice-based and coconut based. Homestead cultivation was also prominent in the study area. Since rice-based farming system was dominant, rice-based IFS models were identified for the study. Mamatha (2017) conducted a study on multidimensional analysis of IFS farmers in Kuttanad and identified the subcomponents of rice-based IFS models to be dairy, duckery, poultry and fisheries. According to Sasidharan and Mathew (2014), one acre paddy field of Kuttanad has the scope to integrate 20,000 fish fingerlings, 300 broiler ducks, 1-2 buffaloes, 20 coconut palms on bunds, 40 banana plants, 20-40 yams or cassava and a single line fodder of 80 m length. The details regarding the average farm size and the number of sample respondents practising the different models is given in Table 4.3.

4.3.1.1 Rice+ Duckery

Integration of duckery with rice cultivation benefitted the farmers mainly in two ways *i.e.*, waste management and nutrient enrichment of the rice fields. After harvesting of rice, the ducks are let into the fields where they feed on the leftover grains and in turn enrich the fields with their droppings. Mostly, local breeds of *Kuttanadan* ducks like *Chara* and *Chemballi* were reared by the farmers. Duck eggs as well as meat fetched a high price in the study area. The average number of birds in the duckery unit was 20 while the average wetland area owned by the farmers was 4.3 acres. An average of 2.8 acres of wetland was leased in by the farmers practising the model. This was the predominant rice-based IFS in the study area, practised by 18 percent of the sample farmers.

4.3.1.2 Rice+ Fish

This model was practised by 16 percent of the sample farmers and was the second most dominant. Fish cultivation supplemented the farmers' income ensuring them good returns. Report of the Kerala Government on special package for post-flood Kuttanad (2018) had identified integration of fish with rice as the best way to increase the profits of rice farmers in the area. The average area of owned wetland was 3.44 acres and leased wetland area was 0.762 acres. The average area of the fish pond of the farmers practicing the model was found to be 0.07 acres. The farmers mainly practised polyculture of Rohu, Catla, Mrigal, Grass Carp and Anabus. Some of them practiced monoculture of Tilapia, GIFT Tilapia and Pearlspot. Apart from market bought fish feed, fish were also fed puffed rice and rice bran although these practices are considered unscientific.

Table 4.3 Rice based IFS models in the study area

Sl. No.	IFS Model	No. of farmers	Wetland owned (acres)*	Wetland leased in (acres)**	Pond area (acres)*	Poultry (No.)*	Duckery (No.)*	Dairy (No.)*	Banana (No.)*	Fodder (acres)*
1	R+ Du	18	4.3	2.8	-	-	20	-	-	-
2	R + F	16	3.44	0.762	0.07	-	-	-	-	-
3	R+ F + P+ Du	13	6.3	0	0.25	15	20	-	-	-
4	R + F + Da	10	4	0.6	0.02	-	-	3	-	-
5	R+ Da	9	4.8	0	-	-	-	3	-	-
6	R+ Da + P	8	4.9	0	-	33	-	4	-	-
7	R + F + P	6	5.5	1	0.05	23	-	-	-	-
8	R +B+ Da+ Du	6	8	0	-	-	26	5	100	-
9	R + F + Du	5	2.8	0.8	0.16	-	14	-	-	-
10	R – F	5	23	-	23	-	-	-	-	-
11	R+ Da + Fo	4	5.38	0	-	-	-	4	-	0.2

*Indicates mean values in the respective domain

**Mean value of leased in land

R- Rice, F- Fish, Da- Dairy, Du- Duck, P- Poultry, B- Banana, Fo- Fodder

4.3.1.3 Rice+ Fish+ Poultry+ Duckery

The second predominant model in the study area was Rice+ Fish+ Poultry+ Duckery. This model was taken up by 13 percent of the sample respondents. Since multiple enterprises were integrated into the model, the level of integration in this particular model was high. The average owned wetland area was 6.3 acres. No farmers in this model practised lease land farming. The average area of the fish pond was 0.08 acres. The unit size of poultry and duckery were 15 and 20 respectively. The ducks were let into the rice fields after harvest so that they feed on the leftover grains. In turn, the ducks enriched the field with nutrient rich droppings for the next crop of rice. Poultry manure was also added to the fish pond to enhance the growth of phyto-planktons that are excellent feed for the fish.

4.3.1.4 Rice+ Fish+ Dairy

Dairy and fish culture along with rice was another prominent model in the study area. Integration of dairy has helped farmers to save upon the otherwise huge amount spent for manuring the rice fields along with transportation and loading charges. The average number of cattle owned by the farmers in the study area practicing the model was three. The average area of owned wetland was 4 acres and leased in land was 0.6 acres. The average pond area was 0.02 acres. The total number of sample respondents that practised the model was 10.

4.3.1.5 Rice+ Dairy

Integration of dairy with rice ensures year-round income to the farmers who previously depended on the payment received from the seasonal crop. The cow dung is utilized as excellent manure in the rice field. In turn, the straw obtained after the harvest of rice is bundled and stored to meet the roughage requirements of the cattle. The average area under rice in the model is 4.8 acres and the average number of cows in the dairy unit is three with at least two in the lactating stage. The average period of lactation of the cows in the model was 302 days. Cows were mostly cross bred or local breeds like the *Vechur*. Though the production was less, the milk of *Vechur* cow fetched a higher price compared to the crossbreds. The milk was mostly sold in the MILMA Cooperative societies where the price was determined by the total fat and SNF content of milk. The maximum price that the farmers' received for milk was Rs 50 per litre. Farmers were also involved in local sale of milk at the market price.

4.3.1.6 Rice+ Dairy+ Poultry

Rice with subcomponents dairy and poultry was another model identified in the study area practised by 8 farmers in the sample. The average area under rice was 4.9 acres with the unit size of poultry being 33 and the number of cows in the dairy unit was 4 with at least two in the lactating stage. The average period of lactation was 252 days.

4.3.1.7 Rice+ Fish+ Poultry

Six percentage of the total sample farmers surveyed followed this model. The average area under rice in this model was 5.5 acres. The average area leased in by the farmers was one acre. The average area of the fish pond was 0.05 acres and the average size of the poultry unit was 23. Integration of poultry, fish along with rice supplemented the farmer's income. The birds in the poultry unit were fed harvested rice grains along with market purchased poultry feed. Single batch of poultry was taken up by the farmers in a year. Fish cultivation included polyculture of different fish species like Rohu, Catla, Mrigal, Grass carp and monoculture of Tilapia and Pearl spot.

4.3.1.8 Rice+ Banana+ Dairy+ Duck

The average area under rice for this model was the highest of all which was 8 acres. The model was the most efficient in terms of space utilization as banana was planted in the dykes of the rice fields which resulted in an additional income to the farmer. *Palayamkodan, Poovan* and *Nendran* varieties were grown in the dykes by the farmers. The average number of bananas grown on the dykes of an 8 acre paddy field was 100. Cost of cultivating banana contributed less than one percent of the total cost of cultivation of the model.

4.3.1.9 Rice+ Fish+ Duckery

The model was practised by 5 percent of the sample farmers in the study area. The average size of owned wetland was 2.8 acres and that of leased wetland was 0.8 acres. The average size of the fish pond was 0.16 acres. The duckery unit had an average number of 14 ducks. In the fish pond too, duck droppings help in the growth of phytoplankton that serve as essential fish feed. Ducks also help in aeration of the fish pond and consume juvenile frogs, tadpoles and dragonflies (Kumar *et al*., 2012).

4.3.1.10 Rice – Fish

Rice–fish sequential farming was practised by five percent of the sample respondents. According to MSSRF report on Kuttanad (2007), ‘one paddy–one fish’ farming in Kuttanad is quite profitable and could lead to organic farming with low chemical inputs for the paddy rotation. According to Padmakumar (2013), judicial integration of rice and fish in the wetlands of Kuttanad has demonstrated to increase the farmers’ income by 40 percent with a significant reduction in the rice production cost, rendering rice cultivation more organic. The scheme for promotion of this IFS model has been propagated by the Agency for Development of Aquaculture (ADAK) under the Fisheries department of Government of Kerala. The farmers are given technical and financial assistance under the scheme for different heads like strengthening of bunds, construction of nursery bunds, purchase of centrifugal pumps, purchase of nets, screens, fish feed, fingerlings etc. This is practised in a *padashekharam* collectively with pooled funds taken up as the initial capital investment. The income from fish cultivation is then divided among the farmers proportionately on the basis of their land holding. Polyculture of Rohu, Mrigal, Catla, and Grass Carp is practised by the farmers. Although the scheme was popular before, several constraints have led to farmers refraining from adopting the model. Constraints include weak outer bunds of fields, huge costs involved in nursery management and the threat posed by birds that feed on the fish. Increasing cost of fish feed and high maintenance costs are some of the reasons farmers cite for non adoption of the model. The fingerlings are raised in the nursery along with the first crop of rice (*Virippu*). Once the rice is harvested, the fish is let into the field. After three months, the fish is harvested employing labourers at the rate of ₹23-25 per kilogram of fish caught.

The fish is then sold in the local markets or transported to the fish markets in Changanacherry and Vaikom where they are sold at prices ranging from ₹140-200 per kilogram.

4.3.1.11 Rice+ Dairy+ Fodder

The model had an average number of 4 cows with at least two in the lactating stage with an average lactation period of 292 days. The wetland area owned by the farmers averaged to 5.38 acres. Four of the sample farmers had integrated fodder along with rice and dairy. The average area under fodder cultivation was 0.2 acres. It benefitted the farmer in cutting the costs involved in feeding the cattle as green fodder was made sufficiently available in the farm through fodder cultivation. Guinea grass and hybrid napier was mainly cultivated by the farmers.

4.3.2 Economic analysis of the rice based IFS models

Economic analysis of the models was done by making use of the cost concepts. The analysis was carried out for a farm of average size as defined in the previous section. The detailed cost analysis of the different IFS models is elucidated in the following section. Returns from the different models are also elucidated in tables. The costs of inputs including seed, fertilizers, manure, and plant protection chemicals along with cost of hired human labour, hired machine labour were calculated. Apart from that, the interest on the working capital was also calculated at the prevailing bank rate. Cost of farm produced inputs like manure, dry fodder and feed were imputed at prevailing market prices. Depreciation on the fixed assets, interest on fixed capital, land revenue, rental value of owned land were also calculated and added to obtain different costs. The value of family labour was imputed and added to obtain Cost C. Returns from the different subsidiary enterprises like fish, dairy, duckery, poultry, banana and fodder through the sale of products obtained are also elucidated in the following section. Products like FYM and straw are recycled within the system by most farmers.

The cost analysis of the different IFS models is elucidated in Table 4.4. The returns obtained from the different models are given in Table 4.5.

Table 4.4 Cost analysis of the rice based IFS models in the study area (₹/average farm)

Particulars	R+F	R+F+ Da	R+F +Du	R+F +P	R+F+P +Du	R+Du	R+D+P	R+Da +Fo	R+Da	R+B +Da +Du	R-F
Rice seed	6280	5917	5107	10177	9613	10615	7500	8715	7751	15764	33810
Fodder Slips	0	0	0	0	0	0	0	500	0	0	0
Banana Sucker	0	0	0	0	0	0	0	0	0	2500	0
Other material inputs	26328	16764	21248	39876	38478	45909	21216	26262	19810	47143	100395
Fingerlings	524	120	950	300	480	0	0	0	0	0	18400
Fish feed	1589	424	3384	1050	2000	0	0	0	0	0	552000
Chicks	0	0	0	700	450	0	990	0	0	0	0
Poultry feed	0	0	0	14000	9000	0	15550	0	0	0	0
Ducklings	0	0	1750	0	2500	2500	0	0	0	3000	0
Duck feed	0	0	2800	0	5000	5300	0	0	0	6000	0
Dairy concentrates	0	117979	0	0	0	0	150000	126875	92361	146000	0
Dry fodder	0	0	0	0	0	0	0	5500	3610	0	0
Hired labour charges	38068	70112	28093	73058	57818	53791	75133	63179	73039	132385	278208
Machine labour	30008	29000	24463	38796	39728	41041	33313	39305	25743	60693	236900
Depreciation	2250	26250	3750	3000	4100	1750	21600	21250	16500	22250	32200
Land revenue	688	800	560	1100	1260	860	1000	1075	960	1600	4140
Imputed value of manures	0	9333	0	0	0	0	12500	15625	8778	43750	0

Particulars	R+F	R+F+ Da	R+F +Du	R+F +P	R+F+P +Du	R+Du	R+D+P	R+Da +Fo	R+Da	R+B +Da +Du	R-F
Imputed value of straw	0	30000	0	0	0	0	33250	33594	17500	60000	0
Imputed value of feed	0	0	0	4125	2750	0	5500	0	0	0	0
Miscellaneous expenses	2500	4000	2700	2230	2000	2100	4300	3500	2278	5000	18400
Interest on working capital	10476	32298	9301	18797	18006	16580	36858	37203	25750	57045	130631
COST A_1	**118710**	**340994**	**104105**	**207209**	**193182**	**180446**	**418710**	**382582**	**294080**	**603130**	**1405084**
Rent for leased in land	13716	10800	14400	18000	0	50400	0	0	0	0	0
COST A_2	**132426**	**351794**	**118505**	**225209**	**193182**	**230846**	**418710**	**382582**	**294080**	**603130**	**1405084**
Interest on fixed Capital	800	14500	1200	1800	2300	1000	14500	17500	14300	23500	4715
Rental value of owned land	61920	72000	50400	99000	113400	77400	88200	96750	86400	144000	345000
COST B	**195146**	**424794**	**170105**	**326009**	**308882**	**309246**	**521410**	**496832**	**394780**	**770630**	**1754799**
Imputed value of family labour	11406	36875	37813	32800	54688	21875	21875	20000	43750	28437	0
COST C	**206553**	**461669**	**207918**	**358809**	**363570**	**331121**	**543285**	**516832**	**438530**	**799067**	**1754799**

R- Rice, F- Fish, Da- Dairy, Du- Duck, P- Poultry, B- Banana, Fo- Fodder

Table 4.5 Returns from the rice based IFS models in the study area (₹/ average farm)

Component	Products	Price (₹/kg)	R+ F	R+F+Da	R+F+Du	R+F+P	R+F+P+Du	R+Du	R+Da+P	R+Da+Fo	R+Da	R+B+ Da+Du	R-F
Rice	Rice	27.5	241804	246599	171072	337838	343035	372543	230175	256085	237197	519750	206250
	Straw	5	27261	0	22500	50104	55000	55875	0	0	14097	0	0
Fish	Fish	200	29524	8000	63200	20000	32105	0	0	0	0	0	20000
Dairy	Milk	48	0	146594	0	0	0	0	175000	170200	167000	447000	0
	FYM	5	0	37000	0	0	0	0	40700	30875	27944	33750	0
Poultry	Egg	8	0	0	0	17500	11340	0	22764	0	0	0	0
	Culled birds	100	0	0	0	3200	1722	0	3550	0	0	0	0
Duckery	Egg	10	0	0	3640	0	5078	5340	0	0	0	6000	0
	Culled birds	220	0	0	2000	0	4000	2880	0	0	0	5000	0
Banana	Banana	20	0	0	0	0	0	0	0	0	0	5000	0
Gross returns (₹)	-	-	**298588**	**438193**	**262412**	**428642**	**452280**	**436638**	**472189**	**457160**	**446238**	**1016500**	**226250**

4.3.2.1 Rice + Fish

The different costs involved in the production process are elucidated in the Table 4.6. The table reveals that the maximum share of Cost A_1 was accounted by the hired human labour (32.07 percent). This was followed by machine labour, cost of fertilizers, interest on working capital, and cost of manure and seeds. Family labour was mainly utilized for activities like feeding and harvesting of fish. The imputed value of family labour was ₹11,406 (15 Man Days).

