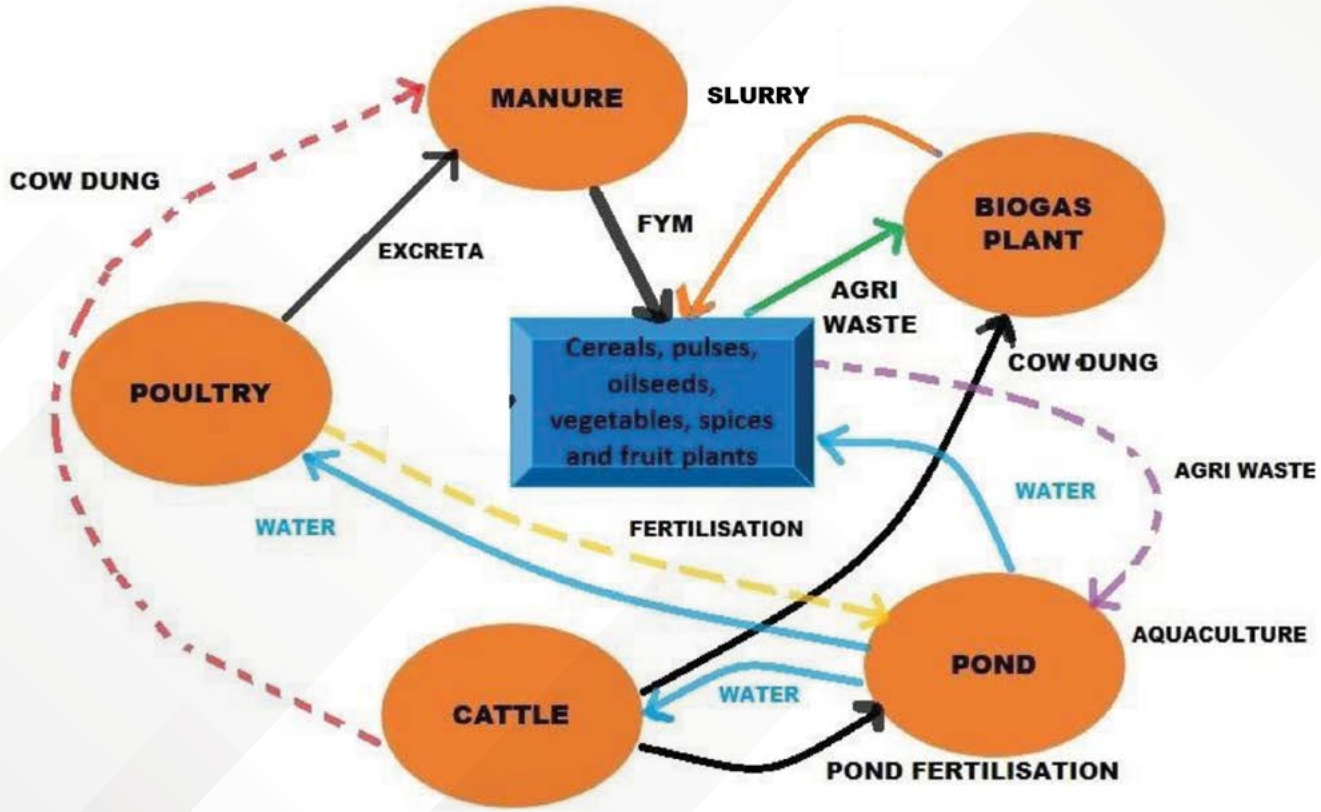
Integrated Farming Systems in West Bengal: A Step towards Sustainable Rural Livelihoods



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• Avijit Haldar • Satyendra Nath Mandal •
• Upama Das • Kunal Roy • Ayan Das •
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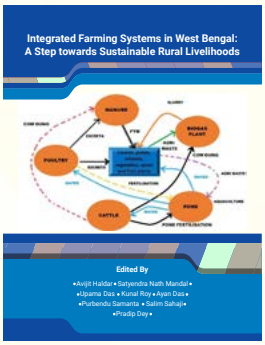

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Preface

Given the complexity of agriculture today, the pursuit of sustainable and economically viable farming systems is a quest that lies at the heart of every farming community. As the global community grapples with the challenges of food security, environmental sustainability, and economic stability, the importance of integrated farming systems (IFS) cannot be overstated. The full potential of IFS to create a more prosperous, resilient and harmonious agricultural landscape lies in the Upanishadic principles of interconnectedness, sustainability, balance and self-sufficiency. By harnessing the synergies between different agricultural components, these systems offer a holistic approach towards enhancing productivity, conserving resources, and improving livelihoods. It is within this context that the exploration of IFS in West Bengal emerges as a crucial endeavor, blending tradition with innovation, and resilience with adaptability.

I do believe that this book is not merely an academic exercise; it is a beacon of hope for farmers, policymakers, and stakeholders alike. The comprehensive study delves deep into the economic landscape of various IFS, offering invaluable insights into their viability within the unique socio-economic milieu of West Bengal. From the green fields of paddy to the rustic homesteads where livestock roam freely, each facet of agriculture is meticulously examined, revealing the intricate interplay of crops, livestock, and other agricultural enterprises.

The book will undoubtedly offer practical guidance on designing, implementing, and managing IFS and help the stakeholders to develop a framework on IFS for the sustainability and profitability across different agro-climatic zones of West Bengal. Further, the book underscores the transformative potential of IFS to foster resilience in the face of climate change, empower rural communities, and chart a course towards a more sustainable and prosperous future. May the document inspire action, ignite dialogue, and pave the way for the widespread adoption of IFS, not only in West Bengal, but across the globe.

(Pradip Dey)
Director
ICAR-ATARI, Kolkata

An Overview

An integratd farming system (IFS) is characterized by temporal and spatial mixing of crops, livestock, fishery, and allied activities in a single farm. It is hypothesized that this complex farm is more productive at a system level and less vulnerable to volatility. It ensures nutrient cycling within the system through a synergistic resource transfer among enterprises to economise and sustain the system and minimizes the dependence of external inputs to earn more profit round the year. Thereby, an IFS can cater the needs of small and marginal farmers, who are the backbone of agriculture in India. However, the adoption of IFS is low across different states in India due to many reasons including agro-ecology, economic, environmental, and social factors. Hence, a study was conducted in West Bengal, a state of Eastern India, covering six broad agro-climatic zones. National Bank for Agriculture and Rural Development (NABARD), Kolkata is duly acknowledged for funding to conduct this study during a period of one and half year. A group of scientists of different Krishi Vigyan Kendras (KVKs) situated in different districts of West Bengal participated actively in this study.

In this book, 24 selected case studies across different agro-climatic zones and contexts were delineated. Through meticulous survey, research, and insightful analysis, the book entitled, “Integrated Farming Systems in West Bengal: A Step towards Sustainable Rural Livelihoods” sheds light on real-world benefits of integrated farming systems for farmers, communities, and the environment alike. Whether you are a farmer looking to enhance the productivity and farm income or to get a bank loan for establishing an IFS, an agricultural researcher seeking innovative solutions to food security challenges, or a policymaker striving to promote sustainable agricultural development, probably this book is for you. These case studies may help the policymakers, practitioners, researchers, and extension workers for policy interventions, supportive extension services, and capacity-building initiatives for mainstreaming integrated farming approaches into broader agricultural development agendas.

I must express my sincere gratitude to Dr. S.S. Singh, the then Director of ICAR-ATARI, Kolkata for his unwavering encouragement and guidance in pursuing this IFS project in West Bengal.

I extend my heartfelt thanks to all those who contributed to the creation of this book– our researchers, editors, and partners– for their unwavering commitment to excellence.

(Avijit Haldar)
Nodal Scientist
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Introduction

Agriculture in India and other Asian countries is facing multiple and complex challenges which are expected to become more severe with the passage of time. Following industrialization, farming became commodity-based depending upon agro-climatic conditions of the area and proximity to industries like sugar factory, soya processing plant, rice mill, oil mill, ginning mill, dal mill etc., similarly poultry farming, dairy farming, piggery, beekeeping, fish cultivation, vegetable farming, fruit farming, floriculture, mushroom farming and gained popularity in the peri-urban areas also to exploit the market of the produce available in the city. However, with the pace of time, the sustainability of single commodity-based farming became questionable because of fluctuating market trends and dependency on external inputs. During last five decades, agricultural research and extension have focused on the development of higher productivity of crop varieties and animal breeds, better farm implements and machinery, increased fertilizer uses and other production technologies which enabled the farmers to grow more food, but at the same time it over exploited the resources and resulted in decreasing farm productivity and profitability. Natural resources conservation has been emerged as the major issue worldwide

The agriculture-based developing countries like India are facing the challenges of agricultural sustainability, productivity of agricultural enterprises, stability of farm income, environment protection, impact of climate change, availability of agricultural labours and marketing. The fact is that about two-thirds of the rural people in developing countries are smallholder farmers having agricultural lands smaller than 2 hectares. The continuous declining trend in size of land holding poses a serious threat to the smallholder farmers in India. The inequitable distribution of land holdings among 86 per cent of small/ marginal farmers, who are cultivating in 45 per cent of area in the country, makes the small and marginal farms the poverty hotspot of the country Thus, the approach has been changed from food security to income security of the farmers.

The emergence of Integrated Farming System (IFS) has enabled to develop a framework for an alternative development model to improve the feasibility, sustainability and profitability of smallholder farming operations. Research on IFS has been taking place across Western Europe since the late 1970s in response to growing awareness of the environmental problems caused by modern farming practices. This stimulated a series of larger scale, long-term and coordinated experiments on IFS within Europe. According to the UNI 11233-2009 European standard, an IFS is described as a farming system where high quality organic food, feed, fiber and renewable energy are produced by using resources such as soil, water, air and nature with nutrient cycling to make farm sustainable.

IFSs are important for achieving multiple sustainable developmental goals, including food security, economic viability, environmental stewardship, climate resilience, and social equity in agriculture. IFSs offer several benefits, such as,

- Food and nutritional security with high-quality food,
- Livelihood security for smallholder farmers and rural communities, especially in resource-constrained settings by diversifying income sources, increasing farm productivity, higher rate of return and generating employment opportunities,
- Reduction of risks by decreasing the dependence on a single crop or livestock species, buffering against crop failure thereby spreading risks and enhancing resilience against market fluctuations, climatic variability, and pest outbreaks,
- Enhancement of resource efficiency by recycling organic matter, nutrients, and energy within the farming system through a synergistic resource transfer among enterprises resulting minimization of waste generation, improvement of overall farm productivity and reduction of the dependence of external inputs to earn more profit round the year,
- Promotion of environmental sustainability by minimizing the negative impacts of agriculture on ecosystems and natural resources through crop rotation, intercropping, integrated pest management, reducing reliance on chemical inputs and promoting biological control methods,
- Biodiversity conservation, protection of natural resources, ecosystem services such as carbon sequestration, pollination, pest control, and soil fertility by practicing for a wide range of plant and animal species within agricultural landscapes,
- Climate resilience by enhancing the adaptive capacity of farming systems to climate change impacts such as erratic rainfall, temperature extremes, and extreme weather events,
- Cultural and social benefits by preserving indigenous agricultural heritage, integrating traditional knowledge, cultural practices, and community values into agricultural production, promoting local food systems and empowering rural communities, especially gendered benefits.

The philosophy of IFS is rooted in principles of “sustainability” encompassing ecological, economic, and social dimensions, “system thinking” in a holistic manner through synergistic interactions and “feedback loops” involving the interconnectedness and interdependencies of different components within the farm system, “biodiversity”, “resource recycling”, “conservation of natural

resources", "regenerative agriculture", "adaptability and resilience to environmental stresses", "revitalization of rural economies", "continuous learning and innovation". At its core, the philosophy of IFS embraces a paradigm shift away from conventional, specialized agricultural practices toward more diversified, resilient, and harmonious approaches to food production. By embracing this philosophy, farmers and communities can work together to build a more sustainable and resilient food system for future generations.

IFSs may be considered as one of the best options to cater the needs of small and marginal farmers who are the backbone of agriculture in India, towards intensification of small holder farm income to ensure sustainable livelihood. However, the management of an IFS is complex and daunting, because it is not supported uniformly across diverse set of farming situations. Of late, different IFS models have been reported in Indian context. Yet, adoption of IFS in India remains low. Since an IFS is run on knowledge-based flexible management processes to manage all resources available, several types of drivers influence the adoption of IFS including economic, environmental, and social. Similarly, the multiple types of risks faced by the farmers give the farmers greater options for coping with and managing risk to run IFS in a specific agro-climatic and social situation. Hence, a study was conducted in West Bengal, a state of Eastern India, covering six broad agro-climatic zones (ACZs) viz. Hill Zone, Teri Zone, Old Alluvial Zone, New Alluvial Zone, Undulating Red and Laterite Zone and Coastal Saline Zone. National Bank for Agriculture and Rural Development (NABARD), Kolkata funded for this study during a period of one and half year. A group of scientists of different Krishi Vigyan Kendras (KVKs) situated in different districts of West Bengal participated actively in this study.

Objective

To explore technically feasible, economically viable, area-specific existing models of integrated farming across six agro-climatic zones of West Bengal

Methodology

Literature review

A comprehensive review of existing literature on IFSs was conducted to understand the theoretical foundations, empirical evidence, and best practices related to IFSs.

Conceptual framework

A conceptual framework was developed to outline the key concepts, variables, and relationships relevant to the study of IFSs. The sampling strategy involving purposive sampling, random sampling or stratified sampling depending on the research objective and context for selecting study sites, farms, or participants were planned.

Research design

A research plan outlining the methods and procedures for collecting data on IFSs was designed. This involved a combination of quantitative and qualitative research methods, such as focus group discussion (FGD), field surveys, interviews and participatory approaches.

Study area

The research study was conducted in West Bengal, a state of Eastern India, covering six broad agro-climatic zones (ACZs) viz. Northern Hill Zone, Terai Zone, Old Alluvial Zone, New Alluvial Zone, Coastal Saline Zone and Undulating Red and Laterite Zone, as delineated in the report of National Agricultural Research Project (NARP) of Indian Council of Agricultural Research (ICAR).

Field mobilization plan

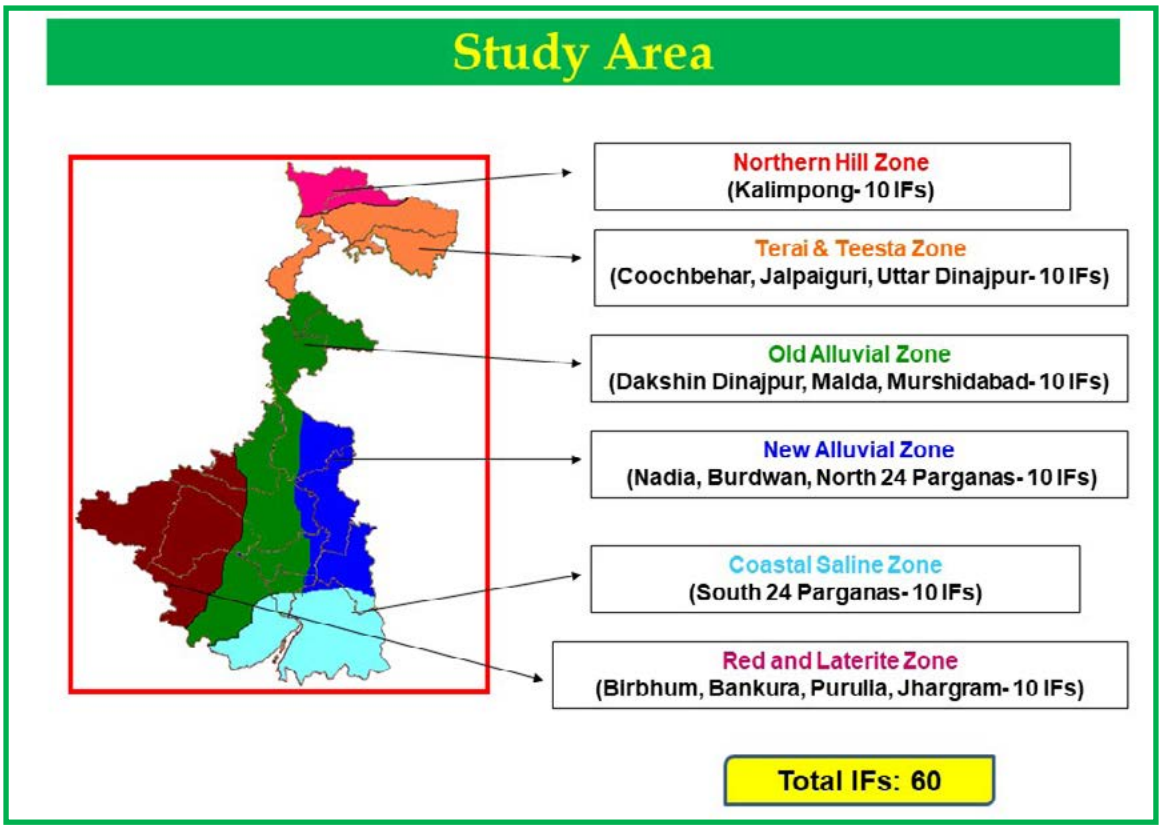
Prior to commencing ground study, a series of online meetings with the Subject Matter Specialists (SMSs) of district Krishi Vigyan Kendra (KVK) was conducted for providing insights on the concept, scope of the study including study approach and methodology to the team members and enumerators.

Sampling procedure

Multi-stage sampling was followed to select respondents for the study. In the first stage, the districts under agro-climatic zone were

selected purposefully. These Districts and/ or KVKs were: (i) Under northern hill zone: (1) Darjeeling, (ii) Under terai and teesta zone: (2) Coochbehar, (3) Jalpaiguri, (4) Uttar Dinajpur, (iii) Under old alluvial zone: (5) Dakshin Dinajpur, (6) Malda, (7) Murshidabad (Additional KVK), (iv) Under new alluvial zone: (8) Nadia, (9) Burdwan, (10) North 24 Parganas, (v) Under red and laterite zone: (11) Bankura, (12) Birbhum, (13) Purulia, (14) West Medinipur, (vi) Under costal saline zone: (15) South 24 Parganas: Nimpith, (16) South 24 Parganas: Narendrapur (Additional KVK).

In the second stage, block was selected purposefully in consultation with District Agriculture Department, Krishi Vigyan Kendra (KVK), local Non- Government Organization (NGO) for developing sampling frame. Then, two-stage stratified random sampling was applied. Village under block was selected on random basis. Further, the farmer who adopted integrated farming (IF) in a village was selected randomly. In this manner, 10 integrated farming (IF) adopted farmers under each agro-climatic zone was selected from the sampling frame. Thus**,** a total of 60 IF adopted farmers (n~60) considering 10 IF adopted farmers from each agro-climatic zone of West



Bengal were selected for the study by 16 KVKs situated in different districts of West Bengal. A list of existing IFs by KVKs across six agro-climatic zones of West Bengal follows.

Data collection

The data used in this study consisted of both primary and secondary data. Secondary data used in the study were obtained from review of literature and FGD on agro-climate, land situations, crop wise land use pattern, soil physio-chemical properties, water resources availability and its chemical properties, resources' availability etc of a district under a specific agro-climatic zone of West Bengal. Further, a desk study for a comprehensive review of the literature and FGD among the farmers, SMSs of district KVK and experts was conducted to prepare a close-ended pre-structured interview schedule covering technical data, socio-economic data, backward and forward linkages, supply and demand scenario, marketing mechanism etc. The interview schedule was then pre-tested and validated with necessary modifications for finalization. An individual farming household operating on IFS was considered as a primary sampling unit. Thus, the primary data were collected from 60 IFS adopted farmers of six agro-climatic zones of West Bengal through 60 field visits for 60 IFSs, observations and face-to-face personal interview using the close-ended pre-structured interview schedule covering quantitative and qualitative questionnaires based on a two-point continuum of agree (Yes= 1) or disagree (No= 0) statement basis and 5- points Likert scale basis.

Development of a digital form

A smart, dynamic digital form with 20 dependent variables and 211 independent variables for data entry, scoring of each variable on

integrated farming system was developed and finally arrived at the total score of an individual IFS. All IFSs were ranked based on scoring of an individual IFS. Then, IFSs were grouped into four categories based on the highest net income of a particular component (agriculture/ horticulture/ livestock/ fishery) and thus found the maximum number of IFSs were horticulture-based (35.0%) followed by livestock-based (25.0%), fishery-based (21.7%) and agriculture-based (18.3%).

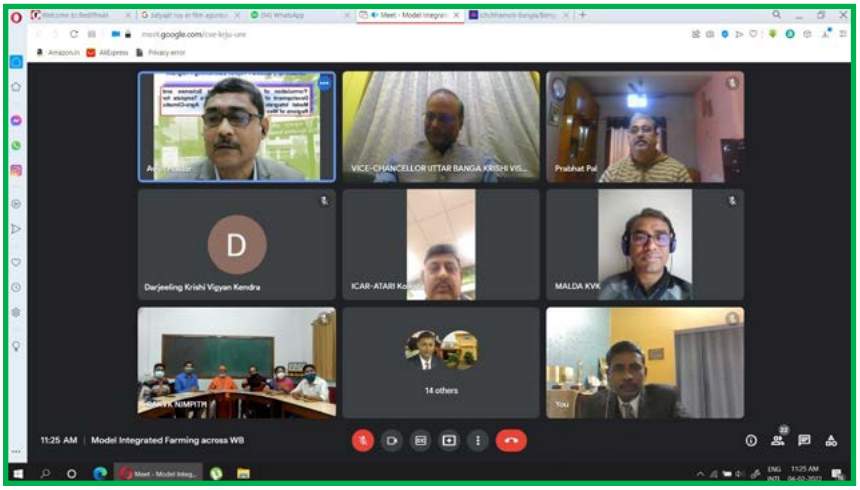
Database generation

A database was generated on land holding and land covered under IFS, layout plan, different resources/ components of existing farming condition and area covered by each component, recyclable resources, integration/ resource recycling system, cropping sequences, month-wise operational activities, technology used (farm mechanisation, integrated nutrient management, integrated pest and disease management, organic farming, diversification, vertical farming, hi-tech farming, climate smart farming, conservation agriculture, precision farming), innovation if any, technical data (varieties used, stocking density, production, productivity, diseases and management measures), economic data (expenditure on agricultural activities, expenditure on allied activities, household expenditure, income from agricultural activities, income from allied activities, income from off-farm activities, BC ratio, net income per ha of agriculture land, net income of the family etc), socio-cultural factors (ability in resources utilization, feeling of economic security, self-reliance on own power, self confidence in managing IF, ability to understand and solve problems, overall satisfaction, self-image in community, dissemination of knowledge in community etc), manpower availability and gender information, employment generation, post-harvest infrastructure scenario, marketing mechanism, demand and supply gap, price variation of commodity, backward and forward linkages, value addition scope, transportation, record keeping and account maintenance, risk and management, constraints etc. A software template/ website with 7 different modules on available IFSs was developed for six agro-climatic zones of West Bengal.

Case study

Each IFS was considered as a case study. Based on the available information and database, the details case study on each IFS was developed. The representative 24 case studies considering 4 case studies from each agro-climatic zone of West Bengal were outlined in this document. Besides, six representative area development schemes (ADSs) for six agro-climatic zones of West Bengal were prepared. These case studies would explore the sustainability metrics, economic benefits including diversified income streams, initial investments required for transitioning to integrated systems, resilience by diversifying production, environmental benefits such as improved soil fertility, enhanced biodiversity, social dimensions including rural livelihoods, the involvement of smallholder farmers, gender dynamics, employment opportunities, information sharing platforms in disseminating best practices, and farmer-to-farmer networks. These case studies would provide valuable evidence-based insights and practical lessons on benefits, outcomes and opportunities for the scalability and replicability of integrated farming models across different agroecological contexts and socio-economic conditions.

Meetings and Project Implementation Plan



Hill Agro-climatic Zone

Horticulture-based integrated farming: A sustainable approach

Pranab Barma

Kalimpong Krishi Vigyan Kendra
Uttar Banga Krishi Viswavidyalaya
Seed Farm, Kalimpong – 734301, West Bengal

Horticulture-based integrated farming

Name of the farmer: **Shri. Kumar Tamang Pakhrin**

Area of the farm: 2.0 ha

Location of the farm: Sakyong village, Algarah II block, Kalimpong district

Shri. Kumar Tamang Pakhrin, a progressive farmer from Sakyong village in the Kalimpong district, has established a profitable horticulture-based integrated farm. Utilizing 2.0 ha of land, he earns a net profit of Rs. 3,88,430.00 by diversifying his farm activities. His farming system integrates no fewer than 12 components, including horticulture crops, field crops, livestock, vermicomposting, beekeeping, nursery sapling production, and fodder cultivation. The diversification of farm activities has allowed Shri. Pakhrin to cater to various market demands and enhance his income streams. Horticulture, including spices, contributes the highest share of the net income at 41.0%, followed by livestock farming at 30.0%. Other enterprises, such as vermicomposting, beekeeping, and nursery sapling production, contribute 23.0%, while field crops (cereals and pulses) account for a smaller portion of 6.0%. This distribution highlights the profitability and potential of this farming system, especially in the horticulture and livestock sectors. Shri. Kumar Tamang Pakhrin's horticulture-based integrated farm is a prime example of how diversification and integration of various farm components can lead to increased profitability and sustainability. Based on the techno-economic data of this successful integrated farm, an area development scheme has been proposed. This farming model holds great potential for other farmers in similar agro-climatic zones for replication, providing a pathway for farmers to enhance their income and resilience against agricultural uncertainties.

Key words

Integrated farming system, Vegetables, Livestock, Hill agro-climatic zone, Kalimpong, West Bengal

Figure 1: Shri. Kumar Tamang Pakhrin, the owner of horticulture-based IFS in Kalimpong

Introduction

Shri. Kumar Tamang Pakhrin, 40 years old farmer of Sakyong village of Algarah II block of Kalimpong district has shown an immense advancement in farming system by adapting the knowledge of horticulture-based integrated farming (IF) at his farm of 2.0 ha (15.0 bigha) land in a hilly terrain. Farming is the main source of income for Sakyong village. The weather condition prevailing in this village is sub-tropical as it favours well with subtropical fruits and vegetables and other horticultural crops. During rabi and zaid season, spring water is the main source of irrigation even though the crops are generally rainfed during kharif season. Horticultural crops perform well in Kalimpong district due to its favorable agro-cliamtic conditions. Some of cash crops such as ginger, large cardamom, mandarin oranges, dalle chilli, and turmeric are grown in this area. The farmers often face challenges in cultivation of such horticultural crops due to some of the biotic and abiotic factors such as infestation of pest and diseases, high downpour coupled with soil erosion which leads to excess leaching of nutrients from the soil resulting in poor crop health and poor yield performance. Remoteness and less accessibility still being common in hills, the availability of resources like seeds, planting materials, animals, feeds, veterinary medicines etc. is still moderate to high which still adds the struggle to complete change to advanced technologies. The inputs for agriculture are not easily accessible in this village. Shri. Kumar Tamang Pakhrin fully engaged in agriculture right after his college. Earlier, he earned a handsome income from a Darjeeling mandarin orange orchard, but he was not getting much income from his mandarin orange orchard since last few years due to declining in yield with smaller fruit size which might be happened because of many reasons such as old and nutrient-exhausted plants; low soil nutrient content, long dry spells during winter lasting until flowering and temperature rise and shift in seasons, lack of irrigation facility, problems of dieback, trunk borer, fruit fly, leaf eating caterpillar, leaf miner, citrus psylla, foot and root rot, powdery mildew and above all poor farm management. To address those problems, he received training from Kalimpong KVK (Krishi Vigyan Kendra) and developed an IF system that allowed him to diversify her income streams. Shri. Tamang Pakhrin's case story highlights the potential of horticulture-based integrated farming as a viable alternative to conventional agriculture for sustaining in farming. The objective of this study is to explore how Shri. Kumar Tamang Pakhrin developed a horticulture-based integrated farm in the remote hilly farming eco-system regardless of various limiting factors.

Farm description

Shri. Kumar Tamang Pakhrin has 2.0 ha (15.0 bigha) of hilly terrain land in Sakyong village of Algarah II block of Kalimpong district. This farm is 11.0 km away from Kalimpong town. The soil of this location is loamy. Shri. Pakhrin has been practicing various agricultural activities in his farm for sustainable agriculture. At present the value of 2.0 ha of agricultural land is about Rs. 50.0 lakhs.

Having the awareness of risk minimization by developing integrated farm and farming practices and its ability to keep the farm economy viable during the failure of other components, Shri. Pakhrin is practicing various agricultural systems in his farm for sustainable agriculture. Shri. Tamang Pakhrin mainly cultivates cole crops, potato, garden pea during rabi season and pumpkin, squash, turmeric and dalle chilli during kahrif season. Fruit crops such as mandarin orange and guava are grown in his field for self-consumption as well as for marketing. He cultivates maize as cereal crop during zaid season and marshium as pulse crop during rabi season. He mainly focuses on growing dalle chili because of maximum returns. He has 3 numbers of Jersey crossbred cows, 3 numbers of Hampshire pigs and 8 numbers of local poultry birds for every production cycle. Except spices, the farm produces are mostly used for home consumption purpose and then sold. The demand for animal protein sources like milk, egg and meat is high in Kalimpong hills, however, he first fulfils his home need of animal protein from his farm produces and then sells the excess. He maintains a fodder unit of an area of 1.8 bigha, where he grows hybrid maize, hybrid napier and cowpea for feeding the cattle. He has a vermicompost unit where organic waste such as kitchen scraps, crop residues and animal manure are used. He has also 5 number of modern beehives where he rears the Indian bee colonies, *Apis cerana indica* for honey production. He has one polyhouse unit where nursery saplings are grown under optimal conditions such as temperature, humidity and light intensity to ensure the production of healthy and disease-free saplings. A pictorial description of his endeavour is shown in Figure 2.

Shri. Tamang Pakhrin having been trained by KVK Kalimpong and elsewhere has adopted many good agricultural practices in making his farm technically feasible to maximize productivity and profit as mentioned below.

- The farm has greater diversity in crops and livestock to fetch more income and adapt to local circumstances.
- Crop rotation by cultivating different crops in different seasons in a sequential manner has not only helped in maintaining the soil fertility of the farm land, lowering the frequent prevalence of insects and diseases, but also reduced the use and need of chemical fertilizer. The rotation of crop includes of leguminous crops which naturally replenish the soil nitrogen content thereby preserving the available natural resources.
- The use of organic fertilizers such as cow dung, poultry manure, vermicompost etc. in the crop field enhances the soil organic matter and promotes the beneficial microbial activity for nutrient availability to the crops.
- Working with traditional agricultural practices, the advanced technologies like the use of hand tiller for land preparation, sowing of the seeds and other purposes have been incorporated.

Figure 2: Various farming components in Shri. Tamang Pakhrin's farm

- By maintaining beehives on the farm, an adequate pollination for crops, resulting in higher yields and better-quality produce is ensured.
- The rearing of livestock along with the crops grown in the land supports the economic stability, and even after the constraints of remote vicinity of the hilly village, the livestock is well looked after by using vaccines in time and veterinary services like artificial insemination for breeding purpose of the cattle as and when necessary, feeding the livestock with vitamin-mineral mix to maintain their health and keeping their shelter clean and dry.
- In an IF, the choice of crops as well as their cropping pattern in a calendar year and also its merit as regard to supply of input for other enterprises is important. Shri. Tamang Pakhrin's farm plan throughout the year is reliable and deserves merit. His cropping pattern in three seasons is depicted in Table 1.

Table 1: Farm of Shri. Kumar Tamang Pakhrin showing cropping sequence of different crops round the year

Season	Cereal	Pulse	Vegetables	Spice	Fruit plants	Other enterprises
Kharif	Maize	Marshium	-	-	Guava	Fodder cultivation, Vermi-ocompost, Bee keeping, Nursery saplings
Rabi	-	Green pea	Potato Cole crops Cucumber	-	Mandarin Orange	
Zaid	-	-	Pumpkin, Squash	Dalle chilli, Turmeric	-	

Farm layout

The layout of Shri. Pakhrin's IFS is shown in Figure 3.

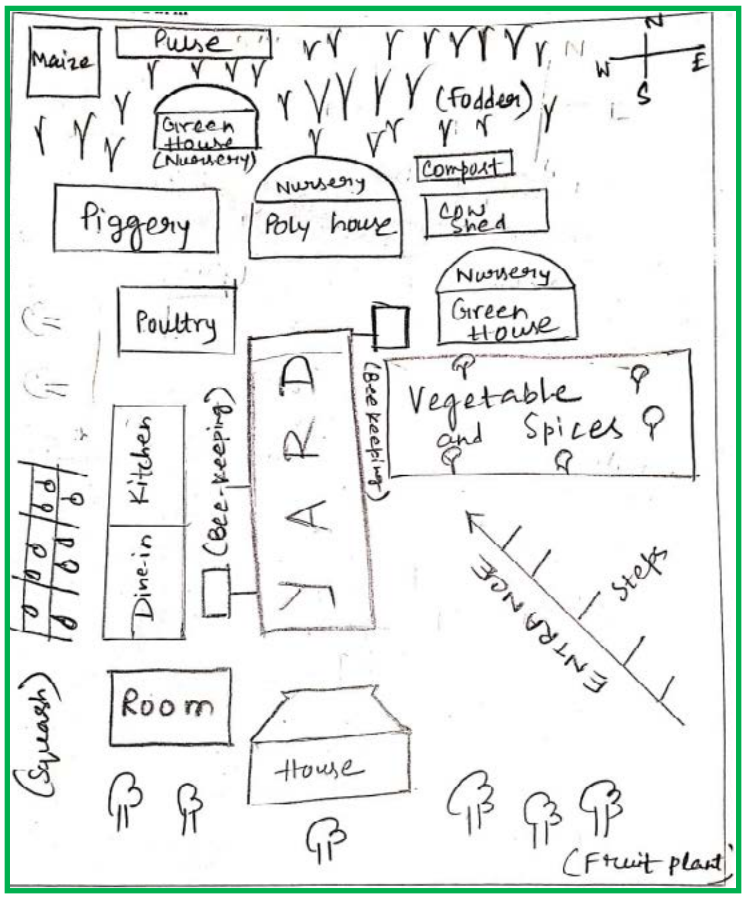


Figure 3: A farm layout with different components of Shri. Pakhrin's farm

Capital cost with financial assistance, if any

To develop such kind of IFS, there is an involvement of capital cost. Though Shri. Tamang Pakhrin received the technical guidance of government institutions, like KVK, line department etc., he did not receive any financial support from any agency. The involvement of capital cost details is given below (Table 2).

Table 2: Capital cost for developing Shri. Pakhrin's farm

Item	Area (Sq. ft.)	Cost per unit (Rs.)	Total cost (Rs.)
Cattle shed	300	12,193.00 per 100 sq.ft.	36,579.00
Pig shed	400	12,544.00 per 100 sq.ft.	50,176.00
Poultry shed	200	14,227.00 per 100 sq.ft.	28,454.00
Vermicompost unit	800	3,000.00 per 100 sq.ft.	24,000.00
Polyhouse	1500	4,000.00 per 100 sq.ft.	60,000.00
Cost of Mandarin Seedling	52 no.	200.00 per seedling	10,400.00
Cost of guava Seedling	45 no.	80.00 per seedling	3,600.00
Bee hive	5 no.	5,200.00 per hive	26,000.00
Total Cost			**2,39,209.00**

Bio-economic circularity of the farm

The case of IF depends on the efficiency of bio-economic circularity of the farm. The concept of circularity has been applied properly by Shri. Tamang Pakhrin which minimizes waste and maximizes resource efficiency. By adopting this approach, inputs and outputs of the farm are carefully managed to ensure minimal environmental impact and maximum economic returns. One of the key components of his farming system is horticulture along with some field crops, which involves the cultivation of fruits, vegetables, cereals and pulses crops. It provides a diverse range of crops that not only contribute to food security but also have high market value. By growing a variety of crops, Shri. Pakhrin is able to diversify his income streams and reduce the risk associated with relying on a single crop.

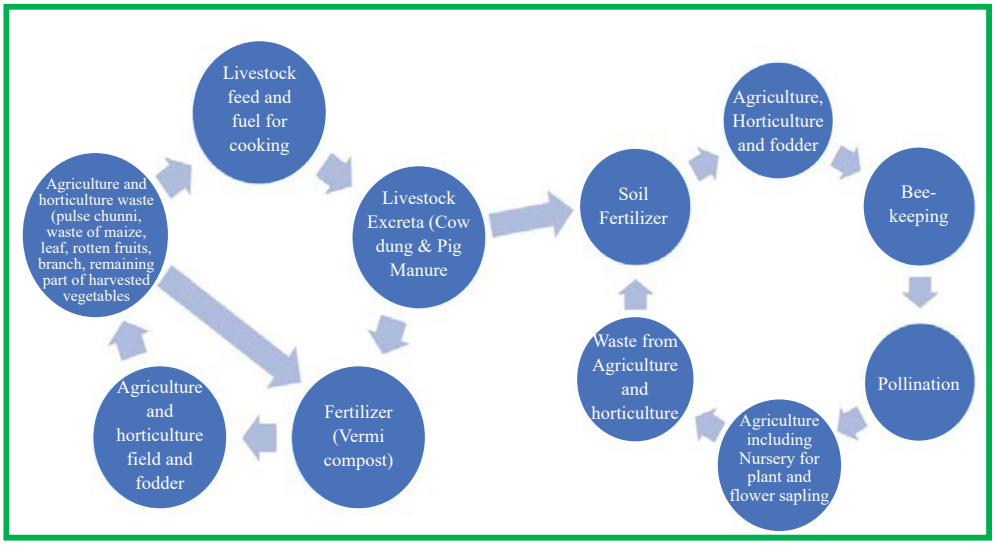


Figure 4: Flow diagram of resource recycling system at the farm of Shri. Pakhrin

Among the recyclable wastes as shown in the Figure 4, wide variety of foods including maize stubbles, grains from pulses, crop residues from vegetables, fruits are used as a source of livestock feed that reduces the dependence on external inputs to some extent and saves Rs. 9,500.00. On the other hand, recycling of livestock waste such as cow dung, pig manure and poultry birds' droppings are used as organic manure for field and horticulture crops and as an input material for vermicompost preparation with a net value of Rs. 14,700.00. Cow dung and urine have also been used for the preparation of Jeevamrit formulation. Jeevamrit is an organic microbial culture that contains beneficial microorganisms such as bacteria, fungi, and actinomycetes. These microorganisms help to improve soil health and promote plant growth by enhancing nutrient availability, suppressing harmful pathogens, and stimulating root development which ultimately minimizes slow decline of mandarin orange to some extent. Thus, a total of Rs. 24,200.00 is circulating as bio-economics in the whole integrated system of this farm.

Farm economic viability

Horticulture-based farming of Shri. Tamang Pakhrin is a profitable venture, where various sectors are contributing to the overall net income. Among different sub-sectors of horticulture unit as presented in Table 3, it is depicted that net income from spices crop is Rs. 70,600.00, vegetables contribute Rs. 55,650.00, and fruits generate Rs. 32,600.00. These figures highlight the profitability and potential of horticultural crops. In the livestock sector, cattle farming contributes the highest net income of Rs. 76,200.00, followed by pig farming at Rs. 35,500.00 and poultry at Rs. 2,580.00. These two sectors provide a stable source of income for his family. In regards to field crops, pulses generate a net income of Rs. 14,000.00, while cereals contribute Rs. 10,400.00. As compared to horticulture and livestock sector, it still plays a crucial role in diversifying the farm's revenue streams. Other enterprises such as fodder production, vermicompost production, beekeeping, and nursery saplings also contribute significantly to the net income. These enterprises generate a combined net income of Rs. 90,900.00. This highlights the importance of diversification and exploring alternative sources of revenue in horticulture-based farming. The net income sharing percentage from horticulture stands at 41%, followed by livestock at 30%, other enterprises at 23%, and cereals at 6% as shown in Figure 5.

Overall expenditure in this farming system is Rs. 1,87,700.00. This includes various costs such as labour, inputs, equipment maintenance, and other operational expenses. However, despite these expenditures, the gross income from horticulture-based farming reaches to Rs. 5,76,130.00. As a result, the net profit from the farming of Shri. Tamang Pakhrin stands at Rs. 3,88,430.00. This demonstrates the profitability and potential of horticulture-based IF.

Table 3: Annual economics of Shri. Tamang Pakhrin's integrated farm

Component	Area	Production (kg)	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereal (Maize)	3.00 bigha	800	5600.00	16,000.00	10,400.00
Pulse (Marshium, Garden pea)	1.80 bigha	540	14,200.00	28,200.00	14,000.00
Vegetables (Potato, Pumpkin, Cole crops, Cucumber, Squash)	5.1 bigha	5240	23,400.00	79,050.00	55,650.00

Component	Area	Production (kg)	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)
Spices (Turmeric, Dalle chilli	0.87 bigha	605	20,400.00	91,000.00	70,600.00
Fruit plants (Guava, Orange)	0.45 bigha	720	7,000.00	39,600.00	32,600.00
Cattle (Jersey crossbred)	3000 sq.ft.	3200 ltr milk	33,000.00	1,09,200.00	76,200.00
Pig (Hampshire)	400 sq.ft	320 kg meat, 3 piglets	20,000.00	55,500.00	35,500.00
Poultry (Desi)	200 sq.ft	180 pcs eggs, 8 kg meat	500.00	3,080.00	2,580.00
Other enterprises (Fodder cultivation, Vermi-compost, Bee keeping, Nursery saplings)	2.84 bigha	21,072	63,600.00	1,54,500.00	90,900.00
Total			**1,87,700.00**	**5,76,130.00**	**3,88,430.00**

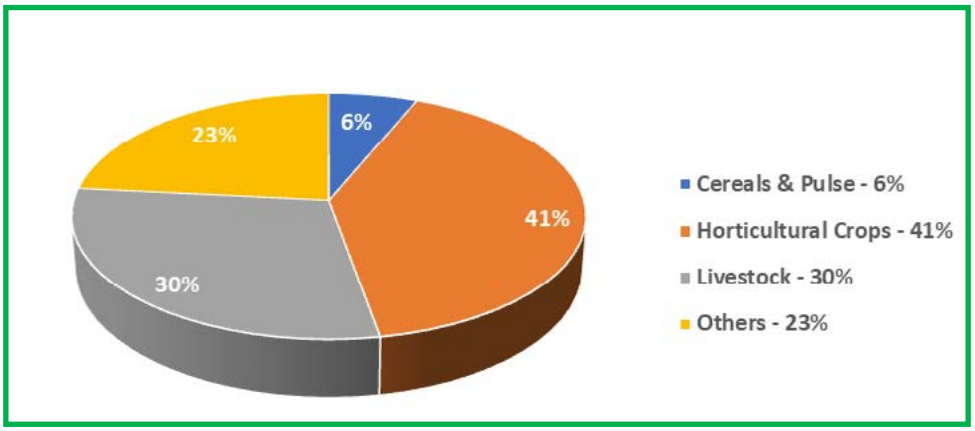


Figure 5: Annual net income sharing (in %) by different components at Shri. Tamang Pakhrin's horticulture-based integrated farm

Financial plan without bank loan

Considering the techno-economic facts and figures of Shri. Tamang Pakhrin's IF in 2.0 ha land, a finncial plan may be developed for an interested farmer who may not take any bank loan and thus invest the capital cost of Rs. 2,39,209.00 from his/ her own. Every year recurring cost of cultivation is considered as Rs. 1,87,700.00 and the capital cost will be recovered in five equal installments. A financial plan is presented in Table 4.

Table 4: Financial plan for area development scheme on horticulture-based integrated farm in 2.0 ha land (without bank loan)

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Capital cost	239209.00	191367.20	143525.40	95683.60	47841.80	0.00
2	Recurring cost of cultivation	187700.00	187700.00	187700.00	187700.00	187700.00	187700.00
3	Recovery of capital cost in equal installment	47841.80	47841.80	47841.80	47841.80	47841.80	0.00
4	Gross income	576130.00	576130.00	576130.00	576130.00	576130.00	576130.00
5	Net income	340588.20	340588.20	340588.20	340588.20	340588.20	388430.00
6	BC ratio	2.45	2.45	2.45	2.45	2.45	3.07

Financial plan with bank credit availability

Considering the techno-economic facts and figures of Shri. Tamang Pakhrin's IF in 2.0 ha land, a finncial plan may be developed for an interested farmer who may look forward for a bank loan to develop such an IF. The total project cost covering capital cost and 1st year recurring cost of cultivation will be based on economic data shown by Shri. Tamang Pakhrin as follows.

Project Cost = Capital Cost + 1st Year Recurring Cost = Rs. (2,39,209.00 + 1,87,700.00) = Rs. 4,26,909.00

A financial plan with bank loan facility is presented in Table 5.

Table 5: Financial plan for bankable area development scheme on horticulture-based integrated farm in 2.0 ha land

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Project Cost	426909.00					
2	Margin @ 15%	64036.35					
3	Bank loan	362872.65					
4	Yearly rate of simple interest @12.0% PA	12.00					
5	Loan O/S at the beginning of the year	362872.65	290298.12	217723.59	145149.06	72574.53	0.00
6	Accrual of interest	43544.72	34835.77	26126.83	17417.89	8708.94	0.00
7	Repayment of principal in equal installment	72574.53	72574.53	72574.53	72574.53	72574.53	0.00
8	Repayment of interest	43544.72	34835.77	26126.83	17417.89	8708.94	0.00
9	Loan O/S at the end of the year	290298.12	217723.59	145149.06	72574.53	0.00	0.00

Repayment plan

The repayment plan against bank loan may be as shown in Table 6.

Table 6: Repayment plan against bank loan

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Repayment of principal in equal installment	72574.53	72574.53	72574.53	72574.53	72574.53	0.00
2	Repayment of interest	43544.72	34835.77	26126.83	17417.89	8708.94	0.00
3	Recurring cost of cultivation	187700.00	187700.00	187700.00	187700.00	187700.00	187700.00
4	Gross income	576130.00	576130.00	576130.00	576130.00	576130.00	576130.00
5	Net income	272310.75	281019.70	289728.64	298437.58	307146.53	388430.00
6	BC ratio	1.90	1.95	2.01	2.07	2.14	3.07

Conclusion

Based on the overall findings of Shri. Tamang Pakhrin's horticulture-based integrated farm, it can be concluded that the farm has achieved high levels of crop diversity. By growing a wide range of fruits, vegetables, spices, cereals and pulses, he has not only increased the variety of produces available but also reduced the risk of crop failure due to pests or diseases. This diversification has also allowed him to cater to different market demands and increase his income streams. He has created a healthier and more environmentally friendly production system. The methods such as composting, vermicomposting and biological pest control have not only improved soil fertility but also enhanced the overall quality and taste of the produces. Additionally, the integration of livestock, such as cattle, pigs and poultry birds into his farm has allowed for efficient nutrient cycling through manure production, reducing the need for external inputs. Moreover, these animals provide he gets milk, egg and meat which provide a source of protein-rich food for his family. By adopting sustainable practices and producing high-quality produces, he has gained a reputation as a reliable supplier within the local market. Shri. Tamang Pakhrin's horticulture-based integrated farm is a successful model in maximizing the profit with the annual net income Rs. 3,88,430.00 from 2.0 ha of land area indicating an annual net income Rs. 1,94,215 per ha with a benefit cost ratio of 3.07. The farm's high crop diversity, efficient resource management, and positive impact on the local community make it a noteworthy example for others in the field of horticulture-based integrated farming. This horticulture-based IF is a best example for making a technically feasible and an economically viable area development strategy for hill agro-climatic zone of West Bengal.

Maximizing income from spices cultivation in horticulture-based integrated farming in Kalimpong hills

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Horticulture-based integrated farming

Name of the farmer: **Shri. Anand Kumar Chetri**

Area of the farm: 2.4 ha

Location of the farm: Sangsey village, Algarah-II block, Kalimpong district

Shri. Anand Kumar Chetri's horticulture-based integrated farm is located on 2.4 ha of hilly terrain in the Kalimpong hills of West Bengal. Despite common hill farming challenges such as soil erosion, crop damage from heavy precipitation, water scarcity in summer, occasional hailstorms in winter, predator attacks, and market accessibility issues, Shri. Chetri has adopted sustainable agricultural practices. By employing a rotational cropping system, he successfully cultivates cereals, pulses, and vegetables across different seasons. His cash crops include spices and golden apples. The integration of cattle, goats, and poultry ensures a continuous flow of farm resources, maintaining the farm's bio-circularity. Income analysis shows that an annual net income of Rs. 3,66,100.00 can be achieved from 1.0 ha, with a resource use efficiency of Rs. 3.40 per rupee invested. The highest annual net income comes from horticultural crops (56.47%), followed by the livestock sector (36.19%). The remaining 7.34% is derived from cereals, pulses, broom grass, and vermicomposting. Shri. Anand Chetri's farm not only generates a significant income but also meets his family's nutritional needs with fresh, wholesome produce. This horticulture-based integrated farm is a testament to technical feasibility and economic viability in a hill agro-climatic setting.

Key Words

Integrated Farming, Sustainability, Horticulture, Agriculture, Livestock, Vermi-compost, Bio-circularity, Hill Farming, Agri-tourism

Figure 6: A horticulture-based integrated farm of Shri. Anand Kumar Chetri

Introduction

Shri. Anand Kumar Chetri, 46 years old farmer, is hailing from Sangsey village of Algarah-II block of Kalimpong district. He has developed a horticulture-based integrated farm at his farm covering 2.4 ha (18 bigha) of hilly terrain land. More than 80% of the total population of Sangsey village depends on farming for their livelihoods. Shri. Anand Kumar Chetri was born in a farmers' family. In the year of 1991, when he passed 10th, he left the school and joined with his parents in farming. In 2015, Shri. Anand Chetri came to know about the integrated farming from Kalimpong Krishi Vigyan Kendra. The weather of Sangsey is cold. But the weather has never been a constraint for farming. The soil is loamy. Though it is rain-fed agriculture in Kalimpong, the spring water is the source of irrigation during rabi and zaid seasons. The agro-climate of Kalimpong district supports the growing of horticultural crops. Kalimpong is well known as a hub of cash crops like ginger, cardamom, apple and oranges. Dalle Khursani (*Capsicum annuum*), a variety of round shaped small, but extremely hot chili, is well grown in the hilly farming situation of Kalimpong. There are several difficulties in cultivating crops in hilly region. Soil erosion, more frequent and heavy precipitation increase the risk of crop damage from flooding. Water scarcity during summer, sometimes hailstorm during winter, weed problem, predator attack etc. also affect the crops. Sangsey is a village located 12 km away from Kalimpong town. The inputs required for farming is not abundant here. Integration is the best process to continue farming here. Of particular interest is to explore how Shri. Anand Kumar Chetri is managing all these problems efficiently to develop a horticulture-based integrated farm in the remote hilly farming eco-system.

Farm description

In horticulture-based integrated farm, Shri. Anand Chetri focusses on cultivation of spices like large cardamom, dalle chilli, ginger and coriander. He also cultivates seasonal vegetables like squash in kharif season and potato, radish and peas during rabi season. Shri. Anand has 40 number of golden apple fruit plants. Considering the rising demand for persimmon, a yellow to orange coloured sweet exotic fruit resembling tomato, he has started the plantation of persimmon fruit tree at his farm. Shri. Anand cultivates maize as cereal crop during kharif season and green pea as pulse crop during rabi season. He has some forest trees and broom grass which provide a handsome amount for earning. Shri. Anand has 4 number of Jersey crossbred cows, 22 number of goats and 11 numbers of local poultry birds along with a stock of 40 number broiler birds for every production cycle. Except spices, the farm produces are mostly used for home consumption purpose rather than selling. The demand for animal protein sources like milk, egg and meat is high in Kalimpong hills, however, Shri. Anand first fulfils his home need of animal protein from his farm produces and then sells the excess.

Figure 7: Homestay of Shri. Anand Chetri

On 2022, Shri. Anand Chetri has decided to take advantage of the beautiful viewpoint of Kanchenjunga Mountain near his house. A clear view of 'Sleeping Buddha' along with the Kanchenjunga peak is a great attraction of tourists. So, he started a new business of homestay, '*The Golden Apple*' with a target to enhance the scope of agri-tourism. The peak seasons of tourism are mainly from September to November and from February to April, when the tourists can enjoy the mesmerizing view of mountain range as well as the freshly peaked golden apples of Anand's garden. He also decorated the homestay with various kinds of ornamental plants to give an aesthetic look to his farm cum homestay unit. He received financial aid from Block Tourism Department of Kalimpong. He invested Rs. 30.00 lakhs for setting up the 2-storied homestay and he is earning a gross income of Rs.1,00,000.00 per month during the peak season. Anand is very much auspicious for his current venture along with the integrated farming.

Shri. Anand has adopted sustainable agricultural practices by following rotation system approach in growing a sequence of different crops in different seasons on the same land for maintaining soil fertility and enabling the available natural resources to be preserved

Figure 8: Kanchenjunga view from homestay

Figure 9: The golden apple of the garden

and utilized more efficiently and helping in control of insects and diseases. He prepares organic manure using wastes of livestock and crops and applies it in agriculture fields. Shri. Anand uses a small hand tiller for preparing soil, sowing seeds and other purposes. He is aware of risk minimization in such integrated farm where one component can keep the farm economy viable during the failure of another component. Remoteness and less accessibility are common in hills. Still, the availability of resources like seeds, planting materials, animals, feeds, veterinary medicines etc is moderate to high. Shri. Anand manages to use artificial insemination for breeding purpose of the cattle in remote hilly village. Nevertheless, he takes all the preventive measures in protecting livestock from diseases using vaccines in time and veterinary medicines as and when necessary. He is very particular about feeding vitamin-mineral mix with feed to the farm animals. He takes care to keep his farm animals in proper and clean shelter.

Table 7: Different crop and animal components at the farm of Shri. Anand Kumar Chetri

Season	Cereal	Pulse	Vegetables	Spice	Fruit Plants	Forest Grass	Cattle	Goat	Poultry	Other Enterprise
Kharif	Maize	-	Squash	Large cardamom, Coriander, Dalle chilli	Golden apple, Persimmon	Broom stick	Jersey cross	Jamunapari Totapuri Izrailey	Desi & Broiler	Vermi-compost
Rabi	-	Green pea	Potato, Radish, Peas	-						
Zaid	-	-	-	Ginger						

West Bengal comes at a second place in cardamom production after Sikkim. Shri. Anand has grown 20,000 numbers of this golden crop, i.e., large cardamom plants for 3 years in a row. Not only he processes the dried cardamom, but also, he sells cardamom plants to the local farmers and the market. Shri. Anand and other farmers of Sangsey village process cardamom in a traditional mud furnace, which causes slight loss of flavour and quality. On the other hand, the farmers who are using machine for drying can produce better quality cardamom. The competition rises and the lower graded cardamom faces a price fluctuation from Rs. 2400.00/kg to Rs. 500.00/kg. Besides, there are the incidents of fungal disease in large cardamom plants. Hence, Anand has decided to shift in ginger and dale chilli more rather than producing large cardamom. Though the scope of value addition is high, the storage facility is poor.

Farm layout

The layout of Shri. Anand Kumar Chetri's IFS is shown in Figure 10.

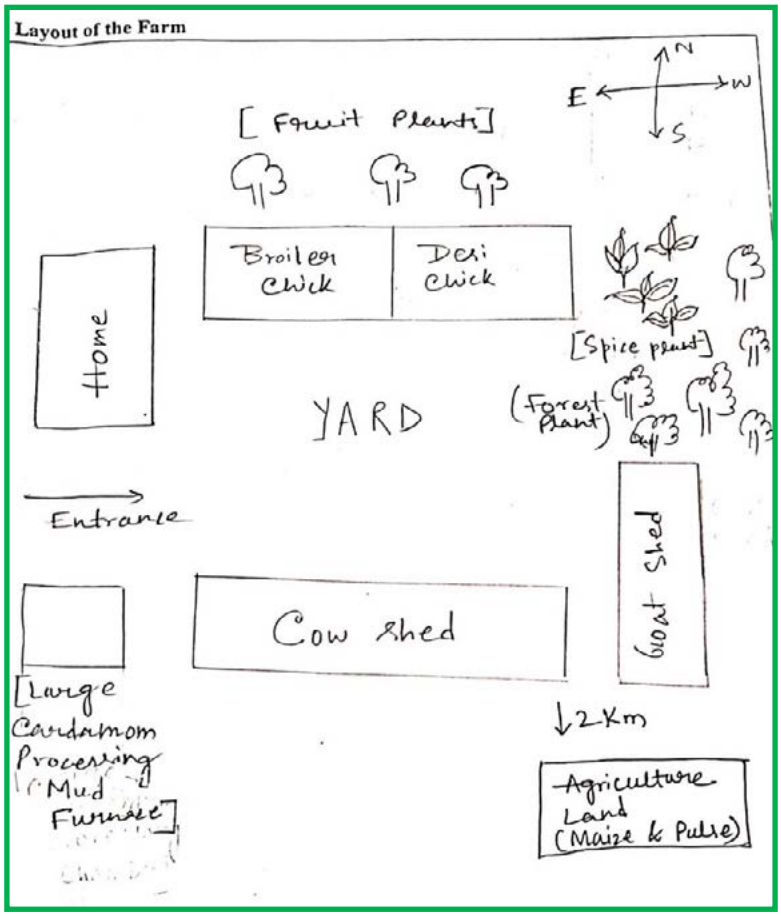

Figure 10: Farm layout with different components

Capital cost with financial assistance, if any

It may be worth mentioning here that the farmers who are willing to develop such kind of horticulture-based integrated farm should have an idea of the establishment cost of such farm. Thus, the capital cost for establishment of such IF is shown in Table 8.

Table 8: Capital cost for developing Shri. Anand Kumar Chetri's IFS

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/ Govt. contribution (if any) (Lakh Rs.)
Cow shed (33.44 m^2)	0.012/ m^2	0.40	0.1 from Agriculture department under Kishan Bandhu/year and 0.80 with the help of Kishan Credit Card
Goat shed (26.01 m^2)	0.023/ m^2	0.60	
Poultry shed (33.44 m^2)	0.009/ m^2	0.30	
Spice garden (6.3 bigha)	0.04/bigha	0.30	
Agriculture land (5 bigha)	0.08/bigha	0.40	
Fruit plants & Agro-forestry (6.65 bigha)	--	0.25	
Cardamom furnace (1 unit)	(0.1/unit)	0.10	
Small implements including vermicompost and miscellaneous	--	0.30	
Total Cost		2.65	

Bio-economic circularity of the farm

Shri. Anand Chetri is not aware of the term 'integrated farming', but he knows how to use waste of one component as input to another component and maximize production and minimize the cost of cultivation as well as environmental pollution. Figure 11 shows that the waste residues from agriculture produces are used as feed resources for livestock and livestock excreta is utilized in preparing vermi-compost which is applied in agriculture field for crop production. Post-harvest wastes of cereal, pulse, spices, vegetables and fruit plants including leaves of forest trees costing Rs. 14,500.00 are used as feed resources for livestock, while the cost of cow dung, goat and poultry droppings is Rs. 22,000.00 that is used for preparing vermi-compost and subsequent use in agriculture field for crop production. A total of Rs. 36,500.00 is circulating as bio-economics in the whole integrated system of this farm.

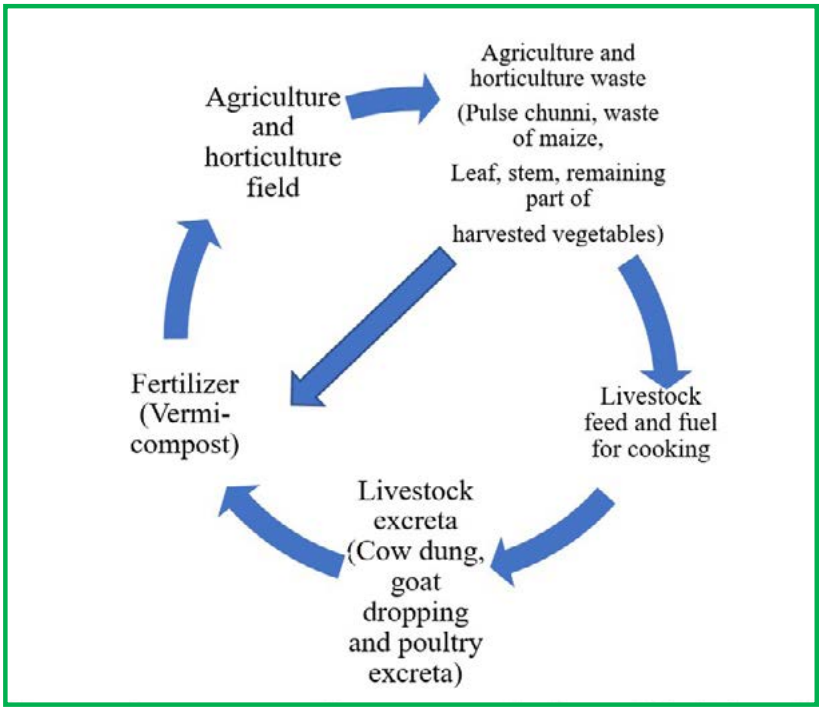

Figure 11: Flow diagram of resource recycling system at the farm of Shri. Anand Chetri

Farm economic viability

In horticulture-based integrated farm, Shri. Anand Chetri recorded the highest net income from spices (Rs. 4,08,500.00) followed by goatery (Rs. 2,12,000.00), poultry (Rs. 61,976.00) and fruit plant (Rs. 40,000.00) as shown in Table 9. He realized the same net income from dairy (Rs. 36,000.00) as well as broom grass (Rs. 36,000.00). Shri. Anand Chetri fetched a good amount of profit from vegetables (Rs. 35,200.00), cereals (Rs. 15,000.00) and pulse (Rs. 11,000.00) as depicted in Table 9. The highest annual net income sharing came from horticultural crops (56.47%) followed by livestock sector (36.19%) as shown in Figure 12. The cereal and pulse contributed 3.03% and others including broom grass and vermin-compost shared 4.31% of annual net income Figure 12. The income analysis revealed that from a small piece of land (2.4 ha), the annual gross income of Rs. 12,13,800.00 could be realized from an investment of Rs. 3,57,124.00 with a resource use efficiency of Rs. 3.40 per rupee invested and a generation of 900 mandays of employment costing Rs. 2,52,000.00 as labour wage including his own labour. According to Shri. Anand Chetri, an annual expense for household purposes covering food, education, health and others was Rs. 2,64,000.00. Since the total annual expense for household and farming purposes was Rs. 6,21,124.00 and the annual net income was Rs. 8,56,676.00, an annual saving of Rs. 5,92,676.00 could be possible from a horticulture-based integrated farm in a 2.4 ha area.