Table 4.6 Cost distribution of Rice+ Fish

Particulars	Value (₹)	Percentage to Cost A_1
Seed	6280	5.29
Fertilizers	12848	10.82
Manure	7500	6.32
Plant protection	1945	1.64
Lime/dolomite	4033	3.4
Fingerlings	524	0.44
Fish feed	1588	1.34
Hired labour charges	38068	32.07
Machine labour	30008	25.28
Depreciation	2250	1.9
Land revenue	688	0.58
Miscellaneous expenses	2500	2.11
Interest on working capital	10475	8.82
COST A_1	**118710**	**100**
Rent for leased in land	13716	-
COST A_2	**132426**	**-**
Interest on Fixed Capital	800	-
Rental value of owned land	61920	-
COST B	**195146**	**-**
Imputed value of family labour	11406	-
COST C	**206553**	**-**

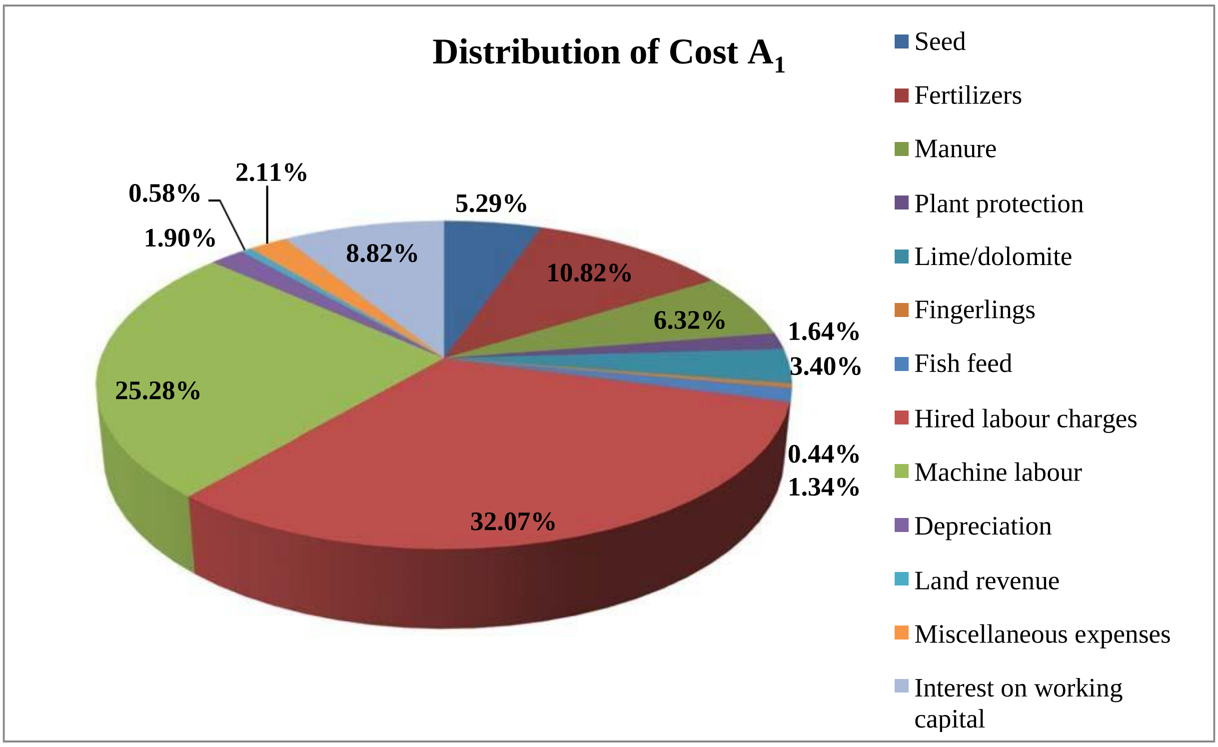

Fig.5 Distribution of Cost A_1 for Rice+ Fish

The percentage share of gross returns from the model is shown in Table 4.7. The table reveals that the gross returns from rice accounted to 80.98 percent of the total returns. This was followed by the returns from fish which was 9.89 percent of the total. The returns from straw which is the byproduct of rice cultivation accounted to 9.13 percent of the total gross returns. The gross returns from the model was ₹2,98,588. The analysis revealed that the fish integration supplemented the farmer's income with an additional return of ₹29,524.

Table 4.7 Returns from Rice+ Fish

Particulars	Returns (₹)	Percentage to total
Returns from grain	241804	80.98
Returns from straw	27261	9.13
Returns from fish	29524	9.89
Gross returns	**298588**	**100**

4.3.2.2 Rice-Fish

The contribution of different inputs to the different costs is given in the Table 4.8. The highest percentage share of Cost A_1 was that of fish feed which accounted 39.28 percent. This was followed by hired labour charges (19.8 percent), machine labour (16.86 percent) and the interest on working capital (9.29 percent). The total Cost A_1 was ₹14,05,084. Cost B amounted to ₹17,54,799. No family labour was involved in the production process and hence Cost B and Cost C were the same. It was observed that farmers skipped application of the third dose of fertilizers, as well as that of organic manure as the fish fertilizes the field before the next crop is sown. Farmers also reported a reduction in weed growth and hence they could save upon the cost of weedicides as well. This was in agreement with the observation made by Khoo and Tan (1980) where the integration of fish with paddy helped in controlling weeds. Sevilleja (1986) had also demonstrated that this integration could result in considerable saving of the fertilizer cost.

Table 4.8 Cost distribution of R-F

Particulars	Value (₹)	Percentage to Cost A1
Seed	33810	2.4
Fertilizers	72565	5.16
Manure	0	0
Plant protection	5750	0.4
Lime/dolomite	22080	1.57
Fingerlings	18400	1.3
Fish feed	552000	39.28
Hired labour charges	278208	19.8
Machine labour	236900	16.86
Depreciation	32200	2.29
Land revenue	4140	0.29
Miscellaneous expenses	18400	1.3
Interest on working capital	130631	9.29
COST A_1	**1405084**	**100**
Rent for leased in land	0	0
COST A_2	**1405084**	**-**
Interest on Fixed Capital	4715	-
Rental value of owned land	345000	-
COST B	**1754799**	**-**
Imputed value of family labour	0	-
COST C	**1754799**	**-**

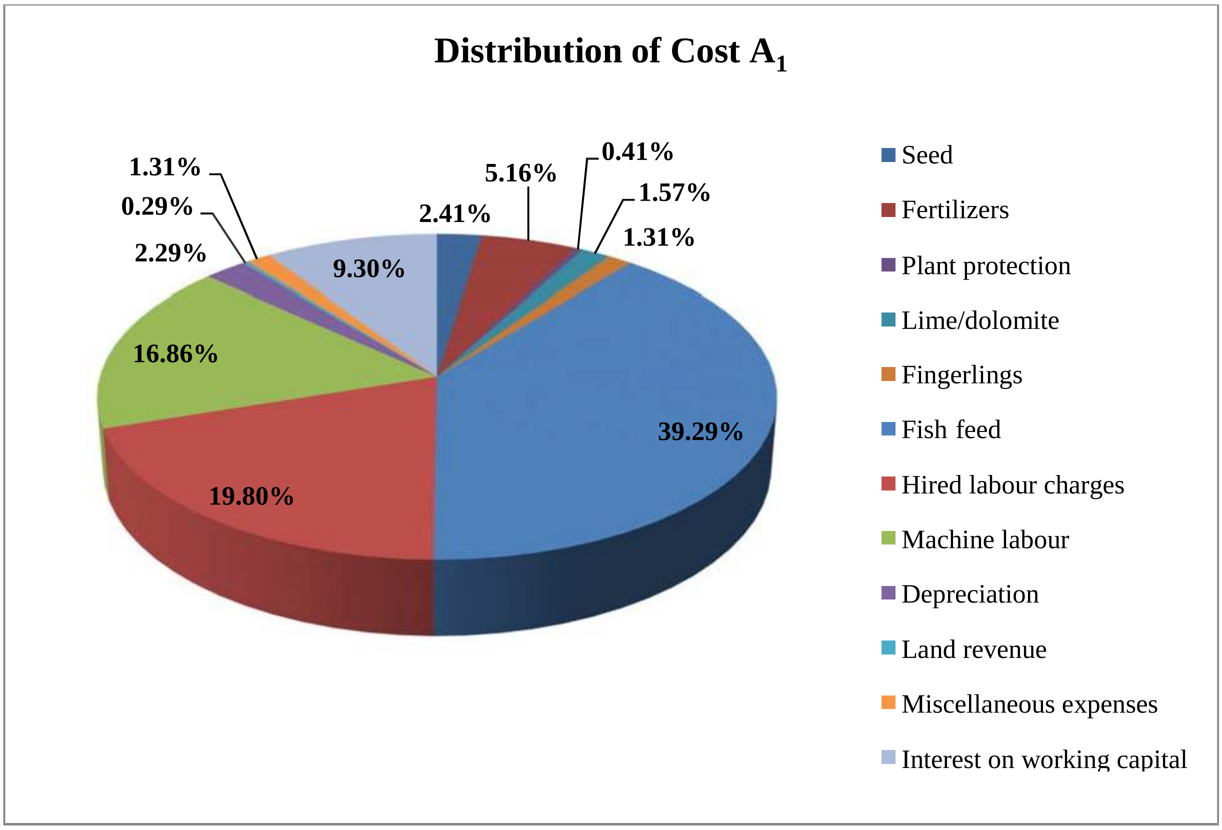

Fig.6 Distribution of Cost A_1 for Rice-Fish

The gross returns from the model amounted to ₹17,77,900. Out of the total gross returns, 89.65 percent was contributed by rice alone. Fish contributed 10.35 percent of the total gross returns. Straw obtained after harvest was let in the field to decompose and hence did not contribute to the total returns. The distribution of the returns is given in Table 4.9.

Table 4.9 Returns from Rice-Fish

Particulars	Returns (₹)	Percentage to total
Returns from grain	1593900	89.65
Returns from straw	0	0
Returns from fish	184000	10.35
Gross returns	**1777900**	**100**

4.3.2.3 Rice + Fish + Poultry

Distribution of the costs involved in the production process in the IFS model is given in Table 4.10. The total cost A_1 was ₹2,07,209. Highest share in the Cost A_1 was contributed by hired human labour (35.26 percent) followed by machine labour (18.72 percent). Together, fish and poultry contributed 10.44 percent of the Cost A_1. Interest on the working capital and cost of fertilizers contributed 9.07 percent of the Cost A_1. Family labour employed was imputed at ₹ 32800 and the total Cost C amounted to ₹3,58,809.

Table 4.10 Cost distribution of Rice+ Fish+ Poultry

Particulars	Value (₹)	Percentage to Cost A_1
Seed	10176	4.91
Fertilizers	18797	9.07
Manure	11700	5.65
Plant protection	3139	1.52
Lime/dolomite	6240	3.01
Fingerlings	300	0.14
Fish feed	1050	0.51
Cost of chicks	700	0.34
Poultry feed	14000	6.76
Hired labour charges	73058	35.26
Machine labour	38796	18.72
Depreciation	3000	1.45
Land revenue	1100	0.53
Imputed value of feed	4125	1.99
Miscellaneous expenses	2230	1.08
Interest on working capital	18797	9.07
COST A_1	**207209**	**100**
Rent for leased in land	18000	-
COST A_2	**225209**	**-**
Interest on Fixed Capital	1800	-
Rental value of owned land	99000	-
COST B	**326009**	**-**
Imputed value of family labour	32800	-
COST C	**358809**	**-**

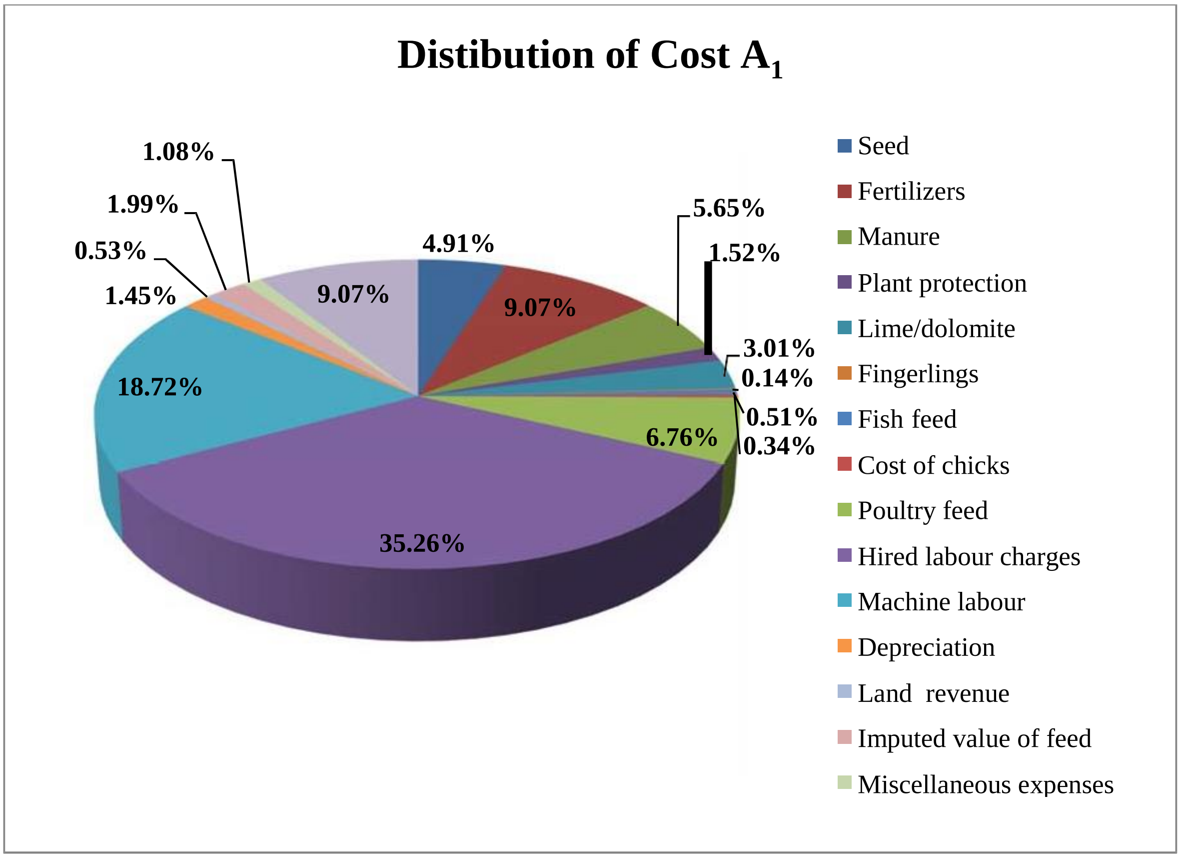

Fig.7 Distribution of Cost A_1 for Rice+ Fish+ Poultry

The gross returns obtained from the model is ₹5,20,641. Rice accounts for 78.82 percent of the total returns followed by straw which accounts 11.69 percent of the total returns. Addition of poultry unit gave the farmers an additional return of ₹20,700. The percentage share of different components on the total gross returns from the model is given in Table 4.11.

Table 4.11 Returns from Rice+ Fish+ Poultry

Particulars	**Returns (₹)**	**Percentage to total**
Returns from grain	337838	78.82
Returns from straw	50104	11.69
Returns from egg	17500	4.08
Returns from culled birds	3200	0.75
Returns from fish	20000	4.67
Gross returns	**520642**	**100**

4.3.2.4 Rice + Fish + Duckery

The share of various costs involved in the production process to the Cost A_1 is given in the Table 4.12. The highest percentage share of Cost A_1 is attributed to cost of hired labour (26.99 percent) followed by cost of machine labour (23.50 percent) and then the cost of fertilizers (9.26 percent). The costs involved in fish and duckery together contributed 8.53 percent of the total Cost A_1 which was ₹1,04,105. Cost A_2, after adding the rent for leased in land was ₹1,18,505. Cost B amounted to ₹1,70,105. The value of family labour imputed was equal to ₹ 37,812 which was added to Cost B to obtain Cost C which was equal to ₹ 2,07,917.

. **Table 4.12 Cost distribution of Rice+ Fish+ Duckery**

Particulars	**Value (₹)**	**Percentage to Cost A_1**
Seed	5107	4.91
Fertilizers	9643	9.26
Manure	6500	6.24
Plant protection	1605	1.54
Lime/dolomite	3500	3.36
Fingerlings	950	0.91
Fish feed	3384	3.25
Cost of ducklings	1750	1.68
Duck feed	2800	2.69
Hired labour charges	28093	26.99
Machine labour	24462	23.50
Depreciation	3750	3.60
Land revenue	560	0.54
Miscellaneous expenses	2700	2.59
Interest on working capital	9300	8.53
COST A_1	**104105**	**100**
Rent for leased in land	14400	-
COST A_2	**118505**	**-**
Interest on Fixed Capital	1200	-
Rental value of owned land	50400	-
COST B	**170105**	**-**
Imputed value of family labour	37812	-
COST C	**207917**	**-**

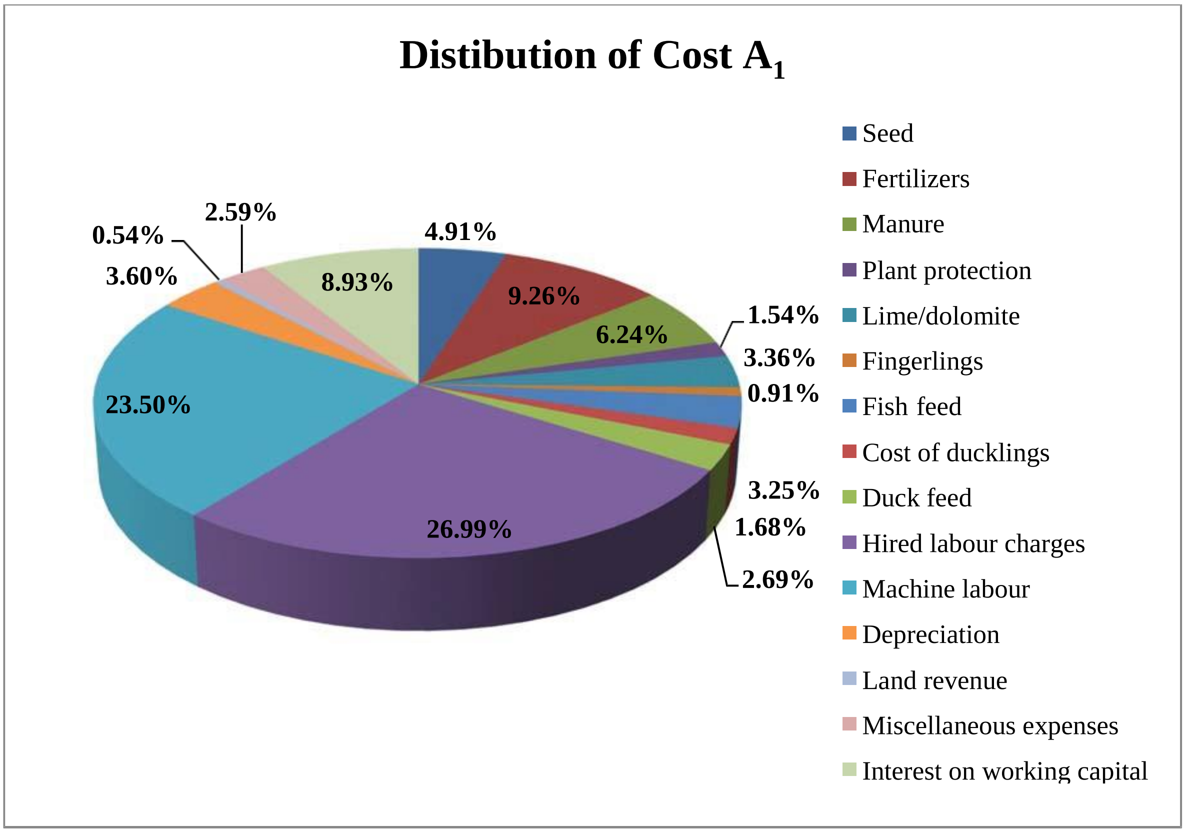

Fig.8 Distribution of Cost A_1 for Rice+ Fish+ Duckery

Gross returns from the system was ₹2,62,412. The maximum share was contributed by rice, followed by fish and duckery. The additional returns to the farmer from integrating fish and duckery was ₹69,140. The Table 4.13 reveals the share of different products on the total gross returns.

Table 4.13 Returns from Rice+ Fish+ Duckery

Particulars	Returns (₹)	Percentage to total
Returns from grain	171072	65.19
Returns from straw	22500	8.57
Returns from egg	3940	1.39
Returns from culled birds	2000	0.76
Returns from fish	63200	24.08
Gross returns	**262412**	**100**

4.3.2.5 Rice + Fish + Dairy

Distribution of costs associated with the model is given in Table 4.14. The highest share of cost A_1 was attributed by dairy concentrates (34.6 percent) followed by hired labour charges (20.56 percent). This was followed by imputed value of straw (8.80 percent). The value of farm produced manure and dry fodder was imputed. This together contributed to 11.3 percent of Cost A_1. The cost A_1 amounted to ₹3,40,994 while cost C was ₹4,61,669.

Table 4.14 Cost distribution of Rice+ Fish+ Dairy

Particulars	**Value (₹)**	**Percentage to Cost A1**
Seed	5917	1.74
Fertilizers	11164	3.27
Plant protection	1760	0.52
Lime/dolomite	3840	1.13
Fingerlings	120	0.04
Fish feed	423	0.12
Dairy concentrates	117979	34.60
Hired labour charges	70112	20.56
Machine labour	29000	8.50
Depreciation	26250	7.70
Land revenue	800	0.23
Imputed value of manures	9333	2.74
Imputed value of straw	30000	8.80
Miscellaneous expenses	2000	0.59
Interest on working capital	32298	9.47
COST A_1	**340994**	**100**
Rent for leased in land	10800	-
COST A_2	**351794**	**-**
Interest on Fixed Capital	1000	-
Rental value of owned land	72000	-
COST B	**424794**	**-**
Imputed value of family labour	36875	-
COST C	**461669**	**-**

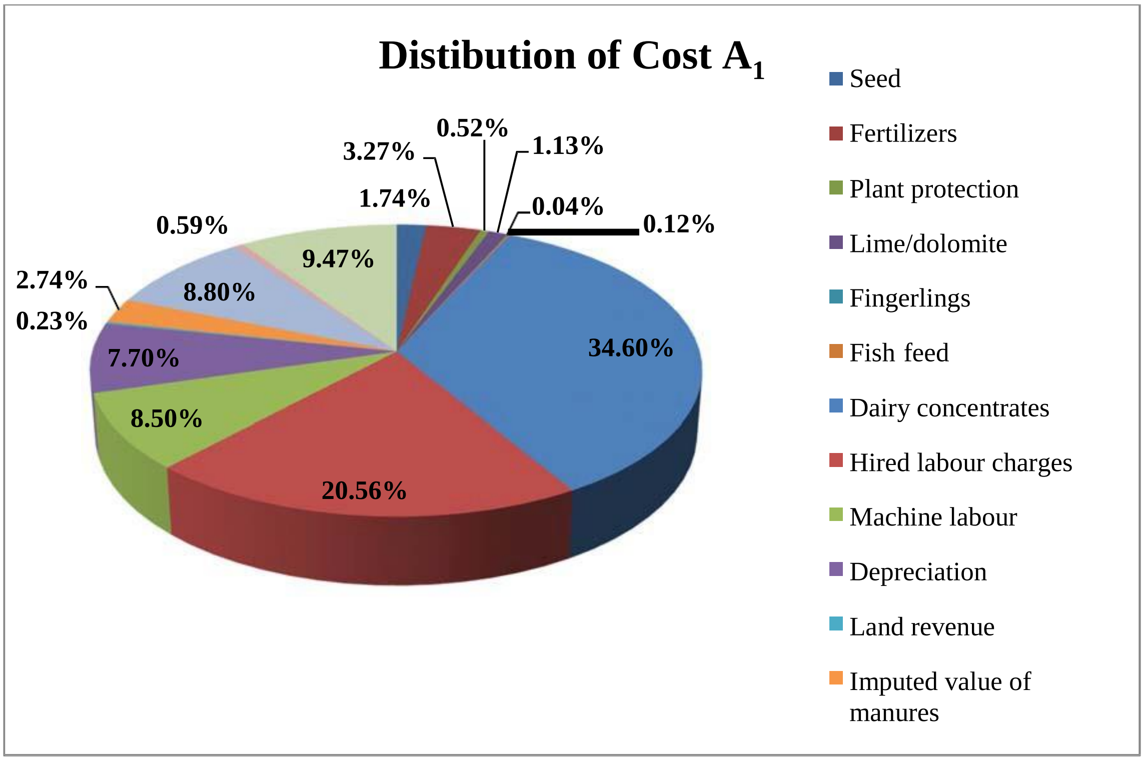

Fig.9 Distribution of Cost A_1 for Rice+ Fish+ Dairy

The total gross returns from the model was ₹4,38,193. Returns from the sale of grain accounted to 56.28 percent of the total gross returns followed by milk (33.45 percent) while contribution from fish is negligible.

Table 4.15 Returns from Rice+ Fish+ Dairy

Particulars	Returns (₹)	Percentage to total
Returns from grain	246599	56.28
Returns from milk	146594	33.45
Returns from FYM	37000	8.44
Returns from fish	8000	1.83
Gross returns	**438193**	**100**

4.3.2.6 Rice + Fish + Poultry + Duckery

Cost distribution of the different inputs associated with the IFS model has been given in Table 4.16. The highest share of Cost A_1 has been attributed to hired labour charges at 29.93 percent. The total cost A_1 was ₹1,93,183. Family labour was imputed at ₹54,687 and added to cost B which was ₹3,08,883 to obtain cost C which was equal to ₹3,63,570.

Table 4.16 Cost distribution of Rice+ Fish+ Poultry+ Duckery

Particulars	Value (₹)	Percentage to Cost A_1
Seed	9613	4.98
Fertilizers	17995	9.32
Manure	11300	5.85
Plant protection	3182	1.65
Lime/dolomite	6000	3.11
Fingerlings	480	0.25
Fish feed	2000	1.04
Cost of chicks	450	0.48
Poultry feed	9000	8.64
Cost of ducklings	2500	1.29
Duck feed	5000	2.59
Hired labour charges	57818	29.93
Machine labour	39727	20.56
Depreciation	4100	2.12
Land revenue	1260	0.65
Imputed value of feed	2750	1.42
Miscellaneous expenses	2000	1.04
Interest on working capital	18005	9.32
COST A_1	**193183**	**100**
Rent for leased in land	0	-
COST A_2	**193183**	**-**
Interest on Fixed Capital	2300	-
Rental value of owned land	113400	-
COST B	**308883**	**-**
Imputed value of family labour	54687	-
COST C	**363570**	**-**

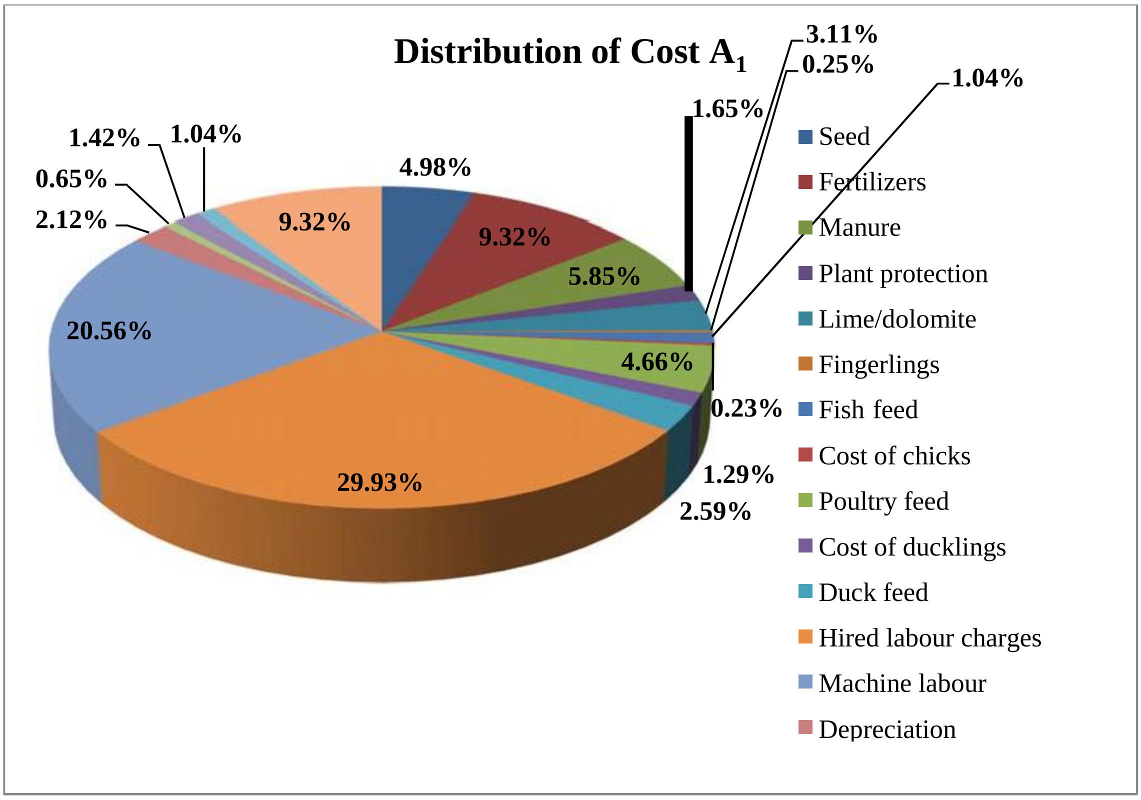

Fig.10 Distribution of Cost A_1 for Rice+ Fish+ Poultry+ Duckery

The total returns from the model was ₹4,52,280. After rice and fish, poultry contributed to the largest share in gross returns followed by duckery.