Table 9: Annual economics of different farm components

Component	Area	Production (kg)	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereal (Maize)	3 bigha	1,000	10,000	25,000	15,000
Pulse (Green Pea)	1.5 bigha	400	5,000	16,000	11,000
Vegetables (Squash, Potato, Radish, Peas)	2.4 bigha	3,400	23,000	58,200	35,200
Spices (Large cardamom, Dalle chilli, Coriander, Ginger)	6.61 bigha	610	98,500	5,07,000	4,08,500
Fruit plants (Persimmon, Golden apple)	0.65 bigha	240	12,000	52,000	40,000
Forest grass (Broom stick)	6 bigha	600	6,000	42,000	36,000
Cattle (Jersey crossbred)	360 sqft	2,400 L milk	48,000	84,000	36,000
Goat (Jaunapari, Totapuri, Izrailey)	280 sqft	180 kg meat, 20 goat kid	96,000	3,08,000	2,12,000
Poultry (Desi. Broiler)	360 sqft	60 kg meat 800 pcs eggs	57,624	1,19,600	61,976
Other enterprise (Vermi-compost)	30 sqft	200 kg	1,000	2,000	1,000
Total			**3,57,124.00**	**12,13,800.00**	**8,56,676.00**

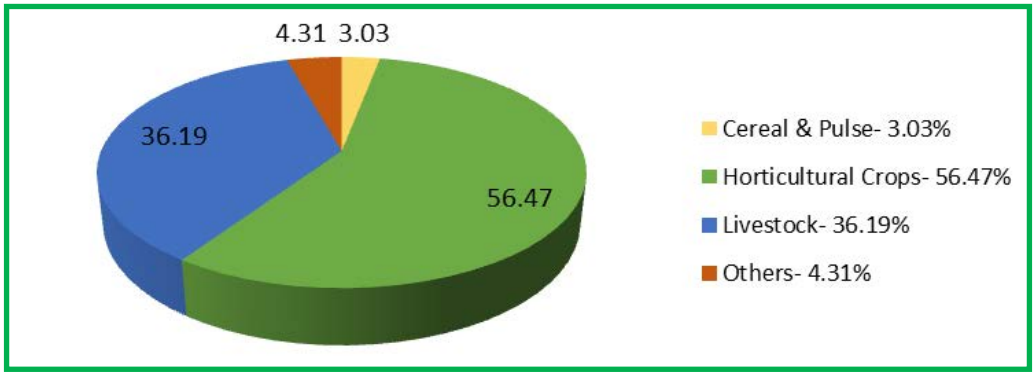

Figure 12: Annual net income sharing (in %) by different components at horticulture-based integrated farm

Conclusion

Farming with a variety of crops (cereal, pulses, vegetables, fruit plants including broom grass) has made the environment green and agriculture sustainable by adopting rotational cropping system. Shri. Anand Chetri is using only 1.4 katha area for animal husbandry which gives him a great return. Using less space to generate more income is a part of farm sustainability. Use of vermi-compost is also enhancing the soil fertility which is very much necessary for good agriculture practices. Shri. Anand Chetri is able to satisfy his 5-membered family nutritional demands of cereal, pulse, vegetables, fruits, milk, meat and egg from his farm grown agriculture and livestock produces. The availability of farm fresh and wholesome food items for nourishing the own family is more important than buying the same from the market. Shri. Anand Chetri wants to continue with the diversification of integrated farming and share his experience and knowledge of integrated farming with the neighbouring farmers for agricultural development in the area. Shri. Anand Chetri is concerned for his next generation who should continue farming. Hence, he wants to educate his children with higher farming knowledge to bring about more case in agriculture farming in near future. The story of Shri. Anand Kumar Chetri clearly indicates that developing horticulture-based integrated farm can technically be feasible and economically viable with a net return of Rs. 3,66,100.00 from a 1.0 ha land.

Piglet production system in livestock-based integrated farming brings wealth and prosperity in farm family

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Livestock-based integrated farming

Name of the farmer: **Smt. Durga Rai**

Area of the farm: 0.91 ha

Location of the farm: Sakyong village, Algarah-II block, Kalimpong district

Smt. Durga Rai owns a 0.91 ha plot in the Algarah-II region of Kalimpong district, West Bengal. For the past 35 years, she has been farming to support her family, gaining extensive experience in managing the natural calamities of the hilly region, seasonal livestock diseases, and various farming challenges. She has adopted a zero-waste farming system by integrating livestock with crop cultivation, striving to maintain the bio-circularity of her farm resources. Smt. Rai has specialized in piglet production through regular breeding of the sows to produce piglets and making a huge profit by selling the piglets. Income analysis reveals that her livestock-based integrated farm is yielding an annual net income of Rs. 1,96,280.00 from the 0.91 ha land, with a resource use efficiency of Rs. 1.70 per rupee invested. The highest annual net income sharing comes from livestock sector (57.96%) followed by horticulture crops (26.59%) and the rest (15.43%) is secured from cereal, pulse, fishery and bee-keeping. Through her farm, Smt. Durga Rai not only earns a significant income but also meets her family's nutritional needs with fresh, wholesome food. Her farm exemplifies the potential for technical and economic success in a livestock-based integrated farming system in a hilly agro-climatic zone.

Key Words

Integrated farming, Sustainability, Livestock, Pig, Horticulture, Agriculture, Bee-keeping, Bio-circularity, Hill Farming

Figure 13: Piggery at integrated farm of Smt. Durga Rai in Kalimpong

Introduction

Smt. Durga Rai, a 53 years old woman, hailing from Sakyong village of Algarah-II block of Kalimpong district. Being the head of her 7-membered family, she is running the family as well as the farming unit very efficiently. Being married at a young age, she confronted poverty and observed migration of people to other cities for employment purpose. But she always wanted her family to stay together at any situation. She took a decision to utilize the 0.91-hectare land which she got at best resource. She also involved her family in farming and started growing vegetables, spices and fruits as well as rearing livestock. Her sons are doing some local seasonal job and also involved in farming practices. At first, she just kept adding various components in her farm and followed the mixed farming system. But as she came in contact with the Subject Matter Specialists of Kalimpong Krishi Vigyan Kendra, she perceived an idea of integrated farming system. She started to include the components and use the waste of one component as input to another component. Thus, she is maintaining an integrated farming system with a total of 8 components. She is utilizing the spring water through irrigation channel in rabi and zaid season while depending on monsoon rain and spring water in kharif season. She cultivates maize, green pea, vegetables, i.e., potato, cabbage, cauliflower, broccoli, spinach, cucumber, spices like ginger, garlic, Dalle Khursani chilli and turmeric, fruit plants like guava and peach in 5 bigha land. Smt. Durga Rai rears an unit of 98 pigs and piglets of different breeds, 12 goats including local and crossbred goats, 15 desi poultry and 12 Khaki Campbell ducks. She has made a small reservoir to culture fish and installed 5 bee-keeping boxes to start apiculture. Sakyong village is located 15 km away from the Kalimpong town. The inputs needed for the farming is costly here. Still Smt. Durga Rai manages to combat the effect of inflation through integrated farming system where she can cut the cost through the usage of waste of a component as a form of input to another component.

Figure 14: Goatery in integrated farm of Smt. Durga Rai in the hilly farming eco-system

Figure 15: Fruit plants in integrated farm of Smt. Durga Rai in the hilly farming eco-system

Farm description

In livestock-based integrated farm, Smt. Durga Rai and her family give a substantial amount of time and effort in livestock rearing. The demand of pork platters is high in fast food chains and restaurants predominantly in Kalimpong hills. Smt. Durga Rai realised that rearing pigs would be a profitable venture. Smt. Durga Rai started with 10 pigs initially, now she owns 98 pigs and piglets. She expressed that it was her husband's idea to breed the pigs for more production. So, they bought healthy quality male and female pigs with the aid of Krishi Vigyan Kendra personnels and bred them successfully. She gets maximum profit from piggery followed by goatery and poultry. She has 39 Duroc, 28 Hampshire and 31 Yorkshire breed of pigs and piglets. She takes well care of the pigs by keeping them in a pakka 6500 sq.ft shed with separate compartments for piglets and adult pigs. The shed has a well-planned drainage system as well. She mostly sells piglets for earning profit. She prefers to keep the adult pigs for breeding purpose, but sometimes she sells the adult pig for meat purpose. Smt. Durga Rai also makes profit from goatery. She has 7 local goats and 5 crossbred goats. Smt. Rai has made wooden frame shelter for the goats. She sells goat kid as well as the adult goat for meat purpose. She started poultry farming with 15 desi poultry birds and 12 Khaki Campbell ducks predominantly for home-consumption of eggs and meat. She follows periodic deworming and vaccination schedule of livestock very meticulously. She also mixes vitamin and mineral in right proportion to the feed of the livestock for a healthy growth of the animals. The sheds are kept clean by using mild disinfectants whiling cleaning.

Winter is a crucial season, when Smt. Durga Rai and her family remain very busy to take special care of livestock and spend time to cultivate pulse, vegetables, spice and fruits mostly in this season. She cultivates green pea, seasonal vegetables like potato, cabbage, cauliflower, broccoli, spices like garlic and harvest fruits from peach tree. In summer time, she grows maize, squash, cucumber, spices like ginger, turmeric and dalle chilli. She has 10 guava plants of different varieties. She also set up a small experimental fishery unit by holding water in a small reservoir. She released some carp which she received from KVK Kalimpong. KVK personnels also inspired her to install 5 bee keeping boxes. With her 35 years of farming experience, she understands the demand of her farming components in her locality, so she adjusts the supply of the produces according to the demand. Smt. Durga Rai sells her produces as well as meets the demand for food for family especially the protein source from her farm.

Smt. Durga Rai has adopted zero-waste and sustainable farming practices by following 'waste to wealth' process of integration between horticulture and livestock. She uses a small hand tiller for preparing soil, sowing seeds and other purposes. She believes that integrated farming system provides a risk minimization model where one component supports if other component fails to gain economic return. In a livestock-based farm, there is a constant demand of water, feed, supplements, medicines, vaccines and other materials. She arranges an ample amount of water for cleaning the pigs and their shed every day. Thus, she bears a huge amount of expense for arranging water for the livestock. Though it was a 'no-profit-no loss' situation at the beginning, she now fetches profit in recent times. The cultivation of seasonal vegetables and spices and fruits like guava and peach gives her a good return.

Table 10: Different crop and animal components at the farm of Smt. Durga Rai

Season	Cereal	Pulse	Vegetables	Spice	Fruit Plants	Pig	Goat	Poultry	Other Enterprise
Kharif	-	-	-	-	Guava, Peach	Duroc, Hampshire & Yorkshire	Desi & Crossbred	Desi & Khaki Campbell	Bee keeping
Rabi	-	Green pea	Potato, Cabbage, Cauliflower, Broccoli	Garlic					
Zaid	Maize	-	Squash, Cucumber	Ginger, Turmeric, Dalle Chilly					

Farm layout

The layout of Smt. Durga Rai's IFS is shown in Figure 16.

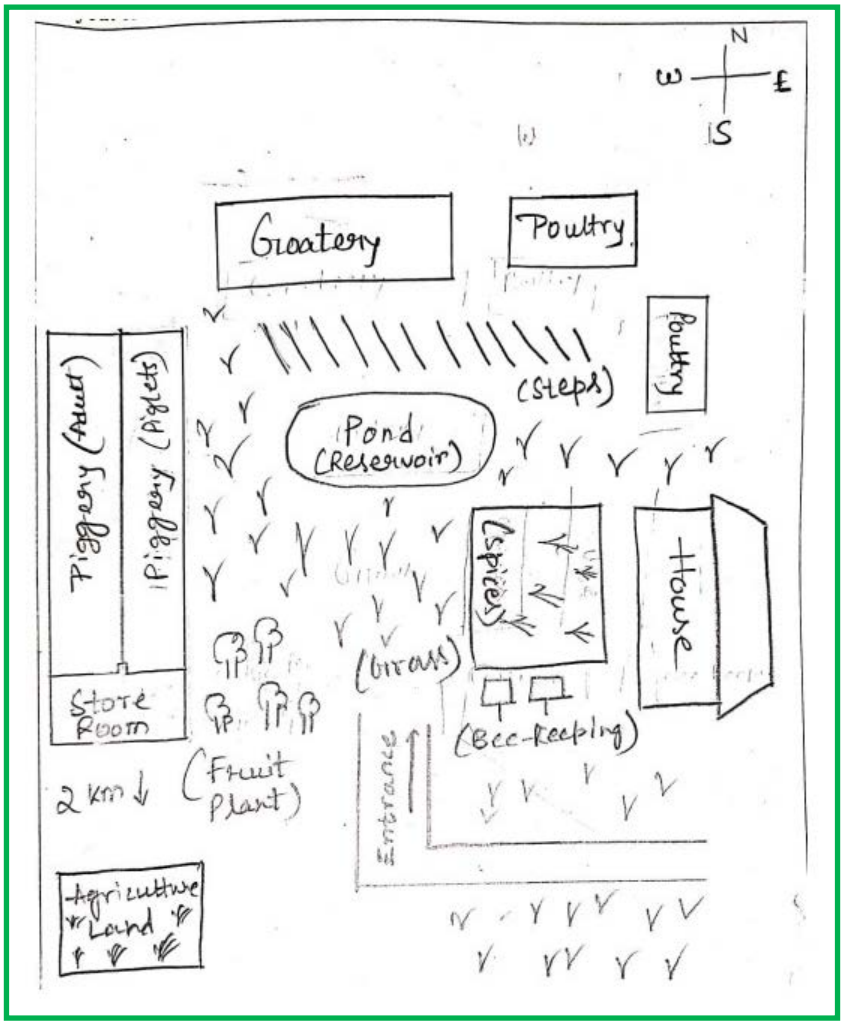

Figure 16: A farm layout with different components

Capital cost with financial assistance, if any

The involvement of capital cost to develop such integrated farming is presented in Table 11.

Table 11: Capital cost for developing the integrated farm of Smt. Durga Rai

Item	Area (Sq. ft.)	Cost per unit (Rs.)	Total cost (Rs.)
Pig shed	650	12,544.00 per 100 sq.ft.	81,536.00
Poultry shed	200	14,227.00 per 100 sq.ft.	28,454.00
Goatery shed	200	11,345.00 per 100 sq.ft.	22,690.00
Duckery Shed	180	9,584.00 per 100 sq.ft.	17,251.00
Pond for fishery	400	250.00 per sq.ft.	1,00,000.00
Polyhouse	1200	4,000.00 per 100 sq.ft.	48,000.00
Cost of guava Seedling	25 no.	80.00 per seedling	2,000.00
Bee hive	3 no.	5,200.00 per hive	15,600.00
Total Cost			**3,15,531.00**

Bio-economic circularity of the farm

Smt. Durga Rai started her farm with mixed farming. Initially, she was not aware of integrated farming system. The waste material from the livestock sections was not utilized before as fertilizer. When she came to know about the integration, she made use of all the components. The excreta of pigs are channelized after cleaning the shed through the drain to use as pig manure at agriculture and horticulture fields. The goat excreta are mixed with leaves to prepare a compost. The compost is used for cultivation of vegetables and spices. The residue portion of vegetables and leaves of fruit trees are used as livestock feed. Bee-keeping helps in better pollination in agricultural crops. The post-harvest wastes of cereal, pulse, spices, vegetables and fruit plants including grass costing Rs. 3,200.00 are used as feed resources for livestock, while the cost of pig faeces, goat and poultry droppings is Rs. 10,500.00 that is used for preparing compost and subsequent use in agriculture field for crop production. A total of Rs. 13,700.00 is circulating as bio-economics in the whole integrated system of this farm.

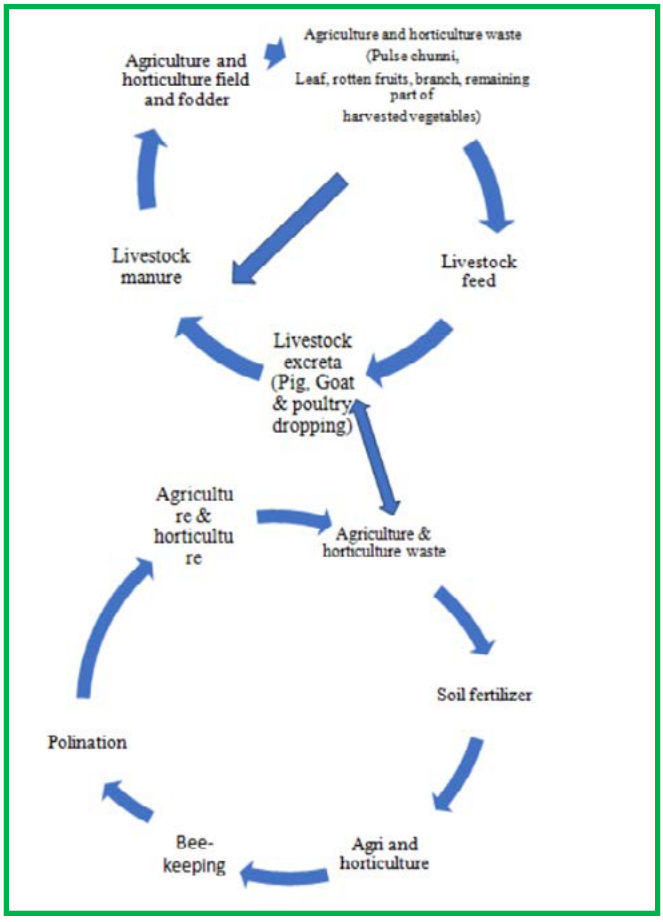

Figure 17: Flow diagram of resource recycling system at the farm of Smt. Durga Rai

Farm economic viability

In livestock-based integrated farm, Smt. Durga Rai has the highest net income from piggery (Rs. 60,000.00) followed by goatery (Rs. 36,800.00), spices (Rs. 26,000.00), poultry and duckery (Rs. 16,970.00), pulse (Rs. 15,000.00), vegetables (Rs. 19,830.00), bee-keeping (Rs. 9,400.00), fruit plant (Rs. 6,380.00), cereal crop (Rs. 4,000.00) and fishery (Rs. 1,900.00) as shown in Table 12. The income

analysis revealed that from a small farm piece of 0.91 ha area, the annual gross income of Rs. 4,74,670.00 could be realized from an investment of Rs. 2,78,390.00 with a resource use efficiency of Rs. 1.70 per rupee invested and a generation of a maximum 2000 days of mandays of employment costing Rs. 6,27,500.00 as labour wage. According to Smt. Durga Rai, an annual expense for household purposes covering food, education, health and others was Rs. 2,51,000.00, which was mostly borne by her sons' local seasonal job as well as from the profit from farming. Since the total annual expense for farming purposes was Rs. 2,78,390.00 and the annual gross income was Rs. 4,74,670.00, the annual net income was Rs. 1,96,280.00. The highest annual net income sharing came from livestock sector (57.96%) followed by horticulture crops (26.59 %) as shown in Figure 18. The cereal and pulse contributed (9.68%) and others including fishery and bee-keeping (5.75%) of annual net income (Figure 18).

Table 12: Annual economics of livestock-based integrated farm of Smt. Durga Rai

Component	Area	Production (kg)	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereal (Maize)	1.50 bigha	200	1,000/-	5,000/-	4,000/-
Pulse (Green Pea)	2.00 bigha	500	5,000/-	20,000/-	15,000/-
Vegetables (Squash, Cucumber, Potato, Cabbage, Cauliflower, Broccoli)	2.35 bigha	1660	12,070/-	31,900/-	19,830/-
Spices (Garlic, Dalle chilli, Ginger, Turmeric)	2.8 bigha	390	24,500/-	50,500/-	26,000/-
Fruit plants (Guava, Peach)	0.08 bigha	220	1,620/-	8,000/-	6,380/-
Pig (Duroc, Hampshire, Yorkshire)	6500 sqft	77 piglets and 400 kg meat	1,80,000/-	2,40,000/-	60,000/-
Goat (Desi & Crossbred)	280 sqft	4 goat kid, 40 kg mea	31,200/-	68,000/-	36,800/-
Poultry (Desi chicken)	360 sqft	1440 eggs, 30 kg meat	12,000/-	20,640/-	8,640/-
Duckery (Khaki Campbell duck)	180 sqft	1260 eggs, 5 kg meat	3,000/-	11,330/-	8,330/-
Fishery	100 sqft	35 kg fish	3,000/-	4,900/-	1,900/-
Other enterprise (Bee-keeping)	0.01 bigha	18 kg	5,000/-	14,400/-	9,400/-
Total			**2,78,390/-**	**4,74,670/-**	**1,96,280/-**

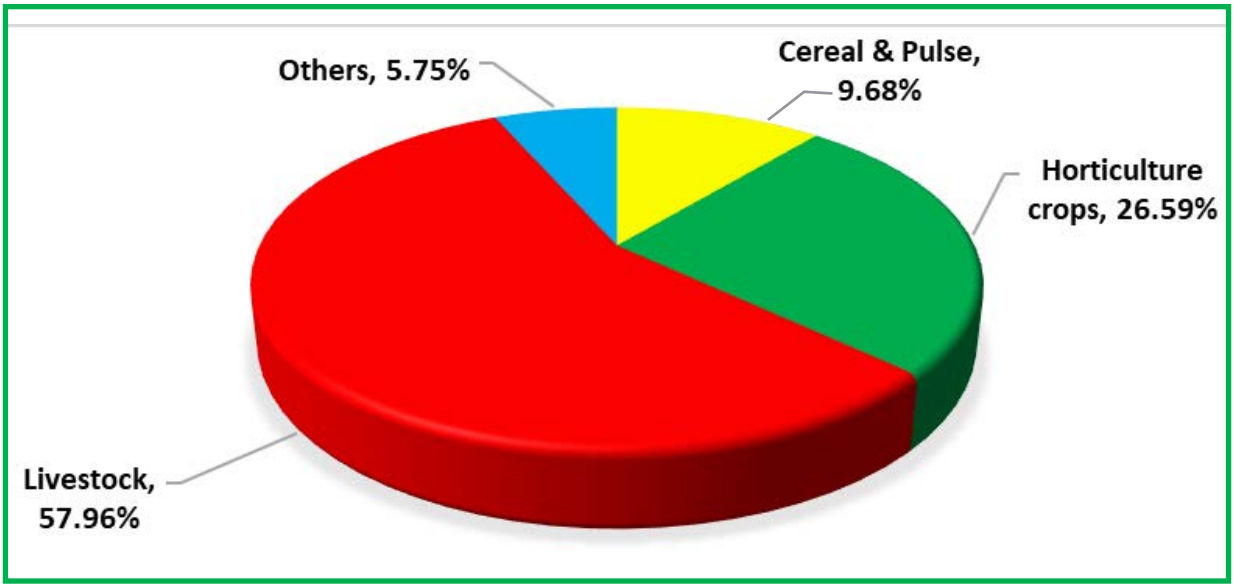

Figure 18: Annual net income sharing (in %) by different components at livestock-based integrated farm

Conclusion

Smt. Durga Rai understands that demand for protein-rich food is increasing day by day. She has a vision of diversifying livestock production especially her goatery and poultry section in order to earn more profit. She believes that her farm is in a growing stage. She uses only 6.52 katha of her total 7 bigha land for livestock rearing purpose which gives her a notable return annually. Generation of income using less space is also a contribution towards sustainability. The farming with a variety of crops (cereal, pulses, vegetables, spices including the fruit plants) has made the farm environment green. Using pig manure, goat dropping and leaves for making compost enhances the soil fertility which is crucial for good agriculture practices. The story of Smt. Durga Rai clearly indicates that developing livestock-based integrated farm can technically be feasible and economically viable with the net income of Rs. 1,96,280.00 from 0.91 ha land. Nevertheless, nourishing the own family with farm fresh vegetables, spices, fruits and eggs has its own benefits and value in terms of quality and cost.

Synergistic livestock and crop integration for sustainable agriculture in Kalimpong hills

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Livestock-based integrated farming

Name of the farmer: **Shri Rambahadur Basnet**

Area of the farm:1.25 ha

Location of the farm: Bong Busty village, Kalimpong district

Shri. Rambahadur Basnet has developed a thriving livestock-based integrated farm on 1.25 ha of hilly terrain in the Kalimpong hills of West Bengal. His diverse farm includes rearing cows, goats, and poultry, alongside the cultivation of various crops such as cereals, pulses, oilseeds, and vegetables, grown across different seasons. In addition to staple crops, Shri Basnet cultivates spices like dalley chilli and turmeric, as well as fruit crops including guava, papaya, and peach. This diversification not only maximizes the use of his land but also enhances the resilience and productivity of his farm. From an economic perspective, Shri Basnet's farm generates an impressive annual net income of Rs. 1,76,700.00. The majority of this income, 75.0%, is derived from the livestock sector, underscoring the significant role of animal husbandry in his farming operations. The cultivation of cereals, pulses, and oilseeds contributes 13.0% to his annual income, while the remaining 12.0% comes from the horticulture sector. The substantial income from his integrated farming activities allows Shri Basnet to comfortably manage his household expenses. His farm is an evidence to the viability and profitability of livestock-based integrated farming in hilly regions, demonstrating how strategic crop and livestock integration can lead to sustainable agricultural success..

Key words

Livestock, Integrated farm, Hilly terrain land, Bong Busty village, Kalimpong

Figure 19: A livestock-based integrated farm of Shri Rambahadur Basnet

Introduction

Shri Rambahadur Basnet, 49 years old farmer, from Bong Busty village of Kalimpong district, studied up to 9th standard. He has a small family with his wife, two daughters and one son. He has own farm with an area of 1.25 ha (approximately 5 bigha) and has been farming since his childhood age. Though he was cultivating paddy, maize and vegetables in his farm through conventional farming system regularly, he was not getting the expected income. He felt that doing agriculture in hilly terrain land was very difficult to cultivate. Soil erosion, more frequent and heavy precipitation increase the risk of crop damage. Water scarcity during winter is the major problem to hinder the better crop stand which ultimately affects the yield. To overcome the problems faced by him, he started searching the new method which could improve the farm productivity, soil health and income. He visited Kalimpong Krishi Vigyan Kendra (KVK) and had the chance to learn about the Integrated Farming System (IFS). With better support and guidance from KVK, he has developed a livestock-based IFS. This farming system involves the integration of various livestock species such as cows, goats and poultry with crop production on his farm. The livestock provide manure for the crops while the crops provide feed for the animals creating a mutually beneficial relationship. This system has made Shri. Basnet dependence on natural fertilizer in replace with external inputs such as chemical fertilizers and pesticides, making his farm more environmentally friendly.

Farm description

The farm of Shri. Rambahadur Basnet is an excellent example of a livestock-based IFS. The farm is located in a rural area and is surrounded by lush green fields and rolling hills, provide a serene and peaceful environment for the animals.

Shri. Basnet has 4 number of Jersey crossbreed cows, 21 number of goats and 12 number of desi poultry birds. The animals are kept in well maintained sheds that are cleaned regularly to ensure hygiene and prevent the spread of diseases. The sheds are equipped with feeders and water troughs to provide the animals with a constant supply of food and water. He is very particular about feeding vitamin-mineral mix

Figure 20: Integrated farm of Shri Rambahadur Basnet surrounded by lush green fields and rolling hills

with feed to the farm animals and about vaccination of his livestock in time. The cows are primarily used for milk production. He collects and processes milk cream into ghee and directly sells to the local market. The goats are raised primarily for meat production, while the desi chickens are kept for egg and meat production.

Shri. Basnet also grows a variety of cereal crops on his farm, including local variety of paddy – Jhapaka and maize, which serve as food for their home consumption and also provide as feed source for his livestock. He cultivates pulses, black gram and green gram as a bund crop during kharif season, that helps to check soil erosion during rain and grows mustard as oilseed crop during rabi season. He also

cultivates different seasonal vegetable crops round the year like beans and tomato during kharif season, potato, radish and cole crops during rabi season and rai leafy vegetable during zaid season and he sells these vegetables in the local market. He grows spices like dalley chilli and turmeric and has some fruit crops like guava, papaya and peach at his farm.

Table 13: Different crops and animal components at farm of Shri. Rambahadur Basnet

Season	Cereal	Pulse	Oilseed	Vegetables	Spice	Fruit plants	Cattle	Goat	Poultry
Kharif	Paddy (Jhapaka Var)	Black gram Green gram		Beans Tomato	Dalley Chili	Guava Papaya	Jersey cross breed	Cross Breed	Desi
Rabi			Mustard	Potato Radish Cole crops	Turmeric	Peach			
Zaid	Maize			Rai Leafy vegetable					

Farm layout

A farm layout with different components is shown in Figure 21.

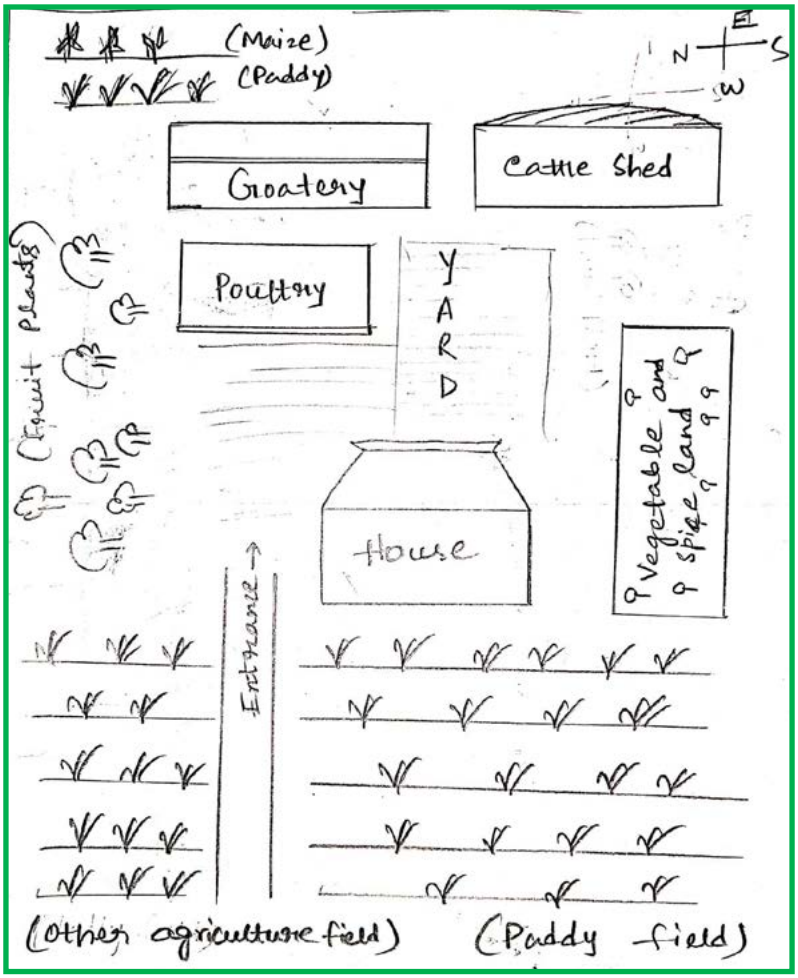

Figure 21: A farm layout with different components

Capital cost with financial assistance, if any

The involvement of capital cost to develop such integrated farming is presented in Table 14.

Table 14: Capital cost for developing the IFS

Item	Area (Sq. ft.)	Cost per unit (Rs.)	Total cost (Rs.)
Cattle shed	360	12,193.00 per 100 sq.ft.	43,894.00
Goat shed	200	12,253.00 per 100 sq.ft.	24,506.00
Poultry shed	100	14,227.00 per 100 sq. ft.	14,227.00
Total Cost			**82,627.00**

Bio-economic circularity of the farm

The IFS of Shri. Basnet is a sustainable agricultural practice that incorporates livestock and crop production in a closed-loop system. One of the key features of this system is the recycling of livestock waste as a source of organic manure for crop. In this system as shown in Figure 22, livestock such as cows, goats and chickens are reared for their meat, milk and eggs as well as manure. The manure is collected and used as a natural fertilizer for crop production. Whereas the waste residues from agriculture and horticulture produce are used as feed resources for livestock. This creates a closed-loop system where the waste from the animals is recycled back into the soil, reducing the need for chemical fertilizers and improving soil health as well as crop production. Post-harvest wastes of cereal, pulse, spices, vegetables and fruit plants costing Rs. 7,800.00 are used as feed resources for livestock, while the cost of cow dung, goat and poultry droppings is Rs. 11,900.00 that is used as manure and subsequent use in agriculture field for crop production. A total of Rs. 19,700.00 is circulating as bio-economics in the whole integrated system of this farm.

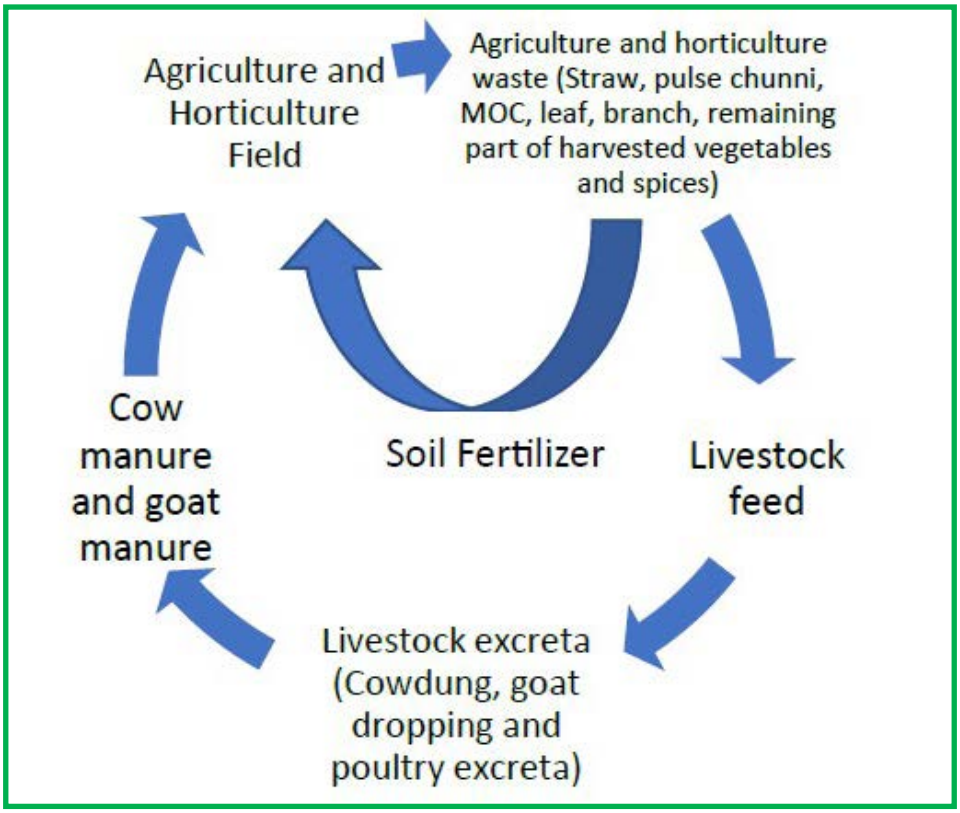

Figure 22: Flow diagram of resource recycling system at the farm of Shri. Ram Bahadur Basnet

Farm economic viability

From the financial analysis of this farm, the highest net income is coming from cattle (Rs. 85,000.00), followed by goat (Rs. 44,000.00), cereals (Rs. 18,100.00) and vegetables (Rs. 11,510.00) as shown in Table 15. Among the revenue collected from different sources, the highest annual net income is coming from livestock sector (75.0%) as shown in Figure 23. Agronomic crop (cereals, pulse and oilseed) sector contributes 13.0% followed by horticultural sector 12.0%. He observed that the farm's gross income for the year was Rs. 3,05,570.00. The expenditure incurred for maintaining the farm was Rs. 1,28,870.00 and thus he got the net profit Rs. 1,76,700.00. With this profit he could easily manage his household expenses of Rs. 1,69,000.00 with a small saving of Rs. 7,700.00 at the end of the year.

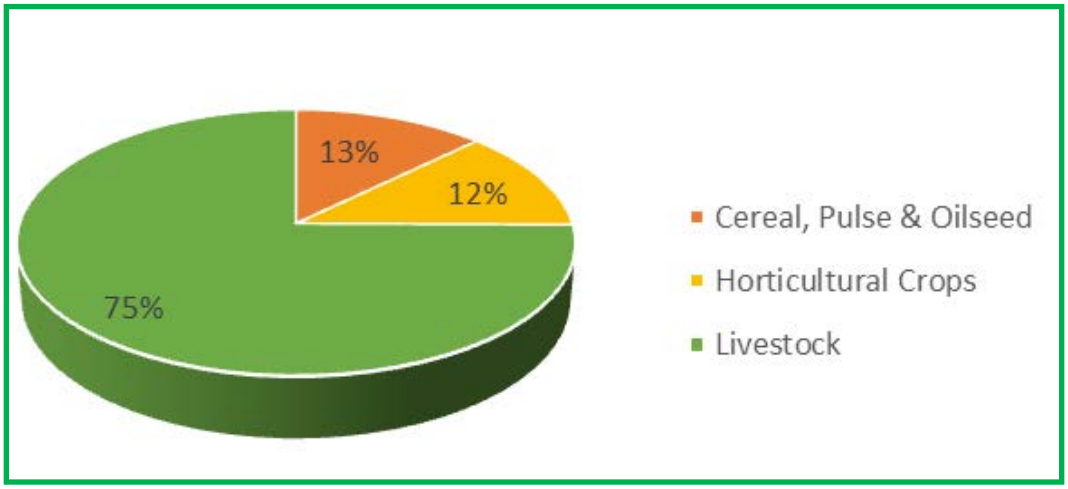

Figure 23: Annual net income sharing (in %) by different components of IFS

Table 15: Annual economics of Shri. Ram Bahadur Basnet's IFS

Component	Area	Production (kg)	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereal (Paddy var. Jhapaka, Maize)	4.5 bigha	1600	37900.00	56000.00	18100.00
Pulse (Green gram Black gram)	0.06 bigha	22	2200.00	3800.00	1600.00
Oilseed (Mustard)	1.5 bigha	100	2000.00	4800.00	2800.00
Vegetables (Beans, Tomato, Potato, Radish, Cole crops, Rai Leafy vegetable)	1.52 bigha	722	7820.00	19330.00	11510.00
Spices (Dalley Chilli, Turmeric)	0.06 bigha	25	2900.00	6000.00	3100.00
Fruit plants (Guava Papaya, Peach)	0.05 bigha	280	3050.00	10400.00	7350.00
Cattle (Jersey Cross breed)	360 sq.ft.	2400 ltr milk	46000.00	131000.00	85000.00
Goat (Cross breed)	200 sq.ft	80 kg meat, 4 kids	24000.00	68000.00	44000.00
Poultry (Desi)	100 sq.ft	1540 pcs eggs, 12 kg meat	3000.00	6240.00	3240.00
Total			**128870.00**	**305570.00**	**176700.00**

Conclusion

Shri. Basnet's livestock-based integrated farming system with a net profit of 1,76,700.00 per annum from 5 bigha of land is a great example of sustainable agriculture. By combining crop production with livestock rearing, he has created a system that not only generates income but also ensures quality organic food from his agricultural produce for his family member. From livestock, he gets milk, ghee, egg and meat which provide a source of protein-rich food for his family. The animals also produce manure which is used to fertilize the crops, reducing the need for chemical fertilizers. It helps to conserve natural resources such as water and land and also check environmental pollution. With this farming, he creates employment opportunities for family members and community members. Hence, this study is an excellent example of sustainable agriculture that motivates other small and marginal farmers in their locality to develop such IFS model in future.

Terai Agro-climatic Zone

Sustainable source of revenue through horticulture-based integrated farm in Jalpaiguri district

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Horticulture-based integrated farming

Name of the farmer: **Shri Hemendranath Adhikary**

Area of the farm: 2.99 ha

Location of the farm: Chowk Moulani village, Mal block, Jalpaiguri district

Shri. Hemendranath Adhikary, a farmer from the Jalpaiguri district in West Bengal's Terai agro-climatic zone, has developed a successful horticulture-based integrated farm on 2.99 ha. His farm features a variety of crops, including seasonal vegetables, spices, fruit orchards, field crops, vermicompost, livestock, pond fish, and tea plantations. By employing crop rotation, crop diversification, and vertical farming, Shri. Adhikary has created a highly efficient and productive agricultural system. The highest annual net income on his farm comes from the horticultural sector, accounting for 38.79% of the total income, closely followed by plantation crops at 38.26%. Livestock contributes 11.07%, while cereals and pulses add 8.06%, with other sources making up the remaining 3.83%. This diversification supports his farming operations and meets his household's nutritional needs. Despite challenges like soil acidity, sandy loam soil, low water-holding capacity, high rainfall, and insufficient storage for raw vegetables, Shri. Adhikary achieves an impressive annual net income of Rs. 1,51,384.61 per ha with a benefit-cost ratio of 2.26. Additionally, his farm generates significant employment, creating numerous mandays costing about Rs. 1,72,500.00 per season. Based on the farm's techno-economic data, an area development scheme has been proposed, making Shri Adhikary's farm a promising model for the Terai agro-climatic zone of West Bengal.

Key words

Terai zone, Horticulture, Integrated farming system, Horticulture, Livestock, Fish, Tea

Figure 24: Shri. Hemendranath Adhikary at his integrated farm in Jalpiguri

Introduction

Jalpaiguri district is situated at the heart of terai agro-climatic zone of West Bengal, India. The farmers of this district mostly belong to scheduled caste category and a large section of the farmers are low to medium land holders. The area of study at Mal block falls upon high rainfall (between 2000-3500 mm annually) area with sandy loam soil besides low carbon availability in soil. The pH of the soil is around 6.00 which is acidic in nature. These farmers are largely engaged in agri-horticultural practices along with small-scale livestock rearing and seasonal fish cultivation in ponds for their income. Although these farmers are cultivating multiple produces in their lands, the actual practice of IFS is not common among the farmers. This study is being observed to look upon the status of integrated farming in this district towards sustainable livelihood generation.

Shri. Hemendranath Adhikary is a 41 years old farmer of well acquaintance with Jalpaiguri KVK since 2015. He is a resident of Chowk Moulani area of Mal block, Jalpaiguri district. Shri Adhikary belongs to SC category. His primary occupation is agriculture and livestock farming. Apart from these, he is also working as pranibandhu under ARD Dept., Govt. of West Bengal. Shri. Adhikary has been entirely involved in the agricultural farming since 2012. Presently, he has more than 10 years of farming experience in agriculture, livestock and fishery. In the year 2017, Shri. Adhikary participated in a Skill Development Training programme on IFS from Jalpaiguri KVK and since then he is in the practice of integrated farming culture.

Shri. Adhikary owns 23 bigha (2.99 ha) of land where he is practicing horticulture-based integrated farming. In addition to horticultural crops like seasonal vegetables, spices and fruit orchards, he is engaged in field crop cultivation like cereals, pulses, oilseeds with livestock and fish farming. Shri. Adhikary has tea plantation on his farm. The acidic nature of soil has developed a keen interest about tea gardening among farmers in the area under study. Among many other complications, hail storming during pre-kharif season and unavailability of storage facility of raw seasonal vegetables are the two main difficulties faced by the farmer. This case study suggests looking out the method used by Shri Hemendranath Adhikary to manage these problems and develop and maintain this horticulture-based integrated farm in terai zone of West Bengal.

Farm description

Shri. Adhikary has 2.99 ha (23 bigha) of land where he is practicing horticulture-based integrated farming in Chowk Moulani area of Mal block, Jalpaiguri district. Shri. Hemendranath Adhikary is practicing various agricultural activities in his farm for sustainable agriculture. The horticulture-based integrated farm of Shri Hemendranath Adhikary has ten different components which are being integrated in a sequential manner. In addition to horticultural crops like seasonal vegetables, spices and fruit orchards, he is engaged in field crop cultivation like cereals, pulses, oilseeds with livestock and fish farming. Shri Adhikary is also having tea plantation at his farm. Shri Adhikary cultivates paddy in about 14 bigha of land during kharif season. Although this paddy is used mostly for in-house consumption, he manages to sell a certain amount of paddy at local nearby market. Along with this cereal crop he is also cultivating black gram as pulse crop in 1 bigha of land during this kharif season as shown in Table 16. During Rabi season, he cultivates mustard in 1.5 bigha of land which is the primary source of household's mustard oil consumption. Along with these crop items, Shri Adhikary is cultivating okra, pointed gourd, bottle gourd and brinjal in 1 bigha, 0.5 bigha, 0.5 bigha and 0.25 bigha respectively during the kharif season. During rabi and zaid season, he keeps himself busy cultivating potato, brinjal, spinach, amaranth with the targets for supplying to the local market and household consumption purpose as well.

Shri Adhikary grows several spices like turmeric, ginger and cassia leaves during kharif season and onion, garlic and black pepper during the rabi season in an average of 0.25 bigha land each. Among the fruit plantations, he has coconut, citrus, banana, mango and jackfruit plants for kharif season and litchi, ber and guava for the zaid season. These spices and fruit plants not only support for his household utilization, but also fetch a considerable amount of income from selling those products at the local market.

Shri Adhikary also has 4 bigha of tea plantations along with 1 bigha of bamboo and 0.75 bigha of arecanut plantation. These plantation crops fetch a handsome amount of income throughout the year based on market supply chain and demand. The fluctuating market value of the vegetables during season/ off season and non-availability of storage facility of the raw vegetables compel the farmer to decrease the area of vegetable and crops cultivation and convert the land to tea plantations. The net profitability of the farmer from the tea gardens (more than six flushing in a year) can account for about Rs. 20,000.00 to Rs. 25,000.00 per bigha irrespective of market value variation.

Shri. Hemendranath Adhikary has 6 number of non-descript local and Sahiwal cross cattle with 8 Black Bengal goats and 40 RIR and desi poultry at his farm. He has also kept Khaki Campbell for layer purpose. He has also a vermi compost unit. He is also having a pond where Indian Major Carps (IMCs) like rohu, katla and other carps are being grown. The requirement of household egg, poultry meat and milk for appropriate quantity of protein in diet is met from the farm itself and the excess amount of products are being sold at competitive rates in the local market which brings a good amount of money to family income.

Shri. Hemendranath Adhikary trained by KVK Birbhum has adopted many good agricultural practices in making his farm technically feasible to maximize productivity and profit as mentioned below.

- The farm is diversified with crops and livestock to make the farm sustainable and fetch more income.
- The crop rotation for production of crops maintains the soil fertility and recycling and preserving the natural resources for their optimum utilization.
- The banana plantation within tea plantation crops not only provides shed but also promotes symbiotic relation among the plants.
- The multilayer cultivation practice like black pepper cultivation through climbing over the areca nut tree promotes optimum land use and more income per unit area of land.
- The vertical farming through cultivating amaranthus below bottle gourd at trevis and turmeric and ginger along with spinach promotes optimum land use and offers more income.
- The practice of deworming and vaccination of the livestock. in time and feeding the livestock with vitamin-mineral mix maintain the health of the livestock.
- The use of organic manure from cattle and goats produces vermi compost that is used in the crop field. The low water holding capacity and low fertility of the sandy loam soil is managed by using vermi compost and humus from the plantation crops. The use of vermi compost curtails the cost of using chemical fertiliser and increases the crop production.
- The use of cattle urine and poultry litter in his tea garden acts as very good fertiliser for the production of organic tea.

In an IF, the choice of crops as well as their cropping pattern in a calendar year is important. Shri. Hemendranath Adhikary's farm plan throughout the year is reliable and deserves merit. His cropping pattern in three seasons is depicted in Table 16.

Table 16: Cropping sequence at the integrated farm of Shri. Hemendranath Adhikary

Season	Cereal crops	Pulse Crops	Oilseed crops	Vegetables	Spices	Fruit Plants	Agro forestry/ Plantation Crop
Kharif	Rice/ paddy	Blackgram	-	Okra, Pointed Gourd, Bottle Gourd, Brinjal	Turmeri, Ginger, Cassia Leaves	Coconut, Citrus, Banana, Jackfruit	Tea, Bamboo, Areca Nut
Rabi	-	-	Mustard	Potato, Brinjal	Onion, Garlic, Black Pepper	Litchi, Ber, Guava, Mango	
Zaid	-	-	-	Spinach, Amaranth leaves	-	-	

Farm layout

The layout of Shri. Hemendranath Adhikary's IFS is shown in Figure 25.

Capital cost with financial assistance, if any

To develop such kind of IF, there is an involvement of capital cost. Shri. Hemen Adhikary received the technical guidance of government institutions, like KVK, line department etc., he also received financial support from Government agency. The involvement of capital cost details is given below (Table 17).

Table 17: Capital cost for developing the IFS

Item	Cost per unit (Lakh Rs.)	Total cost (Rs. In Lakh)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Pond excavation (1 bigha)	1.00/bigha	1.00	0.90 from MGNREGA (90%)
Vermi-compost unit (4 nos)	0.10/unit of 50 m^2	0.40	0.20 from MGNREGA
Cost of fruit plants	--	0.10	0.05 from KVK Jalpaiguri
Total Cost		**1.50**	

Bio-economic circularity of the farm

Shri. Hemendranath Adhikary utilises his knowledge quite well for utilising the output from one component of his farm as input to another component for integration of his farm. Figure 26 shows the resource recycling system of the IF. This figure depicts that straw produced from the paddy and leaves and extra parts of the vegetables are used as feed resource for the cattle and also for the vermi compost. The output products of pulse crops are used as bio-fertilizer. After extracting the oil from mustard, the mustard oil cake is being

used for feeding the cattle and goats. The poultry litter and cow urine are used in the tea garden as good fertilizer. The cow dung and goat droppings are used for vermi compost production and manure production. This vermi compost and manure are again utilized as fertilizer in the crop and plantation fields. The duck droppings in the pond eventually increase the plankton density and natural feed resource of the fish and it minimises the feed cost for the fish. The output products like straw and other waste parts of vegetables cost about Rs. 3000.00 which is used as cattle feed. The cow dung and goat droppings valuing about Rs. 3500.00 are produced from the livestock and utilised to produce vermi compost. This value-added product costing about Rs. 12,600.00 is subsequently utilized as fertilizer in the crop

Figure 25: Layout of the farm of Shri. Hemendranath Adhikary

field. The poultry litter costs about Rs. 400.00 is used in the tea plantation field to produce good quality tea. It is seen that the total sum of Rs. 19,500.00 revolves around the year in the bio-circulatory system of this IF.

Farm economic viability

The production and income from different sectors of this horticulture-based integrated farm of Shri. Adhikary has been tabulated in Table 18. The data in the table demonstrates that Shri. Adhikary has gained highest income from horticulture sector covering vegetables, species and fruit crops i.e. Rs. 1,75,550.00 annually just followed by plantation crops comprising of tea, coconut, bamboo and areca nut (Rs. 1,73,200.00). He has received Rs. 25,000.00 from goat farming which is higher than the income from paddy crop (Rs. 21,000.00) and pulse crop (Rs. 15,500.00). Among other components, the income from duck farming (Rs. 14,640.00) surpasses the income from dairy sector (Rs. 10,500.00). The highest annual net income sharing in this integrated farm is. from horticultural sector (38.79%) followed by plantation crops (38.26%), livestock (11.07%), cereal and pulse crops (8.06%) and others (3.83%).

The income and expenditure analysis of Shri. Hemendranath Adhikary reveals that he is earning a gross of Rs. 8,11,290.00 per year from his IF farm through investing a total of Rs. 3,58,650.00 indicating the sustainability of this IF system. Eventually, he gets Rs. 4,52,640.00 as net income from IF. Moreover, the primary household expenditure like food, education, health etc. of his family accounts for about Rs. 1,92,000.00. Hence, his annual saving accounts Rs. 2,60,640.00. The net income per hectare of IF of Shri Adhikary is reported to be Rs. 1,51, 384.00. In addition, Shri. Adhikary provides about 575 mandays of employment costing about Rs. 1,72,500.00 at his IF farm in every season i.e. more than 1700 mandays of employment costing about Rs. 5,00,000.00 annually including his family labour and external labour engagement. The income analysis of the IF depicts that annual net income per family member is Rs. 34,467.00. The benefit cost ratio hence calculated over this income analysis of the IF is found to be 2.26.

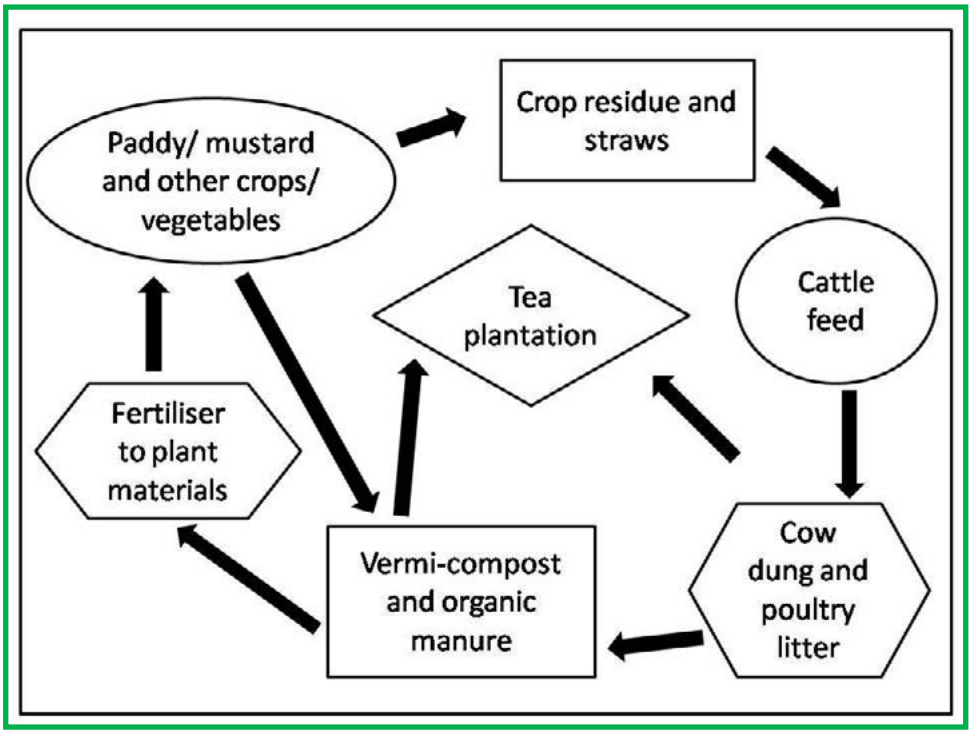

Figure 26: Flow diagram of the resource cycling system in the IF of Shri. Hemen Adhikary

Table 18: Annual economics of Shri. Hemendranath Adhikary's IFS

Sl. No.	Component	Area (Bigha)	Production (Kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
1	Cereal crops (Rice)	14	5600	63,000.00	84,000.00	21,000.00
2	Pulse crops (Black gram)	1	150	2,500.00	18,000.00	15,500.00
3	Oilseed crops (Mustard)	1.5	180	5,250.00	12,000.00	6,750.00
4	Vegetables (Okra, Pointed gourd, Bottle gourd, Brinjal, potato, Spinach, Amaranth)	3.5	7750	77,800.00	1,59,650.00	81,850.00

Sl. No.	Component	Area (Bigha)	Production (Kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
5	Spices (Turmeric, Ginger, Cassia Leaves, Onion, Garlic, Black pepper)	1.5	670	18,900.00	55,600.00	36,700.00
6	Fruit plants (Citrus, Banana,Jackfruit, Litchi, Ber, Guava, Mango)	1.5	3380	16,500.00	73,500.00	57,000.00
7	Plantation crop (Coconut, Bamboo, Tea, Areca nut)	5.85	16605	1,22,300.00	2,95,500.00	1,73,200.00
8	Livestock (Sahiwal cross and desi non-descript Cattle)	6 nos	1800 liter	21,000.00	31,500.00	10,500.00
9	Livestock (Black Bengal Goat)	8 nos	50	15,000.00	40,000.00	25,000.00
10	Poultry (RIR and local)	40	6 pcs.	900.00	2,100.00	1,200.00
11	Ducks (Khaki Campbell)	14	3080 pcs eggs	10,000.00	24,640.00	14,640.00
12	Fisheries (IMC)	1	53	4,500.00	10,000.00	5,500.00
13	Other enterprise (Vermi Compost)	0.01	600	1,000.00	4,800.00	3,800.00
	Total			**3,58,650.00**	**8,11,290.00**	**4,52,640.00**

Financial plan without bank loan

Considering the techno-economic facts and figures of Shri. Hemendranath Adhikary's IF in 2.99 ha land, a financial plan may be developed for an interested farmer who may not take any bank loan and thus invest the capital cost of Rs. 1,50,000.00 from his/ her own. Every year recurring cost of cultivation is considered as Rs. 3,58,650.00 and the capital cost will be recovered in five equal installments. A financial plan is presented in Table 19.

Table 19: Financial plan for area development scheme on horticulture-based integrated farm in 2.0 ha land (without bank loan)

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Capital cost	150000.00	120000.00	90000.00	60000.00	30000.00	0.00
2	Recurring cost of cultivation	358650.00	358650.00	358650.00	358650.00	358650.00	358650.00
3	Recovery of capital cost in equal installment	30000.00	30000.00	30000.00	30000.00	30000.00	0.00
4	Gross income	811290.00	811290.00	811290.00	811290.00	811290.00	811290.00
5	Net income	422640.00	422640.00	422640.00	422640.00	422640.00	452640.00
6	BC ratio	2.09	2.09	2.09	2.09	2.09	2.26

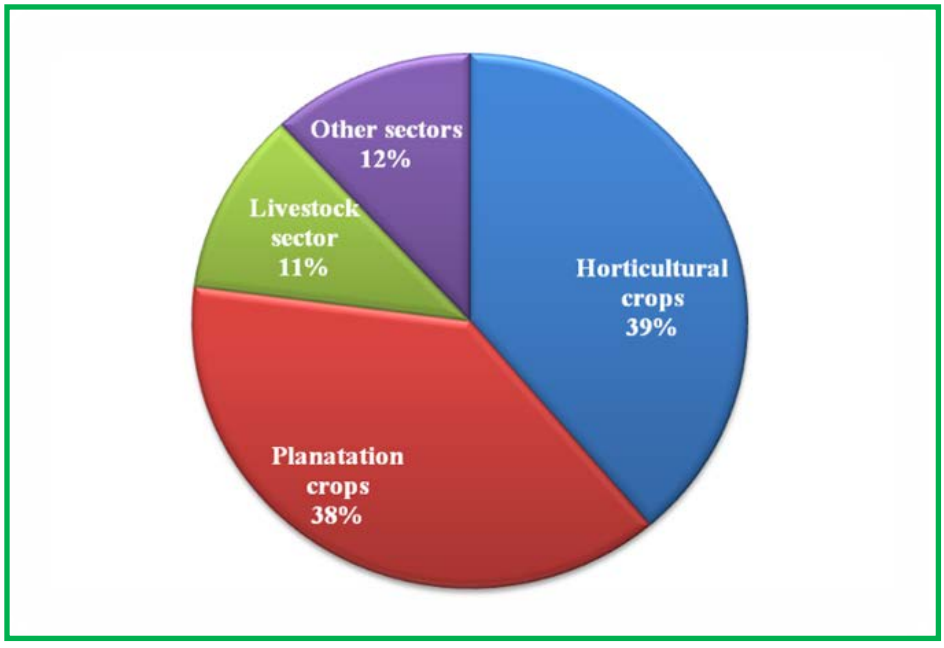

Figure 27: Annual net income sharing of different components of IFS

Financial plan with bank credit availability

Considering the techno-economic facts and figures of Shri. Hemendranath Adhikary's IF in 2.99 ha land, a finncial plan may be developed for an interested farmer who may look forward for a bank loan to develop such an IF. The total project cost covering capital cost and 1st year recurring cost of cultivation will be based on economic data shown by Shri. Hemendranath Adhikary as follows.

Project Cost = Capital Cost + 1st Year Recurring Cost = Rs. (1,50,000.00 + 3,58,650.00) = Rs. 5,08,650.00

A financial plan with bank loan facility is presented in Table 20.

Table 20: Financial plan for bankable area development scheme on vegetable-based IF in 1.5 ha land

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Project Cost	508650.00					
2	Margin @ 15%	76297.50					
3	Bank loan	432352.50					
4	Yearly rate of simple interest @12.0% PA	12.00					
5	Loan O/S at the beginning of the year	432352.50	345882.00	259411.50	172941.00	86470.50	0.00
6	Accrual of interest	51882.30	41505.84	31129.38	20752.92	10376.46	0.00
7	Repayment of principal in equal installment	86470.50	86470.50	86470.50	86470.50	86470.50	0.00
8	Repayment of interest	51882.30	41505.84	31129.38	20752.92	10376.46	0.00
9	Loan O/S at the end of the year	345882.00	259411.50	172941.00	86470.50	0.00	0.00

Repayment plan

The repayment plan against bank loan may be as shown in Table 21.

Table 21: Repayment plan against bank loan

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Repayment of principal in equal installment	86470.50	86470.50	86470.50	86470.50	86470.50	0.00
2	Repayment of interest	51882.30	41505.84	31129.38	20752.92	10376.46	0.00
3	Recurring cost of cultivation	358650.00	358650.00	358650.00	358650.00	358650.00	358650.00
4	Gross income	811290.00	811290.00	811290.00	811290.00	811290.00	811290.00
5	Net income	314287.20	324663.66	335040.12	345416.58	355793.04	452640.00
6	BC ratio	1.63	1.67	1.70	1.74	1.78	2.26

Conclusion

This IFS of Shri. Hemendranath Adhikary describes the fact that the optimum utilisation of rotational cropping systems and crop diversification through various farm components can make IFS sustainable. It also depicts that technically feasible and economically viable horticulture-based integrated farm may be developed within an area of 1.0 ha with an annual profit of Rs. 1,51,384.00 at terai zone of West Bengal. This study also features that the household food items like vegetables, eggs, meat, fish spices etc. may be available throughout the year. The utilization of technologies like zero tillage, weeding by hand tiller, use of bio-fertilizer with green manure, use of bio-pesticides, vertical farming can provide advantages towards increasing the productivity and environmental sustainability of the IFS. The availability of local established market and advantage of nearby tourist centre have facilitated Shri. Hemendranath Adhikary to manage easy and efficient marketing of his farm products at better prices. He is also disseminating the technologies among other farmers in convergence with KVK and state line departments through the members of Dooars Ratna FPC since 2021. Now, Shri. Hemendranath Adhikary stands among one of the progressive farmers recognised by the district authorities. Hence, he represents himself for developing integrated farming among other fellow farmers in Jalpaiguri district.

Fishery-based integrated farming sets an example for augmenting income in Jalpaiguri district

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Fishery-based integrated farming

Name of the farmer: **Shri. Khageswar Roy**

Area of the farm: 0.85 ha

Location of the farm: Bagjan village, Maynaguri block, Jalpaiguri district

This case study presents a compelling narrative of Shri. Khageswar Roy, a traditional farmer and professional animal health worker (pranibandhu) in the Jalpaiguri district of West Bengal's Terai agro-climatic zone. Shri. Roy has developed a fishery-based integrated farm on 0.85 ha of land. In addition to rearing fish and livestock, he cultivates a variety of crops, including cereals, seasonal vegetables, spices, areca nuts, and fruits. Shri Roy's innovative farming approach yields an annual net income of Rs. 2,71,636.00, boasting a benefit-cost ratio of 3.30. The fishery sector stands out as the predominant income source, generating Rs. 1,96,200.00 annually and contributing a substantial 72.23% of the total net income. This significant share underscores the farm's classification as a fishery-based integrated system. The livestock sector follows, providing Rs. 35,250.00 annually, accounting for 12.98% of the net income. The horticulture sector contributes Rs. 26,306.00, making up 9.69% of the net income. Paddy cultivation adds Rs. 9,480.00, representing 3.49%, while the vermicompost unit generates Rs. 4,400.00, contributing 1.61%. Despite the challenges inherent in the Terai agro-climatic zone, Shri. Khageswar Roy's diverse and sustainable farming practices not only ensure a stable income, but also enhance the overall resilience and productivity of his agricultural operations. This model serves as an exemplary blueprint for other farmers in the zone, illustrating the potential of integrated farming systems to thrive in challenging agro-climatic conditions.