Table 4.17 Returns from Rice+ Fish+ Poultry+ Duckery

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Particulars	Value (₹)	Percentage to total
Returns from grain	343035	75.85
Returns from straw	55000	12.16
Returns from poultry egg	11340	2.51
Returns from duck egg	5077	1.12
Returns from culled chicken	1722	0.38
Returns from culled ducks	4000	0.88
Returns from fish	32105	7.10
Gross returns	**452280**	**100**

4.3.2.7 Rice + Duckery

The share of various inputs in the Cost A_1 is given in Table 4.18. The total Cost A_1 amounted to ₹1,80,446. The highest share of cost A_1 was observed for hired labour charges at 29.81 percent which was followed by machine labour at 22.74 percent and fertilizers at 12.72 percent. Family labour was imputed at ₹21,875. Total Cost C amounted to ₹3,31,121.

Table 4.18 Cost distribution of Rice+ Duckery

Particulars	Value (₹)	Percentage share to Cost A_1
Seed	10615	5.88
Fertilizers	22944	12.72
Manure	12780	7.08
Plant protection	3385	1.88
Lime/dolomite	6800	3.77
Cost of ducklings	2500	1.39
Duck feed	5300	2.94
Hired labour charges	53791	29.81
Machine labour	41041	22.74
Depreciation	1750	0.97
Land revenue	860	0.48
Miscellaneous expenses	2100	1.16
Interest on working capital	16580	9.19
COST A_1	**180446**	**100**
Rent for leased in land	50400	-
COST A_2	**230846**	**-**
Interest on Fixed Capital	1000	-
Rental value of owned land	77400	-
COST B	**309246**	**-**
Imputed value of family labour	21875	-
COST C	**331121**	**-**

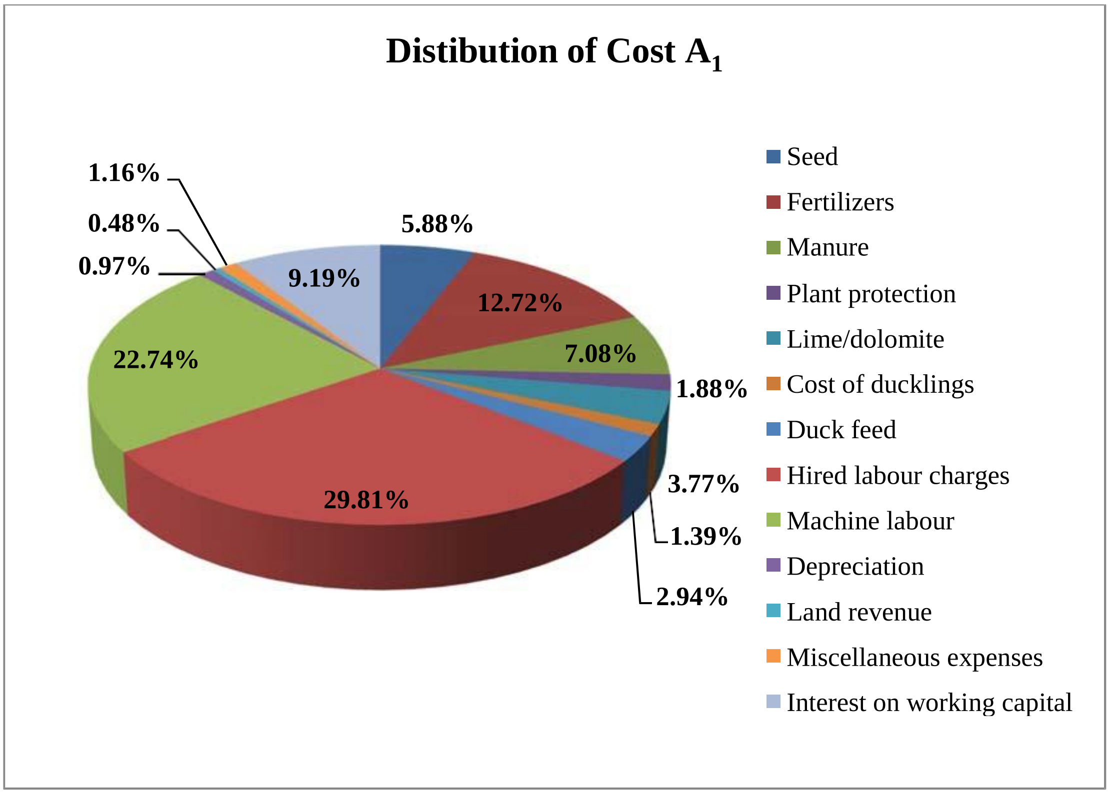

Fig.11 Distribution of Cost A_1 for Rice+ Duckery

Eighty five percent of the total gross returns was obtained from rice alone while the contribution of duckery was around 2 percent. The additional return obtained by the farmer on integrating duckery was Rs. 8220. This was mainly because of the small size of the duckery unit, twenty birds per batch.

Table 4.19 Returns from Rice+ Duckery

Products	Returns (Rs)	Percentage to total
Returns from grain	372542	85.32
Returns from straw	55875	12.80
Returns from egg	5340	1.22
Returns from culled birds	2880	0.66
Gross returns	**436637**	**100**

4.3.2.8 Rice + Dairy

Distribution of cost A_1 for the model Rice+ Dairy is shown in the Table 4.20 below. The highest share in Cost A_1 was observed for dairy concentrates (31.41 percent). Dairy being a labour-intensive activity like rice cultivation, hired human labour had the second highest share in Cost A_1 at 24.84 percent. This was followed by the interest on working capital at 8.76 percent.

Table 4.20 Cost distribution of Rice+ Dairy

Particulars	**Value (₹)**	**Percentage to Cost A_1**
Seed	7751	2.64
Fertilizers	12688	4.31
Plant protection	2521	0.86
Lime/dolomite	4600	1.56
Dairy concentrates	92361	31.41
Dry fodder	3610	1.23
Hired labour charges	73039	24.84
Machine labour	25743	8.75
Depreciation	16500	5.61
Land revenue	960	0.33
Imputed value of manures	8778	2.98
Imputed value of straw	17500	5.95
Miscellaneous expenses	2278	0.77
Interest on working capital	25750	8.76
COST A_1	**294080**	**100**
Rent for leased in land	0	-
COST A_2	**294080**	-
Interest on Fixed Capital	14300	-
Rental value of owned land	86400	-
COST B	**394780**	-
Imputed value of family labour	43750	-
COST C	**438530**	**-**

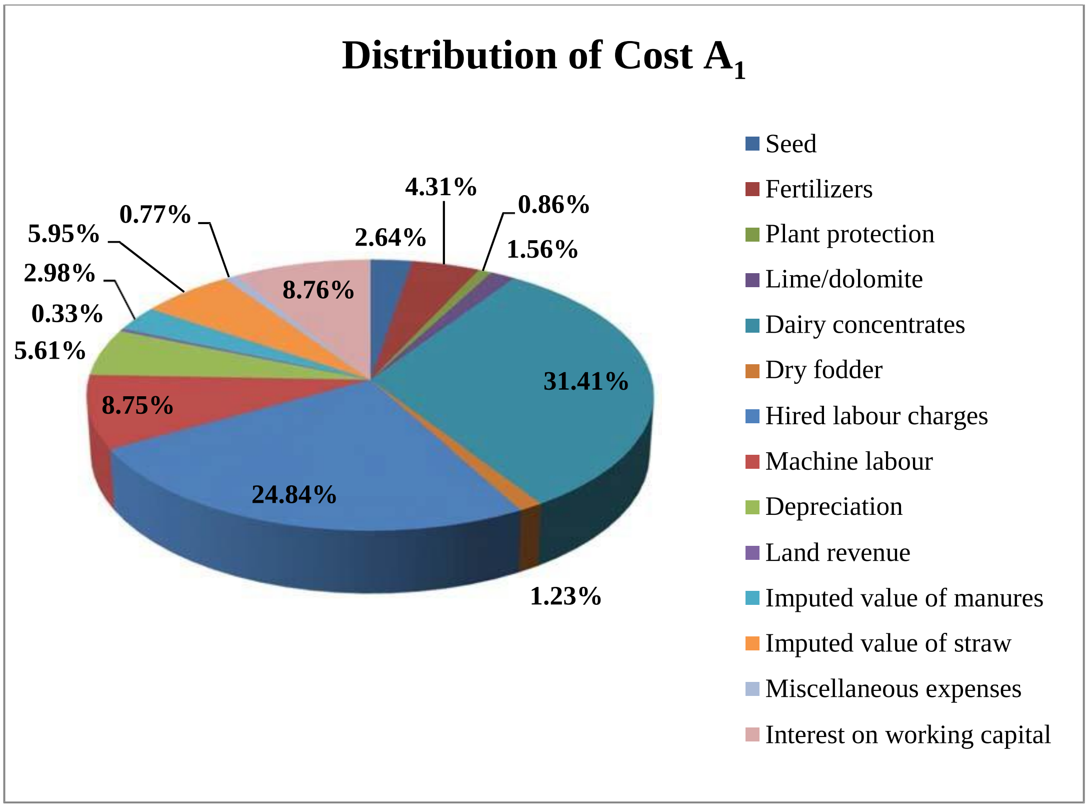

Fig.12 Distribution of Cost A_1 for Rice+ Dairy

The returns obtained from the different enterprises in the IFS model is given in Table 4.21. The highest share of returns from was obtained from the sale of grains which was followed by milk and FYM. The total gross returns obtained from the model is ₹4,46,238

Table 4.21 Returns from Rice+ Dairy

Products	Returns (₹)	Percentage to total
Returns from grain	237196	53.15
Returns from straw	14097	3.16
Returns from milk	167000	37.42
Returns from FYM	27944	6.26
Gross returns	**446238**	**100**

4.3.2.9 Rice+ Dairy+ Poultry

Largest share of Cost A_1 was attributed to dairy concentrates followed by hired labour charges and interest on working capital. Value of manure, dry fodder for cattle and rice grains as feed for poultry were imputed and added to the Cost A_1. Cost of family labour was imputed at ₹21,875.

Table 4.22 Cost distribution of Rice+ Dairy+ Poultry

Particulars	**Value (₹)**	**Percentage to Cost A_1**
Seed	7500	1.79
Fertilizers	13895	3.31
Plant protection	2521	0.60
Lime/dolomite	4800	1.15
Cost of chicks	990	0.23
Poultry feed	15550	3.71
Dairy concentrates	150000	35.82
Dry fodder	0	0
Hired labour charges	75133	17.94
Machine labour	33312	7.95
Depreciation	21600	5.16
Land revenue	1000	0.24
Imputed value of manures	12500	2.98
Imputed value of straw	33250	7.94
Imputed value of feed	5500	1.31
Miscellaneous expenses	4300	1.02
Interest on working capital	36858	8.80
COST A_1	**418709**	**100**
Rent for leased in land	0	-
COST A_2	**418709**	-
Interest on Fixed Capital	19800	-
Rental value of owned land	90000	-
COST B	**528509**	-
Imputed value of family labour	21875	-
COST C	**550385**	-

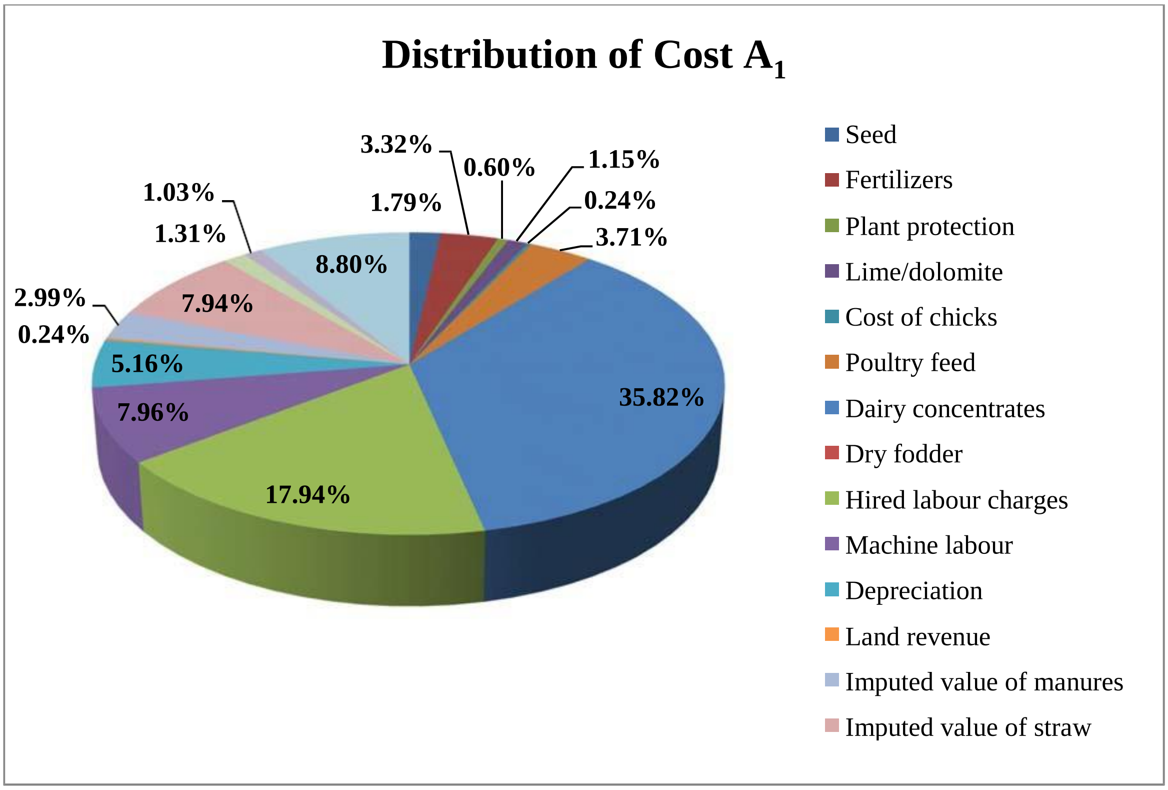

Fig.13 Distribution of Cost A_1 for Rice +Dairy +Poultry

Largest share of returns was obtained for rice which was 55.72 percent. This was followed by the sale of milk (28.5 percent) and the sale of FYM (9.85 percent). Integrating poultry and dairy with rice resulted in an additional income of ₹1,82,899 with dairy being the most remunerative. Although dairy resulted in major share of the returns, the costs involved were much higher especially the hired labour charges and the cost of concentrates. Poultry, though contributed very less to the total gross returns from the system, resulted in better dietary diversity of the farm household which indirectly benefitted the farmers.