Key words

Terai agro-climatic zone, Fishery, Livestock, Pond, Integrated farm, Vermi-compost

Figure 28: Shri. Khageswar Roy at his fishery-based integrated farm

Introduction

In terai agro-climatic zone of West Bengal, Jalpaiguri district offers immense possibilities to develop integrated farming system (IFS) for high returns from unit area as this district is bestowed with numerous varieties of horticultural crops, field crops along with good livestock population and medium to big sized ponds for fish cultivation. Most of the farmers of Jalpaiguri are largely engaged in agriculture, horticulture, livestock and fish cultivation practices for their livelihoods. The farmers of the district are involved in traditional way of farming and systematic IFS is hardly found in their fields. This study depicts how a farmer has adopted IFS for sustainable income generation.

Shri. Khageswar Roy, is a farmer by tradition and an animal health worker (pranibandhu) by profession under Animal Resource Development Department of Jalpaiguri district. He is a resident of Bagjan area Singimari GP under Maynaguri block, Jalpaiguri district. Shri. Roy, aged 60 years old, is Higher Secondary pass and belongs to scheduled caste category. He has almost 40 years of farming experience in fishery, livestock and agriculture. He is well associated with Jalpaiguri KVK for the development of his fishery-based integrated farm in 0.85 ha of land. In the year 2015-2016, Shri. Roy developed this integrated farm after participating in a Skill Development Training programme on IFS organised by Jalpaiguri KVK. The major share of his five-membered family income comes from the fish cultivation. Along with fish and livestock farming, Shri. Roy cultivates several crops like cereals, seasonal vegetables, spices, areca nuts, fruits.

Maynaguri block falls upon high to medium rainfall (between 2800- 3000 mm annually) area with sandy loam soil texture with low carbon availability in soil. The soil pH in this area ranges between 5.20 and 5.50 that is acidic in nature. The primary source of irrigation in his farm is rain water during monsoon and it is borewell water or irrigation channel water during post monsoon season. The pond water depth comes to as high as 12-14 ft during monsoon and it becomes as low as 8-10 ft during rabi season. The pond water source is mainly rain fed and the borewell source is also used for livestock. The irrigation channels are used particularly during rabi and zaid season. High rainfall during pre-monsoon times and hail storming during pre-kharif season, along with pretty low soil and water acidity are the most important complications the farmers are facing for agricultural practices. This case study gazes upon the strategies opted by Shri. Roy to deal with these difficulties and to build up his fishery-based integrated farm in terai zone of West Bengal.

Farm description

Shri. Khageswar Roy has developed his fishery-based integrated farm with eight different components in order to bring more income from unit cultivated area. Shri. Roy owns a total of 6 bigha (0.85 ha) area out of which three ponds are covering 3 bigha areas where he is majorly rearing Indian Major Craps (IMCs) which is the major shareholding enterprise for his livelihoods and income This fishery-based integrated farm consists of horticultural crops like seasonal vegetables, spices and major fruit orchards, paddy as cereal field crops along with livestock farming, agro forestry in pond dyke and vermi compost production.

Shri. Roy cultivates paddy over a stretch of 3 bigha land during the Kharif season mostly for his household consumption. In addition to paddy cultivation, Shri. Roy also cultivates some vegetables such as beans, spinach during the rabi season and bottle gourd, bitter gourd and pumpkin during zaid season (Table 22). The vegetables he produces are totally used for household consumption. Shri. Roy keeps himself busy in cultivation of turmeric and ginger during kharif season and black pepper in multitier cultivation system with areca nut plantation during rabi season. These spices are cultivated for in-house consumption. He is also having some major fruit plants in his farmyard for marketing of fruits and self-consumption as well. During kharif season he sells jackfruits in both green and ripen form to fetch a handsome income from his three jackfruit trees. Litchi, guava and lemon during zaid season are mostly cultivated by him for selling at nearby markets. Shri. Roy is also having areca nut plantations over 0.25 bigha of land and gets a handful income by selling these areca nuts throughout the year.

Shri. Khageswar Roy rears several types of livestock at his farm. He possesses two crossbred Sahiwal cattle which produce an average of 700 kg of milk in a lactation period. He is also having six (6) Black Bengal goats which provide him financial security as and when necessary. Shri. Roy also engaged in farming of ten (10) numbers of RIR birds and ten (10) numbers of Khaki Campbell ducks. These enterprises also provide him a smaller segment of family income and family nutrition.

Table 22: Different components at the integrated farm of Shri. Khageswar Roy

Season	Cereal crops	Vegetables	Spices	Fruit Plants	Plantation Crop	Cattle	Goats	Poultry	Duck	Fish	Other enterprises
Kharif	Rice/ paddy		Turmeric, Ginger	Jackfruit	Areca Nut	Desi Sahiwal cross,	Black Bengal	Local	Khaki Campbell	Rohu, Katla, Mrigal, Silver carp, American Rohu	Vermi-compost
Rabi		Bean, Spinach	Black Pepper	Litchi, Guava, Lemon							
Zaid		Bottle gourd, Pumpkin									

Farm layout

A picturesque farm layout of Shri. Khageswar Roy's farm is depicted in Figure 29.

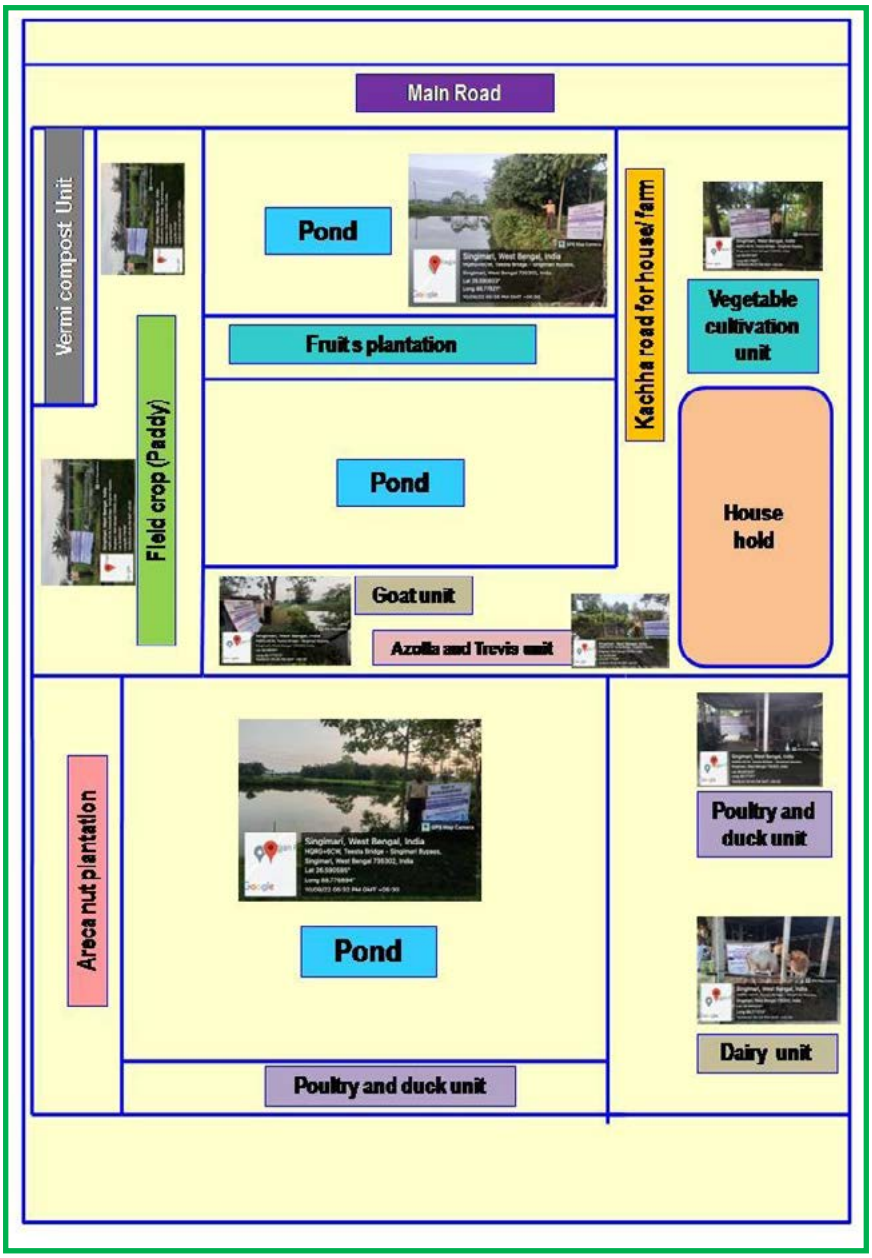

Figure 29: Layout of Shri. Khageswar Roy's IFS

Capital cost with financial assistance, if any

The involvement of capital cost to develop such integrated farming is presented in Table 23.

Table 23: Capital cost for developing the IFS

Item	Cost per unit (Lakh Rs.)	Total cost (Rs. In Lakh)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Pond excavation (3bigha)	1.00/bigha	3.00	2.70 from MGNREGA (90%)
Vermi-compost unit (3 nos)	0.08/unit of 40 m^2	0.24	0.18 from NABARD
Fingerlings (3 bigha)	0.25/ bigha	0.75	0.40 from DFO, Jalpaiguri
Fruit plants	--	0.10	0.05 from KVK Jalpaiguri
Total Cost		**4.09**	

Bio-economic circularity of the farm

Shri. Khageswar Roy develops his wisdom and collects information from KVK scientists and other line departments through regular discussions and attending trainings for making his IFS more efficient and profitable. The resource recycling system of the IFS was developed by Shri. Roy is presented in Figure 30. This figure describes that straw produced from paddy field along with the crop residues from the vegetables are used as feed for the cattle and goats and also for production of vermi-compost. The cow dung and goat droppings worth about Rs. 1,500.00 are used as organic manure in fields and ponds and also for the vermi-compost production. The vermi-compost valuing Rs. 8,400.00 is used for agricultural fields, as well as, in pond water to enhance the growth of planktons. The poultry and duck litter costing about Rs. 500.00 are used after decomposition for increasing the natural feed resources in the pond for better growth of the carps. This practice eventually diminishes the feed cost of fish cultivation and increases net profit from fish cultivation. The paddy straw and parts of vegetables costing about Rs. 2000.00 are used as cattle and goat feeds. It is observed that the bio-resources of Rs. 12,500.00 is circulating at this integrated farm.

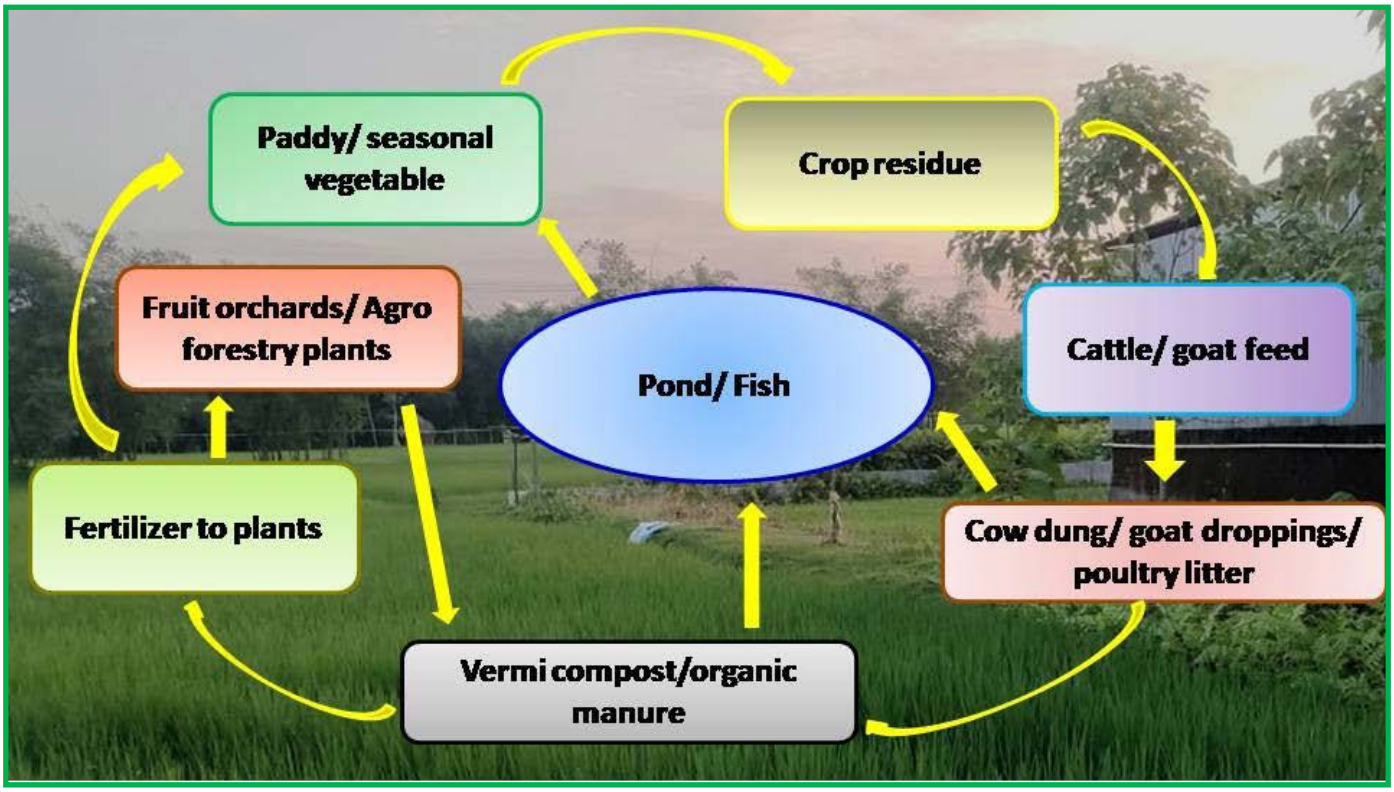

Figure 30: Resource bio-cycling system at IFS of Shri. Khageswar Roy

Farm economic viability

The production and income from different components of this fishery-based integrated farm of Shri. Khageswar Roy is depicted in Figure 31 and Table 24. The data in the table depicts that the fishery sector provides the highest annual net income of Rs. 1,96,200.00 which covers 72.23% of the total annual net income of this integrated farm. The second highest annual net income of Rs. 35,250.00 (12.98% sharing) comes from livestock sector covering cattle, goats, poultry birds and ducks. Shri. Khageswar Roy earns an annual net income of Rs. 13,606.00 (5.01% sharing) from vegetables production, spices cultivation and plantation crops of Areca nuts. Shri. Roy receives an annual net income of Rs. 12,700.00 (4.68% sharing) from fruit plants like jackfruits, litchi and guava and Rs. 9,480.00 (3.49% sharing) from paddy cultivation. Vermi-compost unit gives an annual net income of Rs. 4,400.00 (1.61% sharing). The income and expenditure analysis shows that an annual gross earning of Shri. Khageswar Roy is Rs. 3,89,706.00 on investment of Rs. 1,18,070.00. Ultimately, he gets an annual net income of Rs. 2,71,636.00 from his IFS. His household expenditure for food, education, health and other expenses is about Rs. 2,25,000.00. Shri. Roy is also having an additional income of Rs. 1,20,000.00 from other sources. Hence, Shri. Roy can save Rs. 1,66,636.00 at the end of the year. Since an annual net income of Rs. 2,71,636.00 is realized from 0.85 ha of fishery-based integrated farm by Shri. Khageswar Roy, it can go upto Rs. 3,39,545.00 per ha area of this kind of fishery-based IFS. The benefit cost ratio of this fishery-based IFS is found to be 3.30. Additionally, this IFS provides about 420-man days of employment costing about Rs. 1,68,000.00.

Table 24: Annual economics of Shri. Khageswar Roy's IFS

Sl No.	Component	Area (Bigha)	Production (Kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
1	Cereal crops (Rice)	3	1400	8,520.00	18,000.00	9,480.00
2	Vegetables (Bean, Spinach, Bottle gourd, Pumpkin)	0.22	170	2,100.00	6,100.00	4,000.00
3	Spices (Turmeric, Ginger, Cassia Leaves, Onion, Garlic, Black pepper)	0.3	65	2,050.00	6,656.00	4,606.00
4	Fruit plants (Jackfruit, Litchi, Guava, Lemon)	0.5	640	1,800.00	14,500.00	12,700.00
5	Plantation crop (Areca nut)	0.25	200	5,000.00	10,000.00	5,000.00
6	Livestock (Sahiwal cross cattle)	2 nos	650	17,250.00	26,250.00	9,000.00
7	Livestock (Black Bengal Goat)	6 nos	30	7,400.00	18,000.00	10,600.00
8	Poultry (Local)	10	1275 nos	4,250.00	10,200.00	5,950.00
9	Ducks (Khaki Campbell)	10	2200 nos	7,900.00	17,600.00	9,700.00
10	Fisheries (IMC)	3	1450	57,800.00	2,54,000.00	1,96,200.00
11	Other enterprise (Vermi-compost)	0.05	1200	4,000.00	8,400.00	4,400.00
Total				**1,18,070.00**	**3,89,706.00**	**2,71,636.00**

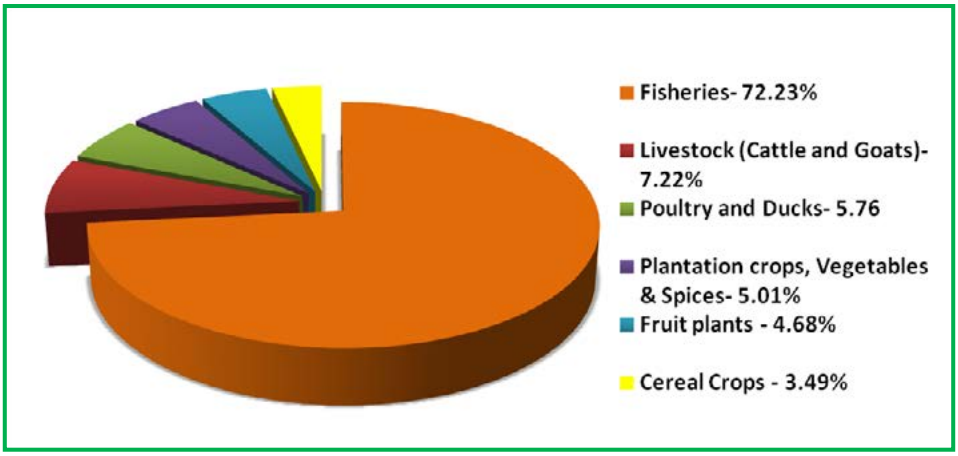

Figure 31: Annual net income sharing of different components of IFS

Conclusion

The fishery-based integrated farm of Shri. Khageswar Roy reveals that with best possible utilisation of resources and crop diversification may provide annual profit of Rs. 3,39,545.00 from 1.0 ha area in Jalpaiguri district under terai agro-climatic zone of West Bengal. Shri. Roy also shows that different household food items like cereals, vegetables, milk, eggs, meat, fish, fruits, spices etc. may be available throughout the year in natural and fresh condition from an integrated farm. The utilization of scientific techniques, use of good quality saplings and fingerlings along with use of bio-fertilizer (vermi-compost) with green manure, bio-pesticides (like neem oil) may offer benefits towards increased productivity and environmental sustainability. Shri. Roy is also involved with Bagjan Pragatishil FPC since 2018 as a board member and is thus disseminating his knowledge and technologies among fellow farmers. Shri. Roy is a man of field level extension worker who always keeps himself busy in upgrading the knowledge of fellow farming communities to develop and promote the scientific integrated farming. Presently, Shri. Roy is a well-acquainted progressive farmer in Maynaguri block recognised by the block and district level authorities.

Intercropping cultivation of fruit plants and vegetables maximizes income in an integrated farming system in Uttar Dinajpur district

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Horticulture-based integrated farming

Name of the farmer: **Shri. Pabitra Roy**

Area of the farm: 2.27 ha

Location of the farm: Chaugharia village, Goalpokhor-II block, Uttar Dinajpur district

Shri. Pabitra Roy has established a horticulture-based Integrated Farming System (IFS) on 2.27 ha of land in Uttar Dinajpur district. Though there is a steady vegetable market in his locality, he thinks differently by introducing different fruit crops in his farm. After a thorough analysis of the market demand and supply chain, he recognized a significant opportunity in fruit cultivation. Consequently, he began cultivating green banana, G-9 banana, Thai guava, Baruipur guava, Red Lady papaya, and dragon fruit. Additionally, Shri. Roy maximizes the use of his land by growing crops like chili, winter vegetables, strawberry, turmeric etc in the interspaces. He has also adopted sustainable agricultural practices by using green manures in his crop fields. As a cash crop, he produces potatoes. To enhance income and maintain the bio-circularity of farm resources, he has integrated cattle and fish into his farming system. Income analysis reveals that Shri. Roy's horticulture-based IFS can generate an impressive annual net income of Rs. 7,21,725.00, with a BC ratio of Rs. 2.33. In this IFS model, horticultural crops account for the highest share of annual net income at 47%, followed by the fishery sector at 34%, and the remaining 19% coming from cereals and oilseeds. Shri. Pabitra Roy's farm not only ensures a substantial income, but also meets his family's nutritional needs. This horticulture-based IFS is a testament to offer a model of innovative and sustainable farming practices in the Uttar Dinajpur agro-climatic zone.

Key Words

Integrated farming system, Sustainability, Horticulture, Agriculture, Fruit crops, Dragon fruits, Papaya, Potato, Bio-circularity, Terai zone

Figure 32: Shri Pabitra Roy in his horticulture-based integrated farm

Introduction

Shri. Pabitra Roy, 39-year-old young farmer, is a resident of Chaugharia village of Goalpokhor-II block of Uttar Dinajpur district under Terai zone of West Bengal. He has developed a horticulture-based integrated farm covering 2.27 ha. More than 92% of the total population of Chaugharia village depends on farming for their livelihoods. Shri. Pabitra Roy, single child of his parents, was born in a farmers' family. Though he was a bright student and completed his Master degree but he was helping his father in farming since childhood. After completion of his master degree, he was fully engaged in farming. In 2008, Shri. Pabitra Roy first came to Uttar Dinajpur Krishi Vigyan Kendra to participate in a training programme and he came to know about the integrated farming system for the first time. As he is an enthusiastic farmer, he is connected with KVK personnel on regular basis. From different horticultural training programmes conducted at KVK, he came to know about the profit in fruit and non-conventional vegetable cultivation. The weather of Chowgharia is suitable for different fruits, vegetables, cereals, pulse and oilseed cultivation. Though the soil is loamy, but irrigation facility is available during rabi and zaid seasons. He first started growing red lady variety of papaya and sold both green and ripened fruit. Gradually he utilized the interspaces of papaya by growing high value crop like zucchini, capsicum, strawberry, broccoli, red cabbage etc. during rabi season and chilli, leafy greens etc. during rainy season. Now-a-days, he has started growing very profitable dragon fruit in his farm. He also cultivates commercial seasonal vegetables in his farm. Oilseeds, pulses, cereals, vegetables, spices are also produced in very small areas for home consumption. His big size pond is now scientifically managed with different Indian Major Craps (IMC) and high yielding Khaki Campbel duck. The inputs required for farming is available and marketing of the produce is also easy in local market and Siliguri market. He has efficiently developed a horticulture-based integrated farm in his locality.

Farm description

In this horticulture-based integrated farm, Shri. Pabitra Roy focuses on cultivation of fruits like papaya, guava, banana, dragon fruit etc. He also cultivates cash crops like potato in rabi season, pointed gourd in kharif season and bitter gourd, elephant foot yam and turmeric during zaid season. He also grows paddy, maize, sesame and mustard. Pabitra has now one bigha area of dragon fruit plants. The area under different crops components of this IFS along with their varieties is mentioned in the Table 25.

Table 25: Area under different crops components of IF

Sl. No.	Crop	Area under IF	Variety of crop
1	Paddy	4 bigha	Swarna, Pratiksha
2	Maize	4 bigha	NK-7720, Samrat-7070
3	Mustard	1 bigha	Jhumka, B-9
4	Sesame	0.5 bigha	Bombay super
5	Pointed gourd	0.5 bigha	Dudhia, Kajli
6	Potato	6 bigha	S-1
8	French Beans	0.7 bigha	Arjun
9	Bitter gourd	0.7 bigha	Jhumka, Akash
10	Turmeric	0.7 bigha	Suranjana
11	Papaya	0.25 bigha	Red Lady
12	Dragon fruit	1 bigha	Moroccan Red
13	Guava	0.25 bigha	Thai, Baruipur

Considering the increasing demand of dragon fruit, he wishes to increase the area for dragon fruit cultivation. Though the initial planting cost of dragon fruit was much more, he got less profit during the first two years, but gradually much more profit he expects to get from this exotic fruit. He has some forest trees around his farm. He has planted 200 no. of areca nut plant surrounding his homestead area and pond as fencing. These plants need less management and also start fruiting now to give a handsome amount of earning to Pabitra Roy. He has 2 bigha pond for IMC cultivation which is also very profitable. He has 50 no. of Khaki Campbel ducklings in his pond now. Shri. Roy has now only one Deshi cow. All the farm produces are mostly used for selling and home consumption. Shri. Roy is efficiently fulfilling his family nutrition.

Shri. Roy maintains proper cropping sequences in his crop fields for better soil health. He uses both chemical fertilizer and organic manures in proportion. He efficiently uses crop wastes in his farm. He uses tractor, small hand tiller, transplanter for preparing soil, sowing seeds, transplanting seedlings and other purposes. He includes varieties of crops in his farm to bring diversification and minimize crop loss and maintain soil fertility. He also increases his land use efficiency by incorporating intercrops in fruit orchards.

The availability of resources like seeds, planting materials, animals, feeds, veterinary medicines etc is moderate to high in his locality. He always gets connected with KVK and ARD department for protecting his poultry birds and cattle from diseases. So, he vaccinates them in time and uses veterinary medicines as and when necessary. He always takes care of the nutrition of farm animal and bird and maintain proper hygiene of their shelter. Not only animal and bird, he also maintains his pond scientifically for fishery. He takes all the measures to protect the IMC from different diseases.

Figure 33: Different intercrops in fruit orchards

Table 26: Cropping sequence of different components at the farm of Shri. Pabitra Roy

Season	Cereals	Oilseeds	Vegetables	Fruits	Spices	Plantation Crops	Birds	Animals	Fishery
Kharif	Paddy		Pointed gourd	Dragon, Guava., Papaya	-	Areca nut	Duck	Cow	IMC
Rabi	Maize	Mustard	Potato, beans	Guava, banana	Coriander, black cumin				
Zaid	-	Sesame	Bitter gourd		Turmeric				

The demand of dragon fruit increases day by day due to its taste and profuse health benefits in spite of its higher market value. He wants to increase dragon field in his farm. Though the initial cost for dragon cultivation is more due to higher establishment cost but after 3-4 years, the profit will be maximised. He also wants to rear more cattle for milk, cow dung and cow urine because he has started making natural farming inputs in his farm. In his locality, maize is a major crop. His farmers Club Group wants to established a small-scale maize processing unit for easy availability of animal feed.

Farm layout

A farm layout of Shri Pabitra Roy's farm is depicted in Figure 34.

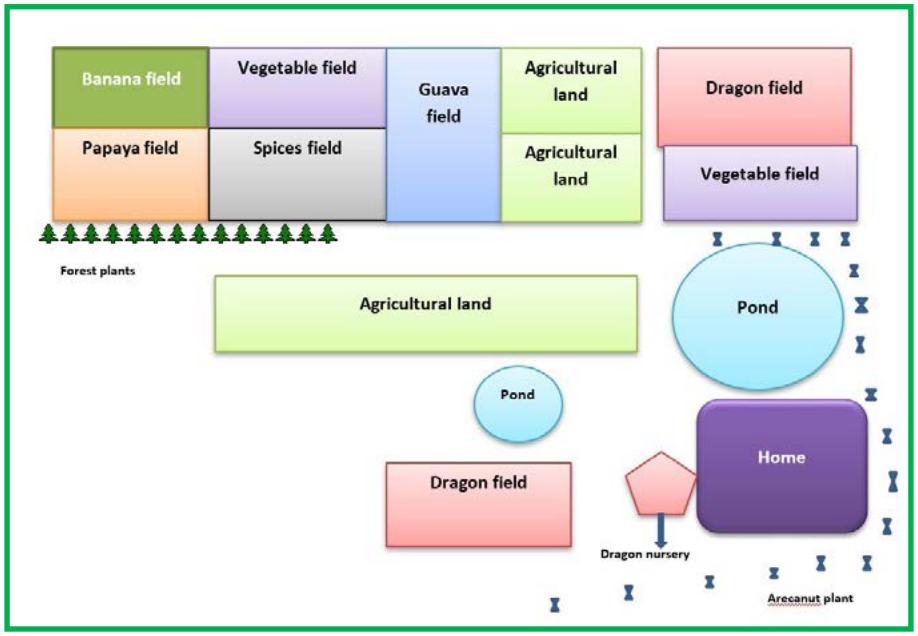

Figure 34: A farm layout of Shri Pabitra Roy with different components

Capital cost with financial assistance, if any

To establish an IFS with different components like fruit crops, birds, animals, plantation crops, huge investment is required. Table 27 clearly shows that Shri. Roy has efficiently utilized different government schemes to establish his IFS with diversified crops. He has chosen different perennial crops and also use own planting material like turmeric, elephant foot yam, dragon fruit, areca nut etc.

Table 27: Capital cost for developing the IFS

Item	Cost/unit (Lakh Rs)	Total cost (Lakh Rs)	Government contribution (Lakh Rs)
Dragon fruit (1 bigha)	0.80/ bigha	0.80	8,000.00 from Uttar Dinajpur KVK for planting material and 20,000.00 from MGNREGA
Papaya (0.25 bigha)	0.21	0.21	10,000.00 from MGNREGA
Guava (0.25 bigha)	0.06	0.06	6,000.00 from ATMA scheme
Turmeric (0.7 bigha)	0.12	0.12	8,000.00 from Uttar Dinajpur KVK for planting material
Areca nut (200 no)	0.04	0.04	2,000.00 from Uttar Dinajpur KVK for planting material
Khaki Campbell ducklings (50 no) with shed	0.25	0.25	10,000.00 from ATMA scheme
Desi cow (1 no)	0.05	0.05	-
Total Cost	1.53		

Bio-economic circularity of the farm

After getting connected with KVK, Shri. Roy is aware of the different components of integrated farming and their connection to each other. Previously, he used only cow dung for preparation of organic manure. But now he scientifically uses the wastes to minimize input cost. Figure 35 shows that he uses crop residues as mulching material and organic manure preparation. This organic manure is used in pond and agricultural field. He collects the weed from the field and uses as feed resources for cattle. He produces organic manure using cow dung and the organic manure is applied in agriculture field for crop production. He uses cow dung in pond for fisheries. There is a good bio-circularity between duck and pond in the IFS. Ducks mainly get aquatic natural food from the pond and provide droppings to the pond. Ducks also increase bio-aeration in the pond. Post-harvest wastes of cereal, pulse, spices, vegetables and fruit plants including leaves of forest trees costing Rs. 8,000.00 are used as mulching material in crop field and organic manure preparation, while the cost of cow dung is Rs. 10,000.00 that is used for preparing organic manure and subsequent use in agriculture field and pond for crop and fish production, respectively. In this integrated farming system, total of Rs. 18,000.00 is circulating within its different components.

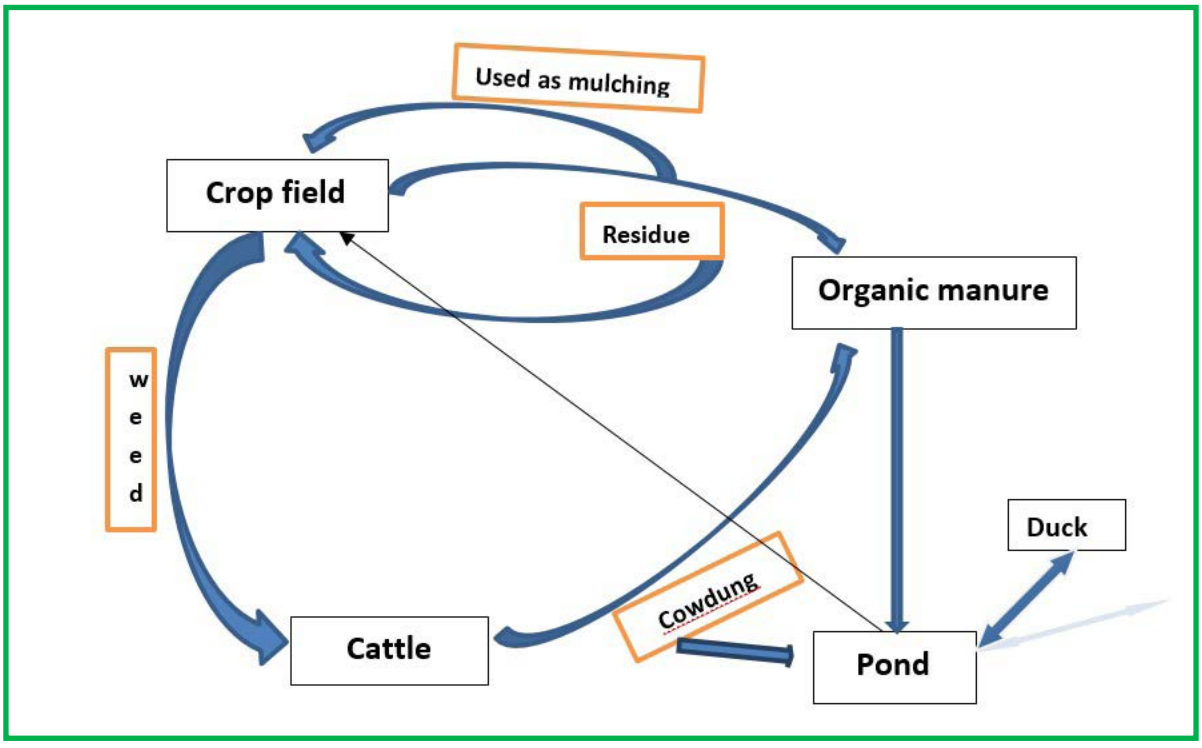

Figure 35: Flow diagram of resource recycling system at the farm of Shri. Pabitra Roy

Farm economic viability

In horticulture-based IFS, Shri. Pabitra Roy recorded the highest net income from horticultural crops covering fruits, vegetables and spices crops (Rs. 3,45,075.00) followed by fishery (Rs. 2,40,000.00), cereals (Rs. 1,17,000.00), oil seeds (Rs. 15,500.00) and plantation crops (Rs. 4,150.00) as depicted in Table 22. In the horticultural crops, he fetched a maximum profit from vegetables (Rs. 1,90,405.00), followed by fruits (Rs. 1,32,000.00) and spices (Rs. 22,670.00) as shown in Table 28. The highest annual net income sharing came from horticultural crops (47%) followed by fishery sector (34%) as shown in Figure 36. The cereal and oil seeds contributed only 19%. The income analysis revealed that from a small farm piece of 2. 27 ha area, the annual gross income of Rs. 12,64,225.00 could be realized from an investment of Rs. 5,42,500.00 with a resource use efficiency of Rs. 2.33 per rupee invested and a generation of 849 days of man days of employment costing Rs. 1,21,800.00 as labour wage including his own labour. According to Shri. Pabitra Roy, an annual expense for household purposes covering food, education, health and others was Rs. 2,05,000.00. Since net income from this IF was Rs. 7,21,725.00, an annual saving of Rs. 5,16,725.00 could be possible from this horticulture-based integrated farm in a 2.27 ha area.

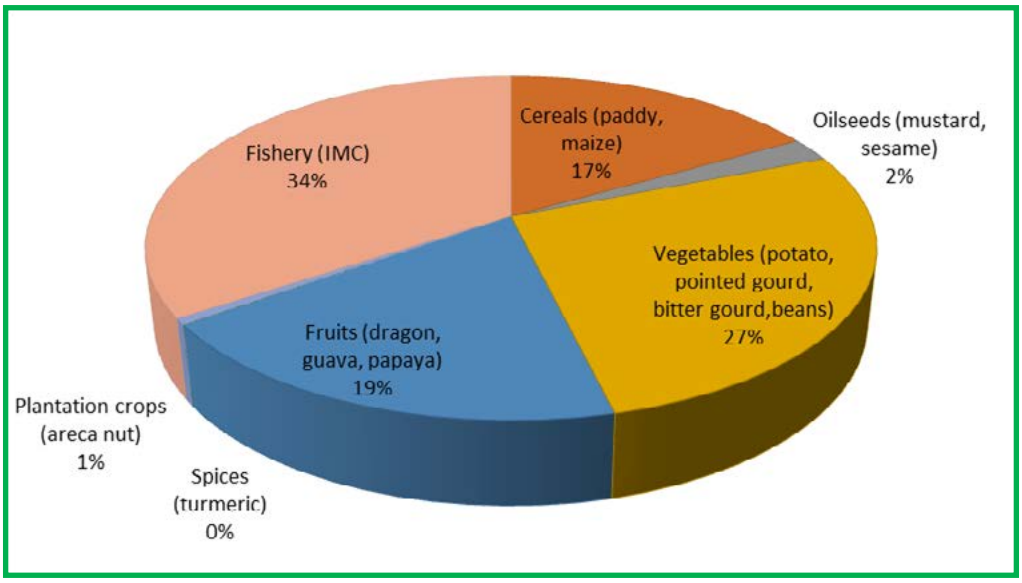

Figure 36: Annual net income sharing (in %) by different components at horticulture-based integrated farm

Table 28: Annual economics of Shri. Pabitra Roy's IFS

Component	Area (bigha)	Production (kg)	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereals (paddy, maize)	8.0	12000.0	115000.00	232000.00	117000.00
Oilseeds (mustard, sesame)	1.5	400.0	9500.00	25000.00	15500.00
Vegetables (potato, pointed gourd, bitter gourd, beans)	7.9	31505.0	160000.00	350405.00	190405.00
Fruits (dragon, guava, papaya)	1.5	3350.0	108000.00	240000.00	132000.00
Spices (turmeric)	0.7	2815.0	28000.00	50670.00	22670.00
Plantation crops (areca nut)	1.5	200.0	2000.00	6150.00	4150.00
Fishery (IMC)	2.0	3000.0	120000.00	360000.00	240000.00
Cattle	120.0 sq. ft.	0	0	0	0
Total			**5,42,500.00**	**12,64,225.00**	**7,21,725.00**

Conclusion

Shri. Pabitra Roy has diversified his farming with different fruit plants. He also augmented his income per unit area of land by growing intercrops in his fruit orchards. He grows variety of crops in every season and such diversification protects him from crop loss due to any sudden problem. Dragon fruit and papaya generate additional income. Pabitra has 2 bigha land of pond where he is successfully doing fish farming. He uses the farm waste effectively in his farming to maintain a bio-circularity at the farm. Shri. Roy is able to satisfy his 5-membered family's nutritional demands of cereal, vegetables, fruits, milk and fish from his farm products. Shri. Pabitra Roy used to share his experience and knowledge of integrated farming with the neighbouring farmers for agricultural development in the area. He is a proud farmer who is very much concerned about the soil health management. This story of Shri. Pabitra Roy clearly indicates that developing horticulture-based integrated farm through intercropping vegetables in fruit orchards can technically be feasible and economically viable with the net return of Rs. 3,17,940.00 from a 1.0 ha land in Uttar Dinajpur district under Terai zone of West Bengal. He has a dream to establish agro-tourism in his farm.

Poultry farming maximizes income in livestock-based integrated farm in Alipurduar district

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Livestock-based integrated farming

Name of the farmer: **Smt. Hitkari Guria**

Area of the farm: 1.33 ha

Location of the farm: Samuktala village, Alipurduar district

Smt. Hitkari Guria has successfully developed a livestock (poultry)-based integrated farming system (IFS) on a 1.33 ha land in Alipurduar district under Terai agro-climatic zone of West Bengal, aiming to enhance production, income, resource recycling, and employment. The farming system encompasses a diverse array of components, including fishery, piggery, poultry, fruit crops, plantation crops, spices, vegetables, vermicomposting, and beekeeping. According to an annual economic analysis, a 1.0 ha livestock (poultry)-based integrated farm can achieve an impressive annual net income of Rs. 3,16,593.98, with a resource use efficiency of Rs. 2.88 for every rupee invested. The livestock sector is the primary contributor to this income, accounting for 45.99% of the total, followed by beekeeping (17.09%), plantation crops (15.15%), the horticulture sector (14.83%), vermicomposting (0.64%), and other activities including fisheries (6.30%). Within the livestock sector, Vanaraja poultry birds generate the highest net income. Smt. Guria's IFS meets her family's nutritional needs, providing a variety of vegetables, spices, fruits, fish, meat, and eggs. Smt. Hitkari Guria has made a significant contribution to sustainable agriculture by developing a livestock (poultry)-based IFS which may be used as reference for potential replication in similar agro-climatic situation.

Key Words

Poultry farming, Bee Keeping, Horticulture, Goat, Integrated farming, Livestock, Pig, Vanaraja, Vermi-Compost

Figure 37: Smt. Hitkari Guria at her integrated farm

Introduction

In Alipurduar district of North Bengal, the majority of the farmers holds less than two hectares of land. These farmers generally practice subsistence farming where they need to produce a continuous, reliable and balanced supply of foods, as well as cash for basic needs and recurrent farm expenditure. Smt. Hitkari Guria, 52 years of age, from Samuktala village of Alipurduar district, West Bengal is a successful woman agri-preneur. She is a sedulous and ingenious farm woman who is always keen to adopt new ideas and technologies. She has incorporated all the major components of integrated farming for diversified agriculture to enhance her farm income. Now, she is a role model for other agri-entrepreneur women in the district for adopting IFS. Smt. Hitkari Guria belongs to a farmers' family. In the year of 1988, when she passed 12th, she left the school and joined with her parents in farming. In 2017, Smt. Hitkari Guria came to know about the IFS from Cooch Behar Krishi Vigyan Kendra (KVK). The weather of Samuktala is sub-tropical and the soil is acidic. Agro-climate of Alipurduar district supports livestock farming, cultivation of agriculture and horticultural crops. Alipurduar is well known as a hub of cash crops like areca nut, tomato, black pepper, turmeric, ginger, tea plantation, lemon and potato.

Farm description

Smt. Hitkari Guria owns 1.33 ha land, out of which 0.7 ha is kept for livestock, 0.4 ha for agriculture and the remaining 0.23 ha for other farming purposes. About 50% land is rain-fed and remaining area is irrigated through perennial streams and 'Nallah'/ canals by adopting portable sprinkler system with the support of KVK. She cultivates seasonal vegetables like bitter gourd, ivy gourd, bottle gourd, ash gourd and sponge gourd in kharif season, runner bean and rai sag during rabi season and kulekhara, ridge gourd, cowpea and okra in zaid season. She focuses on cultivation of spices like turmeric and black pepper in rabi season. She has the fruit plants like guava and lemon which are sold on contract basis and banana as well as jackfruit traded in wholesale markets. She has also some bamboo and areca nut plants which provide a handsome amount for earning. Smt. Hitkari Guria has a unit of 70 numbers of Vanaraja poultry birds and 20 numbers of Khaki Campbell ducks. She also maintains a Ghungroo Pig unit with 2 numbers of Sows, 1 Boar and 7 numbers of Piglets and a Black Bengal Goat unit with 8 numbers of Black Bengal Goats for meat purpose and she uses manures for vermi-compost production. A vermi-compost unit of 2 vermi pits has been constructed with the assistance from KVK. About 5 quintals of manure per year is being produced and used for growing different crops. She uses 0.03 ha land for the cultivation of seasonal fodders like hybrid napier, oats, berseem, cowpea etc. as animal feed to enhance the production performance. She uses azolla as feed supplementation to the poultry birds. She also owns a fishery unit of 0.25 bigha and a bee keeping unit with 18 bee boxes for getting additional income through this venture.

Figure 38: Different components of integrated farm of Smt. Hitkari Guria

To reduce drudgery and increase efficiency in the agricultural operations, she has procured farm implements/ machinery viz. power sprayer, foot sprayer, power weeder, grass cutter etc. Smt. Hitkari Guria manages the marketing of her produce in such a way as to bring her maximum profit with minimum hassle. Before bringing the produce to the market she collects the information about the rates in different markets so that she gets the highest price. She supplies the piglets and kids to the local vendors and to the customers directly for income generation. The demand for animal protein sources like fish, milk, egg and meat is high; Smt. Hitkari Guria first fulfills her home need of animal protein from her farm produces and then sells the excess.

Smt. Hitkari Guria has embraced good agricultural practices (GAP) by implementing the rotation system approach to grow a succession of different crops in different seasons on the same land. This approach helps to maintain soil fertility, allows for the preservation and more effective use of the natural resources already available, and aids in the control of insects and diseases. She creates organic manure from leftover livestock and crop waste and spreads it on farmland. She is successful in using artificial insemination to Black Bengal goats.

She nevertheless takes all essential precautions to safeguard cattle from illnesses, including deworming, timely vaccinations, and the use of veterinary medications as required. She is quite particular about giving the farm animals a vitamin-mineral combination with their meal. She takes care to provide clean, appropriate housing for her farm animals. As a result, she makes a commendable profit from all of her farm ventures, amounting to roughly 3.5 lakh per year, in a very practical manner. Surprisingly, establishment of bee-keeping units in

the integrated farm has substantially reduced wild elephant invasion in the village. It may be due to the fact that buzzing noise produced from bee hives keeps away the elephants from entering the village. She sells the honey to the local markets and to the customers directly for income generation.

Table 29: Different crops and animal components at the farm of Smt. Hitkari Guria

Season	Vegetables	Fruit Plants	Spices	Livestock	Fodder Grass	Fisheries	Plantation Crop	Poultry	Other Enterprise
Kharif	Bitter gourd, ivy gourd, bottle gourd, ash gourd & sponge gourd	Banana, Jackfruit & Guava	-	Ghungroo Pig & Black Bengal Goat	Hybrid Napier, Berseem, Oats	Tilapia, koi	Bamboo	Vanaraja & Khaki Campbell	Vermi – Compost, Bee Keeping
Rabi	Runner bean & rai sag	Lemon	Turmeric & Black Pepper						
Zaid	Kulekhara, ridged gourd, cowpea and okra	-	-						

Farm layout

A farm layout of Smt. Hitkari Guria's farm is depicted in Figure 39.

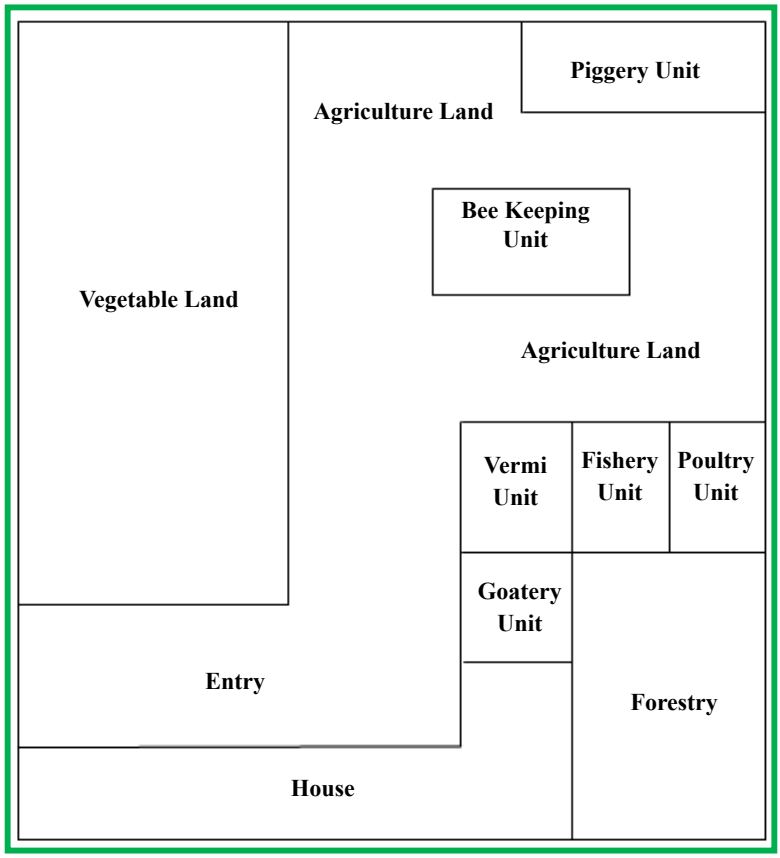

Figure 39: Farm Layout with different components of Smt. Hitkari Guria

Capital cost with financial assistance, if any

The involvement of capital cost to develop such integrated farming is presented in Table 30.

Table 30: Capital cost for developing the IFS

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Poultry Shed	0.10 lakh/ 100 birds	0.10	NA
Vanaraja Chicks	0.001 lakh/ chick	0.07	0.07 from COB KVK
Goat Shed	0.0185 lakh/ 10 sq ft	0.15	NA
Black Bengal Kid	0.038 lakh/ kid	0.30	0.30 from COB KVK

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Pig Shed	0.01 lakh/ 12 sq ft	0.10	0.05 from COB KVK
Ghungroo Piglets	0.055 lakh/ piglet	0.22	0.10 from COB KVK
Honey Bee Box	0.04 lakh/ box	0.80	0.30 from COB KVK & 0.40 from DIC
Fruit Plants	--	0.10	0.06 from COB KVK
Plantation Crop	--	0.15	0.10 from COB KVK
Fishery Unit	2 lakh/ bigha	0.50	NA
Vermi Pit	0.038 lakh/ pit	0.076	0.076 from COB KVK
Small Implements	--	0.15	0.15 from COB KVK
Total Cost		**2.716 Lakh**	

Bio-economic circularity of the farm

While Smt. Hitkari Guria may not be acquainted with the phrase "integrated farming," she is aware of how to MAXIMIZE produce while MINIMIZING costs associated with agriculture and environmental degradation. Figure 40 illustrates the use of agricultural waste as animal feed and the conversion of livestock excreta into vermi-compost, which is then used in agricultural fields to grow crops. In contrast to the usage of cow, goat, and chicken droppings for preparing vermi-compost, which is then utilised in agricultural fields for crop production, post-harvest wastes of spices, vegetables, and fruit plants, including leaves of forest trees, is added to the feed of livestock and poultry. A total of Rs. 29,900.00 is circulating as bio-economics in the whole integrated system of this farm.

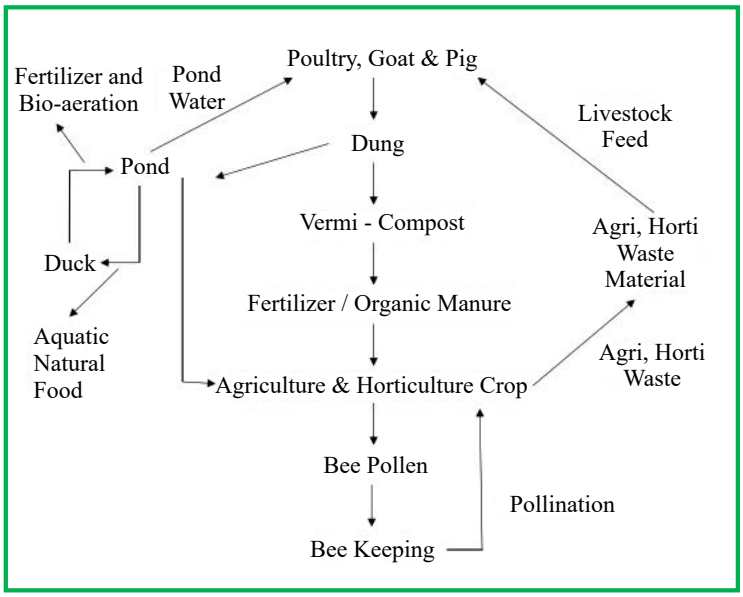

Figure 40: Flow diagram of resource recycling system at IFS of Smt. Hitkari Guria

Farm economic viability

In livestock-based integrated farm, Smt. Hitkari Guria recorded the highest net income from livestock sector (Rs. 1,93,650.00) followed by bee keeping (Rs. 72,000.00), plantation crops (Rs. 63,800.00), horticulture crops (Rs. 62,480.00), vermicompost (Rs. 2,600.00) and others including fisheries (Rs. 26,540.00) as shown in Table 31. Smt. Hitkari Guria fetched highest profit from Vanaraja poultry (Rs. 1,60,000.00), while considering individual component. Hence, it may be considered as poultry-based integrated farming as depicted in Table 31. The highest annual net income sharing comes from livestock sector (45.99%) followed by bee keeping (17.09%), plantation crops (15.15%), horticulture sector (14.83%), vermicompost (0.64%) and others including fisheries (6.30%) (Figure 41). The income analysis revealed that from a small farm piece of 1.33 ha area, the annual gross income of Rs. 6,44,870.00 could be realized from an investment of Rs. 2,23,800.00 with a resource use efficiency of Rs. 2.88 per rupee invested and a generation of 927 days of mandays of employment costing Rs. 1,72,900.00 as labour wage including her own labour. According to Smt. Hitkari Guria, an annual expense for household purposes covering food, education, health and others was Rs. 1,75,000.00. Since the total annual expense for household and farming purposes was Rs. 3,98,800.00 and the annual net income was Rs. 4,21,070.00, an annual saving of Rs. 22,270.00 could be possible from a livestock based integrated farm in a 1.33 ha area.

Table 31: Annual economics of Smt. Hitkari Guria's IFS

Component	Area	Production (Kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
Vegetables (Bitter gourd, Sponge gourd, Cowpea etc.)	0.5 bigha	668	7950.00	22380.00	14430.00
Spices (Turmeric, Black Pepper)	3.5 bigha	400.50	2650.00	7800.00	5150.00
Fruit Plants (Banana, Guava, Lemon etc.)	1.29 bigha	1975	17600.00	60500.00	42900.00
Plantation Crop (Areca nut, Bamboo)	3.15 bigha	1915	13200.00	77000.00	63800.00
Ghungroo Pig	120 sq. ft.	160 kg Meat	12950.00	26000.00	13050.00
Black Bengal Goat	60 sq. ft.	30 kg Meat & 12 Kids	11500.00	32000.00	20500.00

Component	Area	Production (Kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
Vanaraja Poultry	60 sq. ft.	60 kg Meat & 1000 Chicks	105000.00	265000.00	160000.00
Khaki Campbell Duck	30 sq. ft.	15 Eggs	50.00	150.00	100.00
Tilapia Fish	3000 Nos./ Bigha	27 kg	1500.00	3240.00	1740.00
Koi Fish	2000 Nos./ Bigha	6 kg	700.00	900.00	200.00
Bee keeping	1 Bigha	180 kg	36000.00	108000.00	72000.00
Vermi – Compost	0.01 Bigha	500 kg	2400.00	5000.00	2600.00
Fodder Cultivation	0.30 Bigha	600 kg	300.00	900.00	600.00
Others	0.01 Bigha	120 kg	12000.00	36000.00	24000.00
Total			**223800.00**	**644870.00**	**421070.00**

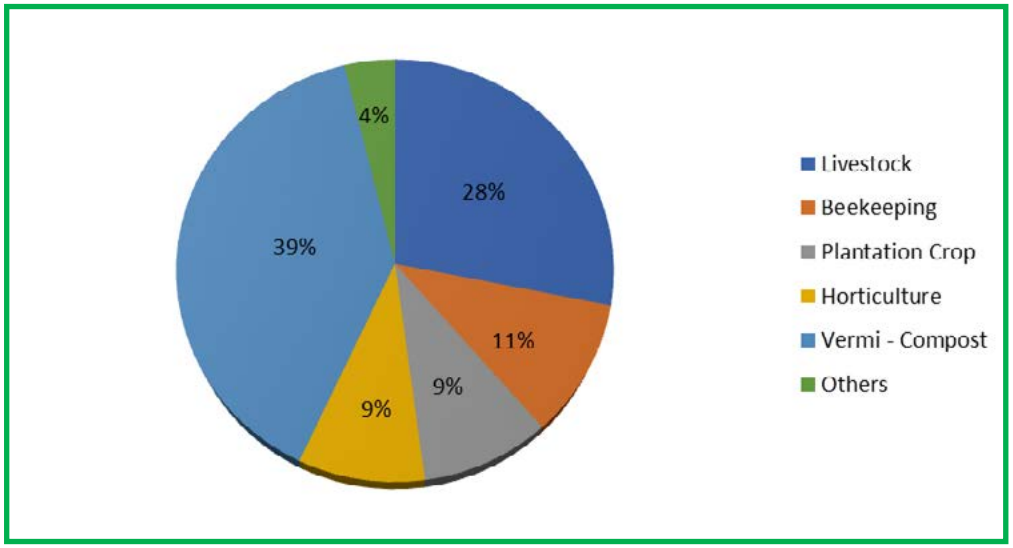

Figure 41: Annual net income sharing (in %) by different components of the farm

Conclusion

The present integrated farming system is a farming system that combines several agricultural components, which are based on the recycling biological concept, and links of input-output approach between the mutual commodities to boost the production and productivity in order to increase farmer income and create environmental friendly conditions. This integrated approach is best to bring about incremental changes in the production system to improve productivity and efficiency. Strengthening of local social institutions and use of the same for putting peer pressure and for service delivery may be another way forward to make this livestock (poultry)-based integrated farming system approach a success. Smt. Hitkari Guria is using 1.33 ha area for livestock-based integrated farming which gives her a great return. Using less space to generate more income is a part of farm sustainability. Smt. Hitkari Guria is able to satisfy her 3-membered family's nutritional demands of fish, vegetables, fruits, meat and egg from her farm grown agriculture and livestock products. Smt. Hitkari Guria wants to continue with the diversification of integrated farming and share her experience and knowledge of integrated farming with the neighbouring farmers for development of more and more IFSs in the locality. Smt. Hitkari Guria is concerned for her next generation who should continue farming in near future. It is thus concluded that IFS can play a good role not only in the issues of food security and nutritional security, but also helpful in generation of income and employment opportunities, if proper policy initiatives are taken. Smt. Hitkari Guria proves that a livestock (poultry)-based integrated farm can technically be feasible and economically viable with a net return of Rs. 3,16,593.98 from a 1.0 ha land.

Old Alluvial Agro-climatic Zone

Maximizing income through integrated goat-based agro-forestry farming system in Dakshin Dinajpur district

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Livestock-based integrated farming

Name of the farmer: **Shri. Ajit Kumar Sarkar**

Area of the farm: 1.86 ha

Location of the farm: Nowapara village, Hili block, Dakshin Dinajpur district

Shri. Ajit Kumar Sarkar, a 62-year-old farmer from Nowapara village in the Hili block of Dakshin Dinajpur district, has established an integrated goat-based agro-forestry farming system on 1.86 ha of land. His farming system covers goatery, fishery, duckery, and poultry farming, alongside the cultivation of seasonal vegetables. During the kharif season, he grows brinjal and chilli, while the rabi season sees him cultivating cabbage, cauliflower, and potato. Additionally, he cultivates paddy as a cereal crop in the kharif season and red gram as a pulse crop in the rabi season. His farm is also home to a variety of forest trees that contribute significantly to his earnings. The highest annual net income comes from the livestock sector, accounting for 53.4% of the total, with goats alone contributing 38.54%. The forestry sector follows with 19.3%, the horticulture sector with 8.2%, and the fishery sector with 7.9%. Other sectors contribute 6.1%, and the agriculture sector accounts for 5.1% of the annual net income. An income analysis reveals that from his 1.86 ha farm, Shri. Sarkar can generate an annual gross income of Rs. 13,01,250.00 from an investment of Rs. 5,23,000.00, achieving a resource use efficiency of Rs. 2.49 per rupee invested. Moreover, this farming system creates 930 mandays of employment, costing Rs. 2,32,500.00 in labor wages, including his own labor. Shri Sarkar's integrated farming system, combining livestock, crops, agroforestry, and fishery, demonstrates the potential for profitable and sustainable agri-business in the limited land holdings of Dakshin Dinajpur district in old alluvial agro-climatic zone.

Keywords

Integrated farming, Livestock, Agroforestry, Horticulture, Area development scheme, Old alluvial agro-climatic zone, Dakshin Dinajpur, West Bengal

Figure 42: Shri. Ajit Kumar Sarkar along with his local Black Bengal goats

Introduction

Shri. Ajit Kumar Sarkar, 62 years old farmer, is hailing from Nowapara village of Hili block of Dakshin Dinajpur district. He has developed a livestock-based integrated farm covering 1.86 ha (14 bigha) of land. Shri. Ajit Kumar Sarkar born in a farmers' family. In 2008, Shri. Ajit Kumar Sarkar came to know about the integrated farming (IF) from Dakshin Dinajpur Krishi Vigyan Kendra (KVK). Dakshin Dinajpur district is situated in the old alluvial agro-climatic zone of West Bengal. The characteristic feature is inundation caused by sudden heavy rainfall due to lack of proper drainage facilities. During kharif season, rice is the major crop. Other important crops grown in rabi season are potato, mustard, vegetables, red gram and chili. The soils are low in nitrogen, phosphorus and potassium content. Integration is the best process to continue farming here. Before started the integrated farm, Shri. Ajit Kumar Sarkar had only one pond, barren land and some forest trees. He did not make profit from that land. At that time he faced many constraints like unproductive land, lack of knowledge on scientific farming, less profit. He received training on IF from KVK and also visited other integrated farms. Later, he planned to develop the farm with IF model. He learnt properly to make the farm profitable. He was purposively selected for a pilot study due to his innovativeness in IF. The farmer was personally interviewed and data was collected with the help of a semi-structured schedule.

Figure 43: KVK Scientist visited different unit maintained by farmer

Figure 44: KVK Scientist interviewed the farmer

Farm description

Shri. Ajit Kumar Sarkar has developed a livestock-based integrated farm covering 1.86 ha (14 bigha) of land at Nowapara village in Hili block of Dakshin Dinajpur district. The soils are clayey loam, light, medium and heavy in texture, upland being lighter and medium to lowlands being heavier. The resource availability for farming is abundant here. At present the value of 1.86 ha land is about Rs. 98.0 lakhs.

In livestock-based integrated farm, Shri. Ajit Kumar Sarkar focusses on goatery, fishery, duckery and poultry farming. He has 100 number of Black Bengal goats and 200 numbers of local poultry birds, a stock of 200 number of Khaki Campbell ducks along with 2 numbers of crossbred cows. He has renovated farm pond with the help of govt. schemes. Shri. Sarkar has started desi poultry, duckery, goatery and fish farming in order to increase his net income. He is the only farmer in the village to take up 7 different crops and 5 other units on 1.86 ha of land. He grows vegetables on 1.8 bigha of land. He cultivates seasonal vegetables like brinjal and chilli in kharif season and cabbage, cauliflower and potato during rabi season. Shri. Ajit Kumar Sarkar cultivates paddy as cereal crop during kharif season and red gram as pulse crop during rabi season. He has some forest trees which provide a handsome amount for earning. He has 140 number of Akashmoni and 100 number of Eucalyptus plants. He also produces mushroom. He has a vermicompost unit. The demand for animal protein sources like milk, egg and meat is high in the district, however, Shri. Sarkar first fulfils his home need of animal protein from his farm produces and then sells the excess.