Table 4.23 Returns from Rice+ Dairy+ Poultry

Particulars	Returns (₹)	Percentage to total
Returns from grain	230175	55.72
Returns from straw	0	0
Returns from milk	115885	28.05
Returns from egg	22764	5.51
Returns from culled birds	3550	0.86
Returns from FYM	40700	9.85
Gross returns	**413074**	**100**

4.3.2.10 Rice + Dairy + Fodder

The distribution of cost A_1 for the model is given in Table 4.24. As is evident from the table, the highest share of cost A_1 has been attributed by dairy concentrates (33.16 percent) followed by hired labour charges (16.51 percent) and machine labour (10.27 percent). The total cost A_1 amounted to ₹3,82,582. Imputed value of family labour was ₹20,000 and the total cost C was ₹5,16,832.

Table 4.24 Cost distribution of Rice+ Dairy+ Fodder

Particulars	Value (₹)	Percentage to CostA_1
Slips	500	0.13
Seed	8715	2.28
Fertilizers	17662	4.62
Plant protection	2600	0.68
Lime/dolomite	6000	1.57
Dairy concentrates	126875	33.16
Dry fodder	5500	1.44
Hired labour charges	63178	16.51
Machine labour	39304	10.27
Depreciation	21250	5.55
Land revenue	1075	0.28
Imputed value of manures	15625	4.08
Imputed value of straw	33593	8.78
Miscellaneous expenses	3500	0.91
Interest on working capital	37202	9.72
COST A_1	**382582**	**100**
Rent for leased in land	0	-

COST A_2	**382582**	-
Interest on Fixed Capital	17500	-
Rental value of owned land	96750	-
COST B	**496832**	-
Imputed value of family labour	20000	-
COST C	**516832**	-

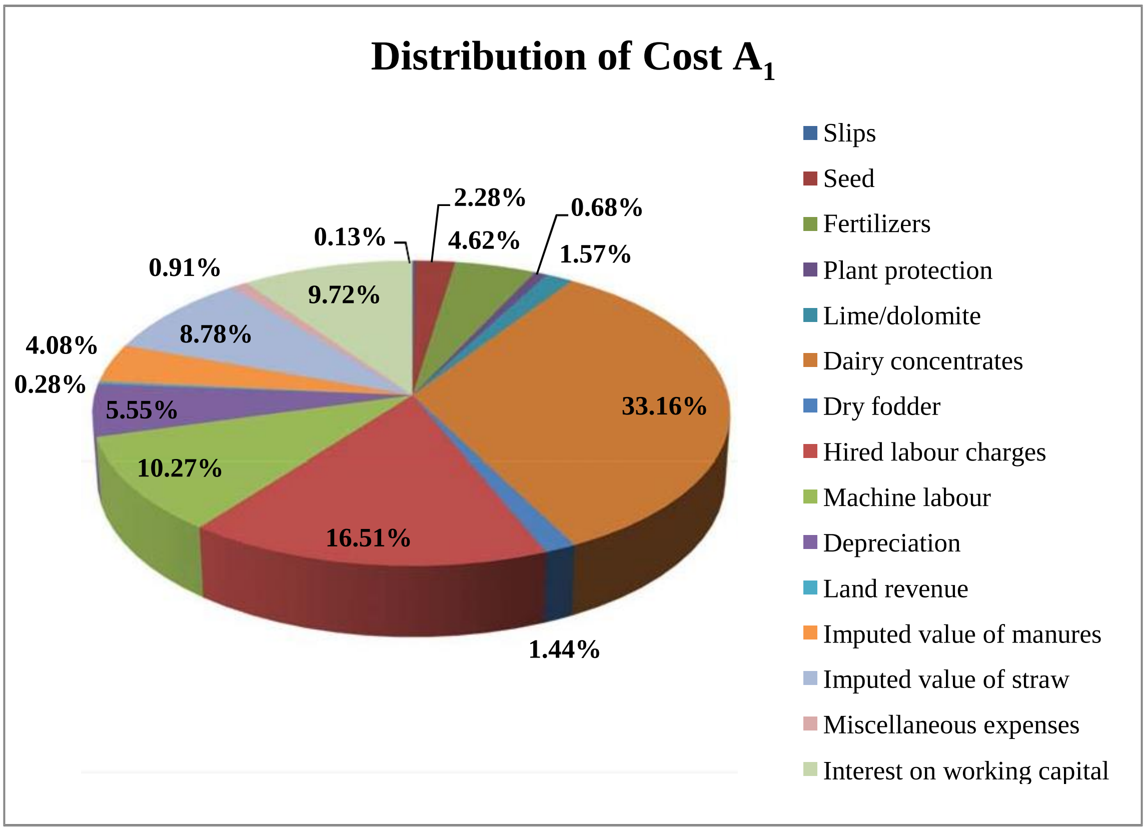

Fig.14 Distribution of Cost A_1 for Rice +Dairy +Fodder

The total returns obtained from the model is ₹4,09,970 and the maximum share is contributed by the returns from the sale of grains (62.46 percent) followed by milk (30 percent).

Table 4.25 Returns from Rice+ Dairy+ Fodder

Particulars	Returns (₹)	Percentage to total
Returns from grain	256085	62.46
Returns from milk	123010	30
Returns from FYM	30875	7.53
Gross returns	**409970**	**100**

4.3.2.11 Rice + Banana + Dairy + Duck

The distribution of Cost A_1 for the model is given in Table 4.26. Cost A_1 was the highest for this model at ₹6,03,130. Imputed value of family labour was ₹28,437 and the Cost C amounted to ₹7,99,067.

Table 4.26 Cost distribution of Rice+ Banana+ Dairy+ Duckery

Particulars	Value (₹)	Percentage to total
Sucker	2500	0.4
Seed	15764	2.6
Fertilizers	34600	5.7
Plant protection	5043	0.83
Lime/dolomite	7500	1.24
Cost of ducklings	3000	0.49
Duck feed	6000	0.99
Dairy concentrates	146000	24.2
Hired labour charges	132385	21.9
Machine labour	60693	10.06
Depreciation	22250	3.68
Land revenue	1600	0.26
Imputed value of manures	43750	7.25
Imputed value of straw	60000	9.94
Miscellaneous expenses	5000	0.82
Interest on working capital	57044	9.45
COST A_1	**603130**	**100**
Rent for leased in land	0	-
COST A_2	**603130**	**-**
Interest on Fixed Capital	23500	-
Rental value of owned land	144000	-
COST B	**770630**	**-**
Imputed value of family labour	28437	-
COST C	**799067**	**-**

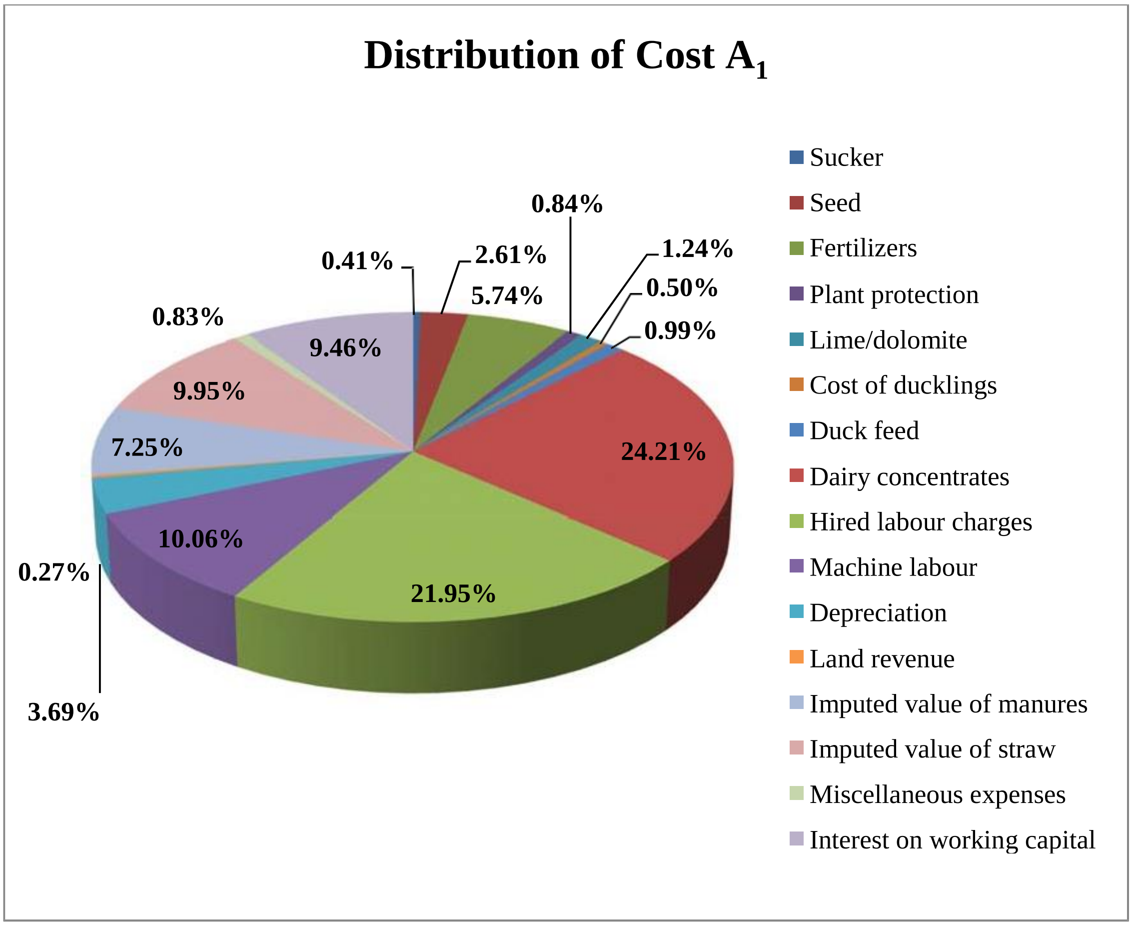

Fig.15 Distribution of Cost A1 for Rice+ Banana+ Dairy+ Duckery

Returns were highest for the model owing to the large extent of land ownership of the farmers. Also, the farmers had an average number of four lactating cows which resulted in high returns from milk and sale of FYM as well. Returns from rice accounted for 51.13 percent of the total gross returns followed by returns from milk which was 43.97 percent. The next maximum returns was obtained from fish which accounted for 3.32 percent of the total gross returns.

Table 4.27 Returns from Rice+ Banana+ Dairy+ Duckery

Particulars	Returns (₹)	Percentage to total
Returns from grain	519750	51.13
Returns from straw	0	0
Returns from banana	5000	0.49
Returns from milk	447000	43.97

Returns from egg	6000	0.59
Returns from culled birds	5000	0.49
Returns from FYM	33750	3.32
Gross returns	**1016500**	**100**

Distribution of farmers in the different models reveals that farmers practising Rice+ Fish were mostly small and marginal farmers. Rice- Fish sequential farming was taken up by medium to large farmers and Rice +Banana +Dairy+ Duckery was mostly taken up by medium farmers.

4.3.3 Employment generation in rice-based IFS models

The employment generation in different IFS models have been elucidated in Table 4.28. Results reveal that the highest employment generation in terms of hired human labour was obtained for R-F sequential farming system (348 PD/yr). This was followed by R+ B+ Da+ Du at 143 PD/yr and R+F+P at 110 PD/yr. The lowest employment generation in terms of hired human labour was observed in R+F model. Highest involvement of family labour was observed in R+ Da (87 PD/yr) followed by R+F+P (65 PD/yr). Larger employment generation in R-F can be attributed to the fact that the area involved is large and the harvesting of fish from such large area is a labour-intensive process.

le 4.28 Employment generation in rice based IFS models in the study area

IFS Model	Hired labour (Person Days/yr)	Family labour (Person Days/yr)	Total (Person Days/yr)
R+F	53	15	68
R-F	348	0	348
R+F+P	110	65	175
R+F+Du	56	50	106
R+F+Da	78	10	88
R+F+P+Du	77	73	150
R+Du	71	43	114
R+Da+P	100	43	143
R+Da+Fo	84	40	124
R+Da	78	87	165
R+B+Da+Du	143	57	200

4.3.4 Farm income measures of the rice-based IFS models

The measures of farm income over different cost concepts were worked out for all the models and the results are given in Table 4.29. Rice+ Dairy+ Poultry showed the highest negative value for family labour income and net income. This indicated that the model was the least profitable. This can be attributed to the huge cost involved in dairy which could not be augmented by any other remunerative enterprise. Farmers raised indigenous breeds of cattle which resulted in lower production both in terms of milk and manure compared to other cross bred as well as exotic breeds. The highest farm business income, family labour income, net income and farm investment income was observed for the model Rice+ Banana+ Dairy+ Duck. This was mainly because of the large area under rice and the higher number of cattle which were mostly cross bred with longer lactation period. In terms of farm business income, R-F had the highest value after R+ B+ Da+ Du. The next most profitable model in terms of farm business income, family labour income and farm investment income was Rice+ Fish+ Poultry+ Duckery. This model included multiple enterprises thus diversifying the farmer's income sources. Many farmers took up these enterprises as part of a scheme to promote Integrated Farming Systems in the homesteads of Kerala called 'Jaivagriham'. As part of the scheme, the farmers were given financial assistance to integrate enterprises like poultry, duckery, dairy and fish in their homesteads. The integration of the enterprises strongly influences the farmer's income as is evident from the income measures. The average net income observed in the case of this model was Rs. 88,709 which was next to that of Rice+ Duckery. This was because of the large share of imputed family labour involved in Rice+ Fish+ Poultry+ Duckery model. Considering the farm investment income, R+ B+ Da+ Du recorded the highest income followed by R-F, R+ F+ P+ D and R+ Du.

Apart from supplementing the farmer's income, integration of a variety of enterprises resulted in better resource recycling, proper waste management and better space utilization. It enriched the diet of the farmer household with diverse and nutrient rich food sources. Most importantly, IFS reduces the market dependency of the farmers for inputs as well as outputs. For instance, integrating dairy, poultry and duckery has resulted in reducing the farmer's market dependency for milk, eggs and meat. On the other hand, it has also reduced the farmer's market dependency for dry fodder, duck and poultry feed although not to a large extent in the study area. Integration of livestock component reduced the dependence on fertilizers to some extent and the by-products of field crops met the fodder requirement of the livestock in turn. Meeting multiple needs of the farm family, cycling of resources between enterprises and stabilization of farm income can thus be highlighted as the prominent outcomes of integrating multiple enterprises into a farming system.