Shri. Ajit Kumar Sarkar having being trained by KVK Dakshin Dinajpur has adopted many good agricultural practices in making his farm technically feasible to maximize productivity and profit as mentioned below.

- This farm has greater diversity in livestock, agroforestry and crops to fetch more income and adapt to local circumstances.
- He has adopted KVK technologies for scientific fishery, goatery, poultry farming, cultivation of seasonal vegetables, paddy, mustard, pulse, vermicomposting and mushroom production.

- The farming with a variety of crops (cereal, pulses, vegetables, spices) has made agriculture sustainable by adopting rotational cropping system.
- He rears goat in semi-intensive system, which provides limited free-range grazing for 3-4 hours daily and browsing on pasture and stall-feeding with balance feed (branded feed) and shelter during night.
- Disease prevention of livestock is strictly maintained following vaccination schedule that boosts the immune system of the livestock.
- Feeding of vitamin and mineral mixtures keeps livestock in good health with optimal production.
- He saves irrigation water by adopting drip method of irrigation in field crops.
- He has been continuously practicing organic farming since the last 8 years. He has initiated organic agriculture practice by using farm yard manure (FYM), compost and vermicompost. Over four years of usage, he has noticed his crops getting better and developed an interest in vermicompost making and its continuous application.
- Good pond management enhances the fish yield.
- Fish-cum-duck has beneficial effects on both fish and duck production.
- The availability of labour is the biggest challenge in the area, because of which he wants to purchase new machinery to substitute labour force for a better yield and help to reduce the drudgery that farm women face.
- In an IF, the choice of crops as well as their cropping sequence is important. The cropping sequence is shown in Table 32.

Table 32: Cropping sequence at the farm of Shri. Ajit Kumar Sarkar

Crop	Season	
	Kharif (Rainy)	Rabi (Winter)
Cereal	Paddy (4) *,	
Other crops		
Oilseed		Mustard (3)
pulse		Red gram (1)
Vegetables	Brinjal (1/2)	Potato (2), Cauliflower (1/2), Cabbage (1/2),
Spices	Chili (1/2)	
Fruit Plant		
Forest tree	Akashmoni and Eucalyptus Plant	
Cattle	Desi cross	
Goat	Black Bengal	
Chicken	Deshi	
Duck	Khaki Campbell	
Fishery	IMCs	
Others	Mushroom	
	Vermicompost	

*Data in parenthesis is the amount of area in bigha

Farm layout

The layout of Shri. Ajit Kumar Sarkar's IFS is shown in Figure 45.

Capital cost with financial assistance, if any

There was an involvement of capital cost to develop this IFS. Thus, the capital cost for developing this IF is presented in Table 33.

Table 33: Capital cost of Shri. Ajit Kumar Sarkar's farm developed in 1.86 ha land

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Pond renovation (2 bigha)	0.15/bigha	0.30	0.30 from ATMA
Vermicompost unit (4 nos)	0.10/unit of 100 m^2	0.40	0.30 from Agriculture department
Micro sprinkler (7.5 bigha)	0.10/3 bigha	0.25	0.25 from PMKSY

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Vegetable	--	0.40	0.30 from ATMA
Cow shed	--	0.80	
Poultry house		0.45	
Duck house		0.30	
Goat house		1.50	
Mushroom unit		3.00	
Total Cost		**7.40**	

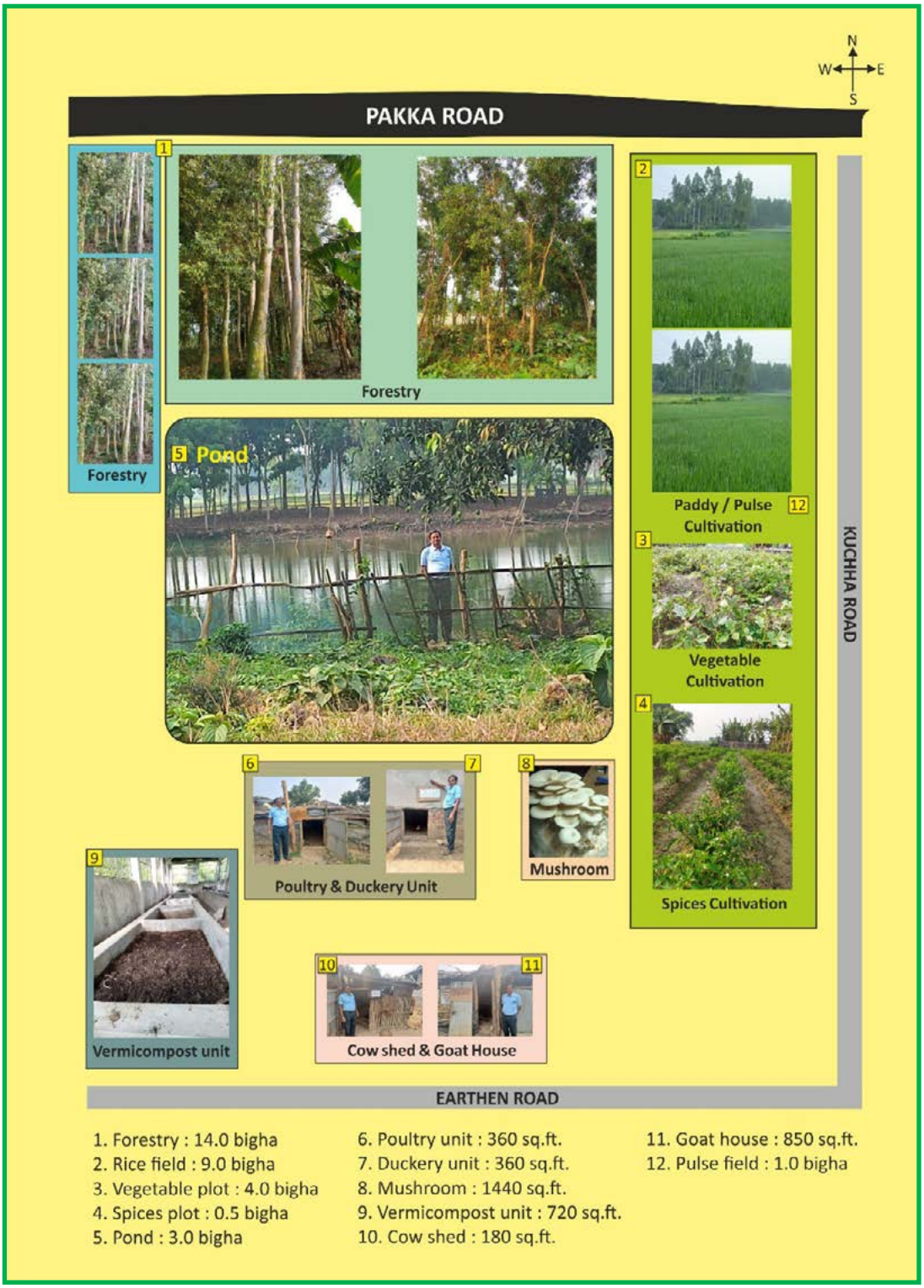

Figure 45: A layout of Shri. Ajit Kumar Sarkar's farm developed in 1.86 ha land

Bio-economic circularity of the farm

The success of IF depends on the efficiency of bio-economic circularity of the farm. Bio-economic circularity of the Farm is presented in Figure 46 showing that post-harvest wastes of cereal, pulse, spices, vegetables and plants are used as feed resources for livestock. On the other hand, livestock excreta are utilized in preparing vermicompost and organic manure which are applied in agriculture field for crop production and fish culture pond where fishes directly consume livestock excreta for protein, carbohydrates, minerals etc. enabling faster growth. Ducks fertilize the pond too by their droppings when given free range over the pond surface. Ducks loosen the pond bottom with their dabbling and help in release of nutrients from the soil, which increase pond productivity. Ducks aerate the water while swimming and this natural aeration is beneficial for fish growth. On the other hand, ducks get their feed requirements in the form of aquatic weeds, insects, larvae, earthworms, etc. The application of the partial decomposed livestock excreta in the pond provides a nutrient base for dense bloom of phytoplankton which helps in development of zooplankton. The zooplankton is an additional food source for fishes. Further, the pond water is used for source of irrigation in agriculture fields. A total of Rs. 36,500.00 is circulating as bio-economics in the whole integrated system of this farm.

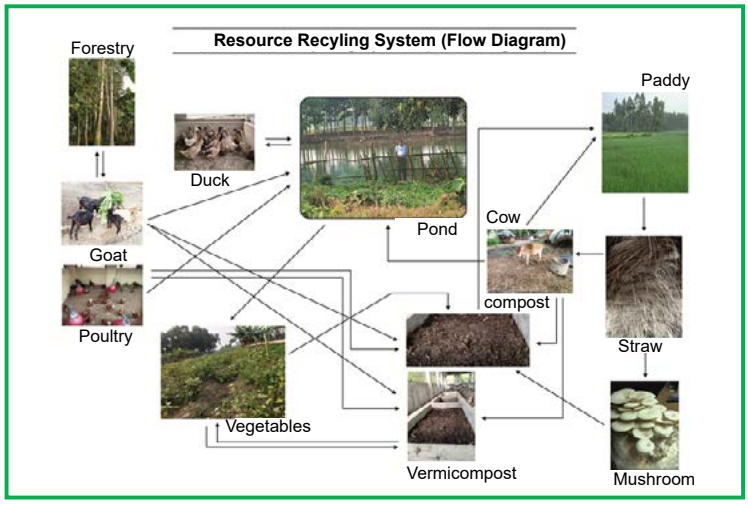

Figure 46: Flow diagram of resource recycling system at the farm

Farm economic viability

In this integrated goat-based agro-forestry farming system, Shri. Ajit Kumar Sarkar recorded the highest net income from goatery (Rs. 3,00,000.00) followed by forest tree (Rs. 1,50,000.00), fishery (Rs. 61,000.00), vegetables (Rs. 47,250.00) and mushroom (Rs. 43,000.00) as shown in Table 34. Shri. Ajit Kumar Sarkar fetched a good amount of profit from duckery (Rs. 42,000.00), poultry (Rs. 40,000.00), cereals (Rs. 36,000.00) and cattle (Rs. 34,000.00) as depicted in Table 34. The highest annual net income sharing came from livestock sector (53.4%) where goat alone contributes 38.54% of total net income, followed by forestry sector (19.3%), fishery sector (7.9%) and horticulture sector (8.2 %) as shown in Figure 47. Other sector contributed 6.1%, and agriculture sector 5.1 % of annual net income (Figure 47). The income analysis revealed that from a small farm piece of 1.86 ha area, the annual gross income of Rs. 13,01,250.00 could be realized from an investment of Rs. 5,23,000.00 with a resource use efficiency of Rs. 2.48 per rupee invested and a generation of 930 days of mandays of employment costing Rs. 2,32,500.00 as labour wage including his own labour. According to Shri. Ajit Kumar Sarkar, an annual expense for household purposes covering food, education, health and others was Rs. 3,41,000.00. Since the total annual expense for household purposes was Rs. 3,41,000.00 and the annual net income was Rs. 7,78,250.00, an annual saving of Rs. 4,37,250.00 could be possible from this integrated goat-based agro-forestry farming system in a 1.86 ha area.

Table 34: Annual economics of Shri. Ajit Kumar Sarkar's IFS

Component	Area	Production(kg)	Cost of production (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereal (Rice)	9.0 bigha*	5040	54,000.00	90,000.00	36,000.00
Pulse (Red Gram)	1.0 bigha	150	5,000.00	9000.00	4,000.00
Vegetables (Brinjal, chilli, cabbage, cauliflower, potato)	4 bigha	9000	34,000.00	81,250.00	47,250.00
Spices (Chili)	0.5 bigha	500	8,000.00	25,000.00	17,000.00
Forest tree	14 bigha	1005 cubic feet	40,000.00	1,90,000.00	1,50,000.00
Cattle (Desi cross breed)	180 sqft	2100 L milk	20,000.00	54,000.00	34,000.00
Goat (Black Bengal)	850 sqft	255 kg meat, 50 goat kid	2,00,000.00	5,00,000.00	3,00,000.00
Poultry (Desi.Broiler)	360 sqft	8400 pcs eggs	20,000.00	60,000.00	40,000.00
Duckery (KC cross)	360 sqft	11000	30,000.00	72,000.00	42,000.00
Fishery	3 bigha	680 kg	90,000.00	1,51,000.00	61,000.00
Other enterprise(Vermi- compost)	720 sqft	200 kg	2,000.00	6,000.00	4,000.00
Mushroom	1440 sq ft	630	20,000.00	63,000.00	43,000.00
Total			**5,23,000.00**	**13,01,250.00**	**7,78,250.00**

*1 bigha= 33 decimal

Financial plan without bank loan

Considering the techno-economic facts and figures of Shri. Ajit Kumar Sarkar's IFS in 1.86 ha land, a finncial plan may be developed for an interested farmer who may not take any bank loan and thus invest the capital cost of Rs. 7,40,000.00 from his/ her own. Every year recurring cost of cultivation is considered as Rs. 5,23,000.00 and the capital cost will be recovered in five equal installments. A financial plan is presented in Table 35.

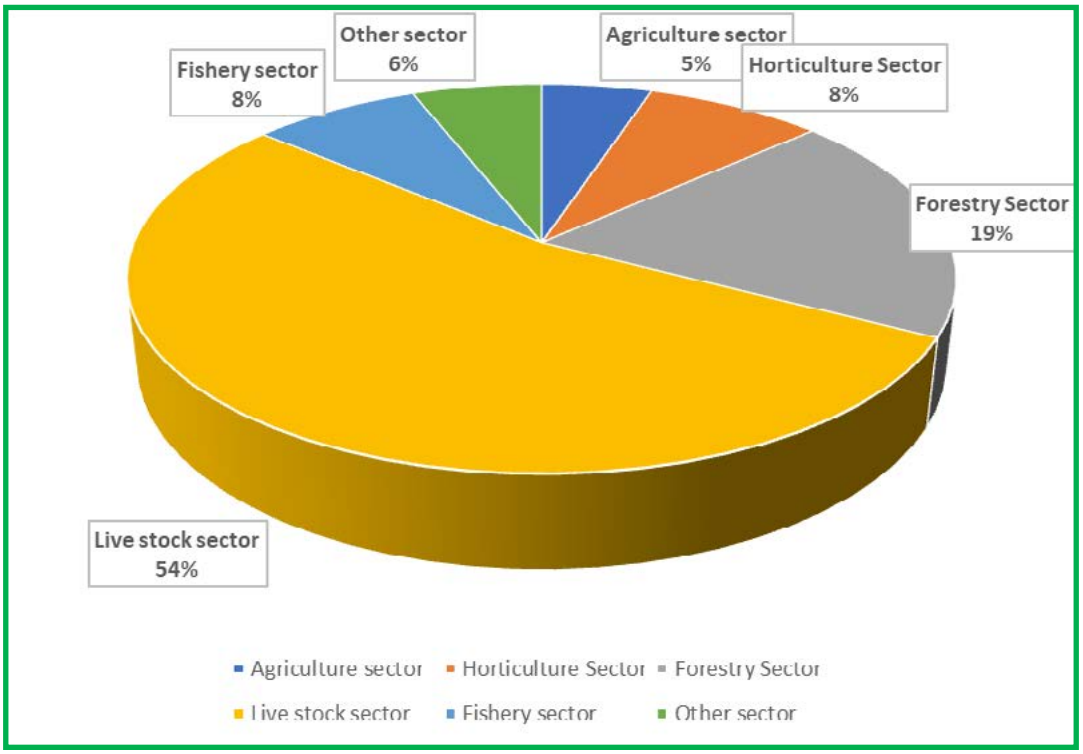

Figure 47: Annual net income sharing (in %) by different components at livestock-based integrated farm

Table 35: Financial plan for area development scheme on horticulture-based IFS in 1.86 ha land (without bank loan)

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Capital cost	740000.00	592000.00	444000.00	296000.00	148000.00	0.00
2	Recurring cost of cultivation	523000.00	523000.00	523000.00	523000.00	523000.00	523000.00
3	Recovery of capital cost in equal installment	148000.00	148000.00	148000.00	148000.00	148000.00	0.00
4	Gross income	1301250.00	1301250.00	1301250.00	1301250.00	1301250.00	1301250.00
5	Net income	630250.00	630250.00	630250.00	630250.00	630250.00	778250.00
6	BC ratio	1.94	1.94	1.94	1.94	1.94	2.49

Financial plan with bank credit availability

Considering the techno-economic facts and figures of Shri. Ajit Kumar Sarkar's IFS in 1.86 ha land, a finncial plan may be developed for an interested farmer who may look forward for a bank loan to develop such an IFS. The total project cost covering capital cost and 1st year recurring cost of cultivation will be based on economic data shown by Shri. Ajit Kumar Sarkar as follows.

Project Cost = Capital Cost + 1st Year Recurring Cost = Rs. (7,40,000.00 + 5,23,000.00) = Rs. 12,63,000.00

A financial plan with bank loan facility is presented in Table 36.

Table 36: Financial plan for bankable area development scheme on vegetable-based IFS in 1.86 ha land

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Project Cost	1263000.00					
2	Margin @ 15%	189450.00					
3	Bank loan	1073550.00					
4	Yearly rate of simple interest @12.0% PA	12.00					
5	Loan O/S at the beginning of the year	1073550.00	858840.00	644130.00	429420.00	214710.00	0.00
6	Accrual of interest	128826.00	103060.80	77295.60	51530.40	25765.20	0.00
7	Repayment of principal in equal installment	214710.00	214710.00	214710.00	214710.00	214710.00	0.00
8	Repayment of interest	128826.00	103060.80	77295.60	51530.40	25765.20	0.00
9	Loan O/S at the end of the year	858840.00	644130.00	429420.00	214710.00	0.00	0.00

Repayment plan

The repayment plan against bank loan may be as shown in Table 37.

Table 37: Repayment plan against bank loan

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Repayment of principal in equal installment	214710.00	214710.00	214710.00	214710.00	214710.00	0.00
2	Repayment of interest	128826.00	103060.80	77295.60	51530.40	25765.20	0.00
3	Recurring cost of cultivation	523000.00	523000.00	523000.00	523000.00	523000.00	523000.00
4	Gross income	1301250.00	1301250.00	1301250.00	1301250.00	1301250.00	1301250.00
5	Net income	434714.00	460479.20	486244.40	512009.60	537774.80	778250.00
6	BC ratio	1.50	1.55	1.60	1.65	1.70	2.49

Conclusion

Integrated farming means for better utilization of resources to get more profit. Shri. Sarkar's income has been increased more than doubled. Farming provides him a considerable income to run his family and maintain a standard living. Shri. Sarkar gets Rs. 7,78,250.00 net profit from his 1.86 ha of land. Shri. Ajit Kumar Sarkar is using only 2.43 katha area for animal husbandry which gives him a suitable return. Using less space to generate more income is a part of farm sustainability. Though Shri. Sarkar is using the spring water for watering the crop and vegetables, he has a future plan to harvest rain water too. Shri. Ajit Kumar Sarkar is able to satisfy his 5 membered family's nutritional demands of cereal, pulse, vegetables, fruits, milk, meat and egg from his farm grown agriculture and livestock produces. Though the food item available of farm is not sufficient for his daily need, he is satisfied with the quality he gets from the system. Shri. Ajit Kumar Sarkar wants to continue with the diversification of integrated farming and share his experience and knowledge of integrated farming with the neighbouring farmers for agricultural development in the area. Shri. Ajit Kumar Sarkar is concerned for his next generation who should continue farming. The case study of Shri. Ajit Kumar Sarkar clearly indicates that developing livestock-based integrated farm can technically be feasible and economically viable with the net return of Rs. 4,18,413.98 from a 1.0 ha land. Nevertheless, the availability of animal food and wholesome food items for maintaining own family is more essential than purchasing the same from the local market.

Employment generation through integrated goat-based agro-forestry farming in Murshidabad district

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Livestock-based integrated farming

Name of the farmer: **Shri. Mainul Sk**

Area of the farm: 1.7 ha

Location of the farm: Bali village, Nowda block, Murshidabad district

In the current Indian landscape, with a strong emphasis on self-reliance, particularly among rural youth, the nation's vision of "Atma Nirbhar Bharat" is being brought to life through the sustainable entrepreneurial efforts emerging across the country. This case study highlights the inspiring journey of an ordinary youth, driven by passion and resilience, who has transcended formidable challenges to achieve extraordinary success. Mainul Sk, hailing from a small hamlet in Murshidabad, has transformed the economic adversities inflicted by the pandemic into a story of triumph. Leveraging the conducive conditions for goat farming prevalent in Murshidabad, he seized the opportunity to maximize the benefits of an integrated farming system (IFS) centered around goat farming. Mainul Sk has ingeniously created a synergistic ecosystem, where the by-products of one component serve as valuable inputs for others, demonstrating efficient resource recycling. Utilizing a total land area of 1.3 ha for agriculture, horticulture, and silviculture, Mainul Sk has achieved an impressive annual turnover of approximately Rs. 10.0 lakhs. The primary source of net income, Rs. 1.15 lakhs, comes from goat farming, followed by Rs. 1.06 lakhs from oilseed and fiber crops. His remarkable journey has inspired many aspiring rural entrepreneurs to explore their own ventures within the IFS framework, focusing on various enterprises. Mainul Sk's success story not only underscores the potential for profitable and sustainable agri-businesses in rural India but also fosters the horizontal expansion of entrepreneurship without compromising environmental integrity. His journey from adversity to prosperity serves as a beacon of hope and a testament to the power of resilience and innovation.

Keywords

Integrated farming system, Goat-based farming, Agri-entrepreneurship, Murshidabad district

Figure 48: Goat-centric agro-forestry field of Shri. Mainul Sk

Introduction

Being largely influenced by the Bhagirathi River, Murshidabad is predominantly a district where diverse types of crops are grown hence called the Crop Museum of West Bengal. It is dominated mainly by old and new alluvial types of soil and a favorable climate for crop cultivation but considering the whimsical behavior of climate and market vagaries in the recent past profitable agriculture is remaining only in the pages of books, not in reality. On the other hand, the congenial circumstances regarding climate, human resources, and high demand in market the livestock farming is being the most profitable in this situation. Taking into consideration the relative advantages of different agri-ventures, goat farming has been emerged as the most profitable as well as feasible entrepreneurial alternative. In the era of moving towards self-reliance, when a number of unemployed semi-educated youth are being engulfed with pessimism and agony, an ordinary youngster with an extraordinary zeal in his mind has come up with a successful goat-based agro-forestry model of integrated farming to show a silver line in front of the agri-entrepreneurship aspirants. Shri. Mainul Sk, a resident of a small hamlet named Bali of Murshidabad, the land of nawabs, in West Bengal, has started his journey as a bread earner for his family in the form of a private sector employee of a Hyderabad-based flamboyant Multi National Company (MNC) and was earning an attractive remuneration there. But during the span of the devastating COVID -19 chapter, the pandemic-stricken situation snatched his job as well as his stability of life led by the worldwide economic crises and subsequent trend of laying off. Nevertheless, a true-life warrior like Shri. Mainul Sk was reluctant to give up rather he culminated the new age eco-friendly approaches of modern farming systems and nourished within the philosophy of relying on mother nature when everything is not running well. With technical assistance from Dhaanyaganga Krishi Vigyan Kendra (DGKVK), Sargachi he has started his own venture on 13 bighas of land, comprising of multiple cropping systems including cereals, pulses, vegetables, fiber crops, fruits, livestock, forestry, vermin-composting, etc. towards yielding a healthy turnover maintaining the sustainability of the eco-systems. This case study is based on a goat-centric agro-forestry model of integrated farming and the primary objective of this inquiry is to depict how a distressed person can turn around his gloomy situation into a better one with the help of a modern farming approach toward a sustainable living with sheer dedication and application of knowledge gained from different scientific institutions.

Farm description

The high demand of goat meat in retail market and the huge human resource involvement in agriculture are the major causes to place goat rearing in the central position of the farming model along with agriculture, horticulture, silviculture, vermicomposting, etc. Mainul Sk has tried to utilize this opportunity and that's why he selected an integrated farming system (IFS) based on goat farming. In this venture, a total of 1.7 ha (13.0 bighas) of land has been taken. Previously, 4.0 bighas of this total land area was occupied with forestry comprising Sagwan, Mahogany, Neem etc. and 0.5 bigha was already occupied with fruits trees like Jackfruits, Mango and Guava. Approximately, 9.0 bighas i.e. rest of the land remained as pasture land but he found that land as cultivable and accordingly started his venture and constructed animal house for livestock raring, and the other parts were converted into a state of tilth with proper tillage operation. He has tried to start some cereal cultivation like rice, maize and wheat in 3.5 bighas area, pulses like lentil, green gram, Bengal gram in 3.0 bighas, vegetable like spinach, okra, spices like turmeric in 0.5 bigha, fiber crops and oilseed in 6.0 bighas and fodder cultivation in 2.0 bighas areas along with vermicomposting. The cropping sequence of the farm is presented in Table 38.

Table 38: Different crop and animal components at the farm unit

Season	Cereal	Pulse	Vegetables / Spice	Forest Tree	Fruit Plants	Fibre Crop/ Oilseed	Cattle	Goat	Other Enterprise
Kharif	Rice Maize	-	Turmeric	Segun Neem Mehgini Mahar	Guava	Jute	Jersey cross	Black Bengal Patnai Cross	Vermi-compost
Rabi	Wheat	Lentil Biuli Bengal Gram	Spinach Amaranthus	,,	,,	Mustard	,,	,,	Fodder Cultivation
Zaid	-	-	Okra	,,	,,	Sesame	,,	,,	,,

DGKVK provided him with all the necessary information and guidance about land utilization, housing, managerial aspects, economic strategy and program planning. Hundred square feet area was covered for semi-pucca housing and ten thousand square feet of area was assigned for grazing the animals. He arranged 100 superior quality crossbred goats to start goat farming. Before incorporating them in the farm, the animals were dewormed and vaccinated properly with the help of Mobile Veterinary Clinics (MVC) of Sagardighi block. He became acquainted with routine managerial practices of the farm, and primary first aid treatment of the animals in response to ailment. SMS (Vet. Sci.) and MVC personnel advised him about the cultivation of different fodder plants depending upon the season and irrigation facilities. Well-thought choices of various kinds of fodder (Rabi, Zaid, and Kharif) cultivation ensured the supply of green fodder throughout the year.

Figure 49: Advisory services provided to Shri. Mainul Sk time to time

Farm layout

The layout of Shri. Mainul Sk's IFS is shown in Figure 50.

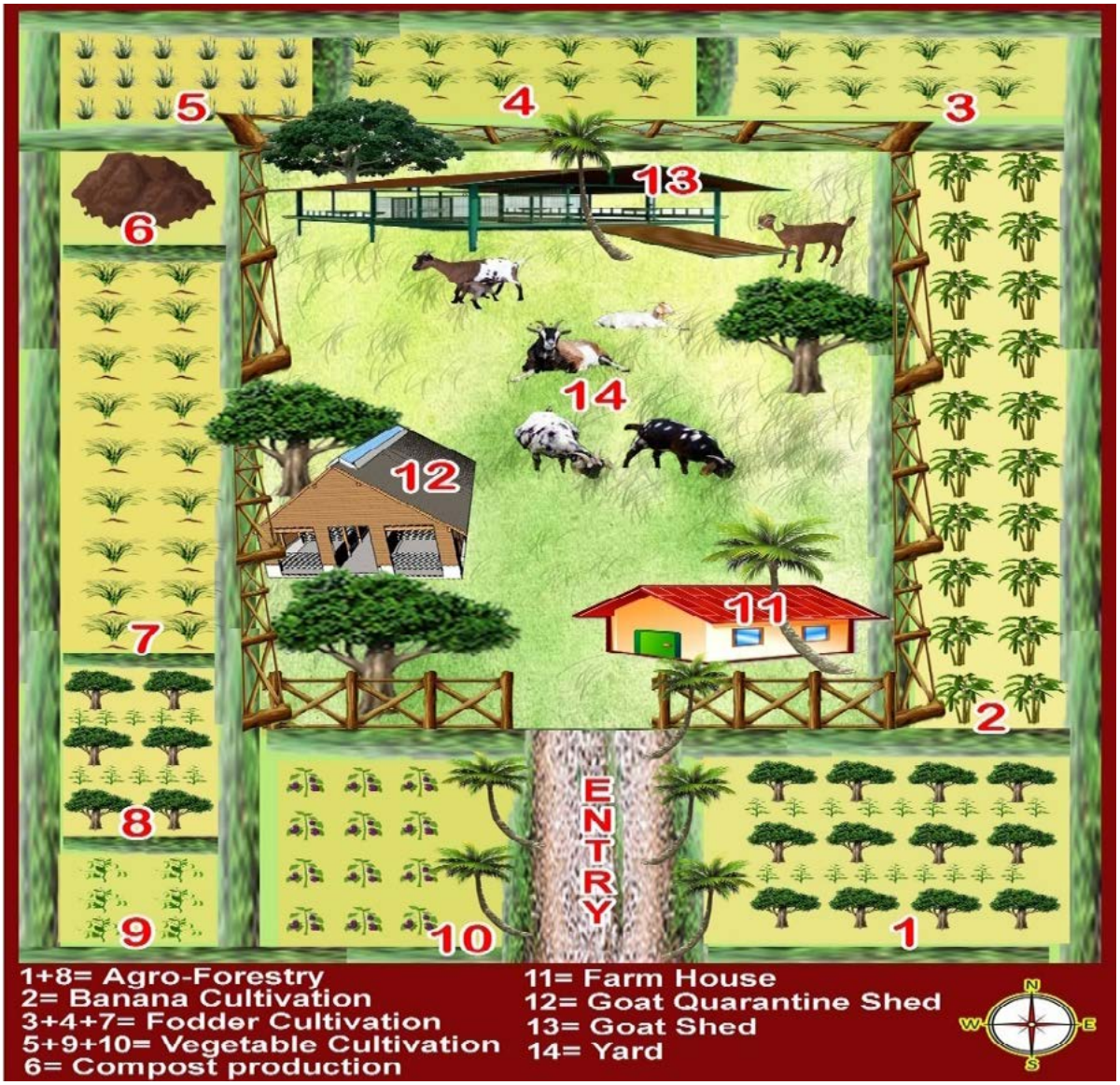

Figure 50: Layout of Shri. Mainul Sk's IFS

Capital cost with financial assistance, if any

The capital cost of such integrated goat-based agro-forestry farming system is present in Table 39 for those who want to start such kind of farming.

Table 39: Capital cost for developing integrated goat-based agro-forestry farming

Items	Area	Cost per unit (in Rs.)	Total Cost (in lakh)	Subsidy/ Govt Contribution (If any)
Goat rearing unit (pucca) with corrugated sheet on the roof	500 sqft	Rs 250/ sqft	1.25 lakh	25% contribution from DGKVK
Dairy Shed (concrete floor) with feeding arrangements and waste management system	250 sqft	Rs 350/ sqft	0.87 lakh	Self-finance
Vermicompost unit with 10 chamber capacity	210 sqft	Rs 200/ sqft	0.42 lakh	25% contribution from DGKVK
Threshing and drying unit (concrete floor)	600 sqft	Rs 100/ sqft	0.60 lakh	Self-finance

Items	Area	Cost per unit (in Rs.)	Total Cost (in lakh)	Subsidy/ Govt Contribution (If any)
Chaff cutter, milk collection utensils, other dairy related implements	-	-	0.50 lakh	100% contribution from DGKVK
Foot sprayer, knapsack sprayer, water pump, thresher, rotovator, mini tractor, other implements	1 no. each	-	5.00 lakh	Self-finance
Total			**8.64 lakhs**	

Bio-economic circularity of the farm

An integrated farming system comprising different interrelated components which are not only cohabitating with each other but also rely heavily on each other. The input of one component is readily available from the discarded materials of other components and hence creating an invisible synergism within the elements of the farming system. The beauty of this kind of approach is that waste materials can effectively be reused and recycled in such a way that the productivity can reach beyond the conventional economic of scale which in turn makes the ventures technically feasible and socially acceptable and subsequently a successful approach of income generation without hampering the sustainability of the farming system. The detailed relationship of the interdependence among the elements of farming system has been tried to be pictorially depicted with the following flow chart diagram (Figure 51).

For instance, it has been found that waste materials (leaves) of fruit crops like Jackfruits, Mango, and Guava could be a highly reliable source of feed for goats and cattle and it saved up to Rs. 12,000.00 in a year. On the other hand, the sheered leaves of forest trees like Sagwan, Mahogany, and Neem were used effectively for composting that was used in horticultural and agricultural fields as a source of organic material that saved up to Rs. 20,000.00 per year as an alternative source of organic manure. The droppings of goats and urine also played a role in liquid manure in crop fields. The straw received from different crops was used for bed preparation of vermicomposting. In this way, a multifarious dimension was being established with a circularity of thousands of rupees. Hence, the biological components were playing a significant role in the economic aspect of the overall farming systems and thus prominently paid a positive bio-economic aspect of this model.

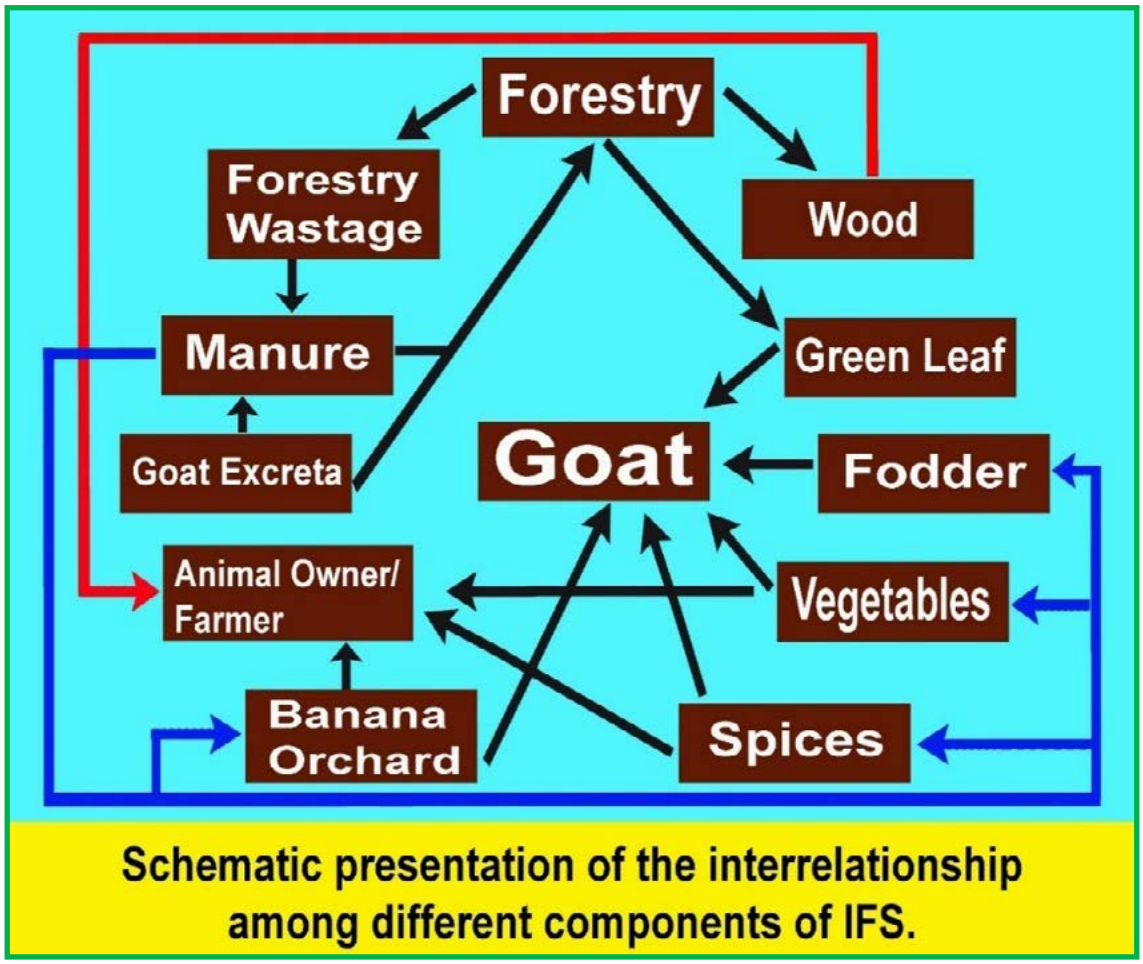

Figure 51: Flow diagram of resource recycling system at IFS of Shri. Mainul Sk

Farm economic viability

A venture cannot be claimed as successful unless it will be economically viable and sustainable. For different categories of crops like cereals, pulses, fibre crops, oilseed, fruit crops, and forests trees along with the key enterprise, i.e. goat farming and other enterprises, gross return, net return and BC ratio have been depicted separately in the following Table 40.

Table 40: Annual economics of Shri. Mainul Sk's IFS

Component	Area (Bigha)	Production (kg)	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)	BC Ratio
Cereal (Rice, Maize, Wheat)	3.5	2500	17000.00	60000.00	43000.00	3.5
Pulse (Lentil, Biuli, Bengal Gram)	3.0	680	4750.00	49000.00	44250.00	10.3
Vegetables/ Spices (Turmeric, Spinach, Amaranthus, Okra)	0.5	420	2000.00	8250.00	6250.00	4.1
Forest Trees (Segun, Neem, Mehgini, Mahar)	4.0	2400	8000.00	42000.00	34000.00	5.3
Fruit plants (Mango, Jackfruit, Guava)	1.0	1400	3000.00	15000.00	12000.00	5.0
Fiber Crops/Oilseeds (Jute, Mustard, Sesame)	6.0	2200	45000.00	151000.00	106000.00	3.4
Cattle (Jersey Cross)	1 nos	2000 L	33650.00	80000.00	46350.00	2.4
Goat	43 nos	-	110000.00	225000.00	115000.00	2.0
Other enterprises (vermin-compost, fodder cultivation)	2.0	8000	8000.00	29000.00	21000.00	3.6
Total			**231400.00**	**659250.00**	**427850.00**	

Conclusion

Successful ventures depend on several factors starting from innovation to profitable marketing of the produce without hampering the environment. Shri. Mainul Sk. has inevitably proved that the farming with comparatively fewer resources could definitely achieve the target, if proper management and a perfect integration could be attained. While excessive use of synthetic chemicals in farming is posing threat on soil-plant-animal-human continuum, the use of bio-resources in IFS may be an effective panacea to provide quality food in one hand and safe environment on the other hand. Shri. Mainul Sk. has exactly paved this path to carry forward this journey from dystopia towards utopia. Experiencing his multi-dimensional activities with the limited resources available in his hand and subsequently producing remuneration beyond expectation is attracting the other aspirants and hence this idea is being expanded horizontally. DGKVK is relentlessly engaged in the process of extending his helping hand may it be regarding managerial advice, may it technical supervision, may it be financially inclusive policy-making, or may it be providing sufficient inputs. Shri. Mainuk Sk is just an instance among the distress rural youth spread over different areas in the district indicating that a person can make his own fate, if he wishes to do so.

A tribal farmer finds alternative to traditional farming through fishery-based integrated farming in Dakshin Dinajpur district

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Fishery-based integrated farming

Name of the farmer: **Shri. Paresh Oraw**

Area of the farm: 0.93 ha

Location of the farm: Shibpur village, Tapan block, Dakshin Dinajpur district

The present case study aims to illustrate the development of a fishery-based integrated farming system (IFS) by Shri. Paresh Oraw, a 55-year-old tribal farmer from Shibpur village in the Tapan block of Dakshin Dinajpur district. Shri. Paresh Oraw has skillfully cultivated a multifaceted IFS on his 0.93 ha land, incorporating fish, ducks, goats, field crops, vegetables, spices, and fruit plants. Despite the small land size, his innovative approach has yielded an impressive annual net income of Rs. 2,56,300.00, with a benefit-cost ratio of 2.97. The majority of Shri. Oraw's income stems from the fisheries sector, which contributes 41% of the total annual net income, followed by horticulture at 30%, livestock at 20%, and agriculture at 9%. This distribution underscores the prominence of fisheries within his IFS, making it a prime example of a fishery-based IFS. In addition to financial success, Shri. Paresh Oraw's IFS meets the nutritional needs of his four-member family. They are self-sufficient in staple grains, oilseeds, pulses, vegetables, fruits, fish, meat, and eggs, all produced within the farm. Shri. Paresh Oraw's achievement demonstrates the potential of small-scale IFS to generate substantial income and ensure food security. His success story serves as an inspiring model for sustainable agriculture, particularly in rural and tribal communities.

Keywords

Integrated farming system, Doubling of farmer's income, Agriculture, Horticulture, Livestock, Fishery, Dakshin Dinajpur, Old alluvial zone

Figure 52: Shri. Paresh Oraw is explaining different units of his IFS before KVK Scientists

Introduction

Shri. Paresh Oraw, a 55-year-old tribal farmer, is from Shibpur village in Tapan block of Dakshin Dinajpur district in old alluvial zone of West Bengal. He has developed a fishery-based integrated farm on 0.93 ha (7 bigha) land. The soil is clay loam, light, medium and heavy texture, with lighter highlands and lower midlands. Soil is poor in nitrogen, phosphorus and potassium. The characteristic feature is flood caused by sudden heavy rains due to lack of proper drainage facilities. During the kharif season, paddy is the main crop. Other important crops grown during the rabi season include potatoes, mustard, vegetables and lentil. The availability of resources for agriculture is abundant here. Integration is the best process to practice agriculture here. Before adopting IFS, he had only pond, barren land and forests. He did not take advantage of this land. In 2008, Shri. Paresh Oraw learnt about IFS from Dakshin Dinajpur Krishi Vigyan Kendra (DDKVK) and visited to other integrated farms in the district. Later, he planned to develop the farm in the model of an IFS.

Farm description

In fishery-based integrated farm, Shri. Paresh Oraw focuses on rearing of goats, ducks along with fish culture. He also grows seasonal vegetables like bitter gourd, ridge gourd, pointed gourd, green chili, brinjal during the kharif season and potatoes during the rabi season. Shri. Paresh Oraw cultivates paddy and black gram during the kharif season and lentil during the rabi season as shown in Table 41. He owns 20 numbers of Black Bengal goats and a flock of 30 numbers of Khaki Campbell per production cycle. Though the demand for animal protein sources such as milk, eggs and meat are very high in the district, Shri. Oraw first meets the domestic demand for animal protein produced at his farm, and then sells the surplus.

Table 41: Cropping sequence and animal components at the farm

Crop	Season		
	Kharif (Rainy)	Rabi (Winter)	Zaid (Summer)
Cereal	Paddy	Mustard	
Oilseed		Mustard	
Pulse	Black gram	Pink lentil	
Vegetables	Brinjal, Bitter gourd, Ridge gourd,	Potato, Brinjal Cabbage, Onion, Pea, Jukni	Brinjal, Drum stick
Spices	Bay Leaf, Green chili	Bay Leaf, Turmeric	Bay leaf
Fruit Plant	Guava, Lemon, Mango		
Goat	Black Bengal		
Duck	Khaki Campbell		
Fishery	Indian Major Craps (IMCs)		

To minimize the cost of production and maximize the income, Shri. Paresh Oraw applies improved technologies on fish farming, goat farming, duckery, cultivation of vegetables, paddy, mustard, black gram and lentil in his farm. He has a good rapport with other farmers and input agents that facilitate a healthy exchange of information. He saves irrigation water by applying drip irrigation method in field crops. He believes that farming can be successful when anyone makes the right decision at the right time and puts a lot of effort into it. As labor availability is the biggest challenge, so he wants to buy machine to reduce the dependency on hired labour.

Figure 53: Shri. Paresh Oraw along with his ducks

Farm layout

A farm layout is presented in Figure 54.

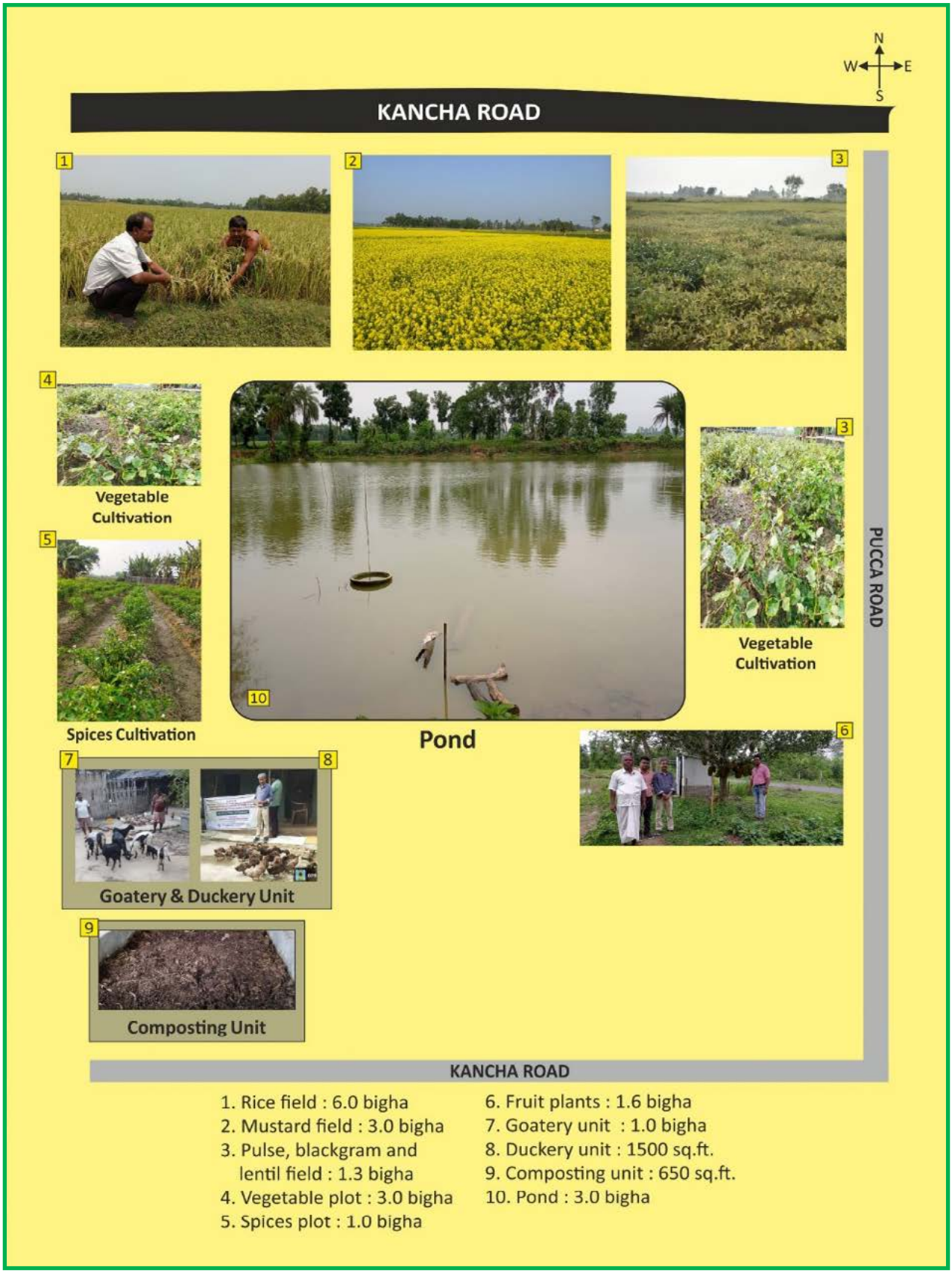

Figure 54: Farm layout of Shri. Paresh Oraw's IFS

Capital cost with financial assistance, if any

He renovated the farm's pond with the help of the Government project under MGMREGA.

The capital cost of developing such IFS is presented in Table 42 as reported by Shri. Paresh Oraw.

Table 42: Capital cost for developing the IFS

Item	Cost per unit (Rs. in lakh)	Total cost (Rs. in lakh)	Subsidy/Govt. contribution (if any) (Rs. in lakh)
Pond renovation (3 bigha)	0.20/ bigha	0.60	MGNREGA
Vegetable	-	0.50	
Duck house	-	0.50	
Cost of 30 ducks	0.002/ duck	0.06	
Goat house	-	1.00	
Cost of 20 goats	0.01/ goat	0.20	
Total Cost		**2.86**	

Bio-economic circularity of the farm

Figure 55 shows the generated agricultural residues such as weeds, straw, and vegetables are used as feed sources for livestock. Animal manure is used to produce organic manure which is used in the agricultural field for crop production and in fish pond for fish feeding. The post-harvest waste of grains, legumes, spices, vegetables and fruit plants is used as a source of feed for livestock. A total of Rs 25,300.00 is circulated as a bio-economy throughout the integrated system of this farm.

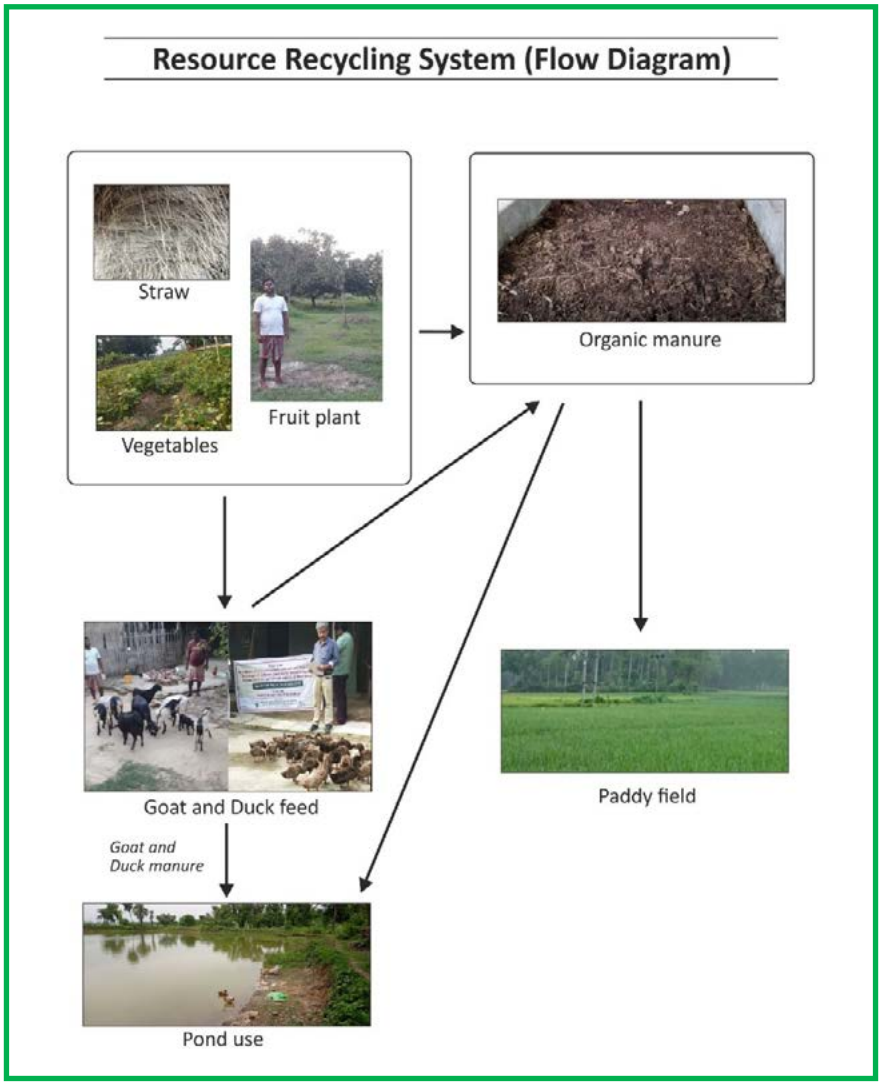

Figure 55: Flow diagram of resource recycling system at the farm

Farm economic viability

In fishery-based integrated farm, Shri. Paresh Oraw recorded the highest annual net income from fish culture (Rs 1,05,000.00), followed by horticultural crops including vegetables, spices and fruits (Rs 77,800.00), livestock component covering goatery and duckery (Rs. 50,000.00) and field crops comprising of cereal, oilseed and pulse (Rs. 23,5000.00) as shown in Table 43. The highest proportion of annual net income comes from fishery sector (41%), followed by horticulture (30%), and livestock (20%) and agriculture (9%) as shown in Figure 56. Income analysis shows that from a small farm with an area of 0.93 ha, a total annual gross income of Rs 3,86,780.00 can be realized from an investment of Rs 1,30,480.00 with an annual net income of Rs. 2,56,300.00 and one can generate 205 man-days at a cost of Rs 61,500.00 in the form of labour wages including one's own labour. According to Shri. Paresh Oraw, annual spending on household purposes including food, education, health and others is Rs. 90,000.00. So, at the end of the year he can save Rs 1,66,300.00 which is further be invested in the next year.

Table 43: Annual economics of Shri. Paresh Oraw's IFS

Component	Area	Production (kg)	Cost (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereal (Rice)	6 bigha	4000	7000.00	14000.00	7,000,00
Oilseed (Mustard)	3 bigha	300	8000.00	16000.00	8000.00
Pulse (Black gram and Lentil)	1.3 bigha	120	3000.00	11500.00	8500.00
Vegetables (Brinjal, Bitter gourd, Ride gourd, parbal, Green Chili, Potato, Drum stick)	3 bigha	4283	28,500.00	54,500.00	26,000.00
Spices (Bay leaf, Turmeric)	1 bigha	366.00	3980.00	9780.00	5800.00
Fruit plants	1.6 bigha	7050	6000.00	52000.00	46000.00
Goat (Black Bengal)	1 bigha	1000	10,000.00	50,000.00	40,000.00
Duckery (KC cross)	1500 sq. ft.	50	4,000.00	14,000.00	10,000.00
Fishery	3 bigha	1644	60,000.00	1,65,000.00	105000.00
Total			**1,30,480.00**	**3,86,780.00**	**2,56,300.00**

1 bigha= 33 decimal

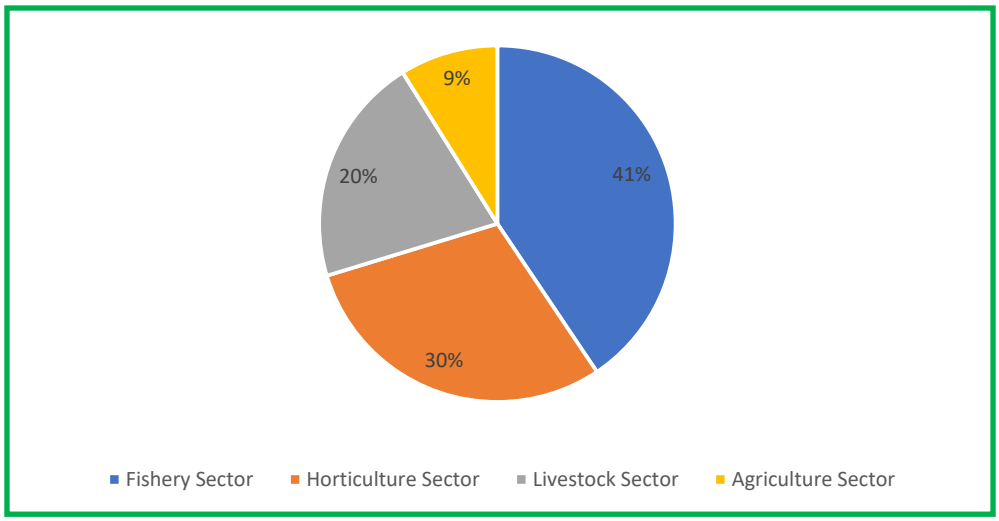

Figure 56: Annual net income sharing (in %) by different components at fishery-based integrated farm

Conclusion

The adoption of IFS gives Shri. Paresh Oraw a huge confidence and a substantial income to support his family and maintain a comfortable standard of living. Shri. Oraw shows how to fetch an annual net income of Rs. 2,56,300.00 from only 0.93 ha of land. Agriculture with a variety of crops has made the environment green and sustainable agriculture through the application of crop rotation system. Shri. Paresh Oraw is able to meet the nutritional needs of his 4-membered family with staple grains, oilseeds, pulses, vegetables, fruits, fish, meat and eggs from his IFS. This case study demonstrates the technical feasibility and economic viability of a fishery-based IFS model which combines many components to run the farm effectively with good planning and management. Hence, this study sets an example of motivation to other farmers to follow similar agricultural practices in a well-thought-out way.

Livestock-based integrating farming for sustainable employment generation

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Livestock-based integrated farming

Name of the farmer: **Shri. Prakash Chowdhury**

Area of the farm: 0.78 ha

Location of the farm: Jannagar village, Ratua- I block, Malda district

The case study was undertaken with the objective of assessing the potential of an integrated farming system (IFS) for generating employment among rural youth in Malda district, West Bengal. This livestock-based IFS, developed on a 0.78 ha land, provides a notable net income of Rs. 1,07,000.00. Within this system, livestock emerges as the predominant component, contributing approximately 39.25% to the total net income. Agricultural crops and fishery also play significant roles, contributing 22.89% and 26.16% respectively, while horticultural crops account for 11.68% of the net income. Throughout the year, this IFS demands around 960 mandays of labor, of which 540 mandays are supplied by family members. This aspect not only enhances the economic viability of the system, but also ensures continuous employment for the family. In addition to financial gains, this IFS fulfills the year-round nutritional needs of the family, offering a diverse array of staple grains, vegetables, fruits, fish, meat etc. The strategic recycling and utilization of agricultural wastes within the system further augment its efficiency and sustainability, rendering this IFS highly beneficial. This case study underscores the potential of livestock-based IFS as a sustainable solution for rural employment and food security. The successful implementation of such a system in Malda district serves as a compelling model for other rural areas aiming to achieve economic stability and self-reliance through innovative agricultural practices.

Keywords

Employment generation, Farm economics, Integrated farming, Livestock, Malda, Old alluvial zone

Figure 57: Shri. Prakash Chowdhury in his broiler poultry farm

Introduction

The present case study was conducted in Malda district under Old alluvial zone of West Bengal. Shri. Prakash Chowdhury of 27 years age belongs to Schedule Caste having under graduate level educational qualification with a land holding of 0.78 ha for developing an IFS. Soil type is deep clay to clay loam low land (Tal), medium sandy loam to loam medium land (Diara) and deep clay loam high land (Barind). The soils are lighter in higher situations and heavier in lower situations, mildly acidic to neutral in reaction (pH 5.2 to 7.0); fairly fertile; rainfall 1500-2000 mm in upper and 1300-1500 mm in lower parts.The area is flood prone. Soil of Malda district contains good physical properties and fertility with soil nutrients to grow major crops in the area. The weather of Malda is usually extremely humid and tropical. Temperatures can reach as high as 42°C (108°F) during the day in May and June and fall as low as 8°C (46°F) during December and January. The business of mango, litchi orchards and sericulture form the backbone of the economy of the district. Paddy, wheat, maize, mustard and potatoes are the major field crops. The total meat production in the district was about 43000 tons in the year 2019-20 where poultry meat contributed the major part of about 24740 tons followed by goat meat by 15000 tons. Livestock has ample scope for its growth in the district due to the availability of grazing area in orchard land. As Malda has many water bodies viz. ponds, dighis, bills and rivers, there is an excellent opportunity for pisciculture. Further, the increasing demand of live fishes in towns and cities has enhanced the market for fisheries in the area.

Farm description

Before developing the integrated farm, Shri. Prakash Chowdhury had a pond of 2 bigha without any other component. With his small holding of agricultural land, it was very tough for him to produce sufficiently to meet his family expenses. After attending a training at KVK, Malda, he decided to add some more components on the bunds of pond and utilize the space. He started broiler farming for meat purpose and duck farming for both egg and meat purpose. Gradually, he started to cultivate field crops as well as horticultural crops. Finally, this farm became integrated with poultry farming (1000 sq. ft.), duck rearing (300 sq. ft), and horticultural crops (1.5 bigha), cultivation of field crops (2.5 bigha) beside a pond (2 bigha) with fisheries. The field crops cultivated were mainly maize and blackgram, whereas brinjal was the major horticultural crop in the farm.

In regards to broiler chicken production, 1000 broiler birds in each cycle are reared in a shed of 1000 sq. ft. area for about 8 times in a year. Ven cobb variety of broiler poultry birds are generally used for rearing. Chicks and poultry feed are purchased through local vendor and sold out to the retailer directly in the local market. Vaccination against Ranikhet disease and Gumboro are done at 3-4 days and 10-12 days of age. Ducks are reared based on scavenging and feeding in the pond only. No additional feed is provided to fishes. Therefore, the expenses on feeding of duck and fish are almost negligible. The livestock-based IFS never faces lack of demand in its product. There is also stable demand of banana and papaya in the market. However, there is lack of demand sometimes in marketing vegetables like brinjal. The cropping sequence is shown in Table 44.

Table 44: Different crop and animal components at the farm

Crop	Season		
	Kharif (Rainy)	Rabi (Winter)	Zaid (Summer)
Cereal			Maize
Pulses		Black gram	
Vegetables		Brinjal	
Fruit Plant	Mango, Banana, Papaya		
Poultry	Broiler		
Duck	Khaki Campbell		
Fishery	IMCs		

Farm layout

A layout of this IFS is presented in Fig. 58.

Capital cost with financial assistance, if any

There was an involvement of capital cost to develop this IFS. The capital cost for three components to develop this IFS is presented in Table 45.

Figure 58: Farm layout of Shri. Prakash Chowdhury

Table 45: Capital cost for developing the IFS

Item	Cost per unit (Lakh ₹)	Total cost (Lakh ₹)	Subsidy / Govt. contribution (if any) (Lakh ₹)
Poultry Shed	0.80	0.80	NIL
Pond excavation (2 bigha)		1.80	NIL
Duck house	0.01	0.01	NIL
Total Cost		**2.61**	

Bio-economic circularity of the farm

Resource recycling is major component in any IFS. Utilization of waste product of one component provides continuous and sustainable income to the farmer. The major potential of any IFS is to compensate the loss of any component from other component of the system. Shri. Prakash Chowdhury is aware of how to use waste from one component as an input to another in order to boost productivity, minimize farming-related costs, and reduce environmental pollution. Poultry excreta is used as manure in agricultural fields to help plants thrive. The cost of commercially manufactured feed is reduced by using leftover agricultural waste as a source of animal feed. When there is a huge drop in the demand of the horticultural crop, it is utilized as input for other sector. Shri. Prakash Chowdhury has reported to feed vegetables to his goat during price drop in vegetables. The pond water is used for irrigation in agriculture and horticulture during scarcity of ground water. Duck dropping is used as fish feed.

Farm economic viability

Table 46 shows that this livestock-based IFS can provide a net income of Rs. 1,07,000.00 from a piece of 0.78 ha land and livestock component contributes about 39.25% net income in respect to total net income from this IFS. The net incomes from agricultural crops and fishery are 22.89% and 26.16%, respectively. The net income from horticultural crop is 11.68%. It is observed that about 540 mandays have been provided by the farm family itself besides hiring of 420 mandays for maintaining this IFS.