Table 4.29 Farm income measures of the rice-based IFS models

IFS model	Farm Business income (₹)	Family labour income (₹)	Net income (₹)	Farm investment income (₹)
R + F	1,66,162	1,03,442	92,035	1,54,755
R-F	3,72,815	23,100	23,100	3,72,815
R + F+ Da	86,399	13,399	-23,475	49,524
R +F +Du	1,43,906	92,306	54,494	1,06,094
R+ F+ P	2,03,432	1,02,632	69,832	1,70,632
R+ F+ P+ Du	2,59,097	1,43,397	88,709	2,04,409
R+ Du	2,05,791	1,27,391	1,05,516	1,83,916
R+ Da+ P	53,479	-49,220	-71,095	31,604
R+ Da+ Fo	74,578	-39,671	-59,671	54,578
R+ Da	1,52,158	51,458	7,708	1,08,408
R+ B+ Da+ Du	4,13,369	2,45,869	2,17,432	3,84,932

4.3.5 Benefit-Cost Ratio of rice-based IFS models

Analysis of the Benefit-Cost ratios of the different IFS models revealed that the highest B-C ratio at Cost A_1 was observed for the models R+F and R+ F+ Du (2.52). This can be attributed to the remunerative nature of the subcomponents and larger size of the average wetland area for the farmers practising the model. This was followed by R+ Du and R+ F+ P+ Du with B-C ratios of 2.42 and 2.34 respectively at Cost A_1. The lowest Benefit- Cost ratio was observed for Rice+ Dairy+ Poultry under all the different costs. This is because of the lowest area under rice in the IFS model and the higher costs of hired labour in dairy and high cost of poultry feed as well as dairy concentrates. The B-C ratios for the model at different costs A_1, A_2, B and C were 1.13, 1.13, 0.91 and 0.87 respectively. It was the least profitable among all the eleven models in the study area.

Still farmers have taken up the model, owing to the dietary diversity it offers and the resource cycling involved. Since many farmers were also involved in lease land farming, the B-C ratios at Cost A_2 were also calculated. The results were the same as that of the B-C ratio at Cost A_1 for R-F, R+ Da+ P, R+ Da+ Fo, R+ Da, R+ F+ P+ Du and R+ B+ Da+ Du since no farmers in these models practiced lease land farming. The ratio was highest for R+ F+ P+ Du (2.34), followed by and R+F (2.25), R+ F+ Du (2.21) and R+ Du (1.89).

Taking into account the rental value of owned land and the interest on fixed capital, Benefit-Cost ratio at Cost B was calculated for the different models. The highest B-C ratio was observed for R+ F+ Du which was 1.54 which was followed by R+ F (1.53) and R+ F+ P+ Du (1.46). After accounting for the imputed value of family labour into Cost C, the B-C ratios for the different models were calculated. The model involving fish, poultry and duckery although had the highest B-C ratio at Costs A_1, A_2 and B, had a lower value of the same at Cost C which can be attributed to the larger utilization of family labour in the system. Involvement of family labour was comparatively lesser in the case of R+ B+ Da+ Du which can be observed from a significantly smaller change in the value of B-C ratio of the model at Cost C compared to Cost B. R+ Da+ P, R+ Da+ Fo and R+ F+ Da showed significantly lower B-C ratios below 1 at Cost C. The ratios were 0.87, 0.88, and 0.95 respectively. The results of the analysis are given in Table 4.30.

Table 4.30 Benefit-Cost Ratio of rice based IFS models

IFS Model	B-C ratio at Cost A_1	B-C ratio at Cost A_2	B-C ratio at Cost B	B-C ratio at Cost C
R+ F	2.52	2.25	1.53	1.45
R-F	1.27	1.27	1.01	1.01
R+ F+ Da	1.29	1.25	1.03	0.95
R+ F+ Du	2.52	2.21	1.54	1.26
R+ F+ P	2.07	1.90	1.31	1.19
R+ F+ P+ Du	2.34	2.34	1.46	1.24
R+ Du	2.42	1.89	1.41	1.32
R+ Da+ P	1.13	1.13	0.91	0.87
R+ Da+ Fo	1.19	1.19	0.92	0.88
R+ Da	1.52	1.52	1.13	1.02
R+ B+ Da+ Du	1.69	1.69	1.32	1.27

4.3.6 Resource use efficiency of rice under IFS

Resource use efficiency of rice under Integrated Farming System in Kuttanad was studied using the Cobb-Douglas production function. The production function was fitted by taking output as the dependent variable and the inputs involved in the production process as the independent variables. The independent variables used to fit the model were wetland area (in acres), value of seeds (₹), value of fertilizers (₹), value of plant protection chemicals used (₹), value of liming materials used (₹), value of hired human labour (₹), and value of hired machine labour (₹). The natural logarithm values of the different inputs were fitted to a linear regression model. The model had a high R^2 value of 95.6 percent, indicating that 95.6 percent of the variation in output was explained by the independent variables chosen. The adjusted R^2 value was 95.29 percent. The results of the regression analysis are presented in Table 4.31.

Table 4.31 C-D production function analysis

Variable	Coefficients	Standard Error	t Stat	P-value
Intercept**	7.8195	1.5850	4.9335	0.0000
Area**	0.6732	0.2145	3.1380	0.0023
Seed	0.2634	0.1422	1.8521	0.0673
Fertilizers	0.0287	0.0438	0.6567	0.5131
Plant protection	-0.1487	0.1444	-1.0303	0.3056
Liming material	0.0273	0.0538	0.5080	0.6127
Human labour*	0.2203	0.1149	1.9170	0.0424
Machine labour	-0.0391	0.0271	-1.4417	0.1529

Note: ** Significant at 1 percent level *Significant at 5 percent level

The variables that turned out to be significant included wetland area and hired human labour respectively at one percent and five percent level of significance. The intercept value was 7.8195, significant at one percent level. The regression result showed that a one percent increase in the land area would increase the total returns to the farmer by 0.67 percent. Similarly, a one percent increase in the human labour hired would increase the returns by 0.22 percent. Although not significant, the beta coefficients obtained for plant protection chemicals and hired machine labour showed a negative value indicating any increase in the use of these inputs would result in a decline in returns to the farmer. Other input factors like seed, fertilizer and liming material gave positive coefficients indicating that an increase in the use of these inputs would further increase farmers' returns. But these variables did not turn out statistically significant in the regression model fitted.

So as to analyse the resource use efficiency of the statistically significant input factors, MVP and MFC of the inputs were calculated. The results are provided in the Table 4.32. The ratio of MVP to MFC was calculated for both land area and hired human labour. The ratio was more than one in the case of area, indicating that the resource use efficiency was high. This implied that the resource was under-utilized in the study area. Employing more of the resource can result in higher production which in turn can result in higher returns. This is nearly impossible in the state of Kerala due to increased fragmentation of land holdings. This points to the relevance of diversification of farm enterprises. In the case of human labour, the ratio of MVP to MFC is found to be less than one, indicating low efficiency in resource use. This in turn implied that the resource was over utilized in the study area. Employing additional labour can result in declining returns from rice in the study area. The reasons for this can be attributed to high wage rates and shortage of labour in Kuttanad.

The results of a similar study conducted by Suresh and Reddy (2006) in Thrissur district showed that land area, hired human labour and plant protection chemicals had the highest MVP/MFC ratio. The ratio was the smallest for hired human labour.

Table 4.32 MVP and MFC of the inputs

Inputs	bi	Xi	Yi	Yi/Xi	MPP	P_Y	MVP	MFC
Area	0.67	4.75	377330	79438	53462	27.5	1470197	1000000
Labour	0.22	36279	377330	10.40	2.29	27.5	62.92	750

Table 4.33 Resource use efficiency of rice under IFS

Inputs	MVP/MFC	Efficiency	Level of resource use
Area	1.47	High	Under- utilized
Labour	0.08	Low	Over- utilized

4.3.7 Economic sustainability of the rice based IFS models

The sustainability index of the different IFS models identified from Kuttanad were analysed using the Sustainability Value Index (SVI) developed by Bohra and Kumar (2015). The System Economic Efficiency (SEE) was calculated to know the returns obtained from the model per day. This was calculated by dividing the total net returns obtained from the different models by 365. The indices obtained along with average net returns of the different IFS models are given in Table 4.34.

Here average net income of the different models was calculated by deducting the cost of inputs, cost of feed and hired labour cost and the fixed costs from the total gross returns of each farm household. The maximum net income model was the highest income obtained from any model among all the models practised by the farmers. The standard deviation of the average net income of the different models from the maximum net returns was also calculated for each model separately.

The results reveal the highest SVI and SEE was obtained for the model R+ B+ Da+ Du. This can be attributed to the fact that the net income attained from the model was the highest in the study area. this was mainly because of the larger area under rice, effective utilization of the bund space in the field by planting bananas and the better returns realized because of the cross bred animal species involved in the model. The model was found to be economically sustainable and the net returns per day obtained by the farmers were ₹1133/day. R-F sequential farming recorded the next highest SVI value of 0.63 and SEE of ₹1021/day. This can be attributed to the fact that area under rice as well as fish was the highest in the model and the average wetland area owned by the farmers was 23 acres. R+ F+ P +Du recorded the third highest value for SVI as well as SEE as is observed from the values which were 0.35 and ₹709/day respectively. The lowest economic sustainability was observed for the model R+ Da+ P at an SVI value of -0.14 and the SEE value was ₹147/day. Three models R+ F+ Da, R+ Da+ Fo and R+ Da+ P recorded negative SVI values of -0.06, -0.08, -0.14 respectively. This can be attributed to the labour-intensive nature and high fixed costs associated with the dairy subcomponent.

Table 4.34 SVI and SEE of the IFS models

IFS Model	ANI (₹)	SVI	SEE (₹/day)
R+B+Da+Du	2,17,432	0.73	1133
R+Du	1,05,516	0.22	563
R+F	92,035	0.13	455
R+F+P+Du	88,709	0.35	709
R+F+P	69,832	0.22	557
R+F+Du	54,494	0.07	394
R-F	23,100	0.63	1021
R+Da	7,708	0.09	417
R+F+Da	-23,475	-0.06	237
R+Da+Fo	-59,671	-0.08	204
R+Da+P	-71,095	-0.14	147

4.4 Estimation of the profitability of KAU recommended rice-based IFS model

4.4.1 Subcomponents of KAU recommended rice-based IFS model

The Integrated Farming System Research Station at Karamana has developed a rice-based IFS model for an area of 0.45 acres. The model consists of several subcomponents like vegetables, green manure crop, duckery unit, dairy unit and a vermicomposting unit. The model has been developed to meet the requirement of a marginal farm holding, along with supplementing the income of the farmer with the subsidiary enterprises. Income stabilization throughout the year along with proper resource recycling has been targeted as the major outcome of the model. Rice being the major component was cultivated in a land area of 0.45 acres. Vegetables like bhindi and brinjal were cultivated on the dykes, thus making maximum use of the space available. Ash gourd was trailed over the fish pond. Monoculture of GIFT Tilapia was done in a fish pond of area 0.02 acres. A dairy unit of one cow was also integrated into the model. Maize was grown as a dual-purpose crop as the sale of cobs added to the income and the crop residue after harvest was an excellent feed for the cattle. Daincha was grown in area of 0.15 acres as a green manure crop. The cow was of Jersey breed with an average lactation period of 308 days. A duck unit of 200 ducks was constructed above the fish pond so that the duck droppings promoted the growth of phyto-planktons in the pond which could act as excellent feed for fish. The entire crop residue and the cow dung were converted into vermicompost in a composting unit the sale of which contributed to additional income. The various components of the model along with their respective areas are given in the Table 4.35.

Table 4.35 Subcomponents of KAU recommended rice based IFS model

Component	Area (acres)/ Nos.
Rice	0.45
Daincha	0.15
Bhindi	0.15
Maize	0.15
Ash gourd	0.02
Vegetables on dyke	0.05
Pond area	0.02
Cattle	1
Duckery	200
Vermicompost unit	7m×1m×0.5m

4.4.2 Cost distribution of KAU recommended rice based IFS model

The share of different inputs in the Cost A_1 for the model has been given in Table 4.36. The highest percentage share of Cost A_1 was observed for hired labour which was pegged to 28.28 percent. Labour was hired for all the major farm activities like preparation of land, weeding, application of manure and fertilizers, plant protection measures and harvesting of different produce. Vermicomposting also required hired human labour. The second highest share of Cost A_1 was for duck feed (19.4 percent). This can be attributed to large unit size of 200 ducks in the model. On the other hand, in the study area, the average number of ducks per unit was observed to be 20. The third largest share was for dairy concentrates (11.53 percent). The value of farm produced manure, straw and green manure was imputed and added to Cost A_1. All these together contributed 12.23 percent of Cost A_1. Since no land was leased in, Cost A_2 was equal to Cost A_1 at ₹3,19,700. After adding the interest on fixed capital and the rental value of owned land, Cost B was calculated to ₹3,57,175. Since no family labour was involved, Cost C was equal to Cost B.

Table 4.36 Cost distribution of KAU recommended rice based IFS model

Particulars	Value (₹)	Percentage to Cost A_1
Seed	2735	0.85
Fertilizers	2679	0.83
Manure	13360	4.17
Plant protection	827	0.25
Fingerlings	3866	1.29
Fish feed	3243	1.2
Ducklings	3000	0.94
Duck feed	62043	19.4
Green fodder	11032	3.45
Dairy concentrate	36880	11.53
Dry fodder	7916	2.47
Hired human labour	90428	28.28
Machine labour	3037	0.94
Imputed value of manure	22230	6.95
Imputed value of green manure	3931	1.22
Imputed value of straw	12999	4.06
Depreciation	20000	6.25
Interest on working capital	24134	7.54
Cost A_1	**3,19,700**	**100**
Rent for leased in land	0	-
Cost A_2	**3,19,700**	-
Interest on fixed capital	19475	-
Rental value of owned land	18000	-
Cost B	**3,57,175**	-
Imputed value of family labour	0	-
Cost C	**3,57,175**	-

4.4.3 Returns from KAU recommended rice based IFS model

The products from the system were highly diverse which included rice, vegetables, duck eggs and meat, green manure, maize, baby corn, milk and fish. Milk contributed to the largest share of returns at 27.90 percent followed by duck eggs at 21.37 percent. This was followed by rice at 14.25 percent, ash gourd (7.01 percent), fish (6.42 percent), bhindi (5.77 percent), culled ducks (4.08 percent) and cowpea (3.03 percent). Vegetables grown on the dykes of the paddy field contributed 2.06 percent to the total gross returns from the system. Vermicompost contributed 2.65 percent to the total gross returns from the system. All the different vegetables grown in the system together resulted in 20 percent of the total gross returns. The share of different products as well as by products of the model to the total gross returns is given in Table 4.37 and Fig. 4.12

Table 4.37 Returns from KAU recommended rice based IFS model

Products	Returns (₹)	Percentage to total
Rice	39185	14.25
Straw	4192	1.52
Bhindi	15878	5.77
Maize	5071	1.84
Fodder maize	414	0.15
Baby corn	3796	1.38
Cowpea	8342	3.03
Ash gourd	19290	7.01
Brinjal	1500	0.55
Vegetables on dyke	5673	2.06
Milk	76736	27.90
Egg (duckery)	58772	21.37
Culled birds (duckery)	11224	4.08
Fish	17667	6.42
Vermicompost	7292	2.65
Total returns	**258939**	**100**

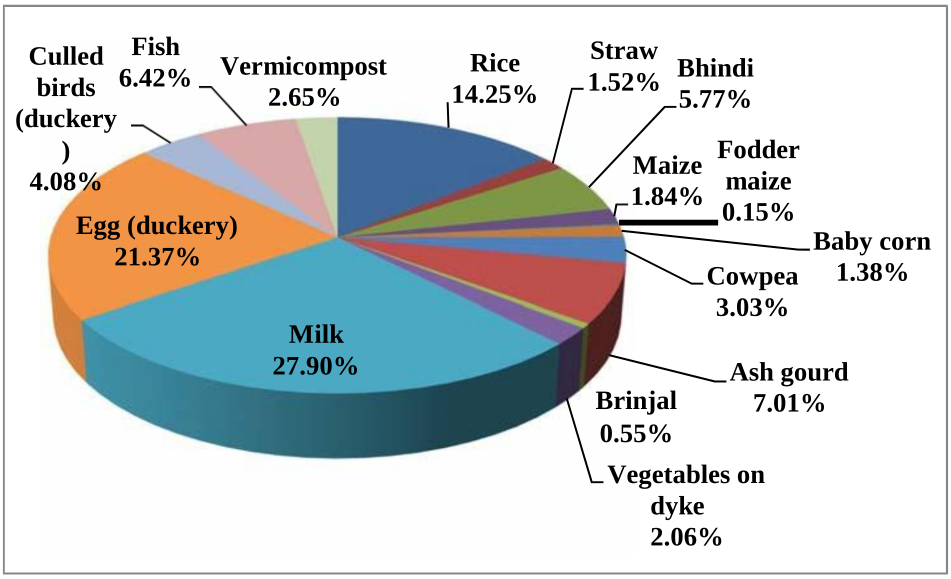

Fig.16 Returns from KAU recommended rice-based IFS model

4.4.4 Profitability measures

The B-C ratio, Net Present Worth and Internal Rate of Returns for the IFS model was calculated at a discount rate of 10 percent for a period of 9 years *i.e.*, from 2011-12 to 2019-20. The results of the analysis are given in Table 4.38. The B-C ratio at discounted rate indicates that the model is profitable since the value is greater than one. The high establishment costs pertaining to larger unit size of duckery and vermicomposting unit and the higher wage rates have significantly resulted in higher costs associated with the model. This has in turn reflected in the B-C ratio. The NPW analysis has resulted in a positive value, indicating that the system is profitable. The IRR was calculated and the value was pegged at 20 percent which is higher than the discount rate of 10 percent indicating that the system is feasible to be employed in a farmer's field, ensuring him good returns and a sustained income.

Table 4.38 Profitability measures of KAU recommended rice based IFS model

Years	Gross returns (₹)	Cost (₹)	Discount factor	Present worth of returns (₹)	Present worth of cost (₹)	Present worth of cash flow (₹)	B-C Ratio	NPW (₹)	IRR (%)
2011-12	0	190000	0.9070	0	171000	-171000			
2012-13	80257	253852	0.8227	72795	230251	-157455			
2013-14	250829	64431	0.7462	206357	53007	153349			
2014-15	297999	278581	0.6768	222371	207881	14490			
2015-16	279853	269007	0.6139	189415	182074	7341	**1.03**	**47,617**	**20**
2016-17	336707	303432	0.5644	206708	186281	20428			
2017-18	265884	226383	0.5131	150084	127787	22297			
2018-19	377839	345350	0.4665	193891	177219	16672			
2019-20	255253	276658	0.4240	119077	129063	-9985			

4.5 Constraints in adoption of rice-based IFS models in Kuttanad

An attempt has been made in this section to identify the major constraints faced by the farmers with regard to adoption of Integrated Farming System models by incorporating specific questions in the interview schedule. The responses of the farmers have been analysed using Garrett's ranking technique and the results are presented in Table 4.39.

Table 4.39 Constraints in adoption of rice based IFS models

Constraints	Score value	Rank	Kendall's W statistic
Unfavourable weather conditions	71.19	1	
Labour scarcity	70.88	2	
Avian diseases	58.38	3	
Soil acidity and salinity	56.89	4	
High input cost	54.06	5	
Crop pests and diseases	48.05	6	**0.634**
Lack of technical knowledge	38.13	7	
Lack of proper extension support	35.9	8	
Lack of improved variety/breeds	33.47	9	
Poor storage facilities	29.74	10	

As is evident from the results, unfavourable weather condition was the major constraint faced by the farmers in the study area. This corresponded to the fact that farmers in Kuttanad face severe hardships as the area gets flooded during the monsoon making it difficult for them to raise cattle, poultry and duckery. Although farmers have come up with coping strategies like constructing cattle shed on raised platforms, these have not received widespread acceptance. Second most important constraint as ranked by the farmers is labour shortage and the resultant hike in wages of agricultural labourers. In

Kuttanad, labour had played a prominent role in transforming the Vembanad Kayal lands into paddy fields. Kuttanad has witnessed a shift in its labour economy. Shift to non–agricultural jobs by the natives due to perceived better social status has led to more migrant labourers being employed in the paddy fields. With the pandemic hitting the state hard, there has been a shortage of migrant labourers as well. Dairy is also labour intensive and the labour shortage has affected the sector. Avian disease like bird flu is the third major constraint that stops farmers from taking up poultry and duckery enterprises on a large scale. As is evident from the results, the unit size of poultry and duckery was very small in the study area as farmers were apprehensive of taking it up on a large scale. Also, they were on a path to recovery from the losses created by the bird flu virus that affected the poultry and duckery sectors in Kuttanad in 2020.

Soil acidity and salinity was the next highest ranked constraint which specifically applied to the rice cultivation in the area. Salt water intrusion and the high acidity of soil, usually attributed to improper drainage of water from the low-lying paddy fields to the lake has been a concern for the farmers since ages. Although several interventions have been done and liming is being practiced, farmers still find it as a major constraint. High cost of inputs mainly, cattle feed, poultry feed and duck feed was ranked the fifth most important constraint by the farmers in the study area. Increase in the prices of feed, especially after the pandemic has led to several farmers opting out of poultry and duckery enterprises. Other constraints the farmers faced included pest and disease incidence, lack of technical knowledge, lack of proper extension support, lack of improved varieties/ breeds and poor storage facilities.

Running Kendall's W statistic returned a value of 0.634. This value suggested that there was a high degree of agreement among the respondents to rank the constraints.

Summary and Conclusions

5. Summary and Conclusions

With ever increasing population and decreasing operational land holding size, the scope of horizontal expansion of agriculture is limited. It is in this context that vertical expansion with thrust on Integrated Farming Systems (IFS) came into forefront. IFS is the best way to obtain higher productivity with substantial nutrient economy along with high compatibility and replenishment of organic matter through effective recycling of the organic residues obtained as a result of integration of appropriate enterprises in the system. Kuttanad (AEU 4) is one among the two major rice production centers in Kerala and is one of the special AEUs owing to the unique below MSL rice cultivation prevalent in the area. Rice-based farming system is the dominant farming system in Kuttanad. With the advent of farming systems research, integration of subsidiary enterprises like fisheries, duckery, poultry, dairy and other horticultural crops has been looked into as the right approach to ensure sustainable livelihoods to the small and marginal rice farmers of Kuttanad. It is in this context that the present study entitled "Economic analysis of rice-based Integrated Farming System models in Kuttanad" was undertaken. The objectives of the study were to analyse the economics of the rice-based IFS models in Kuttanad, assess the profitability of KAU recommended rice-based IFS model and to analyse the constraints in adoption of the IFS models by the farmers.

The study was based on both primary and secondary data. The primary data was collected from 100 rice-based IFS farmers sampled from two blocks in Kottayam and Alappuzha districts of AEU 4 through pre-tested, structured interview schedule. Purposive sampling was done in all the different stages. The secondary data pertaining to the rice-based IFS model developed at IFSRS, Karamana, was collected from the station. The field survey was carried out during the period from April 2021 to August 2021.

The economic analysis of the different rice-based IFS models was done employing the Cost concepts (Raju and Rao, 1990) and B-C ratio. Employment generation from the different models was calculated in terms of Person Days/ year. The economic sustainability of the models was identified using the Sustainable Value Index (SVI) and the System Economic Efficiency (SEE) in ₹/day. The different rice-based IFS models in AEU 4 as identified during the survey in order of their dominance were Rice+

Duckery, Rice+ Fish, Rice+ Fish+ Poultry+ Duckery, Rice+ Fish+ Dairy, Rice+ Dairy, Rice+ Dairy+ Poultry, Rice+ Fish+ Poultry, Rice+ Banana+ Dairy+ Duckery, Rice+ Fish+ Duckery, Rice–Fish (sequential farming) and Rice+ Dairy+ Fodder. The cost analysis revealed that the highest Cost A_1, Cost A_2, Cost B and Cost C were associated with Rice-Fish sequential farming owing to the highest average wetland area, labour-intensive nature of the system and higher costs associated with nursery preparation for nurturing the fish. The highest net income was observed for the model Rice+ Banana+ Dairy+ Duckery at ₹2.17 lakhs which was higher than the average per capita income of Kerala state which accounts to ₹2.04 lakhs (Statista, 2019). This was followed by Rice+ Duckery at ₹1,05,516. The net incomes of all the other models were found to be lower than the state average per capita income.

On analysing the B-C ratio of the different IFS models, it was observed that the highest B-C ratio was obtained for Rice+ Fish (2.52) at Cost A_1 as well as Cost C (1.45). This was followed by the model Rice+ Duckery at B-C ratios 2.42 and 1.32 at Cost A_1 and Cost C respectively. At Cost C, Rice+ Dairy+ Poultry and Rice+ Dairy+ Fodder showed a B-C ratio of less than one at 0.87 and 0.88 respectively. This could be attributed to labour intensive nature of dairy and the high cost of dairy concentrates. Highest employment generation was observed in the model Rice- Fish at 348 PD/yr. This was followed by the models Rice+ Banana+ Dairy+ Duckery (200 PD/yr), Rice+ Dairy (166 PD/yr) and Rice+ Fish+ Poultry+ Duckery (150 PD/yr). Involvement of family labour was highest in the case of Rice+ Dairy (88 PD/yr). It was observed that in the model R-F, no family labour was involved.

Assessment of the economic sustainability of the models revealed that, highest SVI and SEE was observed for Rice+ Banana+ Dairy+ Duckery at 0.73 and ₹1133/day. This can be attributed to the larger area under rice and the higher unit size of the different enterprises involved. Rice+ Dairy+ Poultry showed a negative value of -0.14 for SVI and the lowest SEE of ₹147/day. Apart from it, Rice +Fish+ Dairy and Rice+ Dairy+ Fodder also resulted in negative values for SVI and SEE at ₹237/day and ₹204/day respectively. Less remunerative nature of dairy might have contributed to the lower SVI and SEE of the models. The resource use efficiency of rice under IFS was analysed using Cobb-

Douglas production function. Land area and hired labour came out significant in the analysis. It was observed that the land area was under-utilized at an MVP/MFC ratio of 1.47 and the hired labour was over-utilized in the study area with an MVP/MFC ratio of 0.08. The under-utilization of wetland in the study area points to the importance of diversification as there is no scope for further expansion of wetland area in Kerala due to excessive fragmentation of land holdings with an average operational land holding size of 0.45 acres. The over utilization of hired labour might be the result of labour scarcity and high wage rates prevailing in the study area.

The rice-based IFS model developed by IFSRS, Karamana is specifically for a marginal farmer having a wetland area of 0.45 acres. The model includes subsidiary enterprises like fisheries (0.02 acres), duck (200 Nos.) housed over the fish pond, vegetables on dyke (0.05 acres), dairy unit (1 cow), ash gourd trailed over fish pond (0.02 acres), a third crop of daincha (0.15 acres), vegetables (0.15 acres) and maize (0.15 acres) in the rice field and a vermicomposting unit of size 7m× 1m× 0.5m. The data pertaining to the model for a period of 9 years from 2011-2012 to 2019-2020 was collected for analysing the profitability of the rice-based IFS model. The average Cost A_1 of the model amounted to ₹3,19,700 and the Cost C amounted to ₹3,57,175. The products from the model included rice, fish, duck eggs and meat, milk, maize, vegetables and vermicompost. The average gross returns per year from the model was ₹2,58,939 and the employment generation was 109 PD/yr. The B-C ratio, NPW and IRR was calculated at a discount rate of 10 percent. The B-C ratio was 1.03 at a NPW of ₹ 47,617. A B-C ratio greater than 1, a positive NPW and an IRR value of 20 percent, which was greater than the discount rate, indicated that the model is profitable.

The model had innovative approaches like housing ducks over the fish pond so as to ensure nutrient enrichment of the fish pond for the growth of phyto-planktons, which are excellent fish feed, use of dual-purpose crops like maize which can be fed to the cattle after harvest as an excellent green fodder, trailing of ash gourd over the fish pond and vermicomposting unit to recycle the organic wastes. The model found closest to the KAU recommended model in the field was Rice+ Fish+ Duckery which showed a high B-C ratio of 1.26 at Cost C. Certain components of the model like housing ducks over the fish pond, cultivation of vegetables on dykes and trailing of gourds over the fish pond could be well replicated in the farmers' fields through better demonstrations and trainings. Developing and popularizing models based on the agro-ecological situation of the study area is imperative to achieve the objectives of farming systems research.

The constraints associated with adoption of rice-based IFS models by the farmers in Kuttanad were analysed using Garrett ranking technique. Kendall's coefficient of concordance was employed to check the agreement between the respondents to rank the different constraints. Unfavorable weather condition was ranked by the sample farmers as the most important constraint that deters them from diversifying their farm enterprises. This is mainly because of the recurrent floods in the study area arising out of the specific location of the AEU. Though the farmers have braved the threats posed by changing climate, better coping strategies have to be devised for increasing their resilience. After the devastating floods of 2018, Kerala Government launched the ambitious "Room for Pamba" project, similar to the Dutch "Room for River" programme as part of a special package for post-flood Kuttanad in 2019. The programme aims at draining more water from the Pamba river into the Arabian Sea instead of allowing it to flow northward into Kuttanad, thus reducing the flood risk in the region.

The second most important constraint was found to be labour scarcity and the associated rise in wage rates in Kuttanad with the COVID-19 pandemic worsening the situation due to return of the migrant labourers to their natives. The third most important constraint was the incidence of avian diseases like the bird flu in the study area which is inevitable because of the presence of migratory birds in the Vembanad wetland system. Soil salinity and acidity problems were ranked by the farmers as the fourth most important constraint which can be attributed to poor drainage in the area due to a number of manmade reasons. High input cost, especially for dairy and poultry concentrates, incidence of pests and diseases, lack of technical knowledge, lack of proper extension support, lack of improved varieties/breeds and poor storage facilities have been identified as the other important constraints of the famers in Kuttanad. Kendall's coefficient of concordance value of 0.634 showed that there was a general agreement among the farmers in ranking the constraints.