Table 46: Annual economics of Shri. Prakash Chowdhury's IFS

Component	Area	Production (Kg)	Cost of production (Rs)	Gross income (Rs)	Net income (Rs)
Cereal (Maize)	2.0 bigha	3200	6,000	22,500	16,500
Pulse (Black Gram)	1.0 bigha	220	3,000	11,000	8,000
Vegetables (Brinjal)	0.5 bigha	300	3,500	16,000	12,500
Poultry (Broiler)	500 sq. ft.	1800	150,000	180,000	30,000

Component	Area	Production (Kg)	Cost of production (Rs)	Gross income (Rs)	Net income (Rs)
Duckery (Khaki Campbell)	200 sq. ft.	90	18,000	30,000	12,000
Fishery	2 bigha	480 kg	32,000	60,000	28,000
Total			**2,12,500**	**3,19,500**	**1,07,000**

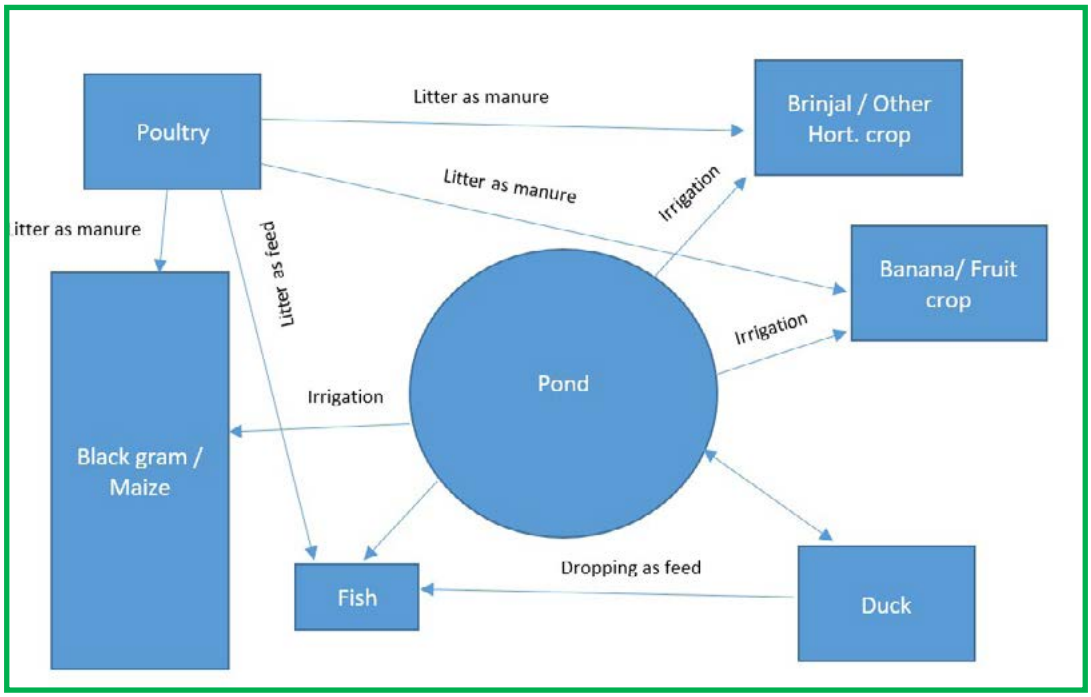

Figure 59: Resource recycling system of Shri. Prakash Chowdhury's IFS

Conclusion

This case study clearly depicts that livestock-based IFS can provide a net income of Rs. 1,07,000.00 with 1.5 BC ratio from a piece of 0.78 ha land making this IFS technically feasible and economically viable besides nutritional security. This livestock-based IFS may be regarded as a preeminent means to achieve self-sufficiency by producing quality edible products along with recycling the by-products of different components. Shri. Prakash Chowdhury is young, self-driven and proud farmer who is pleased in his line of work. Prakash Chowdhury's narrative unfolds a path towards self-reliance, self-dependent and economic prosperity, inspiring a generation of agrarian entrepreneurs to way forward the promise of integrated farming.

Field Visit and Data Collection

Kalimpong District

Dakshin Dinajpur District

North 24 Parganas District

Birbhum District

Uttar Dinajpur District

South 24 Parganas District

New Alluvial Agro-climatic Zone

Vegetables-based integrated farming with good agriculture practices (GAP): A beacon of hope for the farmers of Burdwan district

Dipankar Ghorai

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Vegetables-based integrated farming

Name of the farmer: **Shri. Bapi Shaikh**

Area of the farm: 1.5 ha

Location of the farm: Mirajpur village, KalnaI block, Purba Burdwan district

A vegetable-based integrated farm spanning 1.5 ha, developed by Shri. Bapi Shaikh in the Burdwan district, stands as a beacon of excellence among ten integrated farms studied in the new alluvial agro-climatic zone of West Bengal. This farm is a fabric of not less than ten diverse components, including jute, cereals, oilseeds, vegetables, spices, fruits, fodder, forest trees, livestock, fisheries, and vermicompost, all woven together in harmonious integration. With an annual net income of Rs. 6.45 lakhs, this farm not only sustains Bapi Shaikh's six-member family but does so abundantly. The benefit-cost ratio, an impressive 3.0, speaks volumes of its efficiency. On a per-hectare basis, the farm generates Rs. 4.3 lakhs annually. The income distribution reveals the farm's heart: vegetables contribute a robust 49.0%, followed by livestock at 16.8%, fish at 11.6%, jute at 11.5%, paddy at 5.2%, spices at 2.8%, oilseeds at 1.6%, and fruits at 1.6%. The farm is designated as vegetables-based because the vegetable component provides the highest share of the total income. Shri. Bapi Shaikh judiciously allocates 30.0% of his income towards food, 5.0% for education and health purposes, and 15.0% for other expenses, resulting in a substantial annual saving of Rs. 3.23 lakhs, which is about 50.0% of his total earnings. The farm's remarkable success, both technically and economically, has inspired the development of an area-wide scheme. This scheme, grounded in the techno-economic insights derived from Bapi's farm, aims to replicate this model across the new alluvial agro-climatic zone of West Bengal, promising a sustainable and prosperous future for many more farmers.

Key words

Integrated farming system, Vegetables, Jute, Livestock, Rainwater harvesting, Poly house, Area development scheme, New alluvial agro-climatic zone, West Bengal

Figure 60: Shri. Bapi Shaikh at his vegetable- based IFS

Introduction

Shri Jafar Ali Shaikh had been a peasant for 40 years, growing jute, rice, potatoes, and vegetables through subsistence farming on a 1.5-hectare area in Mirjapur village, located in the far east corner of the Purba Burdwan district. Shri Bapi Shaikh inherited the farm from his father. Jute, a popular crop cultivated during the rainy season in Purba Burdwan district, is a heritage cash crop of India, deeply entwined in the socio-cultural-economic ethos of Indians, especially Bengalis. Beyond its socio-economic importance, its environmental footprint is significant, making it almost obligatory for jute cultivators to carry on the legacy of jute farming.

However, competition from artificial fibers, coupled with high production costs, rising input and labor costs, and the non-availability of good water for retting—the single most important factor for quality fiber production—pose significant challenges. The non-availability of retting water during August-September, due to wide temporal variations in rainfall prompted by climate change, further exacerbates the situation, making jute farming increasingly difficult for many farmers in the district. The problem is snowballing with the advent of climate change, triggering unpredictable spatial and temporal variations in rainfall.

Bapi followed in his father's footsteps to sustain their family until 2016. After coming into contact with KVK Burdwan, his outlook on agriculture changed, and he envisioned shifting from traditional agriculture to agri-business. He came to kow about the imminent water crisis mediated by climate change, and he realized that to sustain his livelihood, he had to rely on surface water irrigation. With training and technical guidance from KVK Burdwan, Bapi dug a pond on a 3-bigha area of his farm in 2016, aided by MGNREGA. By the end of the year, with his assured irrigation source and further guidance from KVK Burdwan, he transformed his farm into a 1.5-hectare integrated farm.

To achieve this transformation, he liaised with various departments through KVK and secured funding to establish the farm. He received funds from the horticulture department to erect a high-tech polyhouse and a vermicompost unit and obtained small farm implements from the department of agriculture. KVK Burdwan thoroughly trained him in advanced agricultural technologies and supplied him with various inputs over time. Later, with KVK's help, he developed expertise in beekeeping and bio-pesticide (Trichoderma viride) preparation.

Bapi has not only made jute farming profitable through integrated farming, but his evangelical enthusiasm also transcended the boundaries of Mirjapur, inspiring his fellow farmers to adopt his ideas and practices in jute farming.

Farm description

Shri Bapi Shaikh's commendable practices have not only elevated the social and economic profile of his family but also provided a model for developing integrated farming (IF) in jute-dominated areas of Purba Burdwan district. Bapi has a total landholding of about 1.5 hectares, which includes a contiguous 1.5-hectare area along with a pond on 3 bighas. Currently, the value of this 1.5-hectare land is about Rs. 88.0 lakhs.

In Bapi Shaikh's IF, there are at least 11 components: jute, cereals, oilseeds, vegetables, spices, fruits, fodder, forest trees, livestock, fisheries, and vermicompost. A pictorial description of his endeavor is depicted in Figure 61.

Shri Bapi Shaikh, having been trained by KVK Burdwan and elsewhere, has adopted many good agricultural practices to make his farm technically feasible, maximizing productivity and profit while minimizing environmental damage, as mentioned below:

- The farm has greater diversity of crops and livestock to fetch more income and adapt to local circumstances.
- As a whole, the farm components are more resilient to droughts, floods, and other impacts of climate change.
- Adoption of precision water and fertilizer management through drip irrigation and fertigation.
- Adoption of improved technologies of jute production concomitant with its integrated farming is the panacea for this profitability aspect. Bapi uses jute cultivation to great effect in his integrated farm.

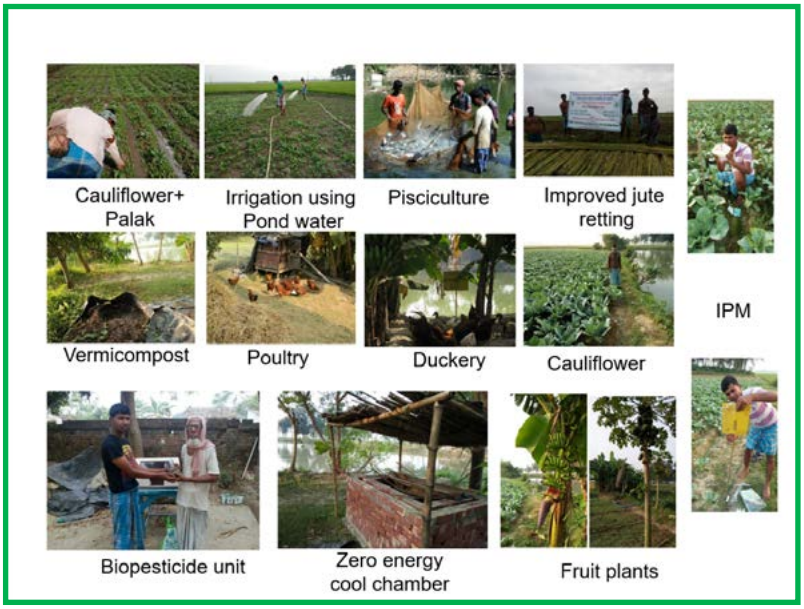

Figure 61: Various farming components and practices in Shri. Bapi Shaikh's IF

- Mechanical weeding in jute using suitable weeders developed by ICAR-CRIJAF for weed and water management in jute crops, reducing the usage of harmful herbicides.
- Retting of jute using the CRIJAF SONA microbial consortium to obtain higher quality and quantity of fiber.
- Agroforestry with neem, subabul, and Albizia lebbeck alongside fruit plants like mango, guava, and citrus.
- Integrated pest management through mechanical, chemical, and biological means, using pheromone traps for mechanical control and Trichoderma, Neemastra for biological pest control.
- Organic farming using vermicompost and NADEP compost, and natural farming using Jeebamrita, Beejamrita, and Neemastra for pest control wherever applicable.
- Conservation agricultural practices with zero-tillage mustard and jute cultivation and mulching with plastic and paddy straw. Applied paira cropping in mustard preceded by rice and broadcasting seed in residual moisture to good effect.
- Crop rotation with sesbania to enrich soil quality.
- Rainwater harvesting.
- Vermicomposting.
- Zero energy cool chamber for storing onions and other perishable produce.
- Intercropping red and green amaranthus with jute for sustainable income and resource conservation.
- Inclusion of jute is the foremost salient feature of the IF. Jute is an excellent crop that benefits both the aerial and soil environments. One hectare of jute crop sequesters an estimated 15 tonnes of CO_2 and releases 11 tonnes of O_2, purifying the air. About 15 tonnes of green leaves are added to the soil, enriching it with organic carbon and improving soil health. Besides, its elaborate and deep rooting profile controls nutrient dynamics in the soil up to 1 meter and improves soil physical properties.
- Regarding demand and supply from his farm, Bapi is in a comfortable zone. He has a high score of 4 out of 5 regarding the demand and supply of cereals, vegetables, and fish from his farm. The supplying capacity of his farm exceeds demand in the areas of oilseeds, spices, and fish. In the case of fruits, he has no demand-supply gap. The agricultural produce includes all three types: perishable, semi-perishable, and non-perishable. While cereals and oilseeds are non-perishable, livestock products like meat, eggs, and fish are perishable. Most of the populace are non-vegetarians, and there is a huge demand for selling livestock produce.
- Except for vegetables, the price variations of the farm produce are generally low. Vegetables, being perishable, have a moderately high price variation. While oilseeds, duck meat, and milk have very low price variation, other products like chicken meat, goat meat, and fish have moderate ranges.
- In an IF, the choice of crops and their cropping pattern in a calendar year, as well as their merit regarding the supply of inputs for other enterprises, is important. Bapi's farm plan throughout the year is scrupulous and deserves merit. His cropping pattern in three seasons is depicted in Table 47.

Table 47: Different crop and animal components at the farm of Shri. Bapi Sk

Crop	Season		
	Kharif (Rainy)	Rabi (Winter)	Zaid (Summer)
Cereal	Rice (4)*, Cauliflower (1), Kharif Onion (2)	Paddy (4), Rabi Onion (2)	
Other crops			Jute (6)
Oilseed		Mustard (3)	Sesame (3)
Vegetables	Okra, Bottle Gourd, Pumpkin, Ridged Gourd	Potato (3), Cauliflower/ Cabbage (4), Spinach (1), Onion (2)	
Spices	Coriander		
Fruit Plant	Mango, Guava, Citrus Banana		
Forest tree	Albizia, Neem		
Plantation crops	Coconut		
Cattle	Desi		
Chicken	Sonali		
Duck	Khaki Campbell		
Fishery	IMCs		
Honey bee	Apis mellifera		

*Data in parenthesis is the amount of area in bigha

Farm layout

The layout of Shri. Bapi Sk's integrated farm is presented in Figure 62.

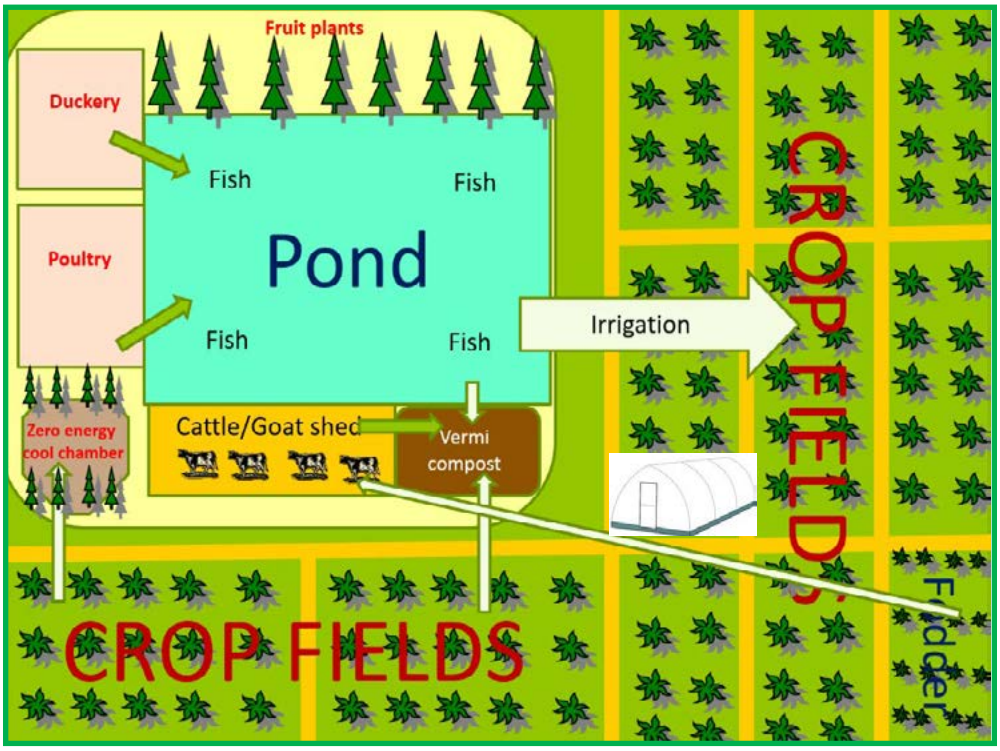

Figure 62: Layout of Shri. Bapi Sk's integrated farm

Capital cost with financial assistance, if any

To develop such a kind of IF, there is an involvement of capital cost. As mentioned earlier, Bapi excavated the pond back in 2016 and obtained the other infrastructures in 2018. Though Bapi received technical and financial support from government institutions like KVK and line departments, the details of capital cost involvement are given below (Table 48). If any interested farmer, having suitable land either owned or leased, wishes to establish such an IF, they would need to bear a capital cost of about Rs. 14.26 lakh.

Table 48: Capital cost for developing the integrated farm

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Poly house	10 lakh/unit of 1000 m^2	10.0	5.0 from RKVY
Pond excavation (2 bigha)	0.90/bigha	1.80	1.71 from MGNREGA (95%)
Vermicompost unit (4 nos)	0.10/unit of 100 m^2	0.40	0.20 from RKVY
Micro sprinkler (1 acre)	0.10/3 bigha	0.10	0.07 from PMKSY
Onion storage	1.50/unit	1.50	0.88 from RKVY
Honey bee unit (4 units)	(0.04/unit)	0.16	0.16 from KVK Burdwan
Fruit plants	--	0.10	0.05 from KVK Burdwan
Small implements	--	0.20	0.20 from KVK Burdwan
Total cost		**14.26**	

Bio-economic circularity of the farm

The success of IF depends on the efficiency of the bio-economic circularity of the farm. There is a saying that "there is no waste in agriculture." IF relies on the idea that waste is merely a misplaced resource that can become valuable material for another product. Experts say that IF is a mixed animal-crop system which envisions animals being raised on agricultural waste products, while the animals are used to cultivate the soil and provide manure to be used as fertilizer and fuel. This holds true for Bapi's model IF! A bio-circularity diagram for this IF is presented in Figure 63.

Among the recyclable wastes, paddy straw generated from paddy is used as mulch and feed for cattle, valued at Rs. 9000.00 per year. Mustard oil cake is used as fish feed worth Rs. 3000.00. Vegetable residue, nutritious jute leaves, and branches of agroforestry plants are used as goat feed, saving a cost towards feedstuff of Rs. 3000.00. Cow dung, goat, poultry, and duck droppings are used to produce vermicompost for field and horticultural crops, thereby contributing to a net worth from livestock of Rs. 2600.00. Bapi Shaikh collects the jute leaves shed in the field after harvesting and storing jute bundles. With these leaves, he makes jute compost, a portion of which is fed to goats, resulting in savings towards fertilizer and goat feed worth Rs. 4000.00-5000.00. Jute retting in pond water in optimal amounts supplies enough plankton as feed for fishes. Jute sticks obtained after retting of jute in the fish pond not only provide enough phytoplankton for fish feeding but are also valued at Rs. 1000.00 and used for vegetable growing, reducing the cost of vegetable cultivation by Rs. 3000.00/ha. Thus, a total of Rs. 18,600.00 is circulated throughout the entire integrated farm.

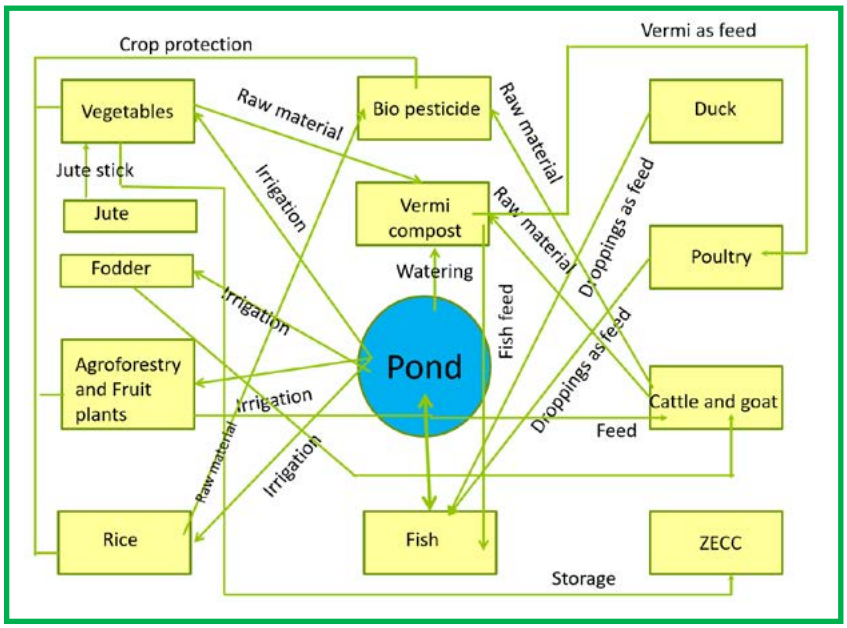

Figure 63: Bio-circularity of Bapi Sk's integrated farm

Farm economic viability

In terms of farm economics, Bapi's situation is more than satisfactory. He earns Rs. 6.45 lakh from his integrated farm (IF) unit, which is more than enough to sustain his family of six members. Out of this income, vegetables contribute about 49.0%, livestock 16.8%, fish 11.6%, jute 11.5%, paddy 5.2%, spices 2.8%, oilseeds 1.6%, and a negligible amount from fruit plants of about 1.6%. Additionally, he produces about 2.5 kg of honey from the honey bee units, which is consumed by his family. The highest annual net income sharing from vegetables (49.0%) justifies the fact that it is truly a vegetable-based IF. His IF farm economics is presented in Table 49. In light of large-scale migration from agriculture, the contribution of agriculture in such an integrated farm is heartening. The percentage contribution of various agricultural components is depicted in Figure 64. It is evident that raising cauliflower in two seasons along with jute for jute farmers is a sound practice to sustain an integrated farm like this. Out of this income of Rs. 6.45 lakh, he spends 30% on food, 5% on education and health, and the remaining 15% on other expenditures, resulting in a total annual saving of Rs. 3.23 lakh, which is approximately 50.0% of his total earnings. His benefit-cost ratio stands at 3.0.

Table 49: Annual farm economics of Bapi's IF

Sl. No.	Crop/Enterprise	Area (Bigha)/no	Total production (Kg)	Cost of production (Rs.)	Gross income (Rs.)	Net Income (Rs.)
	CROPS:					
1	*Kharif* Paddy	5	3600	27000.00	43200.00	16200.00
2	*Rabi* paddy	5	3300	29000.00	46200.00	17200.00
3	Mustard	2.5	300	8000.00	12000.00	4000.00
4	Sesame	3	350	7000.00	13000.00	6000.00
5	*Kharif* Spinach	1.5	750	10000.00	22000.00	12000.00
6	*Kharif* Cauliflower	1	5000	18000.00	50000.00	32000.00
7	*Kharif* Onion	1	2400	16000.00	36000.00	20000.00
8	Potato	2	7000	24000.00	35000.00	11000.00
9	*Rabi* cauliflower	4	20000 nos	71000.00	189000.00	118000.00
10	Cabbage	1	6000 nos	19000.00	60000.00	41000.00
11	*Rabi* Spinach	4	2300	33000.00	68000.00	35000.00
12	*Rabi* Onion	2	3200	25000.00	35000.00	10000.00
13	*Rabi* cabbage	1	6000 nos	21000.00	58000.00	37000.00
14	Coriander	1	300	8000.00	26000.00	18000.00
15	Jute	6	2600	71000.00	145000.00	74000.00
16	Mango	9 nos	150 kg	1000.00	6000.00	5000.00
17	Citrus	3 nos	1200 nos	300.00	1500.00	1200.00
18	Tissue cultured banana	25 nos	35 bunches	4000.00	8000.00	4000.00

Sl. No.	Crop/Enterprise	Area (Bigha)/no	Total production (Kg)	Cost of production (Rs.)	Gross income (Rs.)	Net Income (Rs.)
	LIVESTOCK AND FISH:					
19	Cattle	3 nos	1500 kg milk	10000.00	75000.00	65000.00
20	Goat	9 nos	100 kg meat	10000.00	45000.00	35000.00
21	Poultry	30	25 kg meat	2000.00	8000.00	6000.00
22	Duck	12	15 kg meat	500.00	3000.00	2500.00
23	Fish	4000	1100 kg	35000.00	110000.00	75000.00
24			TOTAL	449800.00	1094900.00	645100.00

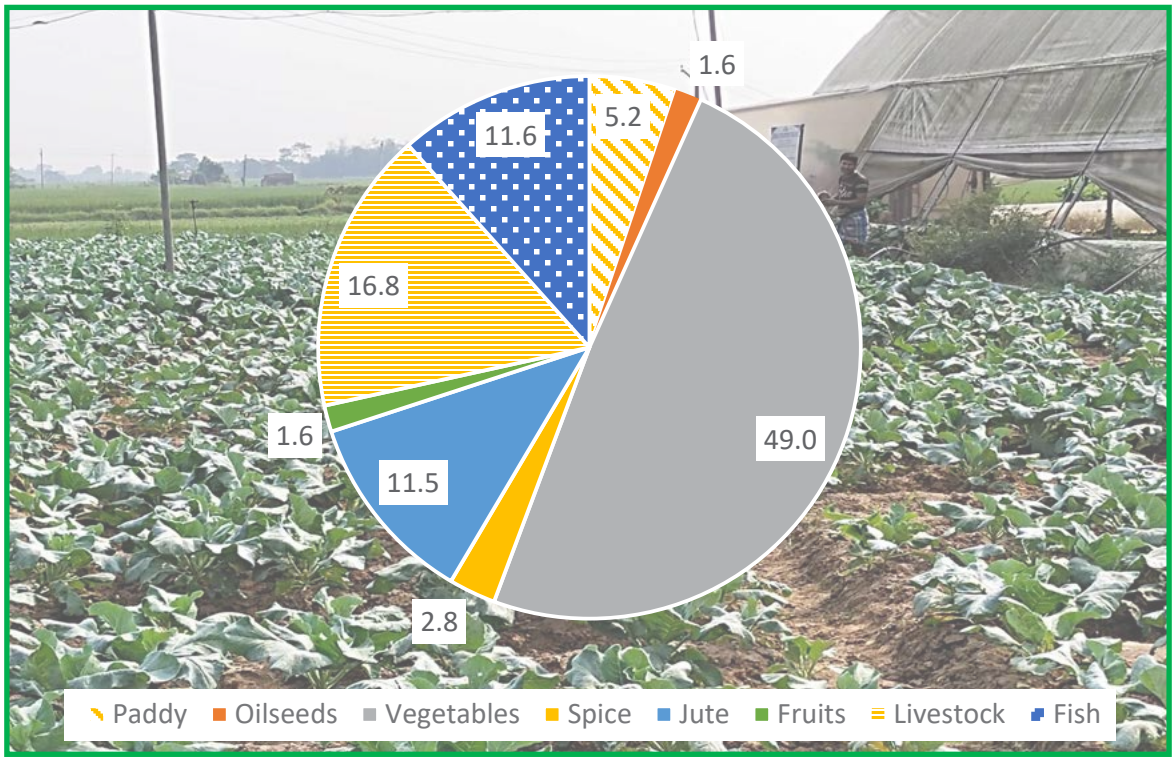

Figure 64: Percent contribution of various components of the IF

Financial plan without bank loan

Considering the techno-economic facts and figures of Shri Bapi Shaikh's integrated farm on 1.5 hectares of land, a financial plan can be developed for an interested farmer who may choose not to take any bank loan and thus invest the capital cost of Rs. 14,26,000.00 from his/her own funds. The recurring cost of cultivation each year is estimated to be Rs. 4,49,800.00, and the capital cost will be recovered in five equal installments. A financial plan is presented in Table 50.

Table 50: Financial plan for area development scheme on vegetable-based IF in 1.5 ha land (without bank loan)

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Capital cost	1426000.00	1140800.00	855600.00	570400.00	285200.00	0
2	Recurring cost of cultivation	449800.00	449800.00	449800.00	449800.00	449800.00	449800.00
3	Recovery of capital cost in equal installment	285200.00	285200.00	285200.00	285200.00	285200.00	0
4	Gross income	1094900.00	1094900.00	1094900.00	1094900.00	1094900.00	1094900.00
5	Net income	359900.00	359900.00	359900.00	359900.00	359900.00	645100.00
6	BC ratio	1.49	1.49	1.49	1.49	1.49	2.43

Financial plan with bank credit availability

Considering the techno-economic facts and figures of Shri. Bapi Shaikh's IF in 1.5 ha land, a finncial plan may be developed for an interested farmer who may look forward for a bank loan to develop such an IF. The total project cost covering capital cost and 1st year recurring cost of cultivation will be beased on economic data shown by Bapi Shaikh as follows.

Project Cost = Capital Cost + 1st Year Recurring Cost = Rs. (14,26,000.00 + 4,49,800.00) = Rs. 18,75,800.00

A financial plan with bank loan facility is presented in Table 51.

Table 51: Financial plan for bankable area development scheme on vegetable-based IF in 1.5 ha land

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Project Cost	1875800.00					
2	Margin @ 15%	281370.00					
3	Bank loan	1594430.00					
4	Yearly rate of simple interest @12.0% PA	12.00					
5	Loan O/S at the beginning of the year	1594430.00	1275544.00	956658.00	637772.00	318886.00	0.00
6	Accrual of interest	191331.60	153065.28	114798.96	76532.64	38266.32	0.00
7	Repayment of principal in equal installment	318886.00	318886.00	318886.00	318886.00	318886.00	0.00
8	Repayment of interest	191332.00	153065.00	114799.00	76533.00	38266.00	0.00
9	Loan O/S at the end of the year	1275544.00	956658.00	637772.00	318886.00	0.00	0.00

Repayment plan

The repayment plan against bank loan may be as shown in Table 52.

Table 52: Repayment plan against bank loan

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Repayment of principal in equal installment	318886.00	318886.00	318886.00	318886.00	318886.00	0.00
2	Repayment of interest	191332.00	153065.00	114799.00	76533.00	38266.00	0.00
3	Recurring cost of cultivation	449800.00	449800.00	449800.00	449800.00	449800.00	449800.00
4	Gross income	1094900.00	1094900.00	1094900.00	1094900.00	1094900.00	1094900.00
5	Net income	134882.00	173149.00	211415.00	249681.00	287948.00	645100.00
6	BC ratio	1.14	1.19	1.23	1.29	1.36	2.43

Conclusion

Integrated farming solutions for individual agricultural farms are prerequisites in the wake of global climate change, greenhouse gas emissions, and shifting hydrological regimes. Solutions must be sought by every living being to ensure the sustenance of mankind and animals on this planet. The rising global population is raising questions about future food security for all. Additionally, changing food habits must be considered. From this standpoint, viable integrated farming models need to be established holistically throughout the country. Shri Bapi Shaikh has proven that adopting vegetable-based IF can maximize profit, achieving an annual net income of Rs. 6.45 lakh from 1.5 hectares of land, resulting in an impressive Rs. 4.3 lakh per hectare. This farm also provides nutritional security to his family year-round with various farm produce such as cereals, oilseeds, vegetables, fruits, eggs, milk, and fish. Shri Bapi Shaikh of Mirjapur has demonstrated to his fellow farmers that with prudent foresight, one can change one's destiny. Approximately 78 small and marginal farmers have followed Bapi's example to establish profitable agri-entrepreneurial integrated farms in the blocks of Kalna I and II and Purbasthali I and II, earning themselves a better living and societal recognition, just as Bapi Shaikh has done. This vegetable-based IF serves as an exemplary model for creating a technically feasible and economically viable area development scheme for the new alluvial agro-climatic zone of West Bengal.

Livestock-based integrated farm of Fazla Haque – instilling new hopes and aspiration among livestock keepers of Burdwan district

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Livestock-based integrated farming

Name of the farmer: **Shri. Fazla Haque**

Area of the farm: 1.61 ha

Location of the farm: Uchchgram village, Galsi I block, Purba Burdwan district

The present treatise unfolds the remarkable journey of Shri. Fazla Haque, a small farmer from Purba Burdwan, who, with his insatiable thirst for knowledge, has metamorphosed his 1.61 ha farm into a thriving livestock-based integrated farming system (IFS) and earns approximatelyRs. 8.71 lakh per annum. The heart of his success lies in the livestock components, which constitute a substantial 72% of his income, rendering this IFS predominantly livestock-centric. Although contribution of cereals may seem meagre (7.35%), their significance is profound. It forms the backbone of the IFS, providing essential feed for his cattle and poultry, thereby boosting overall profitability. Similarly while the fishery component contributes only 4.81%, fish pond not only offers a sustainable source of fish protein for his family but also irrigates his crops and supplies drinking water for his animals and supports duck farming. Again among the individual animal components, Shri. Haque has showcased the exceptional profitability of broiler poultry farming, which accounts for a notable 20.64% of his earnings. His commitment to maintaining high standards of hygiene and healthcare ensures that his cattle, contributing the highest at 23.02%, thrive. Additionally, goat and deshi poultry rearing enrich his income with substantial contributions of 9.17% and 11.47%, respectively. Through his pioneering efforts, Shri Haque is instilling new hopes and aspirations among other animal rearers of the area to revart to embrace this holistic farming approach. He is leading a quiet revolution, steering them away from the prevalent subsistence agriculture towards a more sustainable and prosperous future.

Key words

Integrated farming system, Cattle, Broiler poultry, Desi poultry, Goat, Duck, Rainwater harvesting, Paddy, Banana

Figure 65: Shri. Fazla Haque, a self-made agripreneur

Introduction

In the wake of declining and deteriorating, both qualitatively as well as quantitatively, natural resources with concomitant burgeoning population, conscientious utilization of natural resources - be it soil or water - vis-à-vis harnessing maximum output should be the order of the day for Indian agriculture so as not to put future food security to the sword. Integrated farming system (IFS) is one plausible candidate to be banked upon in this regard. It gives the impression of an oasis when one takes a bird's eye view during the winter seasons– a tinge of greenery among a vast expanse of rice-fallow area. Closing upon, a keen ear can listen to cows bellowing and goats bleating. Closing further, one can hear chickens clucking and merry making ducks quacking, preeening and prancing. A vigilant passerby will find one bare chested, *lungi* clad, tall, slender, dark complexioned man feeding green lentil leaves or tender shoots to the goats or giving fodder to the cattle with stoic indifference to cold on a chilled winter morning or one veiled, small built, incospicuous looking village lady caressing the calves or milking the cattle or catering to the need of ducks and chickens and doing the household chores. Sometimes one may see a boy of 17 or 18 entering the farm gate carrying chicken feed in his bicycle. One will sense happiness engulfing the entire area of 1.61 ha farm being maintained by 3 persons - one farmer, his wife and son, in the outskirts of an hamlet redolent of antiquity named Uchchgram of Galsi I block of Purba Burdwan district.

Welcome to the *Animal Farm* –not of course "Gafur" of Shri. Sarat Chandra Chattopadhyay in "Mahesh", but of Fazla Haque's! It's an integrated animal farm to put precisely. Shri. Fazla Haque, 53, is a self-made agripreneur. Despite not being fortunate to have enough formal education (a Vth standard), which might have been a blessing in disguise for him, he was always keen to learn and was an ardent observer as well as listener. He encountered enough hardship in his childhood for his father, a marginal farmer, was having hard time to make both ends meet. However, Shri. Haque had high aspiration of building a farm of his own that would be mean for their sustenance and wanted to do away with the subsistance farming his father would practice. He got in touch with KVK some 10 years back and would often visit KVK for no reason and look around the various demonstration units maintained at KVK Burdwan and interact with the experts and listen to them in his idiosyncratic manner if chin cupped in palm and continued to learn the art of integrated farming. Thus, and after inheriting a 1.61 ha area, he inched his way towards fulfilling his dream.

Farm description

To start with Shri. Fazla Haque convinced the Block Development Officer on his farm plan and was able to divert some man-days under MGNREGA to excavate one bigha pond that would be adequate for supplying irrigation water when need be and using for duck farming. Next, he constructed one cattle shed over 0.5 katha area, one goat shed on 0.5 katha, one unit for duck and deshi poultry in an area of 0.6 katha each and one broiler poultry unit over 3 katha. Starting with two non-descript cattle, he now owns 11 cattle of which 2 are Jersey cross, 4 Gir cross and 5 non-descript cattle. He maintains a fodder unit where he grows hybrid napier, maize, cow pea and berseem for feeding the cattle. Besides, the cattle are taken for grazing in the adjoining fallow land to feed on the left over paddy straw in an estimated area of 2.5 km^2. He does value addition of a part of the milk by making *ghee* and paneer and also sells 2-3 calves every year. Shri. Fazla Haque's goatery consists of 30 Black Bengal goats those roam and feed on the fodder and tender shoots of agroforestry plants and lentil shoot within the periphery of his farm in an area of 3 bigha. On an average he gets 75-80 kids for selling. For vaccination of cattle and goats, he takes aid of the *Prani Mitra* trainied by KVK Burdwan. He keeps a stock of about 120-150 ducks on an average in his duckery unit consisting of Khaki Campbell and deshi ducks. From this unit he produces about 15000 eggs and 200 kg meat per year. The ducks thrive on the phytoplanktons in pond and feed which he prepares using dried water hyacinth, ground corn and rice at his own end. Besides, he practices rearing of deshi poultry with a stock of 200. He gets about 10000 eggs and 200 kg meat from the stock per year of which he sells about 9500 eggs and 140 kg meat in the market where there are ample takers for his produce and earns handsomely. Rest he uses for home consumption. The birds feasts on the rice husk, broken rice and bran from his own produces. However, one of his practising enterprises that stands out from others is his joint venture with "SUGUNA" – an upcoming startup company in poultry farming. He has joined hands with SUGUNA to rear 10 day-old chicks in his pen for about 2 months until they are full blown for marketing. His investments include electricity, water, broken rice and the pen over 3 katha for which he is paid Rs. 30000 for maintaining 1500 chicks for one cycle. Thus he gets about 6-7 cycles per year which generates a sizable income for his household. Other feed, feeder, medicines all are supplied by the company. The vaccination part is again taken care of by the *Prani Mitra.* The pond, as mentioned earlier, is used for irrigation and duck farming, also used for pisciculture of Indian Major Carps (IMCs) of Rohu, Catla and air breathing fishes as well. Fish meal is the only thing he has to purchase from outside the periphery of his farm. Paddy is the most omnipresent crop in the district by far, in two seasons – *Aman* and *Boro.* As a matter of fact, the soil type in the area being clay loam, rice is the predominant crop in the area and the soil is not conducive for potato or onion cultivation. However, Shri. Haque, driven by his penchant for crop diversification, realised this hindrance and reshaped 2 bigha of his land through land filling and made suitable grounds for potato and onion cultivation which has enabled year long supply of the two prime vegetables and the rest he sells at handsome price. Buoyed by the training received from KVK, he used to practice cultivation of tissue cultured banana in an area of 1 bigha. For storing paddy he has one locally made storage, common in the rural households of Bengal, called *Marai*.

In an IFS, the choice of crops as well as their cropping pattern in a calendar year and its merit as regard to supply of input for other enterprises is important. Shri. Fazla Haque, although not having enough crop diversification, has managed to choose crops meticulously for supply of input for his animal enterprises and deserves merit. His cropping pattern in the three seasons is depicted below (Table 53).

Figure 66: Shri. Fazla Haque's animal-based integrated farm

Table 53: Different crop and animal components at the farm of Fazla Haque

Crop	Season	
	Kharif (Rainy)	Rabi (Winter)
Cereal	Rice (6) *	Rice (6)
Other crops	Kharif onion	Potato
Oilseed		Mustard (1)
Pulses		Lentil (0.5)
Fruit Plant (1)	Banana	
Cattle	Gir, Jersey cross, non-descript	
Goat	Black Bengal	
Poultry	Broiler, deshi,	
Duck	Deshi, Khaki Campbell	
Fishery	IMCs, air breathing fish	

*Data in parenthesis is the amount of area in bigha

With regard to demand and supply from Shri. Haque's farm, he is in a privileged position as animal produces are concerned. As mentioned earlier, all his broiler poultry birds (9000 to 10000 per year) those he rears to marketable size are lifted from his farm by SUGUNA. Except goat, all other animal products are sold in markets within a periphery of 15 km. For goats, he has to rely on market at Burdwan which is 25 km from his farm. Shri Haque has good scope of building upon his animal resources provided he can invest more in regard that animal produces like meat, egg and milk are in very high demand in the locality, whereas suppling capacity of his farm is either high or moderate. Another area he should look into is making of enriched compost/vermicompost with the cattle dung which would surely enhance the productivity of crops besides maintaining soil health.

Farm layout

The layout of Shri. Fazla Haque's animal-based integrated farm is presented in Figure 67.

Capital cost with financial assistance, if any

Aspiring farmers willing to develop such an integrated farm (IF) would be curious about its establishment cost and operational cost. Of course, availability of suitable land at farmers disposal is a prerequisite for developing the IF. As mentioned earlier, Shri Haque started small and then went on to develop his farm into a full-fledged IF over a period of 3 years. He made capital investment of Rs. 3 lakhs to purchase 2 cattle, 5 goats and constructed various units and landfilling. However, his capital cost (Table 54) for developing the farm was minimal on grounds that most of his input was indigenous to him and produced within the periphery of his farm.

Table 54: Capital cost for developing Shri. Fazla Haque's IF

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Pond excavation (1 bigha)	1.0 lakh/bigha	1.00	MGNREGA work
Electricity connection	--	0.25	Nil
Tissue cultured banana orchard	0.60/bigha	0.60	Saplings supplied by KVK
Cattle unit	--	0.50	Nil
Goat unit	--	0.50	Nil
Duck unit	--	0.35	Nil
Broiler poultry unit	--	1.50	Suguna collaboration
Deshi poultry unit	--	0.35	Nil
Total Cost		5.05	

Bio-economic circularity of the farm

The concept of IFS is pivoted upon the idea that by products from one component should be used as input for another component so that there would be no waste. IFS involving animal-crop-fish system is advantageous in regard that bio-circularity factor is very high in such system. IFS, as a mixed animal crop system, envisages animal component being raised on agricultural waste products while the animal is used to cultivate the soil and provide manure to be used as fertilizer. A bio-circularity diagram of the farm is shown in Figure 68.

The underlining advantage of IFS is that it generates a sizable amount of by products that can be used as input and thus can save a handful for the farmers. In case of Shri. Fazla Haque, among the recyclable wastes, straw generated from paddy is used as dry fodder for cattle and is valued at Rs. 4500.00 per year. Mustard oil cake is used as fish feed worth Rs. 2000.00. Lentil straw he feeds to goats and is worth Rs. 1000.00. The lion share of by-products comes from cattle and goat as farmyard manure which is used in crops thus saving him Rs. 25,500.00. Poultry and duck droppings are used as fish feed thereby saving Rs. 5300.00 for fish feed. Thus, a total of Rs. 37,500.00 is circulated in the whole IFS.

Farm economic viability

Shri. Haque is much well off for a three member family from his IFS. Perusal of Table 55 and Figure 69 divulges that about 71.77% of his income comes from his animal components which is why the IFS is predominantly animal based. Although contribution of cereals is 7.35% as compared to the animal component, its presence underpins the profitability of such animal-crop IFS in terms of the feed supply for cattle and poultry from the cereal produce and its by products. Though the economic contribution of fishery component is only 4.81%, the fish pond is the source of irrigation to crops as well as drinking water for animals and duck farming. Again among the individual animal components, it can be notices from Figure 70 that broiler poultry farming in collaborative mode can be exceedingly profitable. In Shri. Haque's case percent contribution of broiler farming is as high as 20.64%. Shri. Fazla Haque receives the highest contribution of 23.02% from his dairy sector. The economic contributions of goat and deshi poultry are 9.17% and 11.47%, respectively.

Table 55: Annual economics of Shri. Fazla Haque's IFS

Sl. No.	Crop/Enterprise	Area (Bigha)/no	Total production (Kg)	Cost of production (Rs.)	Gross income (Rs.)	Net Income (Rs.)
	CROPS:					
	Kharif paddy	6	5450	60000.00	92650.00	32650.00
	Boro paddy	6	4700	62500.00	94000.00	31500.00
	Lentil	0.5	70	600.00	3500.00	2900.00
	Mustard	1	200	4500.00	10500.00	6000.00
	Potato	2	10000	30000.00	80000.00	50000.00
	Kharif onion	1	2200	17000.00	38000.00	21000.00
	Banana	1	450 bunch	30000.00	90000.00	60000.00
	LIVESTOCK AND FISH:					
	Cattle	11 nos	4380 kg milk + 2-3 calves	164250.00	365000.00	200750.00
	Goat	30	80 kids/year	210000.00	290000.00	80000.00
	Broiler poultry *	9000	16200 kg	420000.00	600000.00	180000.00
	Deshi poultry	200	10000 egg + 200 kg meat	40000.00	140000.00	100000.00
	Duck	150	15000 egg + 200 kg meat	45000.00	110000.00	65000.00
	Fish (IMC)	1	550 kg	24000.00	55000.00	31000.00
	Fish (Air breathing)	1	45 kg	5000.00	16000.00	11000.00
	TOTAL			**1112850.00**	**1984650.00**	**871800.00**

*SUGUNA pays Shri Haque @RS. 20.00 per full grown bird

Figure 67: Layout of Shri. Fazla Haque's integrated farm

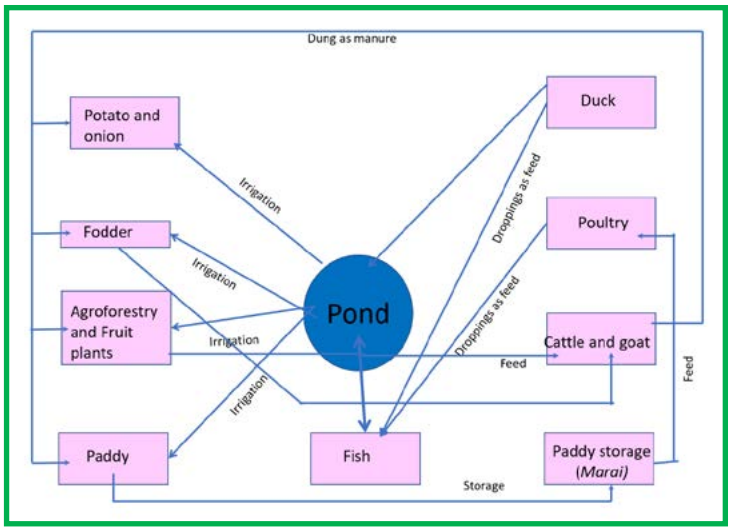

Figure 68: Bio-circularity of Shri Fazla Haque's animal-based integrated farm

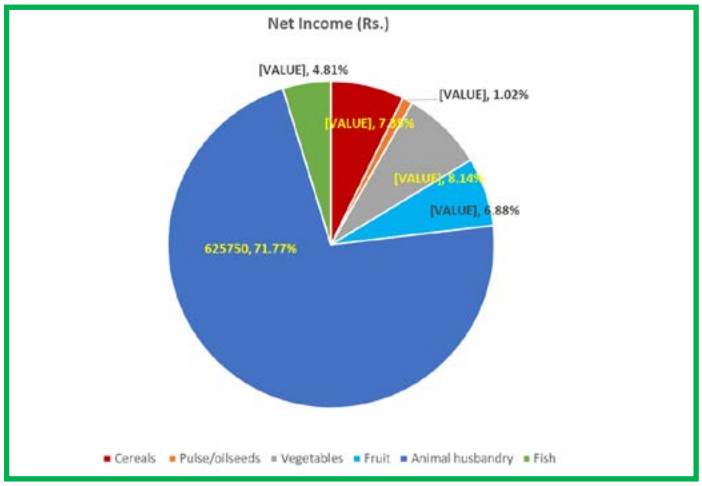

Figure 69: Contribution of various components of the IFS

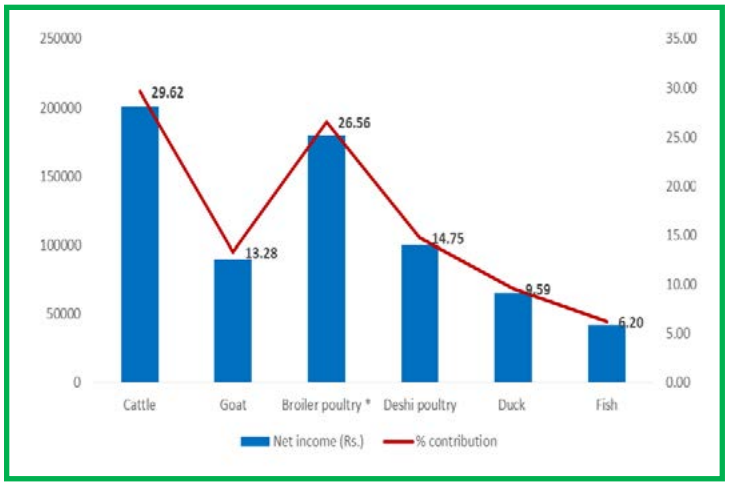

Figure 70: Contribution of animal husbandry and fishery components of the IFS

Conclusion

We have achived self-sufficiency in food production and in many commodities, often topping the charts in numerous commodities. Yet, skeptics may wonder: will this suffice to ensure future food security for our burgeoning population? The fact is, our Nation is endowed with a cornucopia of natural resources essential for agriculture, and we still do have some of the world's most productive soils. By consciously and mindfull utilizing these natural resouces, we can be there with the top leaders in food productivity. Maximizing factor productivity of inputs, with minimal resource waste is imperative. Integrated farming solutions represent a vital approach and should become the norm if we are to secure the food needs of future generations. India's agricultural policy, thus far, have largely been farmer-centric, but we should shift towards farm-centric approach. This change would promote the success stories of individuals like of Shri Fazla Haque, a small farmer without formal education, who earns Rs. 8.71 lakh per annum and inspires other animal rearers. By adopting such integrated farming practices nationwide, our country's agricultural progress will be truly remarkable. So, keep watching as we forge ahead.

Fishery-based integrated farming in vegetables growing area of North 24 Parganas district

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Fishery-based integrated farming

Name of the farmer: **Shri. Haradhan Mondal**

Area of the farm: 1.56 ha

Location of the farm: Babpur village, Barasat I block, North 24 Parganas district

Shri. Haradhan Mondal, a 62-year-old farmer from Babpur village, West Bengal, has developed a unique model of an integrated farming system (IFS) on his 1.56 ha farm. Despite having only primary education, Shri. Mondal has demonstrated remarkable ingenuity in designing and managing his farm, effectively segregating the land according to the specific needs of different crops. The layout of his IFS is meticulously planned: 6 bighas are dedicated to field crops, 2 bighas to vegetable crops and spices, 4 bighas to a fish pond, and a 400 square foot area houses a dairy unit with two crossbred cows and a calf. Shri. Mondal employs best farming practices such as plastic mulching, drip irrigation, and the reduction of chemical fertilizers by utilizing vermicompost, plant residues, vermiwash, cow urine, and bio-pesticides. These practices not only enhance sustainability, but also facilitate resource recycling. From his 1.56 ha, Shri. Mondal achieves an annual net profit of Rs. 3,85,080.00. The highest share of this income comes from the fisheries sector, contributing Rs. 2,60,000.00 (67.52%), which classifies his farm as a fishery-based integrated farm. This is followed by the agriculture sector, contributing Rs. 92,680.00 (24.07%), the livestock sector at Rs. 18,400.00 (4.78%), and other sources, including vermicompost, at Rs. 14,000.00 (3.64%). Shri. Mondal's farm meets all the nutritional needs of his family, providing a diverse array of produce. The fishery-based integrated farm model he has developed shows a benefit-cost ratio of 1.72, underscoring its economic viability and sustainability. His innovative approach serves as an inspiring example for other farmers, demonstrating that with careful planning and sustainable practices, significant economic and environmental benefits can be achieved even on a modest landholding.

Key Words

Integrated farming, Fisheries, Horticulture, Agriculture, Livestock, Vermicompost, North 24 Parganas, New alluvial zone

Figure 71: Shri. Haradhan Mondal at his fishery-based integrated farm

Introduction

North 24 Parganas district under the New Alluvial zone of West Bengal is famous for production of vegetables, fruits, fisheries and livestock produces. In this district, most of the farmers come under small and marginal farmers having not more than 2 hectares of land. To meet the daily needs of the family, most of the farmers practice such a farming system so that they can provide a continuous, reliable and balanced supply of foods to the family, as well as earn cash out of selling a part of agriculture produces for basic needs and recurrent farm expenditure.

Shri. Haradhan Mondal, 62 years old, from Babpur village of North 24 Parganas district, West Bengal is a successful farmer as well as agri-entrepreneur. At this age, he is very much eager to adopt new ideas and technologies related to agriculture and allied sectors and apply them in his field. In search of newer technologies available and to satisfy his lure of knowing the unknown, he visited North 24 Parganas KVK, Ashokenagar and meeting with the experts there he determined to develop his existing farm a model IFS by utilizing every piece of his resources and earn more out of it. In this process, he incorporated all the major components of integrated farming system for diversified agriculture to enhance his farm income. Later with the interventions of the KVK, fisheries sector was developed remarkably. The total area under his IFS is around 12 bigha. The weather of Babpur is subtropical and the soil is loamy to sandy loamy type. Agro-climate of North 24 Parganas district supports cultivation of agricultural and horticultural crops, fisheries, livestock farming etc.

Farm description

Shri Haradhan Mondal has developed a model IFS consisting of fisheries, agriculture, horticulture, dairy and vermicomposting units as shown in Figure 72.

In his 12 bigha of land, Shri. Mondal has kept 6 bigha for agricultural production, 2 bigha for horticultural production, 4 bigha for fisheries and around 400 sq. ft. for livestock. Most of the land is rain-fed and the rest is irrigated by ground water. To retain moisture in the soil, he is adopting straw and plastic mulching in his horticultural fields under the guidance of KVK experts. He produces different seasonal vegetables like brinjal, bitter gourd and green papaya in kharif season, cauliflower, cabbage, beans, turnip and tomato in rabi season and okra in zaid season. To earn more profit, he targets on cultivation of spices like chilli in kharif season. Shri Mondal cultivates paddy (Narendra, Pratiksha and Miniket) during kharif and rabi season. He produces mustard during rabi season in around 2 bigha land. He has fishery units covering 4 bigha land where he produces mainly Indian Major Carps (IMCs) during eight months in a year. He has a small dairy unit consisting of two Jersey crossbred cows and a calf. The milk produced is kept for self-consumption as well as selling. A vermicomposting unit of 2 vermi chambers has been constructed with the assistance from KVK experts. About 3 ton of manure per year is being produced and used for growing different crops and vegetables.

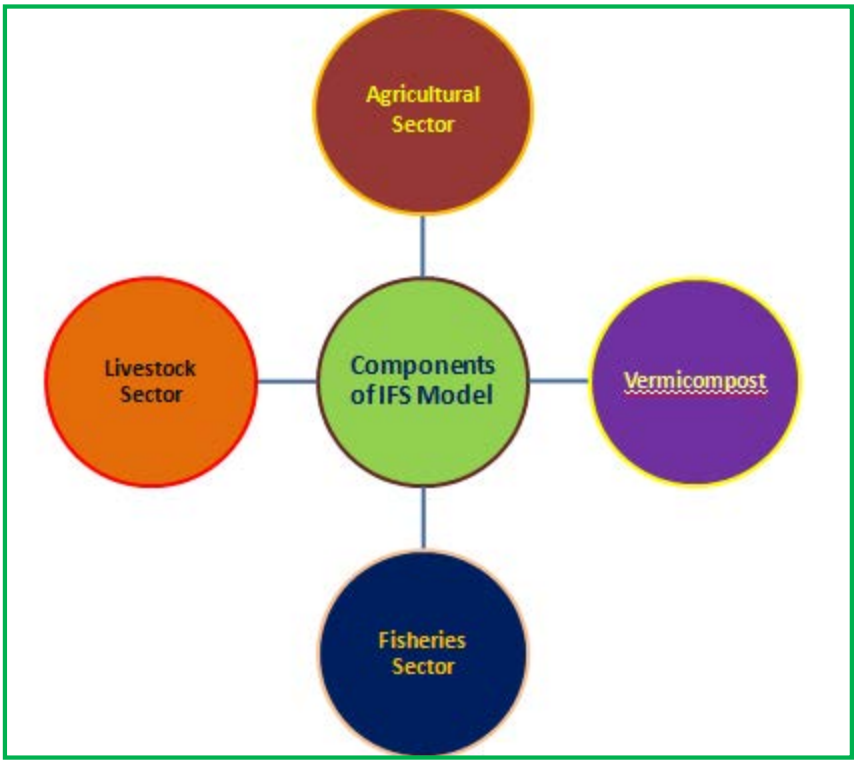

Figure 72: Different Components of IFS model of Shri. Haradhan Mondal

The farm is well connected by road and thus market accessibility is well. Market is within 5 km from the farm. The availability of inputs like seeds, planting materials, fish seeds, fertilizers, fish feed, livestock feed etc. are high to moderate in his area. He takes all the preventive measures as guided by the KVK experts for protecting livestock from diseases by following proper deworming and vaccination schedule and providing veterinary medicines as and when necessary. He is very particular about feeding vitamins and minerals to the farm animals. He takes care to keep his farm animals in proper and cleaned shelter. Shri. Mondal has embraced good agricultural practices by using the rotation system approach to grow a succession of different crops in different seasons on the same land. This approach helps to maintain soil fertility, allows for the preservation and more effective use of the natural resources already available, and aids in the control of insects and diseases.

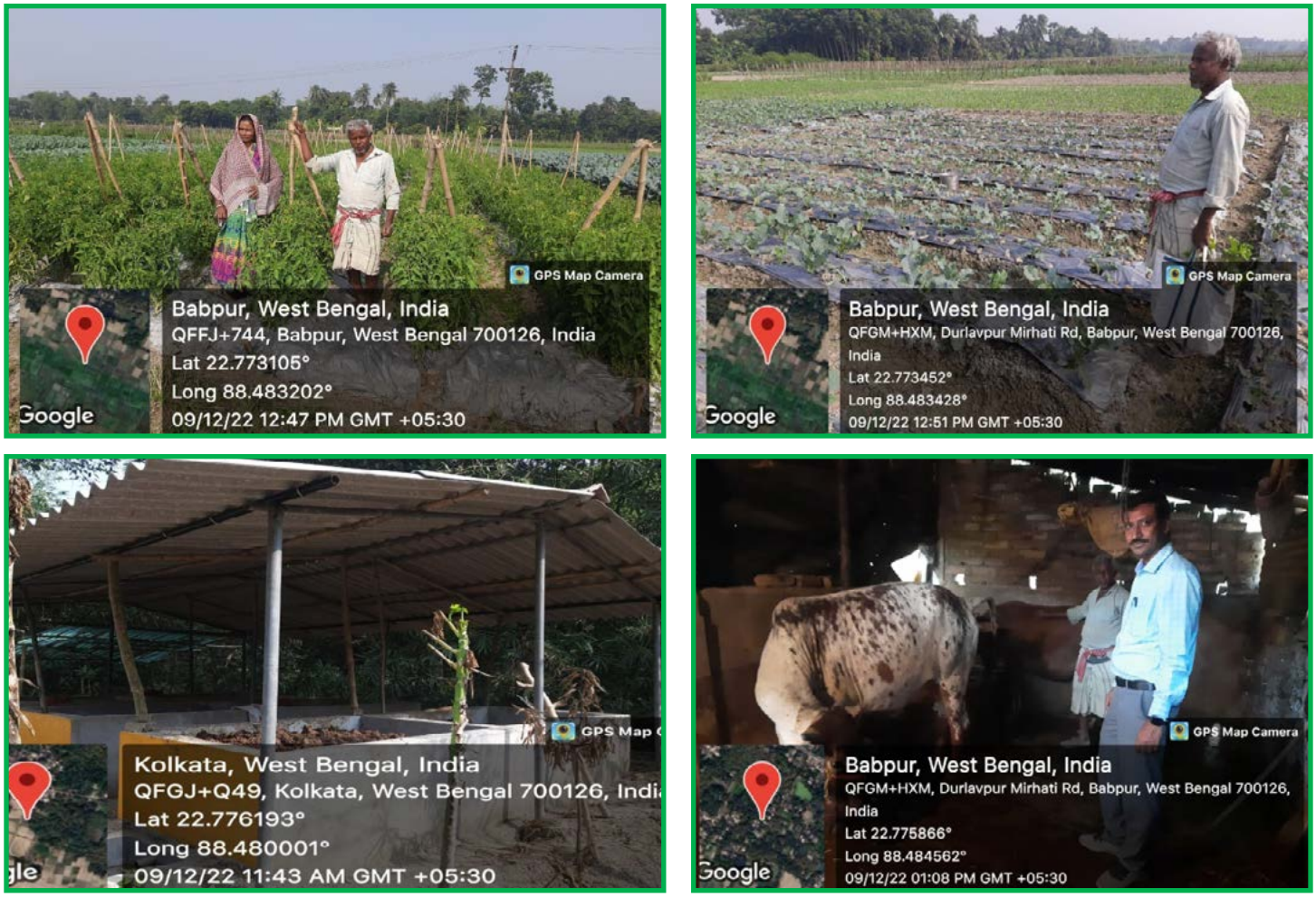

Figure 73: Different components of IFS of Shri. Haradhan Mondal

Table 56: Different crops and animal components at the farm of Shri. Haradhan Mondal

Season	Cereals	Vegetables	Oilseed	Spices	Livestock	Fisheries	Other Enterprise
Kharif	Paddy (Narendea, Pratiksha)	Brinjal, Bitter gourd, Green papaya	-	Chili	Cows (Jersy Cross)	IMCs	Vermicompost
Rabi	Paddy (Miniket)	Cauliflower, Cabbage, Beans, Turnip, Tomato	Mustard	-			
Zaid	-	Okra	-	-			

Farm layout

A farm layout is presented in Figure 74.

Capital cost with financial assistance, if any

Table 57: Capital Cost for developing the integrated farm

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Dairy Shed	0.02 lakh/ 10 sq ft	0.60	NA
Pump Set	0.30 lakh/ unit	0.30	NA
Drip Irrigation Set	--	0.20	0.20 from KVK
Fishery Unit	0.80 lakh/ bigha	3.20	2.0 from Dist. Agril. Dept.
Vermi Pit	0.05 lakh/ pit	0.10	0.10 from RKVY
Small Implements	--	0.15	0.15 from KVK
Total Cost		**4.55 Lakh**	

Bio-economic circularity of the farm

Since decades farmers used to recycle the output of one component of farming system as the input of the other component to maximize the amount of profit. Shri. Mondal was not an exception though he was not so much aware of the term "Integrated farming". He knew very well how to maximize production by minimizing costs associated with farming and also to save the environment from getting polluted. Figure 75 depicts how Shri. Mondal manages to recycle the resources for smart farming. The by-products, residues and post-harvest wastes of agricultural and horticultural produces are being incorporated as a source of animal feed, and the livestock wastes and agricultural residues are being used to produce farm yard manure (FYM) and vermicompost. Both are used as natural fertilizers in agricultural as well as horticultural fields to grow crops and vegetables. Moreover, feed residues from barn are being used as fish feed to reduce the cost of fish production. The excess water of fishery ponds is used for irrigation in agriculture and horticulture during scarcity of ground water. A total of Rs. 10,200.00 is circulating as bio-economics in the whole integrated system of this farm.

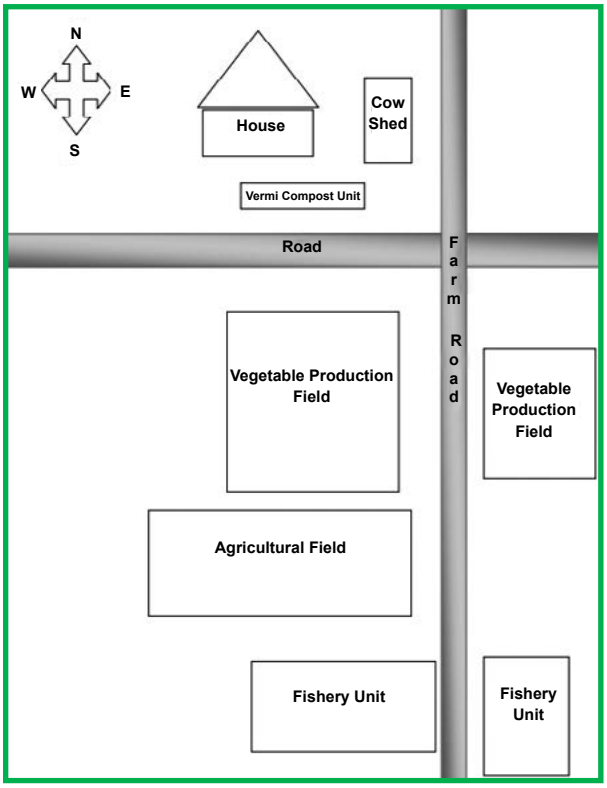

Figure 74: Farm layout with different components of Shri. Haradhan Mondal

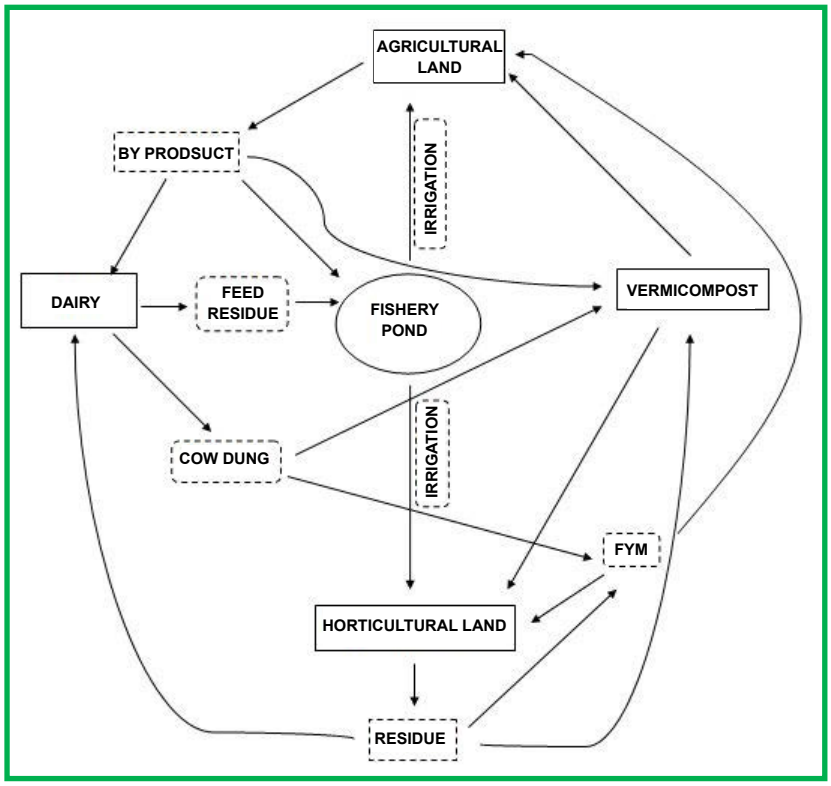

Figure 75: Resource recycling system at the farm of Shri. Haradhan Mondal

Farm economic viability

In this fishery-based IFS, Shri. Mondal obtained the highest net income from the fisheries sector (Rs.2,60,000.00) followed by agriculture and horticulture sector (Rs. 92,680.00), livestock sector (Rs. 18,400.00) and vermicompost (Rs. 14,000.00) as shown in Table 58. Shri. Mondal fetched highest profit from cauliflower (Rs. 18,000.00) while considering individual component of horticultural sector. As the highest net profit is coming from the fisheries sector, it may be considered as a fishery-based IFS. If we convert it in percentage of net profit, then we can see that the highest annual net income sharing comes from fisheries sector (67.52%) followed by agriculture sector including horticulture (24.07%), livestock sector (4.78%) and vermicompost (3.64%) as shown in Figure 76. The income analysis revealed that from a small farm piece of 1.56 ha area, the annual gross income of Rs. 9,17,160.00 could be realized from an investment of Rs. 5,32,080.00 with a resource use efficiency of Rs. 1.72 per rupee invested and a generation of 1190 days of man-days of employment costing Rs. 2,06,000.00 as labour wage including their own labour. According to Shri. Mondal, an annual expense for household purposes covering food, education and health was Rs. 3,46,000.00 and thus he could have a saving of Rs. 39,080.00 at the end of the year. The net income per hectare of land under this IFS is around Rs. 2,46,846.15 with a benefit cost ratio of around 1.72.

Table 58: Annual economics of Shri. Haradhan Mondal's IFS

Component	Area	Production (Kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
Cereals (Paddy)	9.0 Bigha	4140.00	54380.00	75400.00	21020.00
Oilseed (Mustard)	2.0 Bigha	100.00	3200.00	5400.00	2200.00
Vegetables (Brinjal, Bitter gourd, Green Papaya, Cauliflower etc.)	3.44 Bigha	9940.00	85500.00	147560.00	62060.00
Spices (Chili)	0.25 Bigha	480.00	7000.00	14400.00	7400.00
Dairy Unit (2 Jersy cross cows)	360 sq. ft.	1440 lt Milk	32000.00	50400.00	18400.00
Fishery (IMCs)	1500 No / Bigha	5000 kg	340000.00	600000.00	260000.00
Vermicompost unit	0.02 Bigha	3000 kg	10000.00	24000.00	14000.00
Total			**532080.00**	**917160.00**	**385080.00**

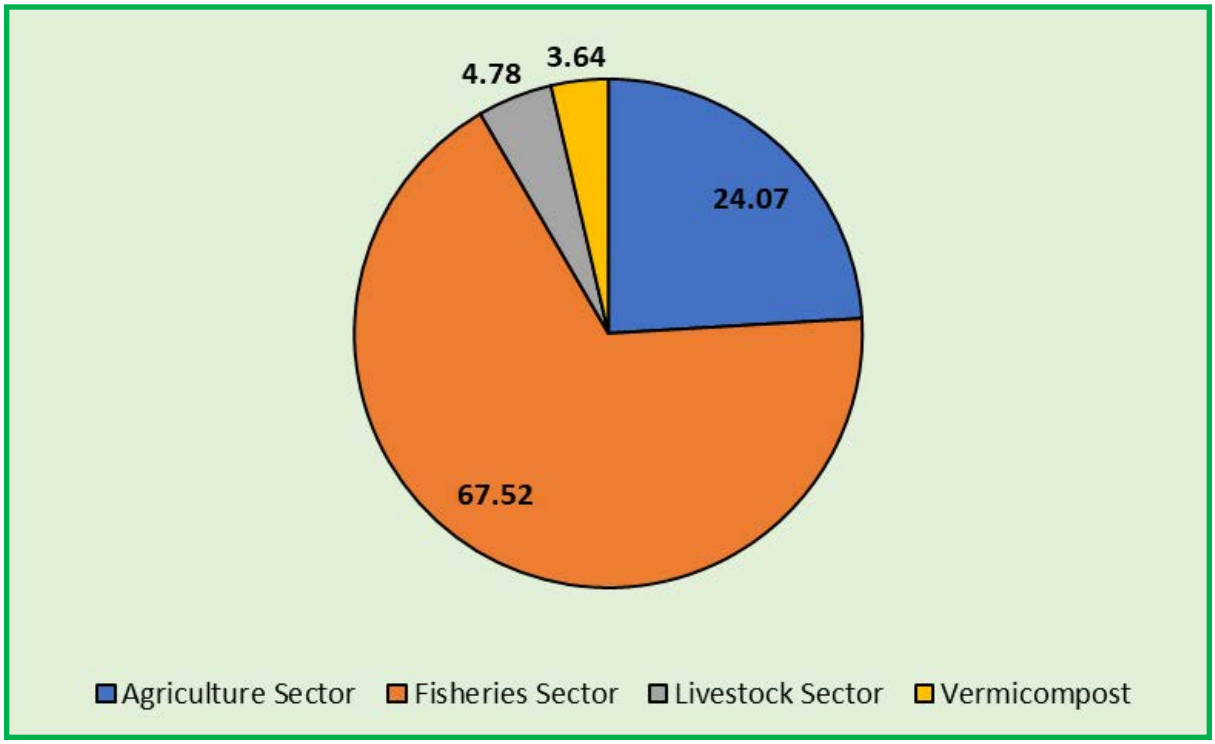

Figure 76: Annual net income sharing (in %) by different components of the farm

Conclusion

In present situation when we give emphasis on maximum utilization of available resources to make maximum profit out of it, the integrated farming is the only way. The present IFS is a farming system that combines several agricultural components, which are based on the recycling biological concept, and linked of input-output approach between the mutually commodities for the purpose of increasing the production and productivity so as to increase farmer's income and make environment friendly. This integrated approach is best to bring about incremental changes in the production system to improve productivity and efficiency. Under such circumstances, it is concluded that the IFS can play a good role not only in the issues of food security and nutritional security in new alluvial agro-climatic zone, but also will be helpful in income and employment generation, if proper policy initiatives are taken. Shri. Haradhan Mondal proves that this fishery-based integrated farm can technically be feasible and economically viable with the net return of Rs. 2,46,846.15 from a 1 ha land. He is an inspiration to the neighbouring farmers who are eager to develop IFS model. Shri. Mondal is a member of one farmers' club named Babpur Krishak Sangha and actively participates in every endeavour of this organization.

Adoption of horticulture-based integrated farming in small holding turns farming sustainable and profitable in Nadia district

Malay Kumar Samanta

Nadia Krishi Vigyan Kendra
Bidhan Chandra Krishi Viswavidyalaya
Gayeshpur, Nadia-741234

Horticulture-based integrated farming

Name of the farmer: **Shri. Sudhin Sarkar**

Area of the farm: 1.41 ha

Location of the farm: Fulia village, Santipur block, Nadia district

The case study on Shri. Sudhin Sarkar, a farmer from Fulia, Nadia, was conducted in the new alluvial zone of West Bengal. Initially, Shri. Sarkar's 1.41 ha landholding was used to cultivate kharif paddy and some winter vegetables, rendering his farming venture non-profitable. However, upon adopting an integrated farming system (IFS) with efficient resource recycling among various components—cereals, pulses, oilseeds, vegetables, poultry, fisheries, a nursery, and fruit trees—his farming transformed into a sustainable and profitable enterprise. According to the annual income analysis of the IFS on his 1.41 ha farm, Shri. Sarkar achieved a remarkable annual gross income of Rs. 10,28,699.00 against an investment of Rs. 5,31,050.00, resulting in a resource use efficiency of Rs. 1.94 per rupee invested. The horticulture enterprise, including the nursery unit, emerged as the most lucrative component, contributing Rs. 3,48,370.00 (70.6%) to the total net income of Rs. 4,97,649.00. This clearly indicates that it is a horticulture-based IFS, which can potentially yield an annual net return of approximately Rs. 3,52,942.55 per ha. Moreover, the fresh harvest of nutritious foods from the farm has significantly reduced the family's dependency on purchased food. Shri. Sarkar's success story is a testament to the transformative power of IFS. His journey from struggling with non-profitable farming to achieving sustainability and profitability serves as an inspiring model for farmers in similar agro-climatic zones.

Key words

Integrated farming system, Horticulture-based IFS, Sustainable farming, Bio-economic circularity, Small holding IFS, Nadia, New alluvial zone

Figure 77: Shri. Sudhin Sarkar at his horticulture-based integrated farm

Introduction

Shri. Sudhin Sarkar of Fulia, Nadia at his mid forty is now making his farming a sustainable and truly profitable. He had left school after class VI and had compelled to join family farming as he had not any option then. His family had only 0.8 ha of medium–low land, which was mainly utilized to grow kharif paddy and some winter vegetables. As these were the predominant cropping sequence of that type of land situation, there was always a market glut causing low market price and hence making the farming only a bare marginal living option. This was the common scenario of Nadia district from the early years of first decade of this century. The small and marginal farm holding could not adopt diversified farming options, only paddy/jute and winter vegetables had covered the fields. Like Shri. Sudhin Sarkar, the small and marginal farmers had only relied on their own family labour wage and the days were miserable. The district Nadia mostly has clay to sandy loam fertile soil with a good record of annual rainfall (1500 mm) and also a strong background of pioneer crop diversification with vegetables and pulses. The area has good economic importance due to it's heritage of textile, which has triggered good facilities of strong marketing network and institutional credit access. With these strong on and off farm background and knowledge backup from Nadia Krishi Vigyan Kendra (KVK) Shri. Sudhin Sarkar decided to change his farming practice and started to think how to make his farming a profitable one. Initially he started to grow some off-season vegetables and a small poultry unit. Introduction of these two new ventures had made his farming reasonably a better remunerative than the previous stage. In the meantime, he came to know about the benefits of practicing integrated farming system during a training course at Nadia KVK. After several discussion and direct technical support of KVK personnel, gradually he developed horticulture-based IFS, where the major component was a nursery unit.

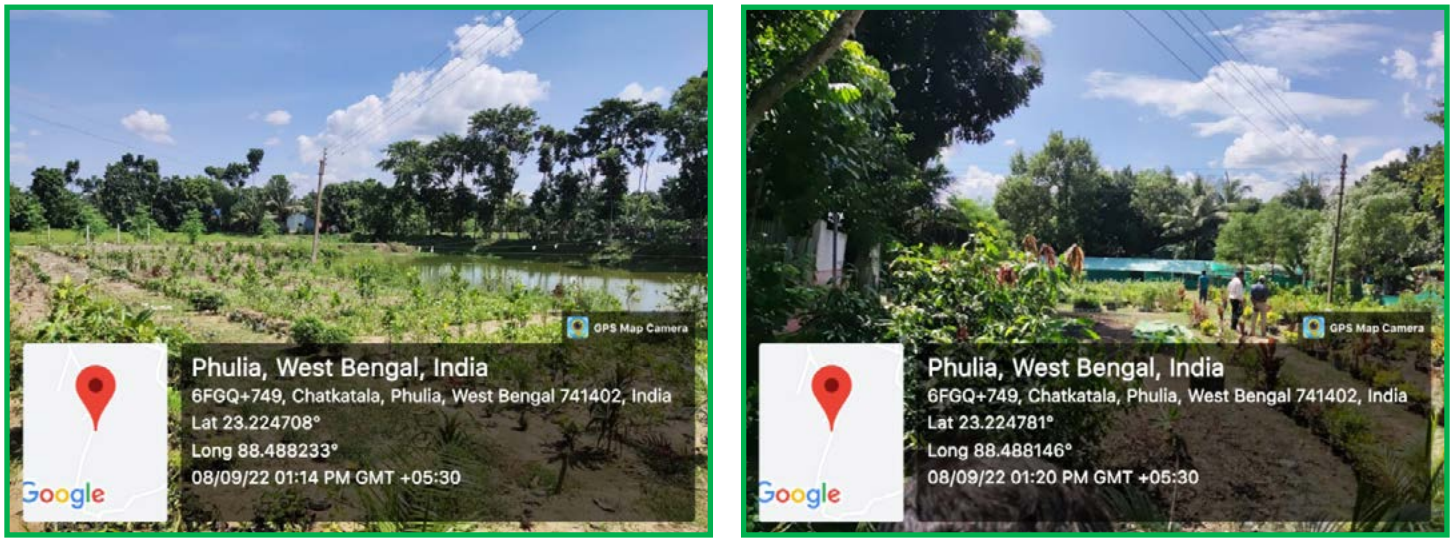

Figure 78: Horticulture based integrated farm of Shri. Sudhin Sarkar

Farm description

Apart from nursery other components are fish pond, poultry, cereal and pulse, agro-forestry as boundary crop and horticulture crops like seasonal vegetables and different fruit crops including new fruit crops like dragon fruit and malta etc. With some leased in land from the neighbouring farmers, the area of the IFS unit is approximately 1.41 ha. Percentile allocation of land for different components are as nursery with mother block 36.9%, fish pond 14.2%, cereal/pulse 18.9%, vegetables 9.5%, fruit 11.3%, vermicompost unit 4.7% and others 4.5%. Basically, the demand and supply scenario has directed Shri. Sudhin Sarkar to bring diversification at his farm through introduction of various components, where the local people are mostly non-vegetarians who live in highly populated peri-urban clusters. The area has steady demand for nursery saplings including the ornamentals, as well as veg. and non-veg. fresh food. The IFS unit has a poultry unit of 2000 birds, which is maintained in cyclic way and production is carried out through contract farming. Normally 3 times yearly production cycle is maintained in poultry unit. Rice-Mustard-Rice or Rice-Mustard-Pulse cropping systems are maintained in low land and three to four harvests of vegetable are done in mid land. The fish pond and fruit orchard are just added to the system. The fish pond mainly used to grow Indian Major Carps (IMCs) having 2000 stocking density per bigha. The fruit orchard is in non-bearing age. In-situ composting of poultry litter as well as crop residues are converted to vermicompost, which is one of the main sources of nutrients to enrich the soil of IFS unit. Saplings of major fruit crops, seedlings of vegetables, flowers and forest plants are raised on seasonal demand basis. Shed net structure has been installed for different nursery operations.

Farm layout

A layout of the farm is presented in Fig. 79.

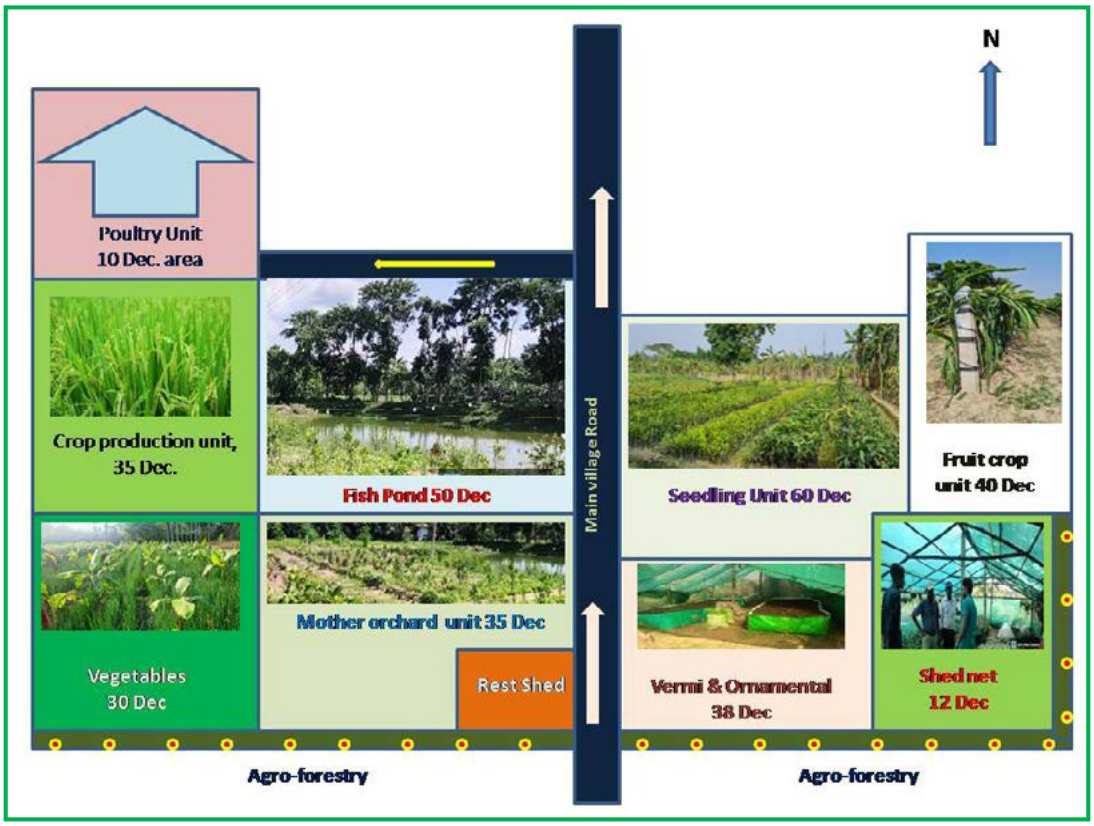

Figure 79: Lay out of the farm

Capital cost with financial assistance, if any

There was an involvement of capital cost for developing such IFS. Thus, the capital cost is presented in Table 59.

Table 59: Capital cost for developing the IFS

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Pond making/ renovation	0.90/bigha	1.20	0.84 from MGNREGA (70%)
Nursery unit	0.50/bigha	1.95	0.25 from Nadia KVK
Poultry unit	2.00 /0.3 bigha	2.00	KCC linked loan
Vermicompost unit (9)	0.016/unit of 2 cubic m	0.15	0.10 from Nadia KVK
Fruit plants	0.32/bigha	0.38	0.05 from Nadia KVK
Forest plants	0.05/100 plant	0.05	0.05 from Nadia KVK
Land shaping	0.30/bigha	0.90	0.81 from MGNREGA (90%)
Farm shed	0.20	0.20	-
Total Cost		6.83	

Bio-economic circularity of the farm

Resource recycling is the prime focusing concern for Shri. Sudhin Sarkar, as he has learned the concept of integrated farming and implemented it as one component waste is converted to resourceful input to another component. Fig.80 has depicted the circularity of the system, where post-harvest residue of crop and other wastes have converted to organic input. These organic inputs have saved around Rs. 31,500.00 per year. The crop residues are also used as natural mulch for the crops leading to soil enrichment in long run. Waste of the poultry unit i.e. poultry litter is used as input for fish which directly consumes poultry droppings for protein, carbohydrates, minerals etc enabling faster growth. The application of the partial decomposed poultry litter in the pond provides a nutrient base for dense bloom

of phytoplankton which helps in development of zooplankton. The zooplankton is an additional food source for fishes. During the pond water recycling process, the fertilized pond water is used for source of irrigation in agriculture fields. Besides, pond water is used for the poultry farm. Estimated value of fish feed supplemented by the partial decomposed poultry litter is Rs. 21,750.00 per year and cost of irrigation water saved through stored water utilization is Rs. 18,000.00 per year. Thus, a total of Rs. 71,250.00 is bio-economic circularity of this IFS, has immensely impacted sustainability and profitability of the farm.

Farm economic viability

Among the different components, horticulture enterprise including nursery unit has the highest contribution of 70.6% out of total net income. The poultry unit has contributed 9.7% and fishery and vermicompost units have added 10.7% and 6.3% respectively to the net income. These four components have contributed 97.3% of the total net income from the IFS under the study as presented in Fig. 81. The income from the agronomic crops is very less i.e. 2.7%, this is the pre-dominant scenario of the district. The marginal or no return from the major agronomic crops has made traditional farming a non-remunerative one and probably this is the cause for farmer quest and adoption for IFS. Even searching for non-agriculture income is also the common scenario for the small and marginal farmer.

Annual income analysis has revealed that from the small farm holding i.e. 1.41 ha, the annual gross income realized from the IFS is Rs. 10,28,699.00 against the investment of Rs. 5,31,050.00 indicating an annual net income of Rs. 4,97,649.00 from IFS with a resource use efficiency of Rs. 1.94 per rupee invested as mentioned in Table 60. The IFS has also generated an annual mandays of 997 including the family labour, which has an employment value of Rs. 2,49,250.00. Out of these 997 mandays generation, 616 mandays have been utilized by own family engagement, which could add Rs. 1,54,000.00 as family income. As studied, the family has annual household expenses of Rs. 3,08,400.00 to meet the expenses for food, education, medical and other purposes. So, Shri Sarkar can save up to Rs. 1,89,249.00 in a year.

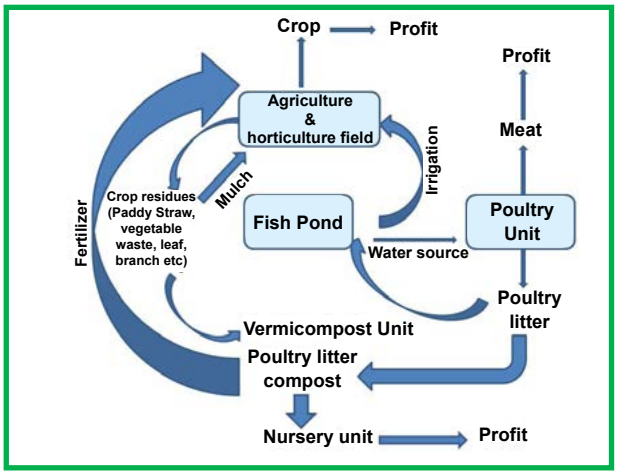

Figure 80: Resource recycling system at Shri. Sudhin Sarkar's IFS

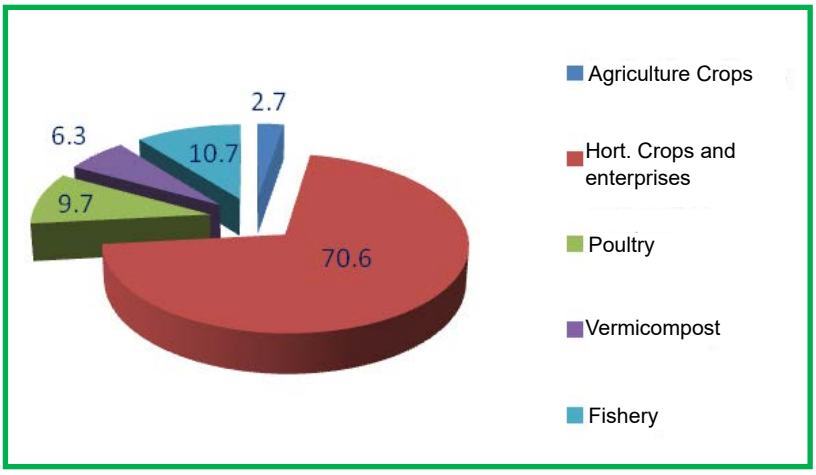

Figure 81: Share of different components in annual net income

Table 60: Annual economics of Shri. Sudhin Sarkar's IFS

Component	Area (Bigha)	Production (Kg)	Gross Cost (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
Cereal (Paddy)	1.0	830	6,600.00	9,265.00	2,665.00
Pulse (Lentil)	0.5	85	3,850.00	7,140.00	3,290.00
Oilseed(mustrad)	0.5	98	3,450.00	10,824.00	7,374.00
Vegetables	1.0	5110	71,000.00	1,07,370.00	36,370.00
Nursery unit	3.9	10000 pc	2,85,000.00	6,00,000.00	3,15,000.00
Poultry unit	0.3	1700	87,650.00	1,36,000.00	48,350.00
Vermicompost	0.5	5000	13,500.00	45,000.00	31,500.00
Fishery	1.5	870	60,000.00	1,13,100.00	53,100.00
Fruit orchard	1.2	Yet to start the production			
Farm shed	0.2	Non-productive infrastructure			
Total	**10.58**		5,31,050.00	10,28,699.00	4,97,649.00

From the Table 61, it reveals that, the production of agronomic crops is utilized for own consumption along with organic manure for the soil enrichment, which is grossly 30% of the production. This data has indicated the concerning issue of farming family food security and soil health of the farm. After own use, vermicompost is sold to add income. As there is a large production surplus in vegetables (92%) and poultry (97%), these are being marketed to fetch a good amount of income. The nursery unit has 100% sellable produce which provides a lion share of income.

Table 61: Product consumption and marketable yield

Component	Area (Bigha)	Total production (Kg)	Production for selling (kg)	Production for self-consumption (Kg)	Selling %	Self- consumption %
Cereal (Paddy)	1.0	830	545	285	66	34
Pulse (Lentil)	0.5	85	72	13	85	15
Oilseed(mustrad)	0.5	98	48	40	49	41
Vegetables	1.0	5110	4700	410	92	8
Nursery unit	3.9	10000 pc	10000	0	100	0
Poultry unit	0.3	1700	1650	50	97	3
Vermicompost	0.5	5000	3500	1500	70	30
Fishery	1.5	870	750	120	86	14
Fruit orchard	1.2	Yet to start the production				
Farm shed	0.2	Non-productive infrastructure				
Total	**10.58**					

Conclusion

Experience of paddy-paddy mono cropping to horticulture-based IFS was the basic motivational force for Shri. Sudhin Sarkar. This had further motivated him to transform his farming a sustainable and profitable one. His limited land holding and low land topography had always been a threat for his livelihood, so quest for diversification of earning source by the way of bringing modifications in farming venture. The learning and adoption of integrated farming system was the paradigm change from poverty-stricken farming to economically sustainable farming. The reasonable land use by the concept of horticultural enterprise centric integrated farming has shown to make a net farming profit of Rs. 3,52,942.55 from a 1.0 ha land in a year. Moreover, this trend has been continuing for last three years indicating the sustainability of the farm. The fresh harvest of nutritive foods has made them least dependent on purchased food. The assured quality living by the way of IFS adoption has made the farming attractive to the fellow farmers within the village and in the adjacent villages. The social acceptance and feeling of achievement have made his next generation to motivate and proudly engage into the family farming activities for successful agri-preneurship.

Red and Laterite Agro-climatic Zone

Agriculture-based integrated farming for improving income and nutrition in upland farming situation of Birbhum district

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Palli Siksha Bhavana, Visva-Bharati
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Agriculture-based integrated farming

Name of the farmer: **Shri. Abu Taher Mallik**

Area of the farm: 3.64 ha

Location of the farm: Mala village, Bolpur Shriniketan block, Birbhum district

An integrated farming system (IFS) on 3.64 ha, developed by Shri. Abu Taher Mallik in Mala village, Bolpur Shriniketan block, Birbhum district, exemplifies an agriculture-based IFS despite challenging conditions. The red lateritic and acidic soil, with its low water holding capacity and fertility, posed significant obstacles. However, Shri. Mallik successfully established a diversified and resilient IFS, incorporating over 12 components, including cereals, pulses, oilseeds, vegetables, spices, fruits, forest trees, plantation crops, cattle, poultry, ducks, and fisheries. This IFS unit records an annual net income of Rs. 4.16 lakhs with a benefit-cost ratio of 2.25. The highest income share comes from cereals, pulses, and oilseeds, contributing 35.93%, followed by horticultural crops at 22.35%, affirming its classification as an agriculture-based IFS. The fishery component adds 19.23%, livestock 11.42%, and other components like plantation crops and forest trees 11.06%. Shri. Mallik's farm not only generates substantial income, but also ensures nutritional security for his family through surplus produce, including cereals, pulses, vegetables, fruits, eggs, meat, milk, and fish. The technical feasibility and economic viability of this agriculture-based IFS highlight its potential as a model for the red and laterite agro-climatic zone of West Bengal. In light of Shri. Mallik's success, an area development scheme has been formulated based on the techno-economic data from this IFS. This initiative aims to replicate his achievements, promoting sustainable and profitable agriculture in similarly challenging environments.

Key Words

Integrated farming system, Agriculture, Horticulture, Livestock, Fishery, Bio-circularity, Area development scheme, Red and laterite agro-climatic zone, West Bengal

Figure 82: Shri. Abu Taher Mallik at his crop field

Introduction

Shri. Abu Taher Mallik, S/o Shri. Abdul Karim Mallik has developed an agriculture-based integrated farming system (IFS) on 3.64 ha land at Mala village of Bolpur Shriniketan block in Birbhum district of West Bengal. Shri. Abu Taher Mallik is 47 years old with a family of four members. After 9th standard, Shri. Mallik left school in the year 1992 and engaged himself in agriculture. In 3.64 ha farm land, there is a fresh water pond measuring 4 bigha (0.53 ha) area and the remaining area is fully utilized for production of different crops like cereals, pulses, oilseed, vegetables, spices, fruit, agro-forestry and animal husbandry activities.

Birbhum district experiences very dry and hot summer with temperatures often rising above normal. The temperature varies from 12.7˚C to 28.3˚C in winter and from 25.5˚C to 41.5˚C in summer. The average rainfall is 1430 mm. The agriculture of Birbhum district is mostly rainfed, partly irrigated. There are certain constraints in farming in Birbhum district like hot and dry weather, water scarcity in summer, low water holding capacity, less soil fertility and mite problem etc. He was formerly dependent on traditional method of cultivation. He was getting low income from farming by the traditional methods of cultivation and the production was also very low. To overcome the problems faced by him, he started searching the new avenue for more income generation. Shri. Mallik visited Rathindra Krishi Vigyan Kendra (KVK), Birbhum and came to know about the scopes and opportunities in farming. He showed interest to improve his skill and knowledge every aspect of new farming method. Due to his eagerness towards new technology and development in the field of agriculture, horticulture, fishery and animal husbandry, a strong linkage has been developed between him and the experts of Rathindra KVK, Birbhum. He was motivated by the KVK scientists to implement IFS at his farm. He realized that IFS and crop diversification would be the most promising holistic and innovative approach to improve the total farm productivity and profitability over existing systems. Considering his need and constraints, Shri. Abu Taher Mallik was trained by Rathindra KVK to develop an agriculture-based IFS at his farm.

Farm description

Shri. Abu Taher Mallik has developed an agriculture-based IFS on 3.64 ha land. The predominant soil type of this farm is clayey loam with low to medium organic carbon, low phosphate content and low to medium potash content. The soil is acidic in nature with pH. ranges 5.5-6.2. The land used by Shri Mallik for cultivation of crops is irrigated by canal water and partly depends on groundwater irrigation. At present the value of 3.64 ha land is about Rs. 108.0 lakhs.

With the guidance of Rathindra KVK, Birbhum, Shri. Abu Taher Mallik started IFS with the plantation of forest trees and coconut trees. Presently, he is growing field crops like paddy (variety MTU-7029-Swarna, Ratna), oilseeds (mustard), pulses (lentil, lathyrus). He cultivates vegetables like okra, bottle gourd, pumpkin, ridge gourd in kharif season and runner bean, cauliflower, cabbage, spinach, tomato in rabi and bitter gourd, colocacia, onion, brinjal and malabar spinach etc. in zaid season. He also cultivates turmeric, coriander, chilly in kharif season. He has some mango and jackfruit trees which provide some earnings. He has two nos. of desi cows, sixteen nos. of Kuroiler birds and thirty nos. of Khaki Campbell duck. Besides, he cultivates Indian Major Carps (IMC) in the farm pond up to eight-month period. Various farming components in Shri. Abu Taher Mallik's farm is shown in Figure 83.

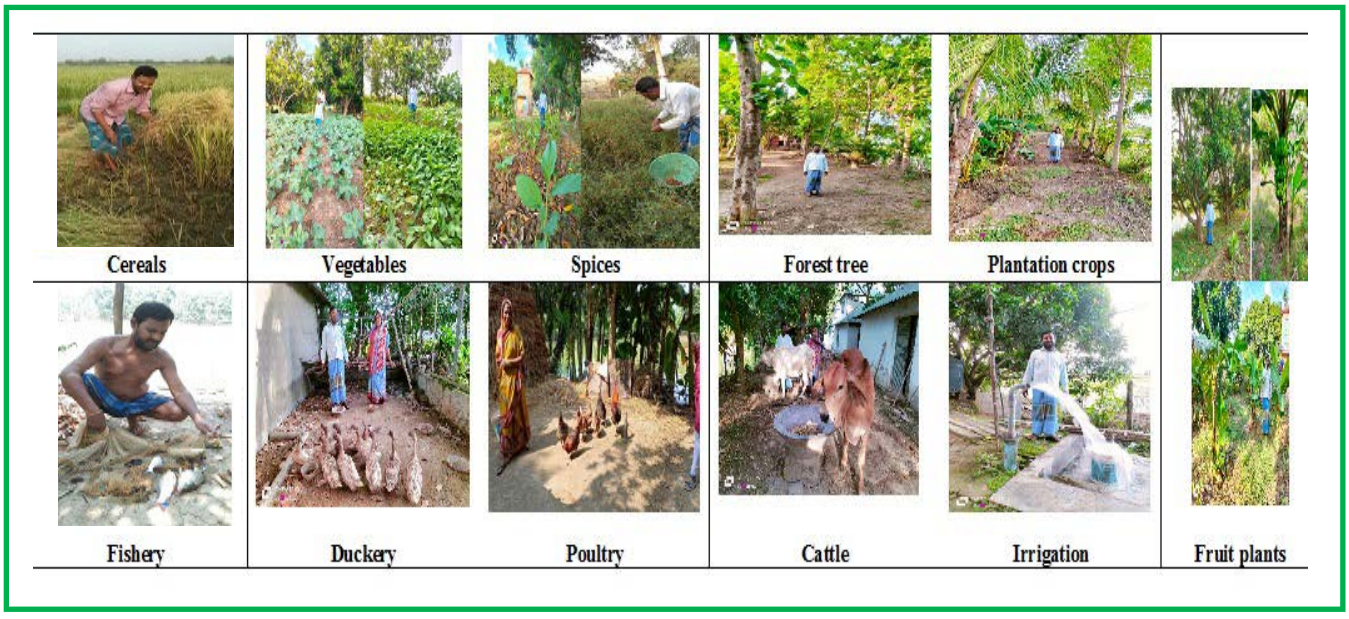

Figure 83: Various farming components in Shri. Abu Taher Mallik's farm

Shri. Abu Taher Mallik having being trained by Rathindra KVK, Birbhum has adopted many good agricultural practices in making his farm technically feasible to maximize productivity and profit while minimizing cost of production as mentioned below.

- The farm has greater diversity in crops and livestock to fetch more income and adapt to local circumstances.
- As a whole, the farm components are more resilient to droughts and other impacts of climate change.
- Plantation of legume forest tree like Acacia has beneficial effect in farming system to boost crop yield by enhancing soil fertility using nitrogen-fixing ability of Acacia.
- Coconut tree plantation provides intercropping and allows other crops to grow under the canopy to maximize the utilization of soil and sunlight for improving crop biodiversity and farm productivity. Coconut tree is a means to sequester carbon and reduce fertilizer consumption, while it helps in increasing farm income.
- Pulse crops have the ability to fix atmospheric nitrogen through symbiotic relationships with bacteria in their root nodules, thus promoting sustainable farming practices. Pulses have deep root systems that improve soil structure and enhance water-holding capacity. Pulses in crop rotations break disease and pest cycles, reducing the need for pesticides.
- Rotation of crops enhances soil fertility.
- Availability of cow dung, poultry manure, duck droppings open the scope for organic farming.
- Keeping animal in properly constructed pucca animal shelters and maintaining the hygiene reduce the costs associated with animal illness. Good animal housing and welfare prevent the spread of diseases and protect both animals and humans.
- Disease prevention of livestock is strictly maintained following vaccination schedule that boosts the immune system of the livestock by developing immunity against disease-causing pathogens and reducing the risk of infection transmission from one animal to another.
- Feeding of vitamin and mineral mixtures keeps livestock in good health with optimal production.
- Good pond management enhances the fish yield.
- Fish-cum-duck has beneficial effects on both fish and duck production.
- In an IF, the choice of crops as well as their cropping pattern in a calendar year are important for farm sustainability and ecological protection. The cropping pattern of Shri. Abu Taher Mallik's IFS in three seasons is depicted in Table 62.

Table 62: Different crop and animal components at the farm of Shri. Abu Taher Mallik

Component	Season		
	Kharif (Rainy)	Rabi (Winter)	Zaid (Summer)
Cereal	Rice		
Pulse		Lentil, Lathyrus (Musur, Khesari)	
Oilseed		Mustard	
Vegetables	Okra, bottle gourd, pumpkin, ridged gourd	Runner bean, cauliflower, cabbage, spinach, tomato	Bitter gourd, colocacia, onion, brinjal and malabar spinach
Spices	Turmeric, Coriander, Chilli		
Fruit Plant	Mango, Jack fruit, Star Fruit, Banana		
Forest tree	Acacia		
Plantation crops	Coconut		
Cattle	Desi		
Chicken	Kuroiler		
Duck	Khaki Campbell		
Fishery	IMCs		

Farm layout

The layout of Shri. Abu Taher Mallik's IFS is shown in Figure 84.

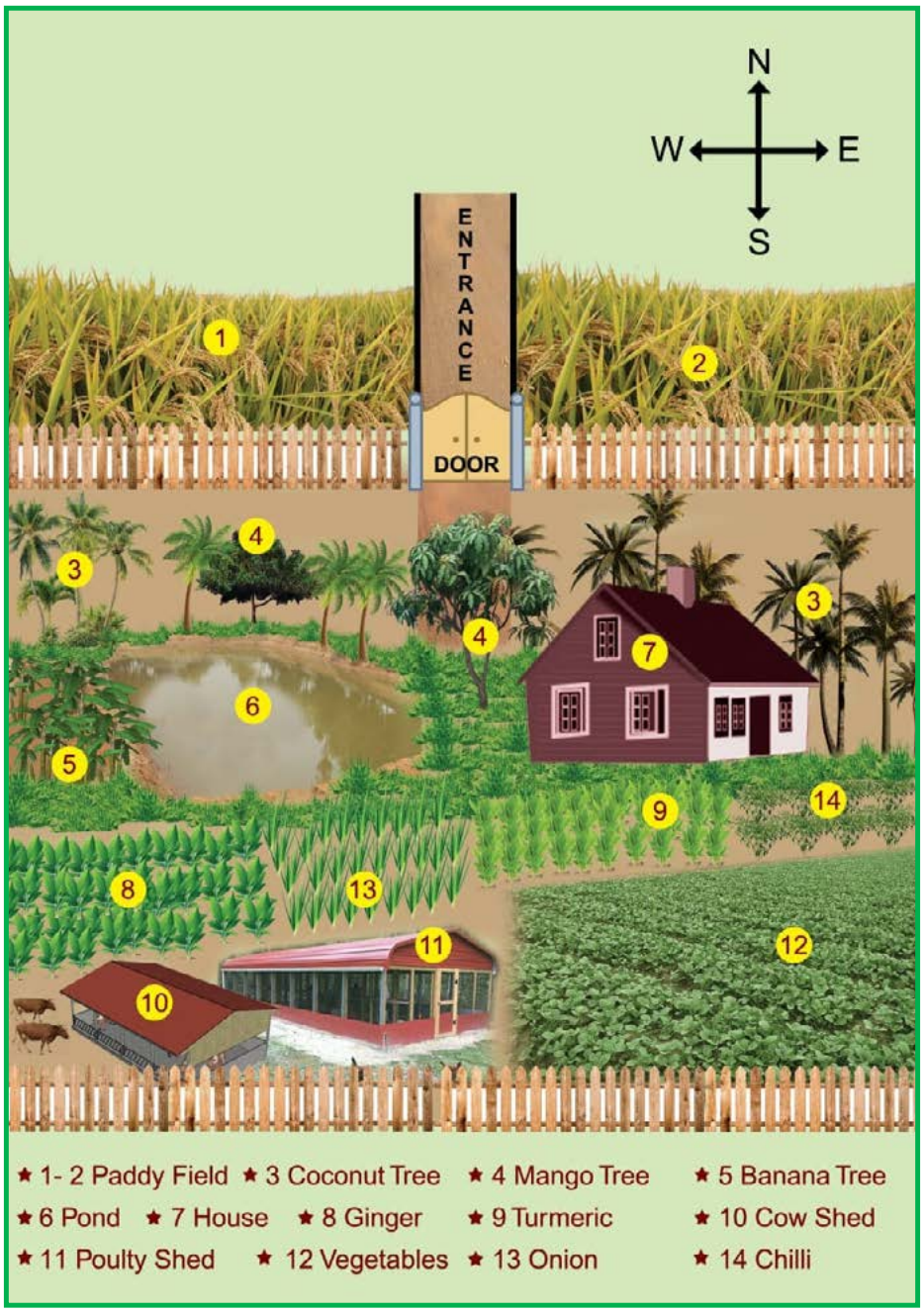

Figure 84: A farm layout with different components on 3.64 ha land

Capital cost with financial assistance, if any

There was an involvement of capital cost to develop such kind of IFS. For any interested farmer who wants to develop such kind of IFS, the capital cost is presented in Table 63.

Table 63: Capital cost for developing IFS of Shri. Abu Taher Mallik

Component	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy /Govt. contribution (If any) (Lakh Rs.)
Pond excavation (4 bighas)	0.25 /bigha	1.00	0.15 (Fish fingerlings supplied by Rathindra KVK)
Poultry shed (one unit)	0.5/unit	0.5	0.05 (Khaki Campbell ducklings supplied by Rathindra KVK)

Component	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy /Govt. contribution (If any) (Lakh Rs.)
Cattle shed (One unit)	0.5/unit	0.5	0.03 from Rathindra KVK as operational cost
Horticulture		0.23	0.07 from Rathindra KVK as operational cost
Fruit plants		0.17	-
Total Cost		**2.4**	

Bio-economic circularity of farm

The higher returns in IFS are not only due to higher productivity of the system, but also due to lower cost of production and recycling of by-products of various components in IFS. Shri Mallik uses organic manure in agriculture field by using wastes of livestock and crop residues from agricultural field to livestock as feed. He recycles duck manure as fish feed. Shri Mallik has introduced bio-economic circularity in the farm. He observed that low-input, high-yielding, and integrated agricultural systems could reduce pressure on agricultural resources and minimize environmental impacts.

Figure 85 shows that the crop residues are used as livestock feed and livestock excreta like cow dung, urine and poultry manure are used as fertilizer in agricultural land. At the same time, fish feed is used as pond fertilizer. Faeces of Khaki Campbell ducks is used as fish feed. Dry leaves and wood are used as fuel and he can save about Rs. 11,000.00 from this venture. Post-harvest wastes of cereal, pulse, oilseeds, spices, vegetables, fruits, forest trees including plantation crops costing Rs. 32,400.00 is recycled. From livestock component such as cow dung and poultry litter costing Rs. 850.00 is recycled in agricultural field and in pond as fish feed. A total of 44250 is recycling in this integrated farm.

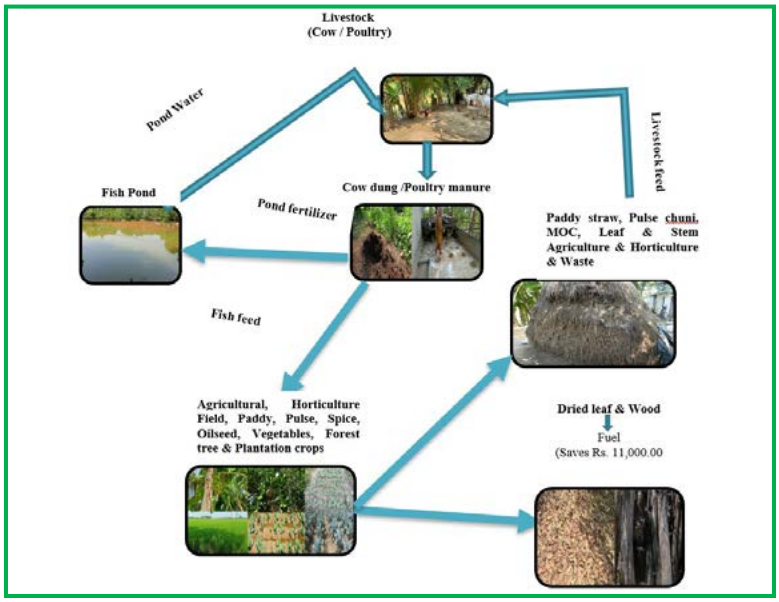

Figure 85: Resource recycling system at the farm of Shri. Abu Taher Mallik

Farm economic viability

In this agriculture-based IFS, Shri. Abu Taher Mallik recorded highest net income from cereals (Rs. 87,000.00) followed by fishery component (Rs. 80,000.00), livestock (Rs. 47,500.00), forest trees (Rs. 45,000.00), fruit plants (Rs. 44,300.00), pulse crops (Rs. 41,800.00), vegetable crops (Rs. 40,470.00), oilseed crops (Rs. 20,200.00), spices (Rs. 8,250.00) and plantation crops (Rs.1,050.00) as represented in Table 64. According to Shri. Abu Taher Mallik, the total annual expenditure for IFS was Rs. 3,31,430.00 and an annual gross income was Rs. 7,47,000.00. So, his annual net income from IFS covering 3.64 ha land was recorded as Rs. 4,15,570.00 with benefit cost ratio 2.25. Since an annual expense for household purposes covering food, education, health and other was Rs.1,06,000.00, Shri. Abu Taher Mallik could save Rs. 3,09,570.00 annually from 3.64 ha IFS. The highest annual net income sharing came from agronomic crops, i.e., cereals, pulses and oilseeds (35.93%) followed by horticultural crops (22.35%) thus indicating to the fact that it was truly agriculture-based integrated farm. Fishery contributed about 19.23% followed by livestock (11.42%) component. Other components like plantation crops and forest trees contributed about 11.06% as shown in Figure 86. This IFS also generated 1130 nos. of man-days outside his family members. Thus, he could contribute a lot in the society within the local community in terms employment generation.

Table 64: Annual economics of Shri. Abu Taher Mallik's IFS

Component	Crops/ Variety	Area	Production (Kg)	Cost (Rs.)	Gross income (Rs.)	Net income (Rs.)
Cereal (Rice)	Swarna	15 bigha (1.99 ha)	14400	1,50,000.00	204000.00	54000.00
	Ratna	5 bigha (0.67 ha)	3600	30000.00	63000.00	33000.00
Pulse	Lentil (Musur)	4 bigha (0.53 ha)	480	10200.00	24000.00	13800.00
	Lathyrus (Khesari)	3 bigha (0.39ha)	240	8000.00	36000.00	28000.00
Oilseed	Mustard	3 bigha (0.39 ha)	480	5000.00	25200.00	20200.00
Vegetables	In Kharif	1.25bigha (0.17 ha)	2330	8500.00	23700.00	15200.00

Component	Crops/ Variety	Area	Production (Kg)	Cost (Rs.)	Gross income (Rs.)	Net income (Rs.)
	In Rabi	0.95bigha (0.13 ha)	1170	5130.00	18900.00	13770.00
	In Zaid	1.35bigha (0.18 ha)	6413	7700.00	19200.00	11500.00
Spices (Turmeric, Coriander, Chilli)	In Kharif	0.25bigha (0.03ha)	100	2000.00	10250.00	8250.00
Fruit plants (Banana, Star Fruits, Mango, Jack fruit)	In Kharif	0.27 bigha (0.04 ha)	2260	13200.00	31000.00	17800.00
	In Zaid	0.6 bigha (0.08 ha)	950	4000.00	30500.00	26500.00
Forest trees (Acacia)		0.5 bigha (0.07 ha)	12500	5000.00	50000.00	45000.00
Plantation crops (Coconut)		0.1 bigha (0.01ha)	60	700.00	1750.00	1050.00
Livestock (Cattle, Poultry)	Cattle (Desi)	200 sq.ft	1000L milk	15000.00	35000.00	20000.00
	Kuroiler	250 sq.ft	1375 eggs, 15 Kg meat	5000.00	12000.00	7000.00
	Khaki Campbell	250 sq.ft	4000 eggs, 250 Kg meat	12000.00	32500.00	20500.00
Fishery	IMCs	4 bigha (0.53ha)	1000 (8 month)	50000.00	130000.00	80000.00
Total				**3,31,430.00**	**7,47,000.00**	**4,15,570.00**

Financial plan without bank loan

Considering the techno-economic facts and figures of Shri. Abu Taher Mallik's IFS in 3.64 ha land, a finncial plan may be developed for an interested farmer who may not take any bank loan and thus invest the capital cost of Rs. 240000.00 from his/ her own. Every year recurring cost of cultivation is considered as Rs. 331430.00 and the capital cost will be recovered in five equal installments. A financial plan is presented in Table 65.

Table 65: Financial plan for area development scheme on agriculture-based IFS in 3.64 ha land (without bank loan)

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Capital cost	240000.00	192000.00	144000.00	96000.00	48000.00	0.00
2	Recurring cost of cultivation	331430.00	331430.00	331430.00	331430.00	331430.00	331430.00
3	Recovery of capital cost in equal installment	48000.00	48000.00	48000.00	48000.00	48000.00	0.00
4	Gross income	747000.00	747000.00	747000.00	747000.00	747000.00	747000.00
5	Net income	367570.00	367570.00	367570.00	367570.00	367570.00	415570.00
6	BC ratio	1.97	1.97	1.97	1.97	1.97	2.25

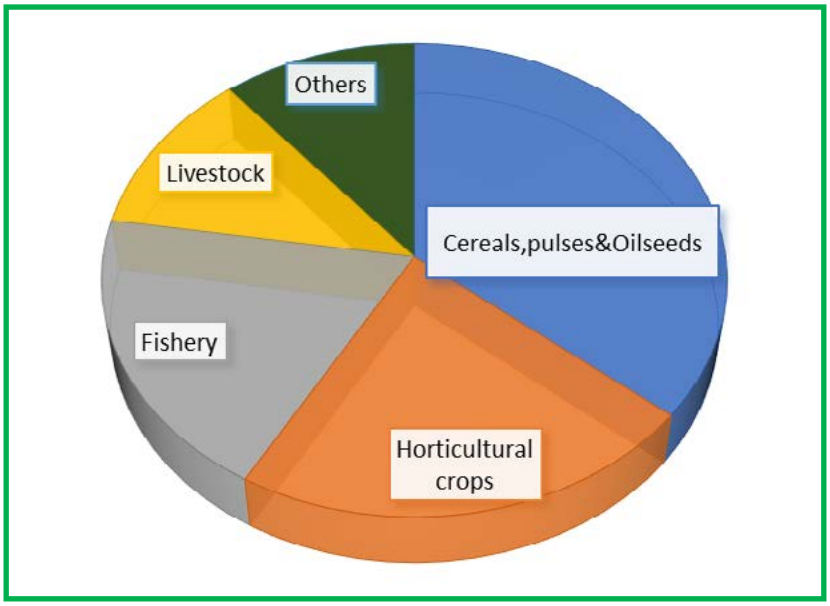

Figure 86: Annual net income sharing (in %) of various components of the IFS

Financial plan with bank credit availability

Considering the techno-economic facts and figures of Shri. Abu Taher Mallik's IFS in 3.64 ha land, a finncial plan may be developed for an interested farmer who may look forward for a bank loan to develop such an IFS. The total project cost covering capital cost and 1st year recurring cost of cultivation will be beased on economic data shown by Shri. Abu Taher Mallik as follows.

Project Cost = Capital Cost + 1st Year Recurring Cost = Rs. (240000.00 + 331430.00) = Rs. 571430.00

A financial plan with bank loan facility is presented in Table 66.

Table 66: Financial plan for bankable area development scheme on agriculture-based IF in 3.64 ha land

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Project Cost	571430.00					
2	Margin @ 15%	85714.50					
3	Bank loan	485715.50					
4	Yearly rate of simple interest @12.0% PA	12.00					
5	Loan O/S at the beginning of the year	485715.50	388572.40	291429.30	194286.20	97143.10	0.00
6	Accrual of interest	58285.86	46628.69	34971.52	23314.34	11657.17	0.00
7	Repayment of principal in equal installment	97143.10	97143.10	97143.10	97143.10	97143.10	0.00
8	Repayment of interest	58285.86	46628.69	34971.52	23314.34	11657.17	0.00
9	Loan O/S at the end of the year	388572.40	291429.30	194286.20	97143.10	0.00	0.00

Repayment plan

The repayment plan against bank loan may be as shown in Table 67.

Table 67: Repayment plan against bank loan

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Repayment of principal in equal installment	97143.10	97143.10	97143.10	97143.10	97143.10	0.00
2	Repayment of interest	58285.86	46628.69	34971.52	23314.34	11657.17	0.00
3	Recurring cost of cultivation	331430.00	331430.00	331430.00	331430.00	331430.00	331430.00
4	Gross income	747000.00	747000.00	747000.00	747000.00	747000.00	747000.00
5	Net income	260141.04	271798.21	283455.38	295112.56	306769.73	415570.00
6	BC ratio	1.53	1.57	1.61	1.65	1.70	2.25

Conclusion

Shri. Abu Taher Mallik is a good example for achieving case in farming through integration of different farm components. With 3.64 ha of land, Shri. Mallik cultivated different crops like cereals, pulses, oilseeds, vegetables etc. By adopting bio-economic circularity of the system with recyclable resources, he has made the environment of the farm eco-friendly. Shri. Mallik intends to diversify the existing production system with compatible enterprises. It is learnt that complementarity interaction among the enterprises would certainly enhance the total farm productivity and profitability. He has a future plan to develop a vermicompost unit in his farm. Shri. Mallik has given inspiration to fellow farmers and unemployed youth to come forward and take up such venture for improving their total farm productivity. Shri. Mallik has proven that the adoption of agriculture-based IFS will facilitate in maximising the profit with the net income Rs. 1,14,167.58 from 1.0 ha of land area. His farm also acts as a means for providing nutritional security from the surplus amount of various components of IFS to his family as he is getting various farm produces such as cereals, pulses, oilseeds, vegetables, fruits, egg, milk, fish, etc. round the year.

Undulating terrain finds alternative for fishery-based integrated farming in Bankura district

Moumita Dey (Gupta) and Abhrajyoti Mandal

Bankura Krishi Vigyan Kendra
West Bengal Comprehensive Area Development Corporation
Sonamukhi, Bankura-722207

Fishery-based integrated farming

Name of the farmer: **Shri. Dilip Kumar Kundu**

Area of the farm: 1.86 ha

Location of the farm: Kochdihi village, Sonamukhi block, Bankura district

In the undulating terrain of Bankura district, nestled within the red and lateritic agro-climatic zone of West Bengal, traditional farming faces challenges due to rainfed conditions and limited irrigation water. Typically, kharif paddy and rabi oilseeds dominate the agricultural landscape under these constraints, where annual rainfall is not less than 1400 mm. However, Shri. Dilip Kumar Kundu has ingeniously transformed these seemingly disadvantageous topographical features into advantageous resources. Employing advanced land shaping techniques, Shri. Dilip Kumar Kundu has converted the low-lying land into deep pocket to create water body surrounded by the upland forest, facilitating fish farming integrated with crop cultivation and animal husbandry. This innovative approach includes adopting indigenous "Bundh Breeding" technology for high-quality fish seed production. From his 1.86 ha fishery-based integrated farm, Shri. Kundu has achieved an impressive annual net income of Rs. 7,51,000.00. The fishery sector alone contributes Rs. 3,80,000.00, constituting approximately 50% of the total income, followed by crop enterprises at Rs. 3,05,000.00 and livestock sectors at Rs. 66,000.00. The farm boasts a remarkable benefit-cost ratio of 2.63, indicating substantial returns on investment. This integrated farming unit not only optimizes resource recycling and on-farm energy use efficiency, but also fulfills the nutrient requirements of Shri. Kundu's family. With a net income of Rs. 4,03,000.00 per ha, this model holds promise for doubling farmers' incomes in rainfed conditions. Ecologically sound and economically viable, it stands as a beacon of sustainable agriculture in Bankura district's challenging agro-climatic environment. Shri. Dilip Kumar Kundu's pioneering efforts exemplify how innovative farming practices can leverage natural landscapes to achieve both environmental sustainability and economic prosperity in marginalized agricultural places.

Key Words

Land shaping technology, Fishery-based integrated farming, Bundh breeding technology, Rain fed farming, Bankura, Red and lateritic zone

Figure 87: Shri. Dilip Kumar Kundu at his fishery-based integrated farm

Introduction

Shri. Dilip Kumar Kundu, aged 55 years, belongs to Kochdihi village of Sonamukhi Block in Bankura district under red and lateritic-agro climatic zone of West Bengal. He started his journey 21 years back when he was an unemployed youth from rural agricultural family with the ownership of 1.86 ha of land. Prevailing adverse agro-ecological conditions like undulating land, red and lateritic soil, shallow to moderately deep coarse loamy soil (hillocks, gravelly situation), early season drought, delayed onset of monsoon have made farming difficult in the district. But eventually with an innovative thought and optimistic attitude, Shri. Dilip Kumar Kundu decided to use the land shaping technology under the technical guidance of WBCADC KVK Bankura and thus excavated the earth in the low-lying land with the building of high embankment surrounded by the upland forest to retain water in the deep pockets and developed water bodies (0.33 ha) for practicing fishery. Thereafter, he integrated other components like paddy cultivation, oilseeds and vegetable production besides livestock rearing. Shri. Dilip Kumar Kundu realized the fact that sustainability in aquaculture primarily depended upon the availability of good quality of fish seed and thus he started the production of quality fish seed following fish breeding technology. Though he used *"Bundh Breeding"* indigenous technology for fish seed production, he constructed one cemented hatchery system at the lower side of the pond under the technical guidance of KVK Bankura. Fish breeding program has fetched him a handsome income round the year and increased the risk-taking capacity too. He took series of training on cereals, oilseed and fish seed production from KVK, Bankura.

Farm description

Four ponds including a cemented hatchery unit occupy about 40% and 2.5 m wide dykes or embankments with palm trees around those ponds cover 10% of the farm area. Having the advantage of low-lying land and surrounding upland forest the ponds always remain full with sufficient water level. The rest 50% area is used for crop husbandry. Shri. Dilip Kumar Kundu incurred the capital cost of Rs 1,20,000.00 for developing such fishery-based IF during 2008.