Suggestions

Based on the results of the study and the observations made during field survey, the following policy suggestions are made:

- Localized weather forecasting and warning systems are important as it ensures that the farmers take up appropriate measures before a calamity strikes and plan accordingly. Crop calendars suited to Kuttanad agro ecological unit and alternate farming techniques would help farmers to cope with changing climate conditions.
- As Kuttanad witnesses severe labour shortage and associated wage hike and as it was also observed that hired labour was over utilized in the study area, capacity building programmes for the skill development and productivity enhancement of labour force especially of the migrant labourers would be beneficial.
- Risk mitigation strategies like insuring of crops, poultry, ducks and cattle which can eventually help the farmers to cope up with the risks posed by natural calamities is necessary in Kuttanad.
- In order to reap the benefits that IFS offers, it is important that the farmers are fully aware of the potential benefits of IFS. Therefore, better extension programmes to improve the awareness of farmers regarding advantages of IFS is to be imparted by the Department of Agriculture and Farmers' Welfare.
- Farmer awareness programmes on scientific fish culture practices and appropriate stocking density of fish, feed quantity, and pond maintenance to be planned as it was observed that these aspects are generally ignored by IFS farmers.
- Mushroom cultivation also has immense scope in the study area owing to the availability of paddy straw substrate. Promotion of mushroom cultivation as part of IFS schemes of the Government can ensure augmentation of farmers' income.
- Twenty five percent of the sample farmers practiced lease land rice cultivation in the study area. But the lease amount levied was found to vary drastically among

the respondents. Hence, an appropriate land leasing policy suitable to Kuttanad may be drafted by the Government.

- In order to ensure better suitability of the IFS models to the agro-ecology of different regions and to ensure greater acceptability of the models among farmers, development of AEU based IFS models has to be taken up by the research system.
- Familiarizing farmers on Short Duration varieties of rice and ensuring its availability can be a strategy to cope with the threats posed by varying weather patterns.
- Setting up of cattle and poultry feed production units utilizing locally available raw materials can help farmers to save upon the huge costs associated with dairy and poultry concentrates.

Plate 1 : Survey in the study area

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APPENDIX

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF AGRICULTURE, VELLANIKKARA

DEPARTMENT OF AGRICULTURAL ECONOMICS

Economic analysis of rice-based Integrated Farming System models in Kuttanad

Interview schedule

District: Block: Panchayat:

1. Socioeconomic profile of the sample farmers

1.1. Name of the farmer:

1.3. Educational qualification:

1.2. Age:

1.4. Contact details:

1.5. Experience in farming (yrs):

1.6. Family details:

Sl No.	Name	Age	Gender	Educational qualification	Occupation	Annual income

2. Land holding

Type	Wetland		Gardenland		Total	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Owned						
Leased in						
Leased out						

3. Farm buildings

Building	Year of construction	Cost of construction	Present value

Farm house			
Cattle shed			
Poultry shed			
Duck shed			
Pond			
Pump shed			
Storage shed			
Mushroom shed			
Threshing/drying yard			
Others			

4. Implements and machinery

Sl no	Item	Own ed	Hire d	Hiring charges	Year of purchase	Purchase price	Maintenance cost
1.	Sprayers						
2.	Pump set						
3.	Tiller						
4.	Tractor						
5.	Plough						
6.	Transplanter						
7.	Thresher						
8.	Winnower						
	Others if any:						

5. Cropping pattern-Rice

Sl no.	Season	Variety	Area
1.	Virippu		
2.	Mundakan		

6. Livestock

Sl. No.	Animals	Number	Breed/ type	Purchase value (Rs)	Current value (Rs)
1.	Milch animals				

	a. Cow b. Buffalo				
2.	Young stock a. Cow b. Buffalo				
3.	Goat				
4.	Poultry				
5.	Duck				
6.	Pig				
7.	Fish				

7. Allied activities

Sl no.	Activity	Unit size
1.	Vermi-composting	
2.	Biogas unit	
3.	Mushroom unit	
4.	Others (Specify)	

8. Loan details

Sl No.	Activity	Type of loan	Interest rate	Source

Do you receive any assistance from schemes of the Dept of Agriculture?

If yes, which scheme?

Assistance received:

9. Land tax:

10. Rental value of land:

11. Irrigation cess:

12. Insurance coverage:

13. Crop component- Rice

Area:

Variety:

Seasons:

Wage rate- Male: Female

No of working hours:

13.1. Operational costs

		Hired human labour (days)		Family labour (days)		Animal labour		Machine labour		Total
1.	Labour	M	F	M	F	Qty (hr)	Value	Qty (hr)	Valu e	
	Nursery preparation									
	Land preparation									
	Liming									
	Sowing									
	Fertilizer application									
	Plant protection									
	Weeding									
	Harvesting									
	Total labour cost									
2.	Inputs	Quantity				Price per kg		Value		Source
		Owned		Purchased						
	Seed									
	FYM									
	Fertilizers									
	Plant protection									
	Total input cost									
3.	Miscellaneous expenses									

13.2 Returns

Sl no.	Item	Quantity		Price	Market
		For sale	Household consumption		
1.	Rice				
2.	Seed				
3.	Straw				

14. Subcomponent- Fish

14.1. Operational costs

No. of batches per year:

No. of fish per batch:

1.	Labour	Hired labour		Family labour	
		M	F	M	F
	Pond maintenance				
	Field preparation				
	Feeding				
	Harvesting				
	Total labour cost				

2.	Inputs	Owned	Purchased	Price	Source
	Fingerlings				
	Feed				
	Fertilizers				
	Total input cost				
3.	Miscellaneous expenses				
4.	Interest on working capital				
	Total operational cost				

14.2. Returns

Sl No	Item	Quantity		Price	Market
		For sale	Household consumption		
1.	Fish				
2.	Fingerlings				

15. Subcomponent: Dairy

15.1. Inputs

Sl No.	Item	Quantity		Price	Source
		Owned	Purchased		
1	Green fodder				
2	Dry fodder				

3	Concentrates				
4	Medicine				
5	Veterinary services and supervision				
6.	Miscellaneous expenses				

15.2. Labour

Sl no.	Activity	Labour			
		Hired		Family	
		M	F	M	F
1.	Roughage collection				
2.	Grazing				
3.	Stall feeding				
4.	Cleaning of sheds				
5.	Cleaning of animals				
6.	Milking				
7.	Transportation of milk				
8.	Others				

15.3. Returns from dairy

	Particulars	Quantity		Price	Market
		For sale	Family consumption		
1.	Milk				
2.	Cow dung				
3.	Sale of animals				

16. Subcomponent: Duckery

No. of batches per year:

No. of ducks per batch:

16.1. Inputs

Sl no.	Item	Quantity		Price	Source
		Owned	Purchased		
1.	Ducklings				
2.	Feed				
3.	Medicines				
4.	Veterinary services and supervision				
5.	Labour				
6.	Miscellaneous costs				

16.3. Egg production

Egg production				
Per day	No. Of days per year	Price (Rs/unit)	Sale of eggs (no/ day)	Family consump tion

16.4. Returns

Sl no	Particulars	Quantity		Price	Market
		For sale	Household consumption		
1.	Eggs				
2.	Birds				
3.	Manure				

17. Subcomponent: Poultry

No of batches per year:

No of chicks/ batch:

17.1. Inputs

Sl no.	Item	Quantity		Price	Source
		Owned	Purchased		
1.	Chicks				
2.	Feed				
3.	Bedding material				
4.	Medicines				
5.	Veterinary services and supervision				
6.	Labour				
7.	Miscellaneous costs				

17.2. Egg production

Egg production				
Per day	No. Of days per year	Price (Rs/unit)	Sale of eggs (no/ day)	Family consumption

17.3. Returns

Sl no	Particulars	Quantity		Price	Market
		For sale	Family consumption		
1.	Eggs				
2.	Culled birds				
3.	Manure				

18. Subcomponent: Banana

Area:

Cultivar:

18.1. Operational costs

1.	Labour	Hired human labour		Family labour		Total
		M	F	M	F	
	Land preparation					
	Pit taking					
	Planting of suckers					
	Fertilizer application					
	Plant protection					
	Intercultivation					
	Harvesting					
	Total labour cost					

2.	Inputs	Quantity		Price	Source
		Owned	Purchased		
	Suckers				
	FYM				
	Fertilizers				
	Plant protection				
	Total input cost				
3.	Miscellaneous expenses				
4.	Interest on working capital				
	Total operational cost				

18.2. Returns

Sl No.	Particulars	Quantity		Price	Market
		For sale	Household consumption		
1.	Banana				
2.	Suckers				

19. Subcomponent: Vegetables

19.1. Operational costs

1.	Labour	Hired human labour		Family labour		Total	
		M	F	M	F		
	Land preparation						
	Liming						
	Sowing						
	Fertilizer application						
	Plant protection						
	Weeding						
	Harvesting						
	Total labour cost						
2.	Inputs	Quantity				Price	Source
		Owned		Purchased			
	Seed						
	FYM						
	Fertilizers						

	Plant protection				
	Total input cost				
3.	Miscellaneous expenses				

19.2. Returns

Sl no.	Particulars	Quantity		Price
		For sale	Family consumption	
1.	Vegetables			
2.	Seeds			

20. Economics of vermi-composting

Sl no.	Activity	Labour			
		Hired		Family	
		M	F	M	F
1.	Pit making				
2.	Watering, maintenance, harvesting				

Quantity of farm waste used for composting:

Quantity of compost produced:

Quantity used for sale:

Price (Rs/kg):

21. Economics of biogas plant

Sl no	Activity	Cost (Rs)
1.	Establishment cost	
2.	Labour charges	

Quantity of animal and kitchen waste fed per day:

Quantity of biogas produced (hrs/day):

22. Economics of Mushroom cultivation

Sl No.	Inputs	Quantity		Price	Source
		Owned	Purchased		
1.	Paddy straw/ sawdust/compost				
2.	Spawn				
3.	Polybags				
4.	Sterilization chemicals				
5.	Labour charges				
6.	Miscellaneous expenses				

Mushroom yield per harvest:

Number of harvests per year:

Quantity used for sale:

Price:

Market:

23. Constraints in the adoption of IFS models

Sl no.	Constraint	Rank
1.	Unfavourable weather conditions	
2.	Soil salinity and acidity	
3.	Poor storage facilities	
4.	Labour shortage	
5.	High cost of inputs	
6.	Lack of proper technical guidance	
7.	Lack of improved varieties or breeds	
8.	Lack of technical knowledge	
9.	Avian diseases	
10.	Crop pests and diseases	

ECONOMIC ANALYSIS OF RICE BASED INTEGRATED FARMING SYSTEM MODELS IN KUTTANAD

By

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(2019-11-145)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment for the degree of

Master of Science in Agricultural Economics

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2021

ABSTRACT

In any developing economy, in order to attain pro-poor growth and economic development, it is necessary that the agriculture sector flourishes, along with improvement in farmers' income. According to Agricultural Census of 2015-16, the average operational land holding in Kerala was found to be 0.18 ha. Hence, the scope of horizontal expansion is limited and the only possible alternative is vertical expansion. Integrated Farming System (IFS) is a resource management strategy that ensures year round income to the farm families with the integration of appropriate subsidiary enterprises. It helps in meeting the diverse requirements of the farm household, ensures employment generation and sustainable livelihood of small and marginal farmers along with minimizing the risk associated with monocropping.

Rice farmers in Kuttanad have taken up subsidiary enterprises like duckery, fish, dairy and poultry to ensure additional returns. The different IFS models identified among the 100 sample farmers from the study area were Rice+ Duckery, Rice+ Fish, Rice+ Dairy, Rice- Fish sequential farming, Rice+ Fish+ Poultry, Rice+ Fish+ Duckery, Rice+ Fish+ Dairy, Rice+ Fish+ Poultry+ Duckery, Rice+ Dairy+ Poultry, Rice+ Dairy+ Fodder and Rice+ Banana+ Dairy+ Duckery. The predominant models in the study area were Rice+ Duckery which was followed by Rice+ Fish and Rice+ Fish+ Poultry+ Duckery. The economic analysis of the rice based IFS models were carried out to identify the most profitable models. It was observed that fish and duckery enterprises were profitably integrated with rice among the farmers in Kuttanad. The model Rice+ Fish and Rice+ Fish+ Duckery showed a high B-C ratio of 2.52 at Cost A_1. Rice+ Duckery was the next most profitable model at a B-C ratio of 2.42. At Cost C, Rice+ Fish showed the highest B-C ratio of 1.45 followed by Rice+ Duckery and Rice+ Fish+ Duckery at B-C ratios 1.32 and 1.26 respectively. The models involving dairy showed significantly lower B-C ratios attributing to the labour intensive nature of the enterprise and high cost of dairy concentrates. Rice–Fish sequential farming showed highest employment generation of 348 Person Days/yr. Economic sustainability of the IFS models were analysed using Sustainable Value Index (SVI) and System Economic Efficiency (SEE). The highest economic sustainability was obtained for the model

Rice+ Banana+ Dairy+ Duckery at an SVI of 0.73 and SEE of ₹1133/day and the lowest was observed for the model Rice+ Dairy+ Poultry at SVI and SEE of -0.14 and ₹147/day respectively. Analysing the resource use efficiency of rice under IFS in Kuttanad revealed that the wetland area was underutilized, and hired human labour was over utilized.

The rice based IFS model developed by The Integrated Farming System Research Station, Karamana was analysed for its profitability. The model included dairy, duckery, fish, vegetable cultivation on the dykes and allied activities like vermicomposting. The model was found to be profitable at a discounted B-C ratio of 1.03, NPW of ₹47,617 and IRR of 20 percent. Components of the model like cultivation of vegetables on dykes and construction of duck shelter over the fish pond could be well adopted by farmers in Kuttanad.

Constraints in adoption of the IFS models by the farmers were studied using the Garrett ranking technique and the agreement between the respondents in ranking the constraints was studied using Kendall's coefficient of concordance. The most important constraint that prevents farmers from adoption of the IFS models was unfavourable weather conditions. This corresponded to the fact that the farmers in Kuttanad face severe hardships as the area gets flooded during the monsoon making it difficult for them to raise cattle, poultry and duckery. Although farmers have come up with coping strategies like constructing cattle shed on raised platforms, these have not received widespread acceptance. The other important constraints were labour scarcity, avian diseases, soil acidity and salinity, high input cost, crop pests and diseases, lack of technical knowledge, lack of proper extension support, lack of improved variety/breeds and poor storage facilities. The Kendall's W statistic of 0.63 indicated that there was general agreement between the farmers in ranking the constraints.

Increasing the awareness of the farmers regarding the benefits of IFS through trainings, capacity building programmes for a more skilled labour force, localised weather forecasting and warning systems, strengthening of risk minimising strategies like insuring the crops and livestock and support for taking up allied activities like mushroom cultivation have been suggested.