The ponds are the huge catchment area in the farm. In Bankura district, the annual rainfall is about 1400 mm, which is harvested in the ponds. Paucity of quality fish seed is considered as one of the major constraints in development of freshwater carp farming. To provide steady supply of quality fish seed to the local fish farmers, Shri. Dilip Kumar Kundu produces fish seeds. A total of 1,15,000 fingerlings of Indian major carps (IMC) consisting of catla (*Labeo catla*, 24%), mrigal (*Cirrhinus mrigala*, 24%), rohu (*Labeo rohita*, 12%) and bata (*Labeo bata*, 12%), common carp (*Cyprinus carpio*, 20%), silver carp (*Hypophthalmichthys molitrix*, 8%) are released in the ponds during the period from May to first week of June. From June to August, Shri. Dilip Kumar Kundu operates 15-20 sets of fish breeding program on IMC. After fish breeding, the eggs are collected and transferred to the hatchery for hatching of eggs. The cemented hatchery unit is connected with the pond by a pipeline to get water supply by siphon process without spending any energy sources (electric pump /diesel pump set). Besides, he has adopted *"Bundh Breeding"* indigenous technology for fish seed production utilizing undulating terrain with vast catchment area in the farm. *"Bundh Breeding"* is a traditional method for quality fish seed production in captivity and practiced by fish seed producers of Bengal since long time. Bundhs are special type of perennial and seasonal ponds where riverine conditions are stimulated during monsoon months. Shri. Dilip Kundu has constructed one earthen dry bundh for laying eggs by the fishes. A dry bundh is a shallow depression enclosed by an earthen wall on three sides, and an extensive catchment area on the fourth side. Bundh gets flooded during the monsoon, but completely dry for a considerable period during the remaining part of the year. According to him, the bottom soil plays a significant role in determining productivity of fishes as well as breeding, fertilization and hatching of fish eggs. He mixes the bottom soil with the water of breeding pool before releasing the brood fishes. He places this soil in front of the inlet drain so that inflowing water automatically carry the soil in it. By doing this, adhesive layer is removed from the surface of eggs and it helps the sperms to come in contact with the eggs easily in absence of any barrier in between and thus this indigenous knowledge increases the fertilization rate by 15% even as compare to normal process. He adds that the particular soil physical characteristics, especially the light and loamy soil increases buoyancy nature that helps the fertilized eggs to float in the water for longer period resulting maximum hatching. He also mentions that the characteristics soil of Bankura district plays a significantly positive role in bringing desired changes in hydro biological parameters of water which in turn enhances fertilization and hatching rate of different fish species. He admits that water temperature plays a vital role in controlling productivity of any pond. Practice of indigenous innovative technology like covering the hatching pool with palm leaves can provide shade to the fertilized eggs and protect fertilized eggs from scorching sun light. The entire process of *"Bundh Breeding"* indigenous technology for fish seed production is presented in Figure 88A to 88F. On a serious note, Shri. Dilip Kumar Kundu believes that the traditional knowledge of the farmers in fish breeding program is better than the artificial fish breeding technology. The fish seeds produced through such indigenous technology is being considered as quality seeds since the seeds are being produced natural setting, while the natural source is declining fast due to several changes in physio-chemical and biological properties of water and air. Increasing demand of air breathing fishes which cost Rs. 800.00 to Rs. 1000.00 per kg as compared to IMCs price (Rs. 120.00 per kg to maximum Rs. 180.00 per kg), has motivated. Shri. Dilip Kundu for air breathing fish farming at separate pond along with IMCs seed production.

Palm trees are grown on dykes. To enhance and upkeep soil fertility and management of natural resources, Shri. Dilip Kundu is growing different crop at different season at his farm. Rather than depending on only one crop he has incorporated different crops in a sequence for three seasons i.e.; Aman-Aus-Boro (Kharif-Rabi-Zaid/Summer), which includes paddy seed and grain production, oilseed seed and

Figure 88A: Netting for collection of broods

Figure 88B: Selection of mature broods for injection

Figure 88C: Injection of WOVA-FH to a Catla fish

Figure 88D: Loading of dedeveloping eggs in aluminum handi

Figure 88E: Hatching bundh filled with water

Figure 88F: Palm leave shade at hatching bund for temperature regulation

grain production, potato seed and tuber production and seasonal vegetables production, respectively. As there is less demand of long duration varieties of paddy (Kharif) and mustard (Rabi), he has shifted to production of short duration varieties. The cropping sequence of the farm is presented in Table 68. He has 4 numbers of crossbred cattle which supply the need of manure and milk for family nutrition.

Table 68: Cropping sequence of the farm

Months	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Crops	Sesame + Brinjal + Chili + Tomato			Aman Rice + Brinjal + Chili + Tomato					Mustard + Potato + Cauliflower + Cabbage			
Growing Period	100 days			135 days					110 days			
Season	Pre Kharif			Kharif					Rabi			

Good quality seeds either of crop or fish is scarce in the district. Being a backward district and far away from the city, the availability of inputs is suboptimal at most times. At the time of sowing season, the farmers hunt around local market for quality seed and their search ends in smoke many a times. In such situation, Shri. Dilip Kundu has made his farm as the seed farm of paddy, oilseed, potato and fish and he meets the local farmers' demand as well as the demand of remote places too. The fish farmers from other districts fetch fish seed from him. The demand and supply status of different commodities of the farm is shown in Figure 89. After meeting the nutrition requirement of 9-member family, Shri. Dilip Kundu does the marketing of farm products. The seasonal variation in price of various farm products is presented in Figure 90.

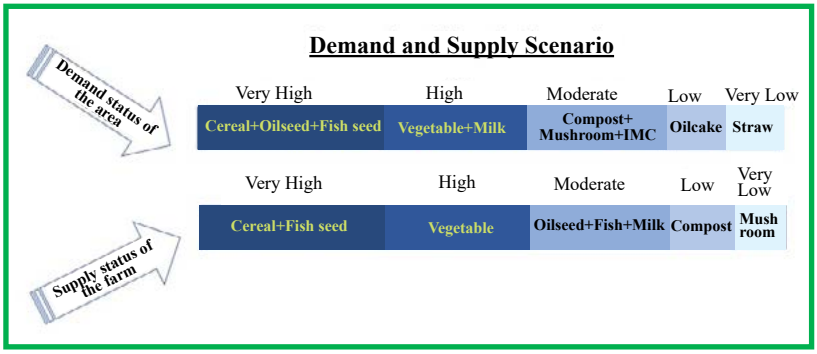

Figure 89: Demand and supply status of different commodities of the farm

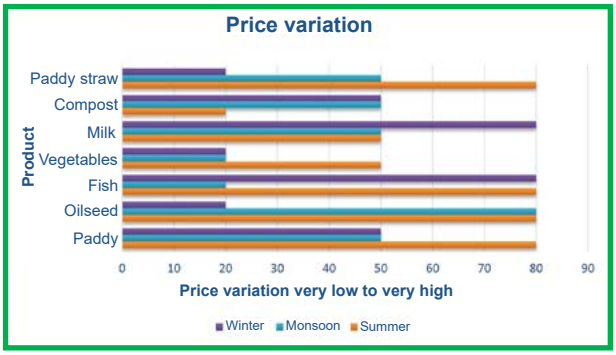

Figure 90: Seasonal variation in farm products price

Farm layout

The layout of fishery-based IF of Shri. Dilip Kumar Kundu is shown in Figure 91.

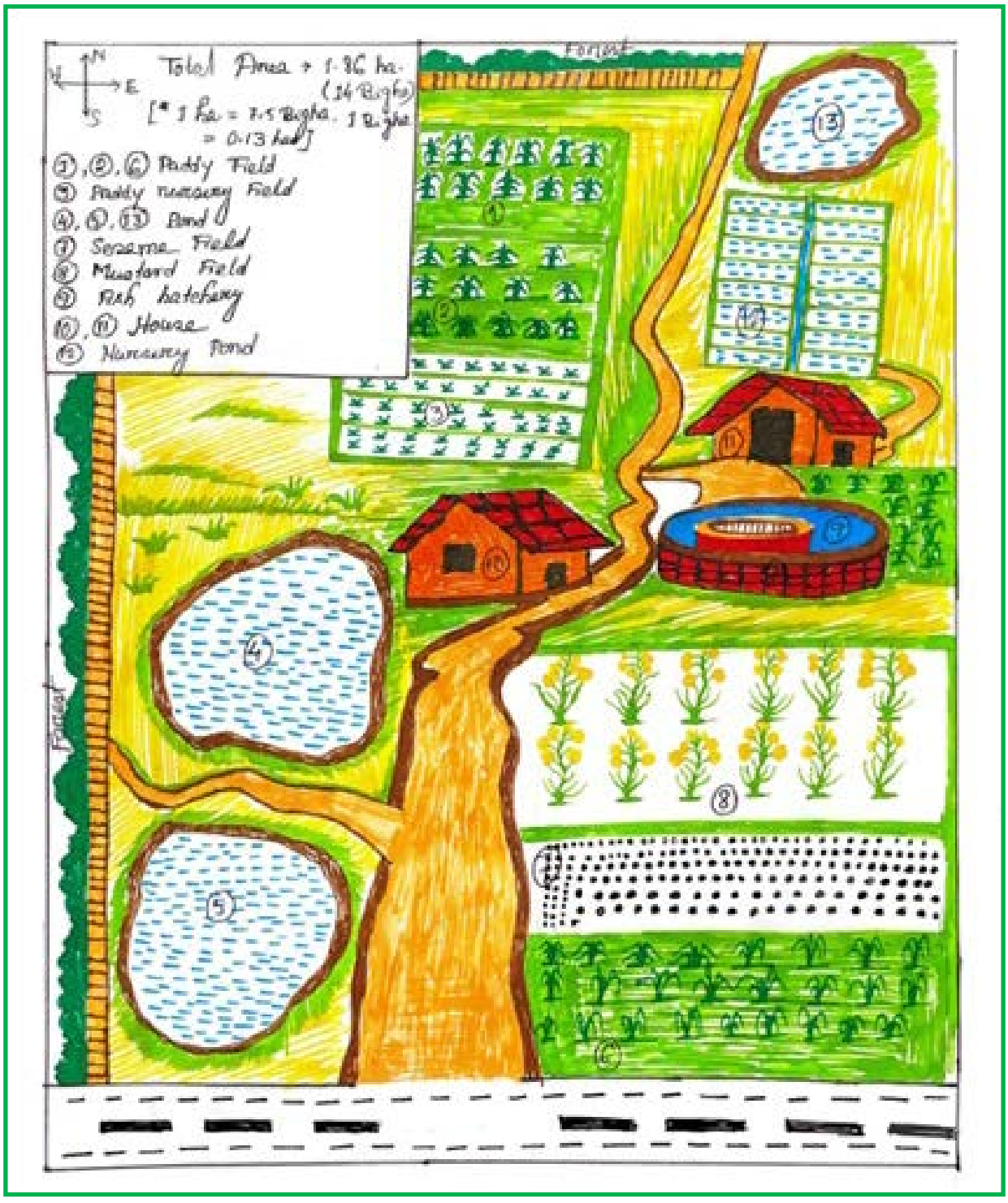

Figure 91: Fishery-based IF layout of Shri. Dilip Kumar Kundu

Capital cost with financial assistance, if any

Though Shri. Dilip Kundu received the technical and financial backstopping of KVK, the involvement of capital cost details is given below (Table 69). If any interested farmer having suitable own land or by leasing land, it would have to bear capital cost of about Rs. 4.57 lakh for establishing such IF farm.

Table 69: Capital cost for developing Shri. Dilip Kumar Kundu's integrated farm

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Pond excavation	0.50	0.50	Nil
Cattle shed	1.0	1.0	Nil
Cost of cattle	0.50	2.0	Nil
Cost of fruit plants	0.0006	0.12	Nil
Vermicompost unit	0.15	0.30	KVK
Hatchery	0.25	0.25	Nil
Farm Machinery	0.20	0.40	CHC Scheme ATMA
Total Cost		4.57	

Bio-economic circularity of the farm

Shri. Dilip Kundu has made an effective and efficient utilization of by-product form different enterprises which eventually help in reduction of cost of cultivation and initiate a practice of natural resource management. The way Shri. Dilip Kumar Kundu has integrated all the components resource recycling is shown in Figure 92.

Table 70 shows the circular economics of different by-products of the farm. Among the recyclable wastes, paddy straw generated from paddy is used as mulch and dry fodder for cattle and is valued at Rs. 15,000.00 per year. Mustard oil cake is used as fish feed as well as cattle feed worth Rs. 15,750.00. Cow dung is used to produce vermicompost which is utilized in agriculture field and fish pond thereby making the net worth from cattle waste of Rs. 20,000.00. It is thus evident from the data that Shri. Kundu realises a circular economics of Rs. 50,750.00 from different by-products and also adds to ecological sustainability of the farm by avoiding the use of branded concentrate feeds for cattle feeding as well as poly-mulch from the market.

Figure 92: Input-Output resource recycling mechanism of Shri. Dilip Kundu's IF unit

Table 70: Circular economics of different by-products of the farm

Components	Area/ Nos	Output/ Recyclable Resources	Amount	Price (Rs.)	Uses
Paddy	10 bigha	Paddy straw	40 q (Kharif + Rabi)	15,000.00	Straw mulching, dry fodder for cattle
Mustard	3 bigha	Mustard oil cake (MOC)	5.5 q	15,750.00	Fish feed, cattle feed
Cattle	4 nos	Cow dung	50 q (one year)	20,000.00	Vermicompost, organic fertilizer for agriculture field and fish pond
Total				**50,750.00**	

Farm economic viability

Integration of various enterprises has enhanced the productivity and economic efficiency of the IF unit of Shri. Dilip Kundu. Table 71 shows Shri. Dilip Kumar Kundu has generated highest income from fishery, i.e., Rs. 3,80,000.00 justifying it is fishery-based integrated farm. He invests Rs. 1,07,000.00 and Rs. 57,000.00 respectively per year for his agricultural and horticultural crop with the net income of Rs. 2,35,000.00 and Rs. 70,000.00, respectively. It is evident from the income analysis that Shri. Dilip Kumar Kundu with the investment of Rs. 4,38,000.00 per year, he is earning net income of Rs.7,51,000.00 annually with a BC ratio of 2.63 from a land of 1.86 ha. This IF generates a net income of Rs. 4,03,000.00 per ha of land area under rain fed situation. Shri. Dilip Kundu's farm has aided in enhancing overall economics and livelihood security. Man-days generation data has revealed that Aman paddy requires the highest man-days, i.e., 120-man days/ annum/ ha, while the highest remunerative component of the farm, i.e., fishery needs 65-man days/ annum/ ha (Figure 93).

Table 71: Annual farm economics of Shri. Dilip Kundu's IF

Component	Area (in ha)	Production (kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
Fishery	0.25	4600000 nos.	220000.00	600000.00	380000.00
Cereals (Paddy)	1.33	7750	92000.00	240000.00	148000.00
Oilseeds (Sesame + Mustard)	0.66	1550	15000.00	102000.00	87000.00
Cash Crop (Potato)	0.13	4000	20000.00	80000.00	60000.00
Vegetables (Cabbage, cauliflower, spinach, tomato	0.13	975	37000.00	47000.00	10000.00
Livestock (Cattle)	0.02	4000 lit	54000.00	120000.00	66000.00
Total			**438000.00**	**1189000.00**	**751000.00**

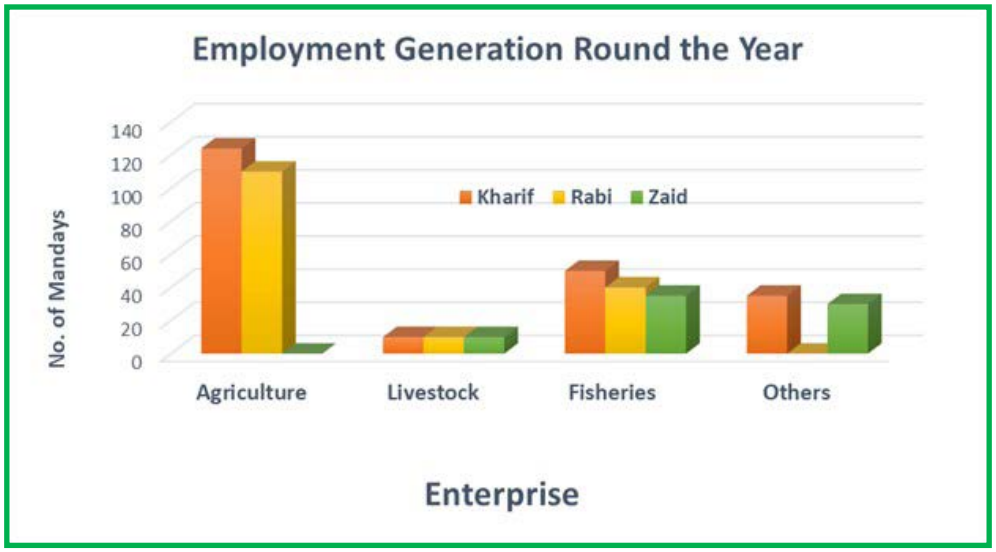

Figure 93: Man-days generation throughout the year

Conclusion

Application of land shaping technology for utilising undulating topography resourcefully for fisheries and diversification through integration of other enterprises have ample potential to improve the livelihood of small and marginal farmer of Bankura district. Adoption of *"Bundh Breeding"* technology which is indigenous method for the district has aided in quality fish seed production in the present case study. This indigenous technology may be more economic and superior in quality fish seed production than the artificial fish breeding technology. Further, fish farming in combination with agriculture and livestock is unique, sustainable and provides higher farm income and the readily available low-cost source of protein to the farm family and also low environmental foot prints due to judicious integration of different components. This model combats the negative effects of intensive farming with high risks and vulnerability. Shri. Dilip Kumar Kundu has shown how undulating topography could be utilized resourcefully to achieve a net income of Rs. 403000.00 per ha of land area. Shri. Kundu is maintaining diversity at all levels, like Field-Farm-Landscape, which is aiding him to reconcile the seemingly dichotomous goals for achieving high quantity and quality of farm produces. He has gathered vast knowledge in all aspects of aquaculture system for over 15 years. He is an innovative fish farmer and pioneer established fish hatchery owner. His farm may be promoted to agro-tourism in near future. He is now a progressive aqua entrepreneur from Kochdihi village of Sonamukhi in Bankura district under red and lateritic agro-climatic zone of West Bengal. The success, diligence and zeal of Shri. Dilip Kumar Kundu appeals to the farmers and experts across the state.

Maximizing income from horticulture-based integrated farm in Jhargram district

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Name of the farmer: Shri. Sandip Ghosh

Area of the farm: 1.95 ha

Location of the farm: Basajuri village, Binpur-II block, Jhargram district

In the rugged terrain of Jhargram, situated within the challenging red lateritic zone of West Bengal, Shri. Sandip Ghosh has crafted a remarkable horticulture-based integrated farm spanning 1.95 ha. Despite contending with severe environmental constraints such as scorching temperatures, scanty rainfall, and soil with minimal water retention capacity, Shri. Ghosh has exemplified resilience through sustainable agri-horticultural practices. Employing a strategic blend of rotational cropping, mulching, and micro-irrigation systems, Shri. Ghosh has not only overcome these adversities, but has also flourished as a successful entrepreneur in the nursery business. His farm hosts a diverse array of agricultural crops including cereals, pulses, and oilseeds, alongside horticultural delights such as vegetables, spices, fruits, and flowers. Integration of cattle further enhances the bio-circularity of farm resources, ensuring efficient utilization and sustainability. The financial analysis reveals a notable annual net return of Rs. 5,48,250.00 from this horticulture-based integrated farm. The nursery segment emerges as the top income generator, closely followed by fisheries and the varied agri-horticultural produce. This substantial income not only supports Shri. Ghosh's family, but also fulfills their nutritional needs with fresh, wholesome food items, all sourced directly from this farm. Shri. Sandip Ghosh's success story underscores the technical feasibility and economic viability of horticulture-based integrated farming ventures in challenging agro-climatic zone. His innovative approach serves as a beacon of inspiration, demonstrating how sustainable practices can transform adversity into opportunity, paving the way for thriving agricultural enterprises in marginalized areas.

Keywords

Integrated farming, Sustainability, Red-lateritic Farming, Horticulture, Nursery, Agriculture, Compost, Bio-circularity

Figure 94: Shri. Sandip Ghosh at his horticulture-based integrated farm

Introduction

Shri. Sandip Ghosh is a 33 years old entrepreneur, from Basajuri village of Binpur-II block of Jhargram district. He has developed a horticulture-based integrated farm as well as a nursery at Chhoto Murgi Village of Binpur-II block of Jhargram district, covering 14.62 bigha area. Shri. Sandip Ghosh was born in a farmers' family. After graduating, he started working in a private organization far from his family. In 2012, Shri. Sandip Ghosh came to know about the integrated farming and nursery business from Jhargram Krishi Vigyan Kendra by participating in KVK organized farmer's training programmes and he decided to implement it and make it viable for his livelihood. The climatic as well as the soil condition was adverse although it never became a constraint for him. Though irrigation can be done through submersible during rabi season, rainfed irrigation is the only solution for cultivation due to extremely less water holding capacity of the soil and low ground water level. Agro-climate of Jhargram is suitable for growing horticultural crops. This case study is to explore how Shri. Sandip Ghosh is managing all these problems efficiently to develop a horticulture-based integrated farm in the red lateritic zone of Jhargram.

Farm description

In horticulture-based integrated farm, Shri. Sandip Ghosh focusses on cultivation of vegetable crops like brinjal, drumstick, spinach in Kharif, cabbage, cauliflower, tomato, radish, green pea in Rabi and elephant foot yam, green banana in Zaid season. He also produces cereals like Basmati paddy in Kharif, pulses like musur, arhar and oilseed like mustard in Rabi as well as sesame in Zaid season. Shri. Ghosh cultivates some spices like chilli in Kharif, coriander in Rabi and curcumin, ginger in Zaid season. He also has guava, dragon fruit, lemon, ber and mango orchards. He produces marigold as flower crop in Kharif. Shri. Ghosh has 2 number of crossbred cows. The farm produces are mostly used both for selling and home consumption, except milk. Shri. Ghosh first fulfils his home need of milk from his farm and then sells the excess. The cow dung is being used both in the crop cultivation as well as for vermicompost preparation, which again is used for the crop cultivation. Other than producing crops for selling he has built up a large-scale horticulture-based nursery where every kind of saplings are available for selling. The crop residues are used for compost preparation, which is then applied in the nursery saplings for nutrition.

Shri. Ghosh has adopted sustainable agricultural practices by following rotation system approach in growing a sequence of different crops in different seasons on the same land that maintaining soil fertility and enabling the available natural resources to be preserved and utilized more efficiently and helping in control of insects and diseases. He prepares organic manure using wastes of livestock and he is aware of risk minimization in such integrated farm where one component can keep the farm economy viable during the failure of other component.

Table 72: Different crop and animal components at the farm of Shri. Sandip Ghosh

Season	Cereal	Pulse	Oilseed	Vegetables	Spice	Fruit Plants	Flower	Cattle	Other Enterprise
Kharif	Basmati Paddy	-	-	Brinjal, Drumstick and Spinach	Chili	Guava, Dragon Fruit, Lemon, Ber and Mango	Marigold	Cross Breed	Vermicompost and Nursery IMC
Rabi	-	Musur and Arhar	Mustard	Cabbage, Cauliflower, Tomato, Radish and Green Pea	Coriander		-		
Zaid	-	-	Sesame	EFY and Green Banana	Curcumin and Ginger		-		

Figure 95: A horticulture-based integrated farm of Shri. Sandip Ghosh

Farm layout

A layout of horticulture-based integrated farm of Shri. Sandip Ghosh is presented in Figure 96.

Figure 96: A farm layout with different components

Capital cost with financial assistance, if any

Shri. Sandip Ghosh was quite aware about the Govt. schemes and subsidies which could help him to minimize the capital investment for developing an integrated farming setup. He approached to the line departments of Jhagram district as well as to Jhargram KVK for any kind of financial benefits and his enthusiasm led him to get some. He got subsidy under RKVY for shade net house, low-cost poly house, pond excavation as well as for vermicompost unit. Also, he got micro sprinkler from PMKSY scheme. From Jhargram KVK he was supported by providing him fruit plants for developing orchrds and with some small farm implements.

Table 73: Capital cost for developing IF unit

Item	Cost per Unit (Lakh Rs.)	Total Cost (Lakh Rs.)	Subsidy/Govt. Contribution (If any) (Lakh Rs.)
Shade net house	355/m sq	3.20	2.00 from RKVY
Low-cost poly house	20 m	0.72	0.36 from RKVY
Pond Excavation(0.5bigha)	0.90/bigha (70*60 ft)	1.5	75% from RKVY
Vermicompost unit (4 nos)	0.10/unit (3*7*1 ft)	0.10	50% from RKVY
Micro sprinkler (1 acre)	0.10/ 1 acre	0.10	18% from PMKSY
Fruit plants	--	0.10	0.05 from KVK Jhargram KVK
Small implements	--	0.05	0.05 from KVK Jhargram
Total Cost		**5.77**	

Bio-economic circularity of the farm

He uses the waste from one unit as input to another to maximize production and minimize the cost of production. Figure 97 shows that the waste residues from agriculture produces are used as feed for livestock and the livestock excreta is again being utilized in preparing vermicompost which in other hand is applied for crop production. Post-harvest wastes of cereal, pulse, spices, vegetables and fruit plants, straw, chunni, crop residue, including leaves of forest trees costing Rs. 18,700/- are recycled in the farm, as feed resources for livestock and also as manure. The straw is again used for mulching. MOC is used for pond fertilization. The cost of cow dung is Rs. 1400/- that is used for preparing vermi-compost and subsequent use in field crop production, pond fertilization, as well as in the nursery. Pond water worth Rs. 500/- is also recycled in the farm. A total of Rs. 20,600/- is circulating as bio-economics in the whole integrated system of this farm.

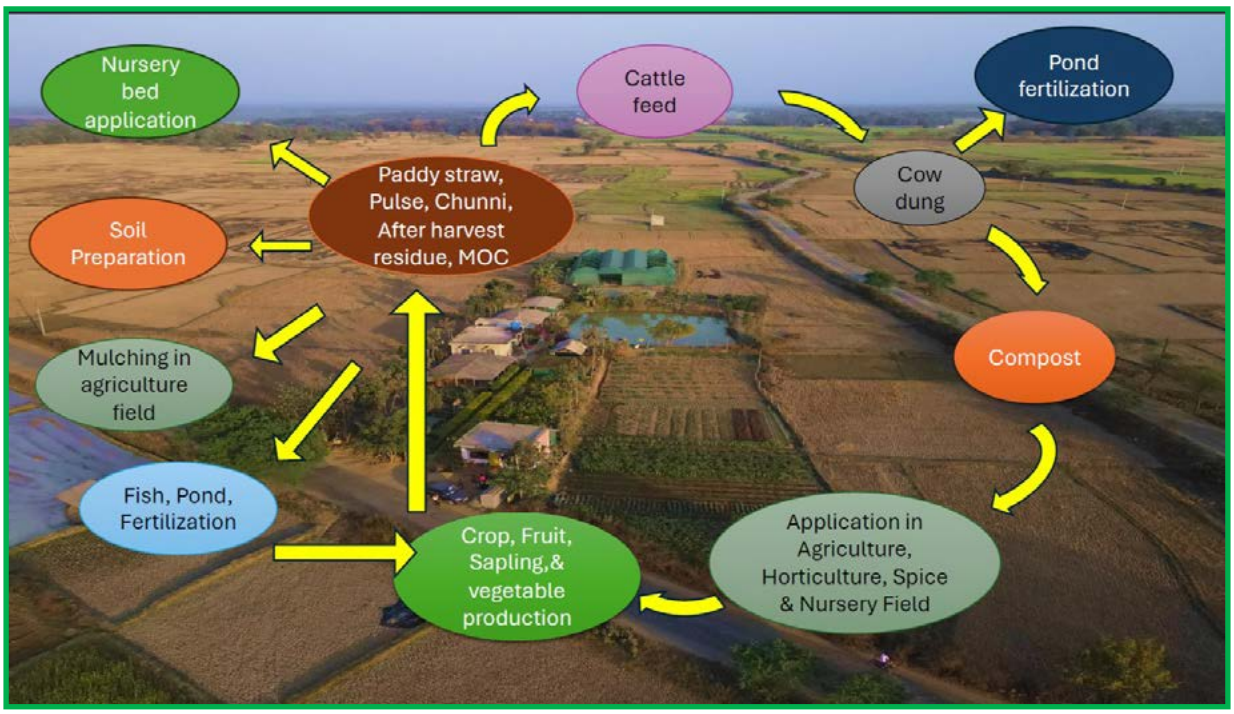


Figure 97: Resource recycling system at the farm of Shri Sandip Ghosh

Farm economic viability

In horticulture-based integrated farm, Shri. Sandip Ghosh recorded the highest net income from nursery and vermicompost (Rs. 368000.00) followed by agricultural crops (Rs. 103300.00), fishery (Rs. 73000.00) and livestock (Rs. 3950.00) as shown in Table 74.

The income analysis revealed that from a small farm piece of 1.95 ha area, the annual gross income of Rs. 1253750.00 could be realized with BC ratio of 1.78, from an investment of Rs. 705500.00 and a generation of 2550 days of mandays of employment costing Rs. 3,39,000.00 as labour wage including his own labour. According to Shri. Ghosh, an annual expense for household purposes covering food, education, health and others was Rs. 7,35,000.00. Post-harvest wastes of cereal, pulse, spices, vegetables and fruit plants, straw, chunni, crop residue, including leaves of forest trees, cow dung etc costing a total of Rs. 20,600.00 is circulating as bio-economics in the whole integrated system of this farm.

Table 74: Annual economics of Shri. Sandip Ghosh's IF unit

Component	Expenditure (Rs.)	Gross income (Rs.)	Net income (Rs.)
Agriculture	86200.00	189500.00	103300.00
Livestock	7300.00	11250.00	3950.00
Fisheries (IMC)	62000.00	135000.00	73000.00
Other enterprise (Nursery and Vermicompost)	550000.00	918000.00	368000.00
Total	**705500.00**	**1253750.00**	**548250.00**

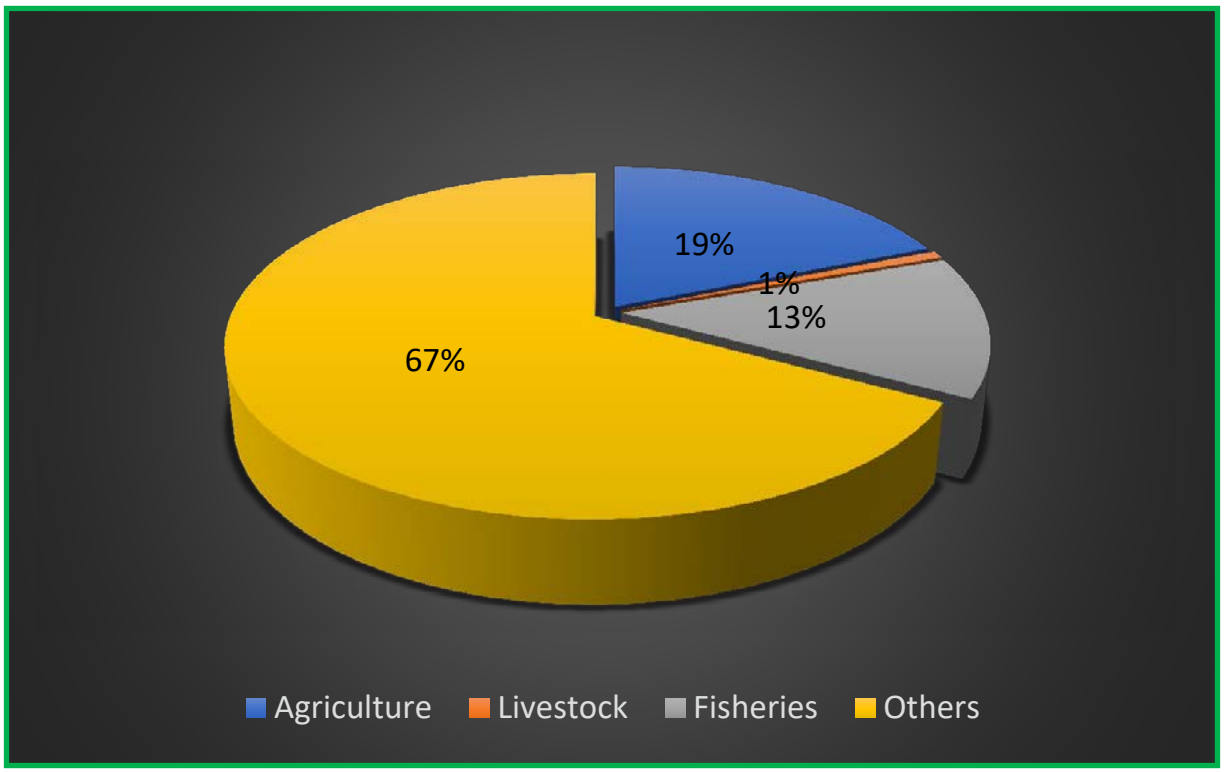


Figure 98: Annual net income sharing (in %) by different components at horticulture-based integrated farm

Conclusion

Sustainable agriculture can be achieved by adopting rotational cropping system and also by using less space to generate more income. Use of vermi-compost can be a good agriculture practice to enhances soil fertility. Shri. Sandip Ghosh is able to satisfy his family nutritional demands of cereal, pulse, vegetables, fruits, milk and fish from his farm produces, to some extent. However, he is satisfied with the quality he gets from the system. Shri. Sandip Ghosh encouraged the neighbouring farmers with the diversification of his integrated farming system and by sharing his experience and knowledge with them for agricultural development in the area. He is also concerned about his next generation who should continue farming and hence wants to educate his children with higher farming knowledge. The story of Shri Sandip Ghosh clearly indicates that a small piece of land can technically be feasible and economically viable for developing horticulture-based integrated farm in Jhargram. Nevertheless, the availability of farm fresh and wholesome food items for nourishing the own family is more beneficial than buying the same from the market.

Entrepreneurship through sustainable poultry-centric livestock-based integrated farming system in Purulia district

Dhiman Chandra Mahato, Debdyuti Datta and Manas Kumar Bhattacharjya

Kalyan Krishi Vigyan Kendra
Vivekanandanagar, Purulia-723147

Livestock-based integrated farming

Name of the farmer: **Shri. Sagar Bauri**

Area of the farm: 1.33 ha

Location of the farm: Uka village, Raghunathpur –II block, Purulia district

In the serene expanse of Purulia district, Shri. Sagar Bauri has sculpted a thriving livestock-based integrated farm spread across 1.33 ha. His journey began modestly with goat farming, a venture that soon blossomed into a multifaceted agricultural enterprise. Diversifying his efforts, Shri. Bauri expanded into dairy farming, fisheries, poultry, and vermicompost production, alongside a robust seasonal vegetable cultivation unit. This integrated approach exemplifies his astute utilization of vegetable residues as livestock feed or compost for further vegetable cultivation, fostering a closed-loop system. An annual net income of Rs. 5,45,813.00 stands testament to the farm's success, achieving a commendable benefit-cost ratio of 1.7. The livestock sector emerges as the primary income contributor, commanding 58.78% of the total net income, followed by seasonal vegetable production at 20.29%, fisheries at 9.39%, and various ancillary activities such as vermicompost and fodder production at 11.54%. Beyond fulfilling household consumption needs, the farm yields surplus produce that meets the demand in local industrial areas, where access to fresh agricultural products is often limited. Shri. Sagar Bauri's integrated farm not only demonstrates technical feasibility and economic viability, but also serves as a model of sustainable agricultural practices in Purulia district. His innovative approach underscores the potential for rural entrepreneurship to thrive through integrated farming system, paving the way for enhanced livelihoods and agricultural resilience in red lateritic zone of West Bengal.

Keywords

Integrated farming system, Livestock, Fishery, Vermicompost, Seedling production, Seasonal vegetable cultivation, Purulia

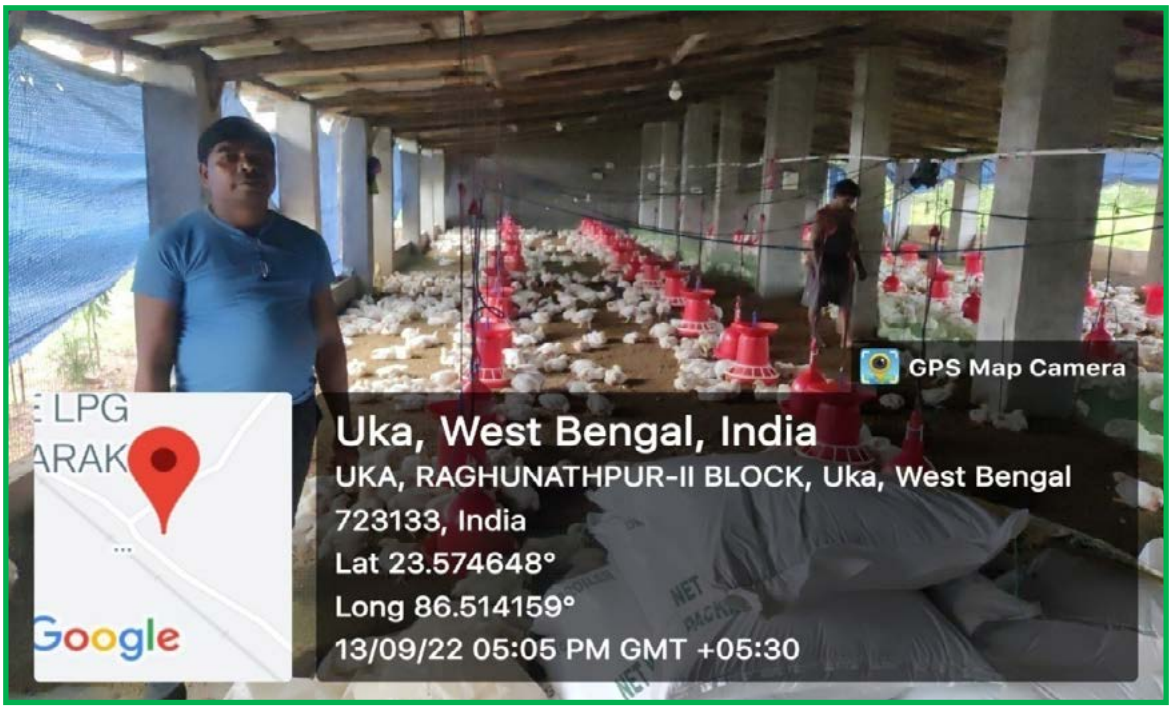


Figure 99: Shri. Sagar Bauri at his livestock-based integrated farm

Introduction

Shri. Sagar Bauri 43 years, is coming from Uka village of Raghunathpur –II block of Purulia district. He has developed a livestock-based integrated farm on 1.33 ha (10 bighas) land. The area is totally industrial belt where near about 40% people attach with sponge iron industry and 50% people depend on farming for their livelihoods and the rest 10% people engage in service. The soils of Uka village are mostly red and lateritic having poor fertility status and less water-holding capacity. Due to several burdens on crop cultivation, livestock-based farming system has come up as the best option to continue farming here. Of particular interest is to explore how Shri. Bauri is managing all these problems efficiently to develop a livestock-based integrated farm in the red and laterite zone of West Bengal. Various training programmes provided by KVK Kalyan, strong linkage with the line departments and Banks have immensely helped Shri. Sagar Bauri to develop knowledge and skill to became a successful entrepreneur.

Farm description

Shri. Sagar Bauri focused on poultry farming mainly broiler farming through intensive system of management and also associated with the rearing of indigenous breed of poultry i.e Aseel in total 2095 sq ft poultry house. He owns a dairy unit with 9 numbers of crossbreed Jersey in 710 sq ft cattle shed, goatery unit with 35 numbers of Black Bengal goat in 380 sq ft goat house along with 1 acre of pasture land for producing fodders throughout the year. He has established a fish-cum-duckery unit in 1 acre of pond for fish rearing mainly Indian Major Carps (IMC) along with 150 numbers of Khaki Campbell ducks in 465 sq ft duck house. He has installed two numbers of small incubators with the capacity of 500 eggs at a time for providing quality, disease-free day-old hatched chicks (total 6000 numbers/ year) to the interested farmers mainly farm women of SHG groups for their own income generation. For further development he has invested Rs. 10.0 lakhs from his own for renovation and modification as well as extension through new construction of poultry shed, as well as hatching unit. From the dairy unit, he regularly sells 22 to 25 liter of milk daily in the local market. For having more return, he is planning to establish a sweet shop in the Block Market. He has also developed 3 numbers of vermicompost unit (6 ft X 3 ft X 2 ft) for fulfilling the demand of vegetables' nursery unit. He is using 1 acre of land for seasonal vegetable cultivation like okra, cucurbits, cabbage, cauliflower etc during rabi season, and watermelon during summer season.

Table 75: Farm components with season wise cultivation

Crop/Enterprise	Area (Bigha/No/Sq ft)	Kharif	Rabi	Summer	Remarks
Okra	1.5				
Cucurbits	1.5				
Cabbage	1.5				
Cauliflower	1.5				
Vermicompost	0.028				
Watermelon	0.74				
Dairy Animals (Jersey cross)	710 Sq ft				Grazing area 6 bigha
Poultry birds	2095 Sq ft				
Ducks	465 Sq ft				Grazing area 1 bigha
Fish (IMC, Prawn)	1 Bigha				
Goat (Black Bengal)	380 Sq ft				Grazing area 6 bigha

Shri. Sagar Bauri is aware of risk minimization in such an integrated farm where one component can keep the farm economically viable during the failure of another component. Still, the availability of resources like planting materials, animal feeds, veterinary medicines, etc is moderate to high. Nevertheless, he takes all the preventive measures in protecting livestock from diseases through proper time vaccination and deworming, and providing veterinary services in his surrounding locality with his established strong linkage with the ARD Department. For increasing milk production and combating malnutrition, he has already established fodder unit and adopted different technologies like urea molasses mineral block (UMMB) licking, feeding of low-cost feed using locally available ingredients, feeding of azolla to both fish as well as animal and poultry birds. Demand of the product of his farm is very high in the local market as he maintains proper hygiene as well as organic farm efficiently.

Farm layout

A layout of livestock-based integrated farm of Shri. Sagar Bauri is presented in Figure 100.

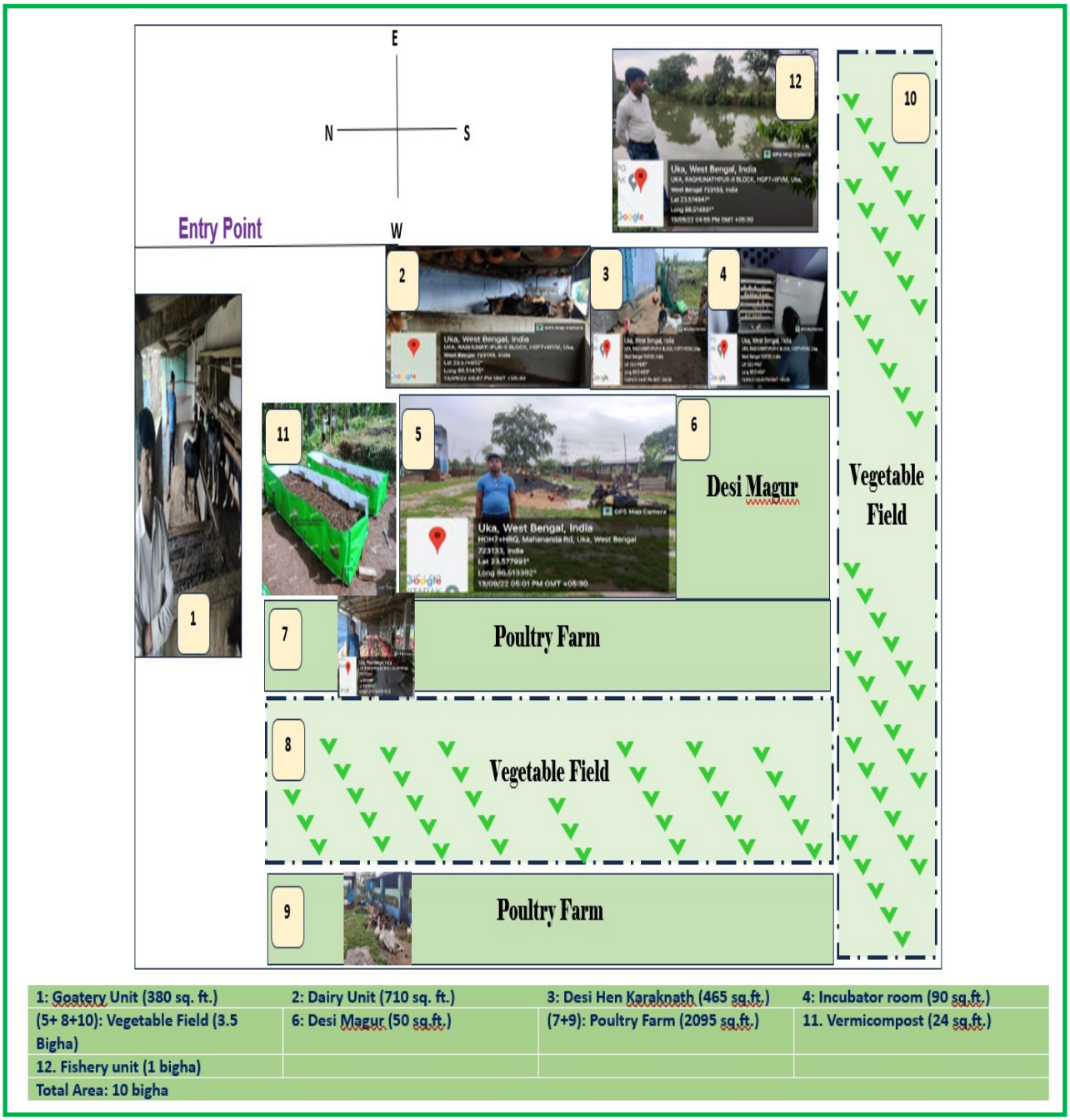


Figure 100: Farm layout of livestock-based integrated farm of Shri. Sagar Bauri

Capital cost with financial assistance, if any

Aspiring farmers willing to develop such an integrated farm may be curious about its establishment cost. Of course, availability of suitable land at farmers disposal is a prerequisite for developing it. The capital cost involved for developing such integrated farm is mentioned below in Table 76.

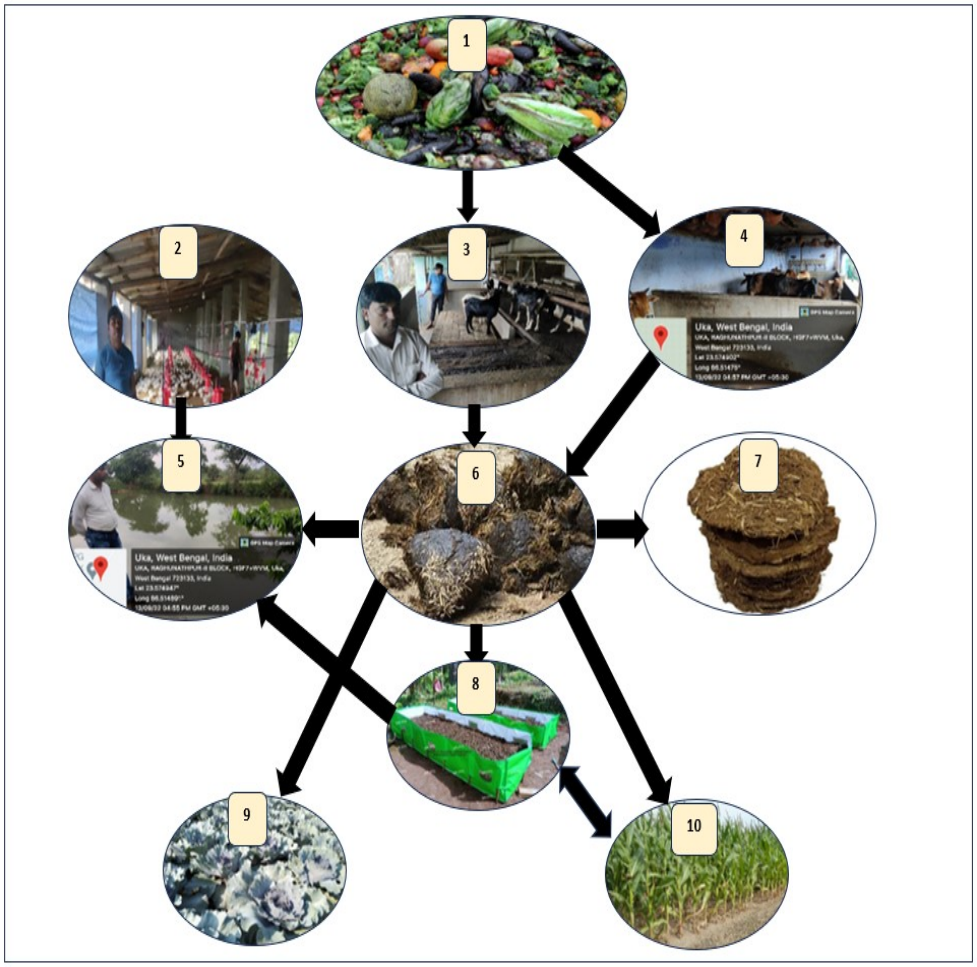
Table 76: Capital cost for developing Shri. Sagar Bauri's IFS

Item	Cost per unit (In Rs.)	Total cost (in Rs.)	Subsidy/Govt. contribution (if any)
Pond excavation	310000.00	310000.00	MGNREGA work
Cattle shed	200000.00	20000.00	Nil
Cost of cattle	40000.00/ Jersey cross	360000.00	NIl
Goat shed	100000.00	100000.00	Nil
Cost of goats	6000.00/ goat	210000.00	Subsidy 100000.00 (KVK, ATMA)
Duck shed	110000.00	110000.00	Nil

Item	Cost per unit (In Rs.)	Total cost (in Rs.)	Subsidy/Govt. contribution (if any)
Cost of ducks	40.00/ duck	6000.00	Subsidy 6000 (KVK, ATMA)
Poultry shed	300000.00	300000.00	Nil
Cost of poultry birds	40.00/ bird	100000.00	100 % subsidy (ATMA)
Egg hatching unit	55000.00/ unit	110000.00	55% subsidy
Vermicompost units	20000.00/ vermi bed	60000.00	100% subsidy by KVK Kalyan
Total Cost		**16,86,000.00**	

Bio-economic circularity of the farm

Shri. Sagar Bauri has adopted livestock-based IFS model where efficient utilization of farm by-products and/ or residues with complimentary as well as supplementary relationship exists. Residue, waste product, by-product of one component is utilized as input to another component to maximize production and minimize the cost of production and environmental pollution. Figure 101 shows that by-products and/ or residues from vegetable produces are used as feed resources for livestock, while livestock excreta (cow dung, poultry excreta) are utilized for enhancing planktons in pond for fish feed. The pond is also used by ducks so that natural aeration occurs specially for fish cultivation. Cow dung, goat faeces and poultry excreta are properly utilized for vermicomposting, and direct utilization in the vegetable field. The cost of total residue from livestock component like cow dung is Rs. 22,000.00 which is used for preparing 8 q vermicompost valuing Rs. 12000.00 and cow dung cake as extended by-product valuing Rs. 20,000.00 used for fuel purpose.



1: Vegetable Residue stem remaining part of the vegetables, Fodder use as a feed	2: Poultry field/ Duckery Field	3: Goatery Unit	4: Dairy Unit
5: Fishery	6: Manure	7: Cow dung cake use as fuel	8: Vermicompost
9: Vegetable field	10: Fodder field		

Figure 101: Bio-circularity of livestock-based integrated farm of Shri. Sagar Bauri

Farm economic viability

Shri. Sagar Bauri has received the highest net income from the livestock unit (Rs.3,40,838.00) followed by vegetable production (Rs. 1,10,725.00), vermicompost (Rs. 62,000.00) and fisheries (Rs. 51,250.00) as depicted in Table 77. The poultry sector played the central role in providing the highest annual net income of Rs. 1,40,000.00 among all components. The highest annual net income sharing came from the livestock sector (58.78%) followed by vegetables (20.29%), vermicompost (11.54%) and fisheries (9.39%) as shown in Figure 102. The income analysis revealed that from a small farm piece of 1.33 ha area, the annual gross income of Rs.13,24,375.00 could be realized from an investment of Rs. 7,78,562.00 with a benefit cost ratio (B:C) of 1.7:1. Shri. Sagar Bauri has achieved to generate 1800 man-days amounting Rs. 2,70,000.00. His annual expenses for household purposes covering food, education, health, and others accounted Rs. 2,50,000.00 and the total labour engagement charge reported Rs. 2,70,000.00 and thus, Shri. Sagar Bauri could save Rs. 25,813.00 out of net income of Rs. 5,45,813.00 in a year.

Table 77: Annual economics of Shri. Sagar Bauri's IFS

Component	Area	Production (Kg)	Expenditure (Rs.)	Gross Income (Rs.)	Net Income (Rs.)
Vegetables (Okra, cucurbits, Cabbage, Cauliflower, Watermelon)	3 bigha	8,045 Kg	51,000.00	1,61,725.00	1,10,725.00
Cattle (Jersey crossbred)	710 sqft	7925 L milk	2,52,362.00	3,17,000.00	64,638.00
Goat (Black Bengal)	380 sqft	105 kg meat	84,200.00	1,25,000.00	40,800.00
Poultry birds	2095 sqft	3600 kg	3,00,000.00	4,40,000.00	1,40,000.00
Ducks	465 sqft	9300 pcs eggs	45,000.00	74,400.00	29,400.00
Asil birds	220 sqft	785 kg meat	24,000.00	70,000.00	46,000.00
Fishery	1 bigha	235 Kg	10,000.00	61,250.00	51,250.00
Vermicompost	0.028 bigha	600 kg	10,000.00	72,000.00	62,000.00
Fodder cultivation	1.5 bigha	2000 kg	2000.00	3000.00	1000.00
Total			7,78,562.00	13,24,375.00	5,45,813.00

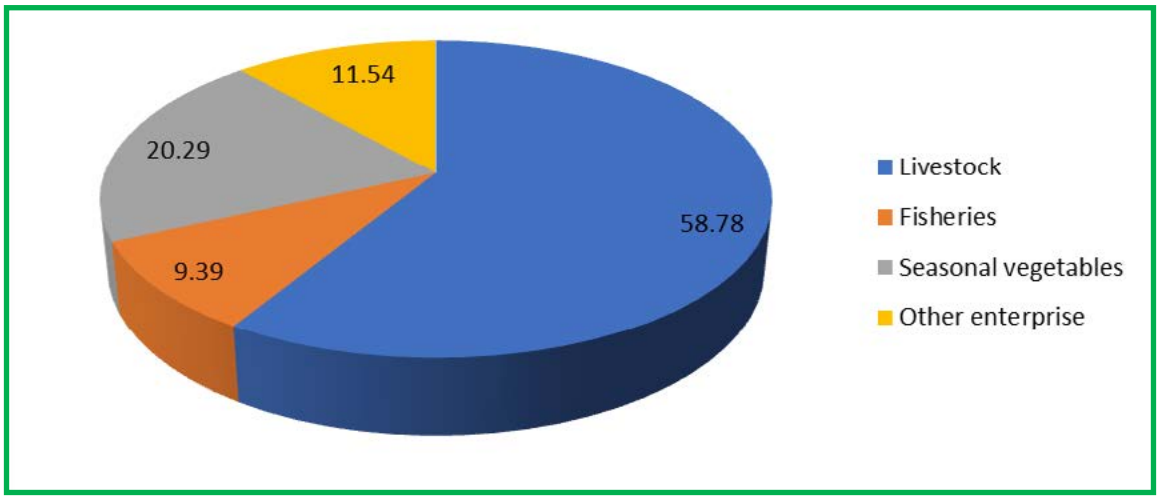


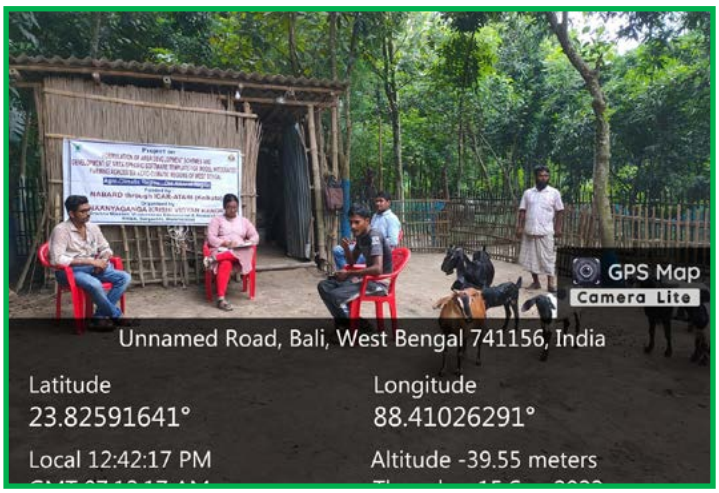
Figure 102: Annual net income sharing (in%) by different components at the livestock-based integrated farm of Shri. Sagar Bauri

Conclusion

Integrated farming system developed by Shri. Sagar Bauri in 1.33 ha area indicates that out of the total net income Rs. 5,45,813.00, the highest contribution (Rs. 3,40,838.00) comes from livestock sector and hence, it is livestock-based integrated farm. Again, the highest annual net income of Rs. 1,40,000.00 is coming from poultry sector, further considering it is poultry-centric livestock-based IFS. This scientific integrated farming of Shri. Sagar Bauri has inspired many farmers in the locality to go for poultry farming, dairying, goatery, vermicomposting, vegetable cultivation, fisheries etc. His regular interaction with the farmers has further influenced them to work closely with him and seek guidance as and when required. He has also employed 6 people for the maintenance of the farm and marketing of produces throughout the year. Shri. Sagar Bauri is not only good entrepreneur, but also an idol and inspiration of many aspirant youth and farmers in Purulia district.

Field Visit and Data Collection

Kalimpong District



Murshidabad District

Purba Burdwan District

South 24 Parganas District

Coochbehar District

Bankura District

Coastal Saline Agro-climatic Zone

Sustainable livelihood generation through fish-based integrated farming in South 24 Parganas district

P. Chatterjee, S. Mahato and C.K. Mondal

Ramkrishna Ashram Krishi Vigyan Kendra
Nimpith, South 24 Parganas-743338

Fishery-based integrated farming

Name of the farmer: **Shri. Ananta Naskar**

Area of the farm: 0.65 ha

Location of the farm: Bongheri village, Kultali block, South 24 Parganas district

In the verdant expanse of Bongheri village, nestled within Kultali block of South 24 Parganas district, Shri. Ananta Naskar has pioneered a transformative fish-based integrated farming model across his 0.65 ha of land. By adopting an innovative land shaping technology, Shri. Ananta Naskar has not only diversified his income streams, but also revitalized formerly mono-cropped fields into a thriving multiple cropping system which is a unique model for boosting income by cultivating year-round freshwater fish, complemented by the cultivation of vegetables and fruits on the pond's embankment and main field with assured pond irrigation during rabi and summer months and high yielding variety (HYV) paddy during kharif season. Additionally, he rears cattle, the dung of which is used for preparing vermicompost. The cornerstone of his economic prosperity lies in fishery, which alone accounts for Rs. 1,32,950.00 (59.0%) of his total annual net income of Rs. 2,25,320.00 with a benefit cost ratio of 4.39 from his 0.65 ha farm. Agricultural produces contribute an additional Rs. 87,070.00, with livestock activities adding Rs. 5,300.00. After meeting domestic expenditures, including family sustenance, Ananta saves Rs. 66,320.00 annually. Critical to the success of Ananta's integrated farm is the judicious utilization of waste from various components as fertilizers, feeds, and fodder, effectively lowering cultivation costs. Ananta Naskar's exemplary venture serves as a beacon of rural entrepreneurship, inspiring similar endeavors and fostering agricultural resilience in South 24 Parganas district. His integrated farming approach not only promises sustainable livelihoods, but also holds potential for broader socio-economic impact, making it a blueprint for future agricultural development schemes in coastal saline zone of West Bengal.

Key Words

Fish-based integrated farming, Indian major carps, Indigenous fish, Vegetables, Pond embankment, Resource recycling, Coastal saline zone

Figure 103: Shri Ananta Naskar at his fish-based integrated farm

Introduction

The district of South 24 Parganas is endowed with innumerable freshwater ponds with almost all the households possessing at least one pond and hence it has a huge potential for freshwater fish farming. Being fish loving people, every year, the inhabitants of this district stock these ponds with fry or fingerlings of Indian major carps (IMCs) like catla, rohu and mrigal, in addition to minor carps like bata, calbasu, sarpunti and a variety of indigenous fish species like magur, singhi, pabda, koi, tangra, etc. These fishes cater to the daily nutritional demand of the farm families and also fetch a lucrative income because of their high demand in the market. Unlike other agricultural commodities, marketing of table fish is instantaneous as buyers usually throng the farm ponds once the news is out that harvesting is in process.

However, considering the increase in natural calamities in the coastal areas of the district, the Ramkrisha Ashram KVK (RAKVK), Nimpith has been promoting the integration of fish culture and livestock rearing in tandem with agriculture. Its well-established technology of "Land shaping and rainwater harvesting" effectively demonstrates the procedure of optimising yield by upgrading a piece of land and implementing integrated farming approach. This helped in minimizing risk involved in farming of a single commodity and hence the farmers started adopting this multiple farming approach. In the year 2012-13, under the NICRA project, the RAKVK reached to Shri. Ananta Naskar of Bongheri village, Kultali block to include him as a beneficiary. He only had a small pond of 0.065 ha, but was enthusiastically growing different kinds of indigenous fish as he knew that to make a living he needed to grow and sell such high valued fish along with the regular carp fish which he used for domestic consumption. However, as he only had a small pond, he had to strive hard to sustain his family comprising of 6 members. Ananta was also making use of whatever scanty space he had around his hutment to grow vegetables. He also had a single stretch of low land where he cultivated low yielding traditional paddy for domestic consumption purpose.

In this backdrop, when the land shaping technology was implemented in his land, a pond of 0.13ha had to be excavated for which he received the much-needed impetus to cultivate fish on a larger scale. As he was also an avid vegetable grower, he was thrilled to see that through this technology the land and pond embankments could also be strengthened with the excavated soil and hence facilitated profitable vegetable farming as well. With the help of this technology, Ananta transformed himself from a simple fish farmer to a leading farmer in the locality pursuing fish-based integrated farming and began to reap rich benefits of the technology which has been well exemplified by the extent of sustainability he achieved in generating his livelihood. There has been almost 10-fold increase in his earnings, as nowadays, by selling the diverse farm produce, he could earn a net income of more than Rs.2.0 lakh per year.

Farm description

Shri. Ananta Naskar has established the fish-based integrated farming (IF) in 0.65 ha land in the Bongheri village of Kultali block in South 24 Parganas district. Ananta's farm is situated almost in the centre of the village Bongheri and faces north-south direction with his house located in the northern part of his land and facing south from where he can have a panoramic view of his landscape. The total area of his farm is 0.65 ha, inclusive of 2 ponds measuring 0.065 ha and 0.13 ha respectively. The soil of the farm is clayey loam with soil organic carbon between 0.4 and 0.5% and soil pH between 6.5 and 7. At present the value of 0.65 ha land is about Rs. 35.0 lakhs. This farm is 26.0 km away from Joynagar town.

Fish farming is the main component of this IF. He has 2 desi cows, the dung of which is fed into his small cemented rectangular vermicompost tank that he has established at the backside of his house. The cow dung is also regularly used as organic manure to generate planktons for fish in the pond and for land preparation to cultivate vegetables. Ananta now produces his own fish fingerlings in the smaller pond by growing the fry procured from fish vendors. From only a kilogram of fry he can grow the fingerlings required to be stocked in the bigger pond for growing into table fish round the year. He also acquired the knowledge, by getting trained in the KVK, to grow diverse fish species at the desired stocking rate. He grows almost 15 different types of fish including carps and indigenous fish. The pond embankment, which is about 4 feet wide and 3 feet high, enables the cultivation of high value vegetables round the year. In kharif, the main land is utilized for growing HYV paddy, while in rabi and pre-kharif it is used for growing brinjal and cucumber, respectively. The land and pond embankments are utilised for growing cow pea in kharif, chilli in rabi and bitter gourd in pre-kharif season. The pond embankments are also used for growing his 8 sapota plants.

The land shaping technology involves excavation of a pond of 8ft. depth in 1/5th portion of a low land and spreading the resultant soil on the entire area besides raising the land and pond embankments.

- The land shaping and rainwater harvesting technology has created two ponds measuring 0.065 ha and 0.13 ha which help for fish farming at larger scale than the previous situation.
- Besides growing fish, the pond water is also used for providing irrigation to the vegetables in the dry months of rabi and pre-kharif seasons.
- This offers a much higher land suitable for high yielding paddy cultivation in kharif and also vegetable cultivation in the rabi season with the rainwater harvested in the pond.

Figure 104: A view of Shri. Ananta Naskar's farm

- The farm has greater diversity in crops and livestock to fetch more income and adapt to local circumstances.
- Crop rotation by cultivating different crops in different seasons in a sequential manner has helped in maintaining the soil fertility of the farm land and lowering the frequent prevalence of insects and diseases.
- In an IF, the choice of crops as well as their cropping pattern in a calendar year is important. The cropping pattern of Shri. Ananta Naskar's farm in three seasons is depicted in Table 78.

Table 78: Cropping sequence in the integrated farm of Shri Ananta Naskar

Season	Crops			Livestock	Fish
	Cereals	Vegetable and Spices	Fruit		
Kharif	Paddy	Cow pea	Sapota	Cattle (Year round)	IMC, Indigenous fish, Prawn (Year round)

Farm layout

The layout of Shri. Ananta Naskar's IF is shown in Figure 105.

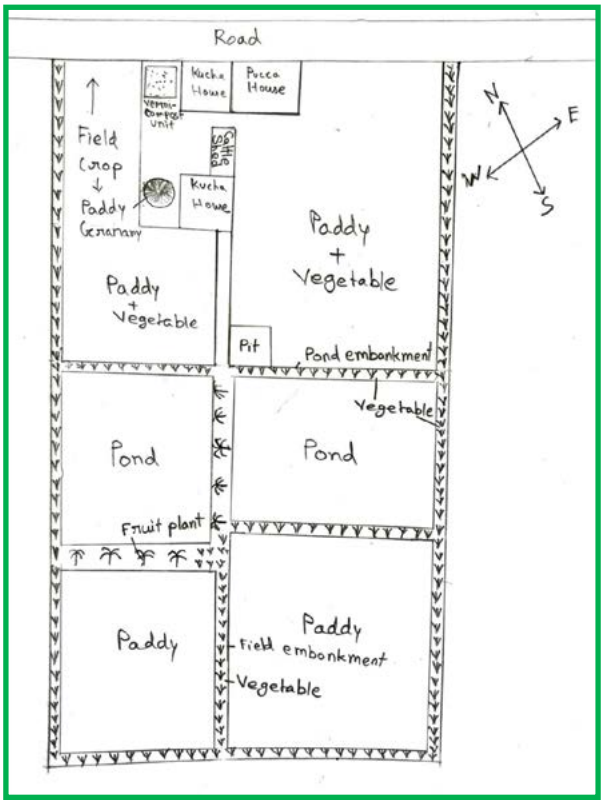


Figure 105: A layout of Shri. Ananta Naskar's farm developed in 0.65 ha land

Capital cost with financial assistance, if any

To develop such kind of IF, there is an involvement of capital cost. It may be worth mentioning here that farmers who are willing to develop a fishery-based integrated farm should have an idea of the establishment cost of such farm. Shri. Ananta Naskar's integrated farm was established in the year 2012-13 with the assistance from ICAR-NICRA project on his 0.65 ha land and at that time the capital cost for developing this farm was Rs.1,27,320.00. If the total capital cost is considered to be escalated by 5 times in 2022-23, the total capital cost during 2022-23 may be Rs. 6,36,600.00 as mentioned in Table 79.

Table 79: Capital cost for developing Shri. Ananta Naskar's integrated farm

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Land shaping by pond excavation	95,000.00	95,000.00	NICRA Project
Cattle shed	9,000.00	9,000.00	Nil
Cost of cattle	6,500.00	13,000.00	Nil
Cost of fruit plants	80.00	320.00	Nil
Vermicompost unit	10,000.00	10,000.00	NICRA Project
Total capital cost of the farm (2012-13)		1,27,320.00	

Bio-economic circularity of the farm

The case of IF depends on the efficiency of bio-economic circularity of the farm. Being an experienced farmer, Shri. Ananta Naskar considers waste as a misplaced term. His remarkable case in developing into a progressive farmer of the locality is mostly based on his judicious use of residues of one crop for the betterment of other crops. By following this approach, he increases his earnings by reducing the overall expenditure of inputs required for different crops. The following flow diagram (Figure 106) exemplifies the circularity of farm wastes amongst the diverse farm components of Ananta.

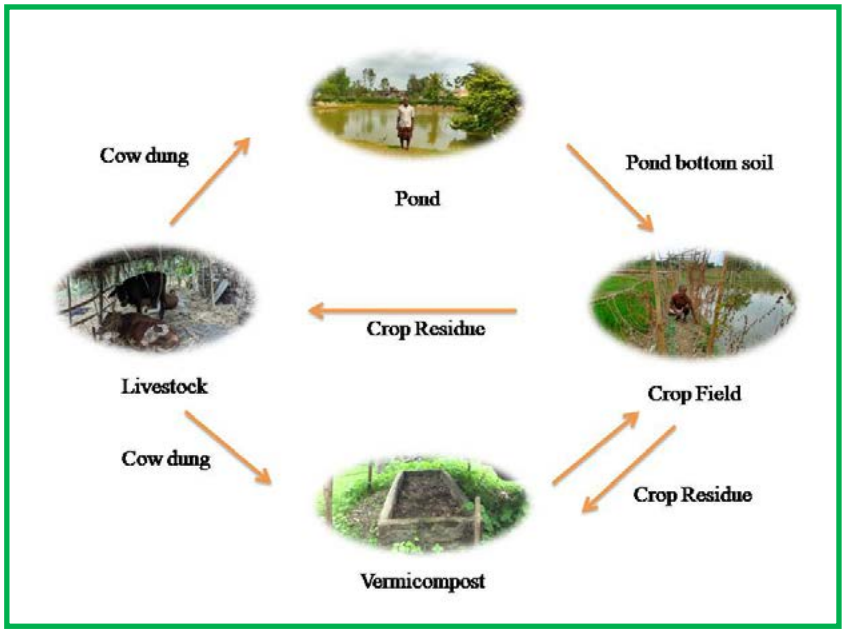


Figure 106: Resource recycling among the different farm constituents

Ananta is meticulous enough to utilize the cow dung worth Rs.2,500.00 to good effect and as such he uses it as organic manure in fish ponds to produce natural fish food organisms or planktons thus reducing the feed cost to a great extent. In this way, he can save annually about Rs.1500.00 which is equivalent to the market price of about 40 kg of fish feed. He also uses the cow dung to produce about 600 kg of vermicompost worth Rs.4,000.00 which is used as organic manure for crops thus providing almost 10 kg of nitrogen, 2 kg of phosphorus, 3 kg of potassium and other nutrients. In addition to this, the fertile bottom soil from the pond, which has exceptional manuring properties for crop growth, is applied on the land and pond embankments, once a year. Besides, crop residues worth Rs.2,300.00 including paddy straw, residues of vegetable and fruits provides good quantity of fodder for the cattle. Not only that, it is also used for making vermicompost. Hence, in this fish-based integrated farm, although farm waste equivalent to only Rs.10300.00 is being recycled, the ultimate gain obtained by producing the end products is remarkable and leads to an eco-friendly practice by harnessing the wastes judiciously

Farm economic viability

The farm is a truly fish-based integrated farm which is exemplified in Table 80 and Figure 107. Figure 107 indicates that 59.0% of the net income i.e. Rs.1,32,950.00 is obtained from fish out of a total net income of Rs. 2,25,320.00. This is further supported by the fact that the BC ratio is highest (7.04) from fish cultivation. Ananta also earns a net income of Rs. 87,070.00 from different agricultural produces (cereal, vegetables and fruits) and Rs. 5,300.00 from livestock including vermicompost. The BC ratio from his entire system is calculated to be 4.39. This fish-based IF has generated 165 man-days of which 36 man-days are being hired from outside, while the rest is contributed by the family members. The total household expense of Ananta is Rs. 1,59,000.00 as indicated in Table 80, out of which the educational expense is Rs.20,000.00 per year for his grandson. It has been observed that the yearly savings of Ananta is Rs. 66,320.00 which is deposited in the bank for meeting occasional emergency expenditures of his family

Table 80: Annual economics of Shri. Ananta Naskar's integrated farm

Sl. No.	Item	Expenditure towards agricultural activity (Rs.)	Gross income (Rs.)	Net income (Rs.)	Expenditure towards domestic purpose (Rs.)	Net yearly savings (Rs.)	B:C Ratio
1.	Cereal	4,000.00	13,200.00	9,200.00	--	--	3.30
2.	Vegetables	30,000.00	1,06,270.00	76,270.00	--	--	3.54
3.	Fruits	800.00	2400.00	1,600.00	--	--	3.00
3.	Fish	22,000.00	1,54,950.00	13,2950.00	--	--	7.04
4.	Livestock	85,00.00	10,800.00	2,300.00	--	--	1.27
5.	Vermicompost	1,000.00	4,000.00	3,000.00	--	--	4.00
6.	Food purchased from outside	--	--	--	55,750.00	--	--
7.	Food from farm	--	--	--	44,250.00	--	--
8.	Education	--	--	--	20,000.00	--	--
9.	Health	--	--	--	15,000.00	--	--
10.	Others (Travel, clothing, etc.)	--	--	--	2,4000.00	--	--
Total		**66,300.00**	**2,91,620.00**	**2,25,320.00**	**1,59,000.00**	**66,320.00**	**4.39**

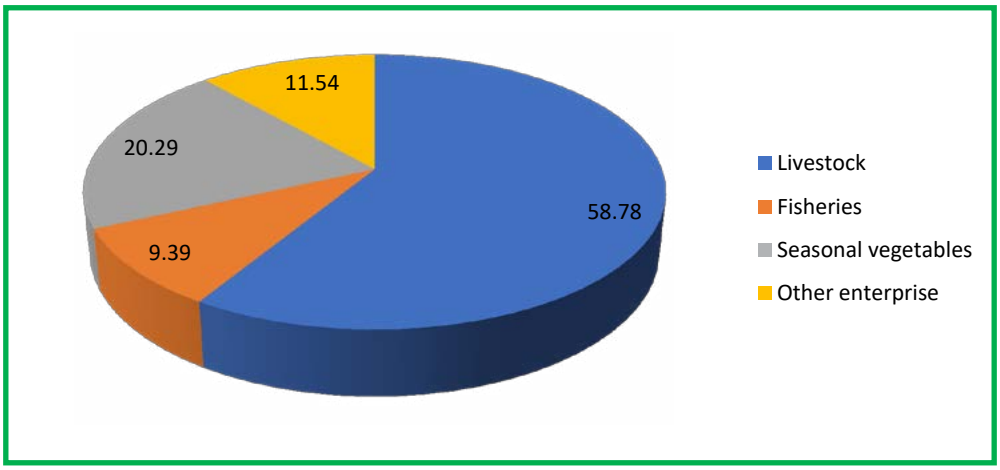


Figure 107: Net income and percentage sharing from different components of integrated farm of Shri Ananta Naskar

Financial plan without bank loan

Considering the techno-economic facts and figures of Shri. Ananta Naskar's IF in 0.65 ha land, a finncial plan may be developed for an interested farmer who may not take any bank loan and thus invest the capital cost of Rs. 6,36,600.00 from his/ her own. Every year recurring cost of cultivation is considered as Rs. 66,300.00 and the capital cost will be recovered in five equal installments. A financial plan is presented in Table 81.

Table 81: Financial plan for area development scheme on fishery-based integrated farm in 0.65 ha land (without bank loan)

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Capital cost	636600.00	509280.00	381960.00	254640.00	127320.00	0.00
2	Recurring cost of cultivation	66300.00	66300.00	66300.00	66300.00	66300.00	66300.00
3	Recovery of capital cost in equal installment	127320.00	127320.00	127320.00	127320.00	127320.00	0.00
4	Gross income	291620.00	291620.00	291620.00	291620.00	291620.00	291620.00
5	Net income	98000.00	98000.00	98000.00	98000.00	98000.00	225320.00
6	BC ratio	1.51	1.51	1.51	1.51	1.51	4.39

Financial plan with bank credit availability

Considering the techno-economic facts and figures of Shri. Ananta Naskar's IF in 0.65 ha land, a finncial plan may be developed for an interested farmer who may look forward for a bank loan to develop such an IF. The total project cost covering capital cost and 1st year recurring cost of cultivation will be based on economic data shown by Shri. Ananta Naskar as follows.

Project Cost = Capital Cost + 1st Year Recurring Cost = Rs. (6,36,600.00 + 66,300.00) = Rs. 7,02,900.00

A financial plan with bank loan facility is presented in Table 82.

Table 82: Financial plan for bankable area development scheme on vegetable-based IF in 0.65 ha land

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Project Cost	702900.00					
2	Margin @ 15%	105435.00					
3	Bank loan	597465.00					
4	Yearly rate of simple interest @12.0% PA	12.00					
5	Loan O/S at the beginning of the year	597465.00	477972.00	358479.00	238986.00	119493.00	0.00
6	Accrual of interest	71695.80	57356.64	43017.48	28678.32	14339.16	0.00
7	Repayment of principal in equal installment	119493.00	119493.00	119493.00	119493.00	119493.00	0.00
8	Repayment of interest	71695.80	57356.64	43017.48	28678.32	14339.16	0.00
9	Loan O/S at the end of the year	477972.00	358479.00	238986.00	119493.00	0.00	0.00

Repayment plan

The repayment plan against bank loan may be as shown in Table 83.

Table 83: Repayment plan against bank loan

Sl. No.	Item	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
1	Repayment of principal in equal installment	119493.00	119493.00	119493.00	119493.00	119493.00	0.00
2	Repayment of interest	71695.80	57356.64	43017.48	28678.32	14339.16	0.00
3	Recurring cost of cultivation	66300.00	66300.00	66300.00	66300.00	66300.00	66300.00
4	Gross income	291620.00	291620.00	291620.00	291620.00	291620.00	291620.00
5	Net income	34131.20	48470.36	62809.52	77148.68	91487.84	225320.00
6	BC ratio	1.13	1.20	1.27	1.36	1.46	4.39

Conclusion

The fish-based integrated farm of Shri Ananta Naskar in the coastal and saline agro-climatic zone of the South 24 Parganas district provides hope for the multitude of fellow farmers possessing similar topography. Adopting such eco-friendly practice is the need of the hour for sustaining the unique agro-ecosystem of the region. Diversification of farming by growing different types of crops by adopting the land shaping technology has contributed in reducing the risk involved in agriculture in this region plagued by frequent climatic aberrations like late or insufficient rainfall, increased dry spell, excess rainfall in a short span of time, etc. In this region, characterized by 6 months intense rainfall followed by 6 months dry spell, the newly excavated pond opens up the possibility of harvesting the rainwater for subsequent use in the dry season for irrigating the crops as well as culturing the fishes. The steady and high demand of fish in the district, in particular, and the state, in general, will undoubtedly encourage farmers like Ananta to adopt fish-based integrated farming which provides a BC ratio as high as 4.39. As the news of case of Ananta spread, about 35-40 fellow farmers from far and near visited the farm and have been encouraged to adopt this farming system. The produce from the farm, apart from providing livelihood opportunity to Ananta, also provides year-round nutritional security to his family. Moreover, through proper utilization of farm wastes he is able to reduce the cost of cultivation thereby increasing the overall profit.

Land shaping and rainwater harvesting technology: Ushering a new vista in sustainable agriculture through vegetable-based integrated farming in South 24 Parganas district

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Horticulture-based integrated farming

Name of the farmer: **Shri. Bibekananda Haldar**

Area of the farm: 0.39 ha

Location of the farm: 27 no lat village, Mathurapur-II block, South 24 Parganas district

Embracing the transformative "Land shaping and rainwater harvesting" technology has proven pivotal for Shri. Bibekananda Haldar, a resilient smallholder farmer in Mathurapur II block of South 24 Parganas district. This innovative approach has not only elevated his once low-lying mono-cropped land, but also facilitated its conversion into a thriving multiple cropping system. Now, with strategic irrigation provisions, Bibekananda has unlocked the potential for cultivating vegetables in both the main field and newly reclaimed lands and pond embankments during rabi and summer months, alongside high-yielding paddy during kharif. Central to his success is the judicious integration of fish farming in the excavated pond, utilizing its soil to enhance land elevation. This synergy has enabled him to achieve a commendable net income of Rs. 2,13,320.00 annually from his 0.39 ha farm. Notably, vegetable cultivation stands out as the primary income generator, contributing Rs. 1,33,440.00, which constitutes 62.55% of his total earnings. Additionally, integrated practices with paddy, sunflower, and cattle add Rs. 49,880.00, complemented by earnings of Rs. 30,000.00 from other agricultural activities. After covering essential household expenditures, including food costs, Bibekananda enjoys an annual savings of Rs. 1,32,990.00. His vegetable-based integrated farm exemplifies a circular economy, effectively recycling farm wastes and residues across subsystems, minimizing the cost of production. Bibekananda Haldar's success story serves as an example of agricultural innovation, demonstrating how transformative technologies can empower smallholder farmers to enhance productivity, profitability, and sustainability. His integrated farming approach not only promises food security, but also holds promise for inspiring similar initiatives and fostering rural prosperity across South 24 Parganas district.

Key Words

Vegetable based integrated farming, Land shaping and rainwater harvesting, Livestock, Fish, Cultivation on embankment, Resource recycling, Coastal saline zone

Figure 108: Shri. Bibekananda Haldar at his vegetable based integrated farm

Introduction

The district of South 24 Parganas falls under coastal saline agro-ecosystem. However, a large part of the district is considered to be promising for vegetable cultivation because of the presence of rich alluvium of the Ganges making the land naturally fertile. Consequently, the village of 27 no. Lat in Mathurapur II block is endowed with a fertile landscape with enormous possibility of horticulture-based farming. However, water for irrigation remains a major concern to pursue profitable horticulture throughout the year as the region is said to "suffer from water for 6 months and water for another 6 months" due to insufficient drainage facility and excessive evaporation loss. Besides, the low-lying nature of the land seldom offers opportunity to grow a second crop. In this backdrop it was pertinent that a sustainable model of integrated farming could be implemented by creating a suitable source of water.

Hence, in the year 2011, the RAKVK came up with idea of providing its well-established technology of "Land shaping and rainwater harvesting" in the plot of a small holder farmer, Shri Bibekananda Haldar of this village. Bibekananda possessed a single stretch of land which was too low for which it was only possible to cultivate low yielding deep water paddy during kharif followed by green gram in the month of January. It was only after implementation of the land shaping technology, that the appearance of his land changed radically thereby providing him with multiple options and a secured source of irrigation for the dry season.

Through this technology, a pond of 0.13 ha in area with 8 feet depth was excavated in his 0.39 ha agricultural land to provide him year-round source of irrigation. The soil obtained by excavating the pond was sufficient enough to raise the main land by 1.5 ft and provided strong embankment around the pond and also around his entire land. The power of the transfer of technology was revolutionised and thus made his vision towards farming and provided the much-needed impetus to take up integrated farming involving the cultivation of vegetables along with high yielding paddy, sunflower, fish and livestock. The integrated approach not only provided diversified farm outputs, but also helped to minimise the risk factor involved in cultivation of a single crop. This technology appeared to be a game–changer in the life of Bibekananda with respect to livelihood generation as he could now support his family by earning about Rs.3,00,000.00/annum in comparison to only Rs.45,000.00 which he used to earn previously.

Farm description

The farm of Bibekananda is situated near the north eastern periphery of the village 27 no. Lat and encompasses an area of 0.39 ha or 3 bigha. High yielding paddy is grown in the main land in kharif, while in rabi the land is utilised for growing sunflower and vegetables. The pond, used for fish cultivation and as a source of irrigation, is about 0.13 ha or 1 bigha in area and is situated in the northern portion of his land. The pond embankment, which is about 10 feet wide and 3 feet high, enables the cultivation of high value vegetables round the year. In kharif, it is utilized for growing bitter gourd, cow pea and brinjal, while tomato, cauliflower and cabbage are grown during rabi season. In zaid, the entire pond embankment is utilized for growing cucumber. The elevated land of pond embankment ensures early sowing of these vegetables which in turn creates the possibility of early harvesting and marketing, thus allowing him to get a lucrative return. The entire raised land embankment is also utilised for growing vegetables round the year. He also possesses 2 desi cows, the dung of which is utilised as organic manure in the pond and agricultural land. Besides meeting the challenge of household food security, Bibekananda can now supply his farm merchandise to the local market which has a steady demand.

Table 84: Cropping sequence in the Integrated Farm of Shri. Bibekananda Haldar

Season	Crops			Livestock	Fishery
	Cereals	Vegetable	Oil Seeds		
Kharif	Paddy	Bitter Gourd, Cow Pea, Brinjal	--	Cattle (Year round)	Rohu, Catla, Mrigal, Bata, Calbasu, Mola, Pacu, Tilapia, Prawn (Year round)
Rabi	--	Tomato, cauliflower, Cabbage, Okra	Sunflower		
Zaid	--	Cucumber	--		

Farm layout

A layout of Shri. Bibekananda Haldar's IFS is presented in Figure 109.

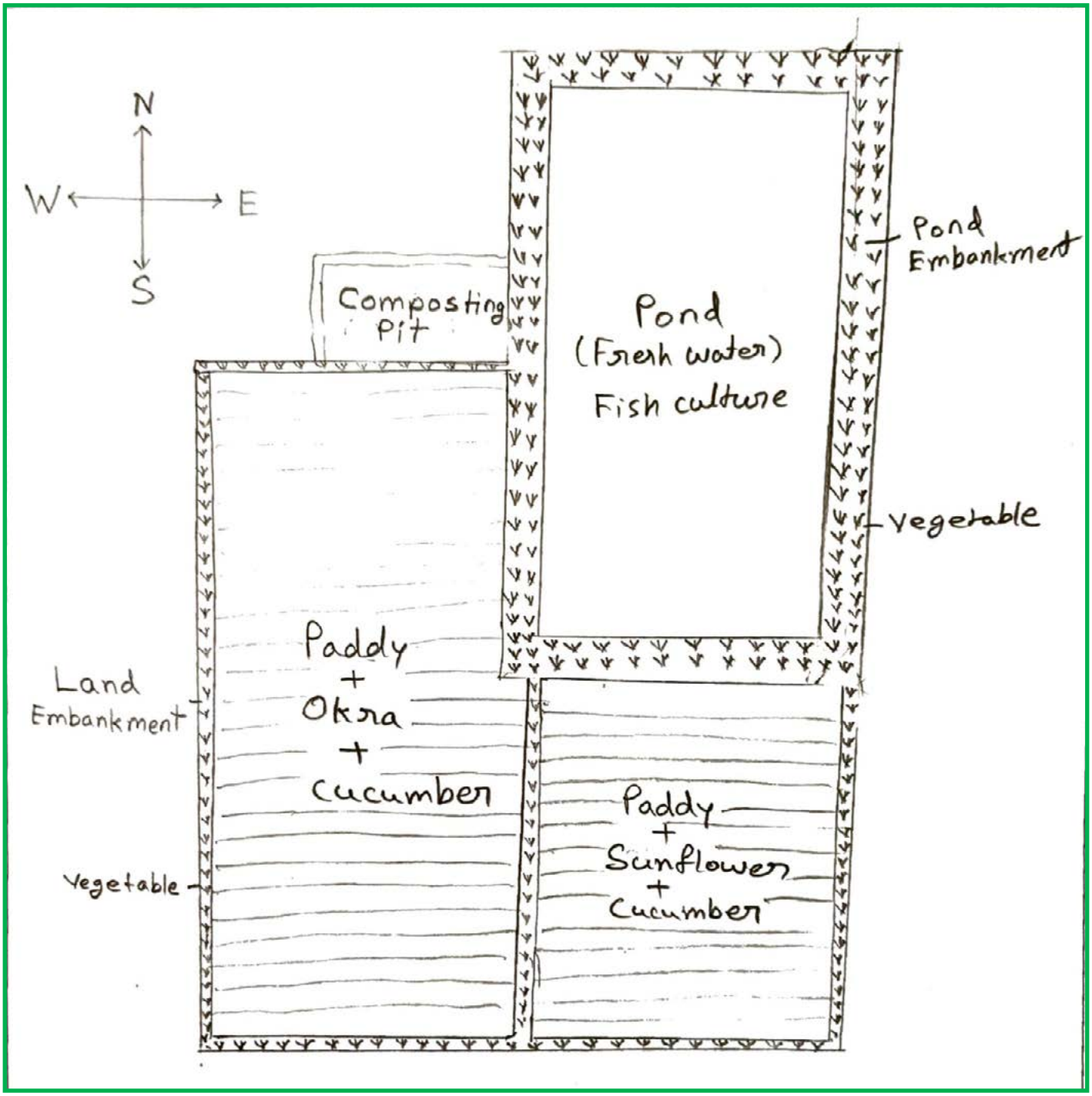

Figure 109: Layout of the farm depicting the different components

Capital cost with financial assistance, if any

Table 85 gives an idea of the establishment cost of Shri Bibekananda Halder when it came up in the year 2011. It is implicit that anyone willing to develop such integrated farm should have a land in his possession. At that time the capital cost for developing this farm was only Rs.69,400.00, as mentioned in Table 85, most of which was availed from the NWDPRA project.

Table 85: Capital cost for developing Shri. Bibekananda Haldar's integrated farm

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Land shaping by pond excavation	0.50	0.50	NWDPRA, GoI
Cattle shed	0.07	0.07	Nil
Cost of cattle	0.06	0.12	Nil
Manure pit		0.0004	Nil
Total capital cost of the farm		0.694	

Bio-economic circularity of the farm

Since he started reaping rich benefits of the technology, Bibekananda was wise enough to consider "waste is wealth", indeed. His remarkable case was based on the incorporation of the residues of one crop as a precious input for another. This approach has helped him to increase his earnings from the farm by reducing the cost of cultivation. The following flow chart illustrates the judicious utilisation of farm wastes among the different farm components.

It has been estimated that by using cow dung as organic manure in fish pond to produce natural fish food organisms or planktons, he could save about Rs.2,500.00 in a year equivalent to the market price of 70 kg of fish feed. Thus, at 1:3 food conversion ratio (FCR), this amount could be used to produce about 23 kg of fish worth Rs.4,600.00. Moreover, the rest of the cow dung is decomposed along with the fodder and crop residues to obtain organic manure worth Rs.5,000.00 thus providing the nitrogen requirement for the entire paddy field. In addition to this, the fertile bottom soil from the pond is applied on the land and pond embankments, once a year, which has exceptional manuring properties for crop growth. Besides, crop residues worth Rs.4,700.00 including paddy straw, thalamus of sunflower and raw vegetable leaves provides good quantity of fodder for the cattle. Particularly, the sunflower thalamus helps to augment milk production in cow. Consequently, though an amount of only Rs.12,200.00 is being circulated in the form of bio-economics in the farm, bigger gains may be clearly visualised not only in terms of profit but also in terms of sustainability and positive environmental impact generated as a result of such practices.

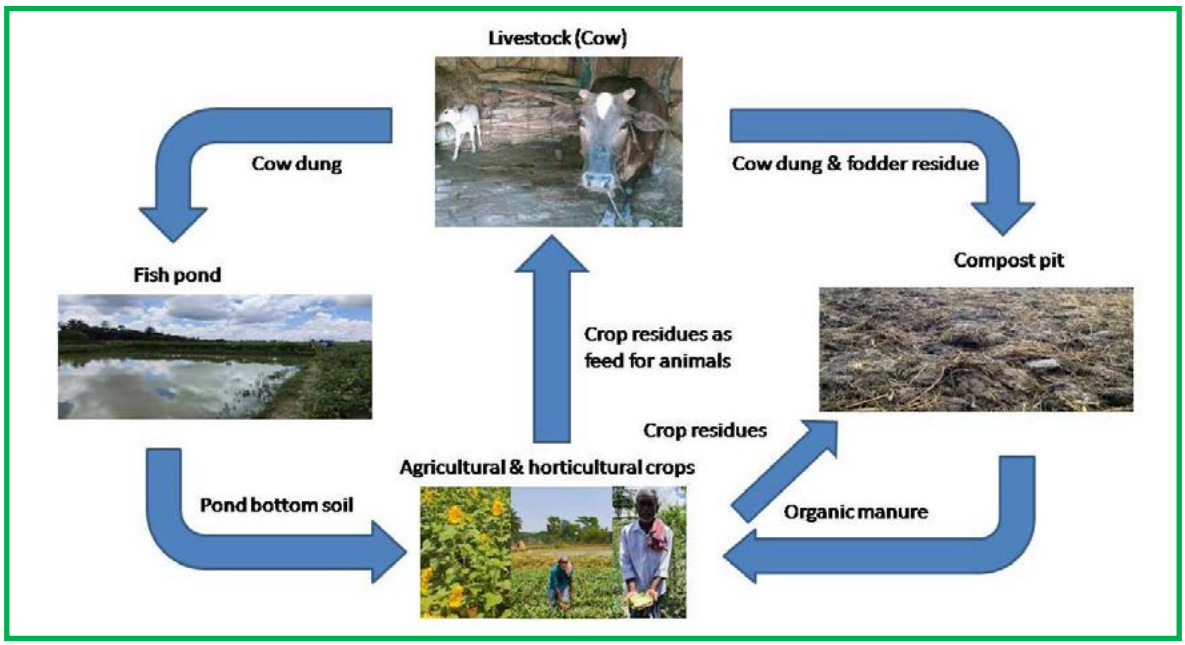

Figure 110: Resource recycling among the different farm constituents

Farm economic viability

As illustrated in Table 86 and Figure 111, 62.55% of the net income i.e. Rs.1,33,440.00 is obtained from vegetables out of total net income of Rs. 2,13,320.00 thus indicating to the fact that it is a truly vegetable based integrated farm. Moreover, BC ratio is also the highest (3.5) from vegetable cultivation which further consolidates this fact. In addition, he generates a net income of Rs. 31,980.00 from fish farming, Rs. 13,500.00 by cultivating paddy and sunflower, and Rs. 4,400.00 by raising cattle. Besides he also earns Rs. 30,000.00 from other activities. The BC ratio was found to be 3.45 while considering the entire expenditure and gross income from agricultural activities. The present study also reveals the generation of 159 mandays worth Rs.63,600.00. Table 86 also indicates that the total household expense of Bibekananda is Rs. 80,330.00. There is no expense for educational purpose as none of his family member is engaged in studies. It has been observed that at the end of the reporting year Bibekananda can achieve a net saving of Rs. 1,32,990.00 which he keeps in the bank thus ensuring financial security for his family.

Table 86: Annual economics of Shri. Bibekananda Haldar's integrated farm

Sl. No.	Item	Expenditure towards agricultural activity (Rs.)	Gross income (Rs.)	Net income (Rs.)	Expenditure towards domestic purpose (Rs.)	Net yearly savings (Rs.)	B:C
1.	Cereal & oilseed	9,000.00	22,500.00	13,500.00	-	-	2.5
2.	Vegetables	54,100.00	1,87,540.00	1,33,440.00	-	-	3.5
3.	Fish	20,000.00	51,980.00	31,980.00	-	-	2.6
4.	Livestock	4,000.00	8,400.00	4,400.00	-	-	2.1
5.	Other activities (labour, tuition, etc.)	-	30,000.00	30,000.00	-	-	-
6.	Food purchased from outside	-	-	-	36,000.00	-	-
7.	Food from farm	-	-	-	22,830.00		
8.	Agricultural newsletters & magazines	-	-	-	500.00	-	-
9.	Health	-	-	-	6,000.00	-	-
10.	Travel, clothing, etc.	-	-	-	15,000.00	-	-
	Total	**87,100.00**	**3,00,420.00**	**2,13,320.00**	**80,330.00**	**1,32,990.00**	**3.45**

Conclusion

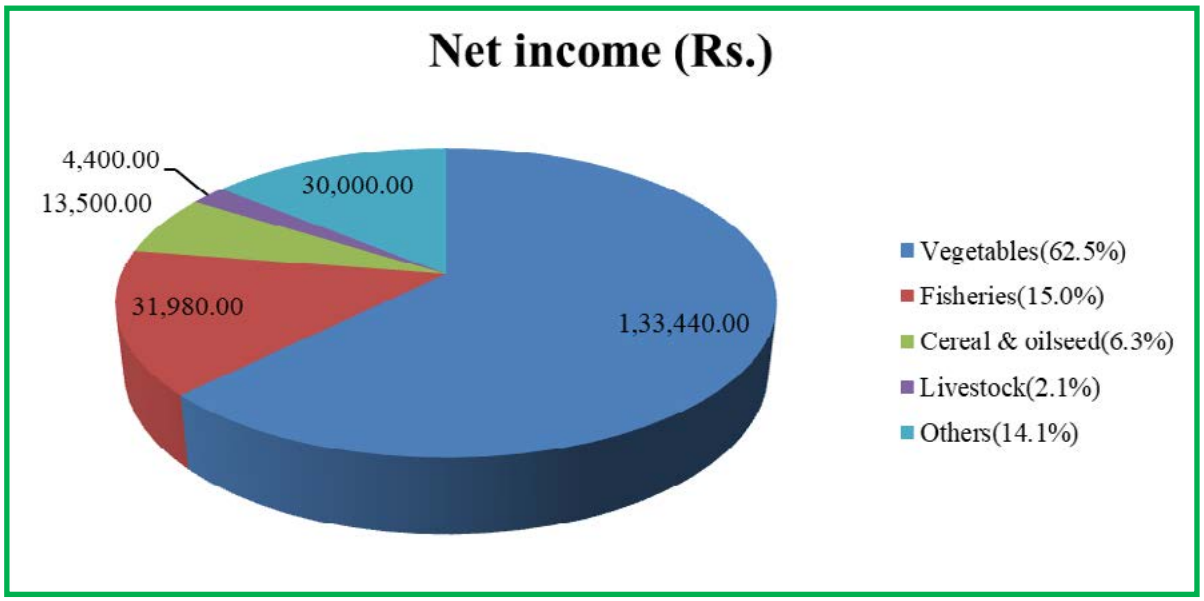

Figure 111: Net income and percentage sharing from different components of integrated farm

The vegetable based Integrated Farm of Shri Bibekananda Halder in the coastal saline agro-climatic zone is bound to offer much greater ramifications to the society, environment and the ecosystem in terms of sustainability as exemplified by the nature of his bio-economic circularity. The concept of "waste is wealth" and harvesting of rainwater by excavating pond and upgrade the land for second crop cultivation has gradually begun to permeate within the farming community of his locality. So far about 50-60 fellow farmers have already adopted this technology and raised their lands to create opportunity for vegetable cultivation and have started judicious utilisation of their farm wastes and by-products for reducing the cost of cultivation by cutting down on the use of chemical fertilisers thereby maximising profit. Moreover, the BC ratio of 3.45 in terms of agricultural income and expenditure provides a gratifying picture of the sustainability of his farm which is worth emulating by fellow farmers. As his produce is mostly obtained by utilising farm wastes, it offers quality nutrition for his family and the quantity of diverse crops grown across different seasons in his farm also ensures food security for the family round the year. Thus, from a simple farmer, growing only paddy and greengram in his once mono-cropped land, Bibekanada has now become an iconic integrated farmer in his locality with his sustainable vegetable based integrated farming model inspiring scores of other farmers to consider such model which is not only sustainable, but also profitable as it can withstand the risk factor associated with farming of a single crop.

Cultivation of vegetables on land embankment as a component of integrated farming: A profitable and sustainable farming practice

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Horticulture-based integrated farming

Name of the farmer: **Shri. Ramdeb Mondal**

Area of the farm: 0.66 ha

Location of the farm: Kaikhali village, Kultali block, South 24 Parganas district

Integrated farming system (IFS) stands as a steadfast guiding light for sustainable agriculture, offering a comprehensive solution to achieve year-round productivity and income stability. Shri. Ramdeb Mondal's exemplary journey underscores the transformative potential of integrating cereals, pulses, horticultural crops, fish, and livestock within a single farming unit. From his modest 0.66 ha land, Shri. Ramdeb Mondal reaps a commendable gross income of Rs. 3,98,940.00 annually. Notably, vegetables emerge as the cornerstone of his earnings, contributing Rs. 2,73,300.00 in his integrated system. With the strategic implementation of land embankment technology, he further augments his income by an impressive Rs. 1,05,640.00. By embracing a vegetables-based integrated farming approach, Shri. Ramdeb Mondal has diversified his agricultural portfolio, enabling continuous cultivation of cereals, pulses, fruits, spices, livestock, and fish throughout the year. This holistic integration not only mitigates the risks associated with monoculture, but also enhances resilience against crop losses, ensuring a secure and sustainable year-round income. Annually, Shri. Ramdeb Mondal realizes a net income of Rs. 3,00,140.00. Importantly, after meeting all household and operational expenses, he saves a substantial Rs. 1,05,140.00, underscoring the financial security and prosperity enabled by his integrated farming model. In essence, Shri. Ramdeb Mondal's case study exemplifies how IFS empowers farmer to achieve economic self-sufficiency while promoting ecological resilience. As agriculture navigates challenges posed by climate variability and market fluctuations, the holistic approach of IFS emerges as a beacon of hope, fostering sustainable livelihoods and food security for farming communities across coastal saline agro-climatic zone of West Bengal.

Key words

Integrated farming, Land embankment, Vegetable-based cultivation, Recycling of farm waste, South 24 Parganas

Figure 112: Shri. Ramdeb Mondal at his vegetables-based integrated farm

Introduction

South 24 Parganas is a complex, diverse and risk prone district of West Bengal, where climatic threats are the part of people's life. Due to the climatic vulnerability of the area, severe damage to crop and livestock forces the villagers to migrate in search of livelihood. Besides, crop cultivation is also hampered due to the scarcity of irrigation water and salinity in the soil during *rabi*-summer season. However, under these circumstances, it is observed that land embankment, locally known as "*ail*", due to its raised topography, prevents salinity and submergence, ensures year-round vegetable and fruit cultivation. The "*ail*" also provides an opportunity for paddy cum fish culture as the raised land provides for a boundary around the cultivable low land thus integrating agriculture with fishery.

By following the above principle, Shri. Ramdeb Mondal, 51years old, from Kaikhali village of Kultali block in South 24 Parganas, developed an IFS in his own land. He got the impetus to develop his farm in the year of 2021-2022 when RAKVK, Nimpith implemented "Land embankment" technology under 'National Innovations in Climate Resilient Agriculture' project. Previously, Ramdeb used to cultivate traditional low yielding paddy in Kharif and local green gram variety in rabi season. To implement this technology, he first excavated a pond of 8 feet depth and with the resulting soil he raised the pond dykes and land embankments all around his plot to establish the IFS model. This integrated farming creates a scope of vegetable production throughout the year, along with different agronomical crops, fish and livestock. By following this approach, Ramdeb can now sell his farm produces year-round in the nearby local market and thus minimise the risk associated with cultivating a single crop.

Farm description

Shri. Ramdeb Mondal has possession of 0.66 ha of land at Kaikhali village. After raising and strengthening his land embankments, he now grows vegetable crops on it throughout the year. Before adopting this technology, the "*ail*" used to get inundated during the rainy season. But now, it is raised up to 1 m of height around his main low land area with a top width of 90 to 100 cm and base width of 150 cm. At the time of Kharif season, the land embankment is used for cultivating bitter gourd, snake gourd and okra.

In rabi, the land embankment is utilized for growing bitter gourd, cucumber, okra, chilli, cowpea while in *zaid*, the entire "*ail*" appears as a canopy of bitter gourd cultivated in bowers. The embankments of the centrally located pond are used for cultivating different fruit plants covering an area of 0.015 ha. Ramdeb utilizes the intermediate space between the trees by cultivating turmeric. Besides, he also grows fish like Indian major craps (IMCs), seabass, pangus, rupchand and air-breathing fishes in his two ponds covering 0.133 ha of area. At the northern part of his land, paddy is cultivated in Kharif season and green gram in rabi season which covers an area of 0.33 ha and 0.133 ha, respectively. Besides growing field and horticultural crops, he also maintains 2 desi cattle, 8 desi poultry and 2 khaki campbell ducks. Now-a-days, Ramdeb is effortlessly vending his farm cultivated products to the local market after fulfilment of his own household demand.

Table 87: Cropping sequence in the integrated farm of Shri. Ramdeb Mondal

Season	Crops				Livestock	Fish
	Cereals	Vegetable	Fruits	Spice		
Kharif	Paddy	Bitter Gourd, Snake Gourd, Okra	Guava, Sapota, Banana	Turmeric	Cattle (Desi), Poultry (Desi), Duck (Khaki campbell)	IMCs, Seabass, Pangus, Rupchand, Air-breathing fishes
Rabi	Green gram	Bitter Gourd, Cucumber, Okra, Chilli, Cowpea	--	--		
Zaid	--	Bitter Gourd	--	--		

Farm layout

A layout of this IFS farm is presented in Figure 113.

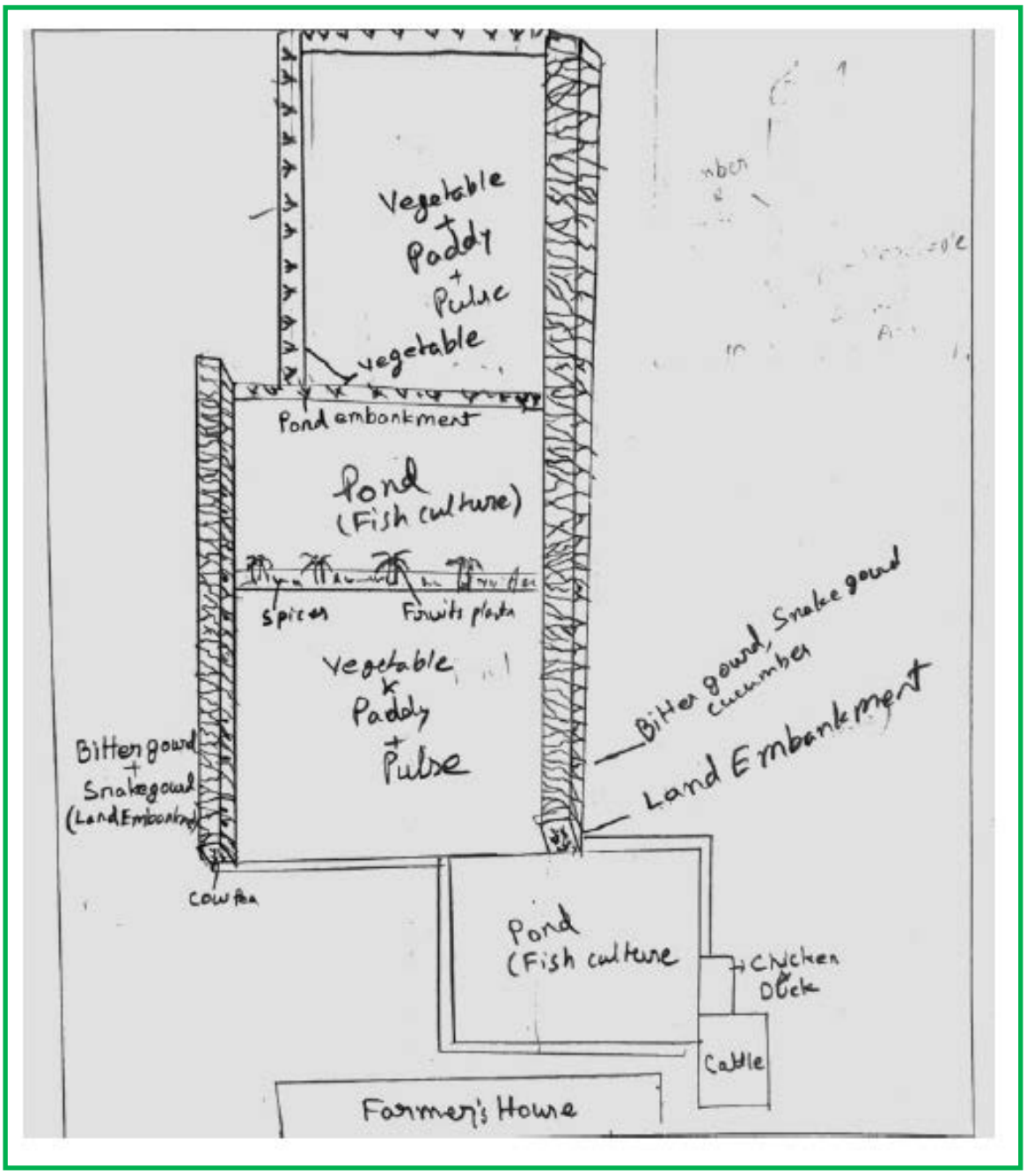

Figure 113: Layout of the farm depicting the different constituents

Capital cost with financial assistance, if any

The estimated costs of different units are mentioned in Table 88. The total capital cost for establishing this farm was Rs. 59,270/-, a part of which was provided from the NICRA project in the year of 2021-2022.

Table 88: Capital cost for developing Shri. Ramdeb Mondal's integrated farm

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Land embankment	0.3394	0.3394	NICRA project
Cattle shed	0.11	0.11	Nil
Cost of cattle	0.12	0.12	Nil
Manure pit	0.008	0.008	Nil
Duck and poultry shed	0.015	0.015	Nil
Cost of duck and poultry	0.0003	0.003	Nil
Total Cost		0.5927	-

Bio-economic circularity of the farm

Shri. Ramdeb Mondal is very passionate with his integrated farming system. Considering that organic manure plays an important role for restoring soil health, he collects all crop residues along with cow dung and litter from livestock and dumps in a pit for composting. The organic manure produced from this pit is used in soil preparation for crop cultivation and also for preparation of pond before stocking fishes. The husk, straw, "chunni", etc. from crops are used for feeding livestock, mulching purpose as well as composting materials. The pond water is used for irrigation purpose in crop and vegetable fields. Therefore, the unit nevertheless is truly eco-friendly in terms of waste management and is also a good source of income by recycling natural waste without much drudgery.

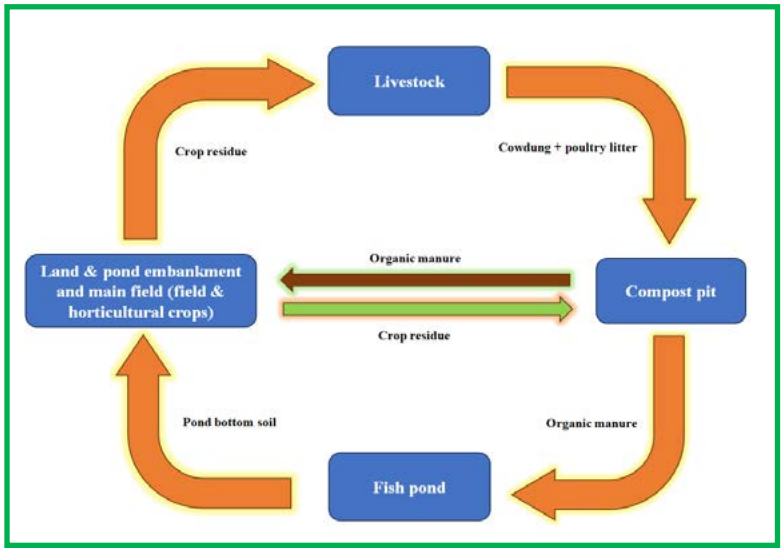

Figure 114: Resource recycling among different farm components

Farm economic viability

Table 89 and Figure 115 show that the gross BC ratio of the farm is 4.04. It also illustrates that 70% of the net income i.e., Rs. 2,10,000.00 is obtained from vegetables alone with a BC ratio of 4.31. In this farm, vegetables have the highest BC ratio followed by livestock (3.85) and fruits (3.38). It is revealed from the results, that the vegetable cultivation exhibits maximum gross income (Rs.2,73,300.00) from this integrated farming system followed by fish (Rs.46,040.00) and cereals and pulses (Rs. 37,000.00). It is also clear that Ramdeb spends an amount of Rs. 1,13,186.00 for purchasing food from market and saves Rs. 66,814.00 from the income of this IFS. A total of 370 mandays/ year is required to fulfil all the farm activities. It has also been observed that a total of Rs. 15,000.00 is utilized towards education, health, travel and clothing purposes. On the other hand, out of the total expenditure of Rs. 98,800.00, input and labour cost towards vegetable cultivation constituted Rs 63,300.00 followed by fishery (Rs. 17,200.00), cereal and pulse (Rs. 12,000.00), livestock (Rs. 4,100.00), fruits (Rs. 1,300.00) and spice (Rs. 900.00). With his year-round engagement in the field of IFS, he can make a net yearly savings of Rs. 1,05,140.00 out of a total net income of Rs. 3,00,140.00 which provides the necessary support for sustaining his family.

Table 89: Annual economics of Shri. Ramdeb Mondal's integrated farm

Sl. No.	Item	Expenditure towards agricultural activity (Rs.)	Gross income (Rs.)	Net income (Rs.)	Expenditure towards domestic purpose (Rs.)	Net yearly savings (Rs.)	B:C
1.	Cereal &pulse	12,000.00	37,000.00	25,000.00	-	-	3.08
2.	Vegetables	63,300.00	273300.00	2,10,000.00	-	-	4.31
3.	Spice	900.00	2,400.00	1,500.00	-	-	2.66
4.	Fruits	1,300.00	4400.00	3,100.00	-	-	3.38
5.	Fish	17,200.00	46,040.00	28,840.00	-	-	2.67
6.	Livestock	4,100.00	15,800.00	11,700.00	-	-	3.85
7.	Other activities (labour)	-	20,000.00	20,000.00	-	-	-
8.	Food purchased from outside	-	-	-	1,13,186.00	-	-
9.	Food from farm	-	-	-	66,814.00		
10.	Education	-	-	-	5,000.00	-	
11.	Health	-	-	-	8,000.00	-	
12.	Travel, clothing etc.	-	-	-	2,000.00	-	
	Total	**98,800.00**	**3,98,940.00**	**3,00,140.00**	**1,95,000.00**	**1,05,140.00**	**19.95**

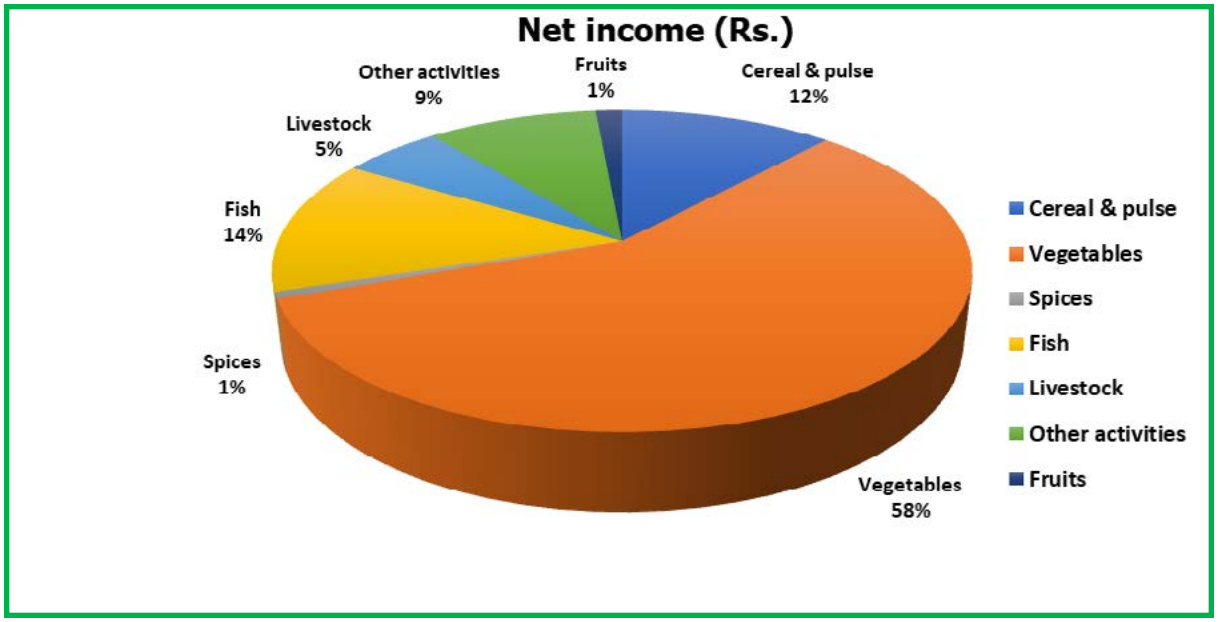

Figure 115: Net income and percentage sharing from different components of Integrated Farm of Shri. Ramdeb Mondal

Conclusion

Shri. Ramdeb Mondal is a very enthusiastic and hard-working farmer of his village. At the very beginning of his farming journey, due to low lying field condition, he mostly cultivated low-yielding long duration traditional rice during Kharif season and rest of the season the land remained fallow due to scarcity of water. Now, he has a scope to harvest the rain water and utilize rainwater throughout the year and that creates an opportunity to produce year-round crops after adopting IFS model of cultivation in which cultivation on land embankment plays a major role. His remarkable progress in vegetables-based IFS has attracted other farmers from the surrounding villages to adopt his techniques. His unique contribution in the development of agriculture in his own and surrounding villages lies on the fact that he has not only updated his farming by adopting IFS but also given due importance on the disposal of farm wastes by judiciously utilising the available vegetable and crop residues, cow dung, poultry litter etc. in producing farm compost. He also spreads the fertile pond bottom soil as manure on pond and land embankment because of its high nutrient value. Gradually, Shri. Ramdeb Mondal has been able to convert his mono cropped land into a diversified farming system by adopting IFS and also became an influencing factor for other farmers of the locality to go for diversified farming throughout the year without wasting any farming area.

Wetlands in coastal and saline regions of West Bengal find the eco-friendly, profitable farming venture through fishery-based integrated farm

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Fishery-based integrated farming

Name of the farmer: **Smt. Suniti Mondal**

Area of the farm: 4.0 ha

Location of the farm: Saheberabad II village, Sonarpur block, South 24 Paraganas district

In the saline and cyclone-prone landscape of South 24 Parganas district, Smt. Suniti Mondal has orchestrated a remarkable transformation by harnessing the potential of wetlands for integrated aquaculture farming. Her visionary approach not only mitigates the inherent risks associated with coastal farming, but also exemplifies sustainable agricultural practices that thrive amidst adversity. Smt. Suniti Mondal's integrated farm have diverse enterprises including fishery, vegetable cultivation, spices, cattle rearing, goat farming, poultry, and duckery. Leveraging the expansive water resources of the wetlands, fisheries emerge as the cornerstone of her operations. She has curated a diverse fishery ecosystem with Indian major carps, chitala, tilapia, and air-breathing fishes, maximizing productivity in the face of environmental challenges. The financial viability of her 4.0 ha fishery-based integrated farm is underscored by a robust Benefit-Cost ratio of 2.45, yielding an impressive annual net income of Rs. 27,17,450.00. Fisheries spearhead this economic success, contributing Rs. 22,92,000.00, followed by cereal production (Rs. 1,83,000.00), animal husbandry (Rs. 1,16,600.00), vegetables (Rs. 1,00,350.00), and spices (Rs. 19,500.00). Smt. Suniti Mondal's farm surpasses her family's nutritional needs, providing a bounty of fish, cereals, spices, vegetables, milk, eggs, and meat from farm-fresh sources. This holistic approach not only secures food security, but also underscores the potential of wetland-based integrated farming in challenging coastal environments with an annual net return of Rs. 6,78,612.50 from a 1.0 ha area. Smt. Suniti Mondal's success story illuminates the path towards resilient and environmentally friendly agriculture, demonstrating that with innovation and determination, coastal wetlands in West Bengal can flourish as centers of sustainable aquaculture and integrated farming, fostering economic prosperity and food sovereignty.

Key Words

Integrated aquaculture, Sustainability, Wetland aquaculture, Cereal, Vegetable culture, Spice, Agriculture, Livestock, Coastal and saline zone, South 24 Parganas

Figure 116: Smt. Suniti Mondal at her fishery-based integrated farm

Introduction

A 38-year-old women farmer named Smt. Suniti Mondal is the native of Saheberabad II village in the Sonarpur block of the South 24 Paraganas district (Fig.117). The settlement of Saheberabad II is located 8 kilometers from Sonarpur Town. On her farm, she has created an integrated aquaculture system that works with animal husbandry and crops. Farm situated in 30 Bigha (4.0 ha) wetland area coming under coastal and saline region. It is a portion of the magnificent east Kolkata wetlands (EKW). In Saheberabad II village, integrated fish farming provides a living for more than 80% of the inhabitants. Smt. Suniti Mondal was born into a family of farmers who belong to the clade of scheduled caste minorities of India.

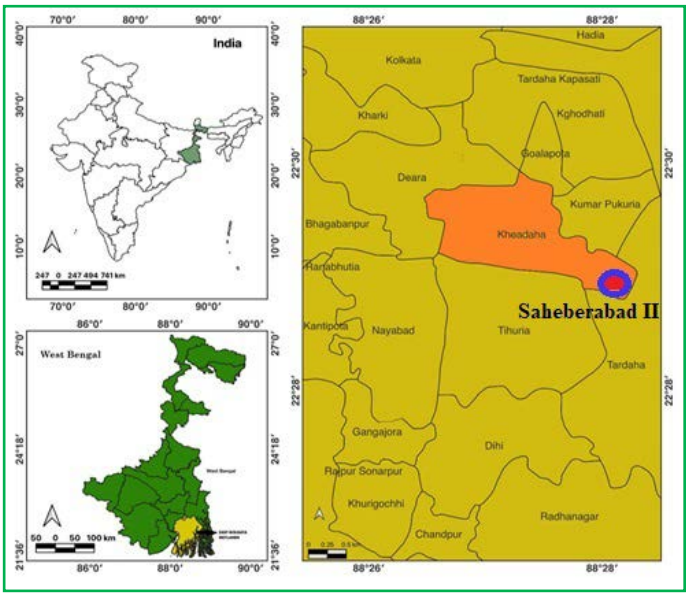


Figure 117: Map showing the aquaculture-based integrated farm of Smt. Suniti Mondal in Saheberabad II

In the year of 1982, after completing her 12th standard, she joined her parents in farming. In 2015, Sasya Shyamala Krishi Vigyan Kendra (SSKVK) informed Smt. Suniti Mondal about integrated farming. From November to February, Sonarpur experiences cold weather. The summer months of March through June are hot, and July through October sees sporadic rainfall. Yet farming has never been restricted by the weather. Humas-filled Gangetic black-clay makes up the soil. Even though it is sewage water aquaculture in Saheberabad II, the pond water is occasionally refreshed by rain and used for irrigation during the months of rabi and zaid seasons.

The Saheberabad II agro climate is favorable to the cultivation of agricultural crops such as vegetables, cereals, and spices. It is commonly known that the Sonarpur wetlands are a major producer of crops including bottle gourd, bitter gourd, amaranthus, spinach, tomato, pumpkin, and chilli. The various varieties of fish raised in the ponds include tilapia, catla, rohu, mrigal, and catfish. Flooding from cyclones and significant rains raises the risk of crop damage. Disease outbreaks, water shortages, and weed issues plague the aquaculture, agriculture, and animal husbandry sectors in the summer. Because of the fertile soil, this terrain is particularly fruitful for crop farming, aquaculture, as well as animal husbandry. The best method for sustaining fish farming here is integration. Our focus is on understanding how Smt. Suniti Mondal is effectively handling each component in order to successfully run an integrated aquaculture-agriculture-animal husbandry farm in the remote coastal and saline wetland eco-system (Fig. 118).

Figure 118: Integrated farm of Smt. Suniti Mondal

Farm description

Sustainable integrated fish farming has been maintained by Suniti Mondal. Fish farming employs air-breathing fish, Indian Major Carps (IMC), chitala, and tilapia species. In composite/polyculture ponds that are used for semi-intensive culture, she also raises mono-sex tilapia. She grows seasonal vegetables including bottle gourd, bitter gourd, amaranthus in the kharif season, spinach, tomato in the rabi season and pumpkin in the Zaid season. Sixteen desi cattle, 4 Black Bengal goats, 54 roosters (Kaveri, Desi, and Kadaknath) and 67 ducks (Khaki Campbell and White Peckin) are owned by Smt. Suniti Mondal. In response to the rising demand for grains, she also produces Gobindabhog and Jeerakathi during the rabi season and Swarna sub I during the Zaid season. Every piece of garbage generated

by this farm is entirely utilized for fertilization in the pond and soil. The farm has adopted vertical farming of vegetable and duck. The majority of farm products are consumed at home, while any excess may be sold to others. Although the Sonarpur market has a steady demand for sources of animal protein including milk, eggs, and meat, Smt. Suniti Mondal first uses the animal protein produced on her farm to meet her own needs before selling the extra. Smt. Suniti Mondal received input supports from the SSKVK and ICAR CIFA, including Shovels drums, tanks, polythene sheets, and fertilizer. Table 90 describes production costs.

Table 90: Production cost for each components of integrated farm

Components	Production cost involved (Rs)
Vegetable	141750.00
Spice	25500.00
Duck	52650.00
Poultry	21000.00
Cattle	52000.00
Fishery	1423000.00
Fodder Cultivation	1000.00
Goat	17000.00
Cereal	123000.00
Total production cost	**18,56,900**

Smt. Suniti Mondal uses sewage aquaculture and rainwater collection, which put less strain on the groundwater, to practice sustainable integrated farming methods. The biggest danger involved with growing vegetables, spices, and fish is the risk of natural catastrophes, such as floods, cyclones, water shortages during the summer, thunderstorms, or salt intrusion. Disease outbreaks and insect issues are major obstacles in wetland integrated fish farming. Knowledge, expertise, involvement in risk management training, the availability of technical advice to manage risk, and proficiency in handling risk are a few of these obstacles.

This progressive woman farmer uses the most up-to-date technology in her perfectly managed animal husbandry facilities, including hydroponic fodder production, artificial insemination in cattle, immunization, disinfection, and farm yard manure (FYM) manufacture. She is very particular about feeding vitamin-mineral mix with feed to the farm animals. She takes care to keep her farm animals in proper and cleaned shelter.

Seasonal crop rotation on the same plot of land helps to keep the soil fertile, retain and use the available natural resources more effectively, and manage insects and illnesses. She prepares organic manure from leftover livestock and crop waste and spreads it on farmland. Smt. Suniti Mondal employs small, medium, and large machines for farming and aquaculture tasks like seeding and soil preparation. She is aware that risk can be reduced in an integrated farm where one part can maintain farm economic viability even if another part fails.

Common issues in wetlands include isolation and limited access to markets. Yet, resources like seeds, planting supplies, animals, feed, veterinary medications, etc. are still moderately to highly accessible. Smt. Suniti Mondal processes the fish but also, she sells fish, vegetable, spice, egg and meat products to the local farmers directly and in the market through middlemen.

Farm layout

Smt. Suniti Mondal has maintained sustainable integrated fish farming through the use of floating cages for poultry birds over ponds, kit/probe use for water quality checking, rainwater harvesting and utilization, improved shelters for reducing heat stress in livestock, scientific fish farming, and professional advice. The farm layout is presented in Figure 119.

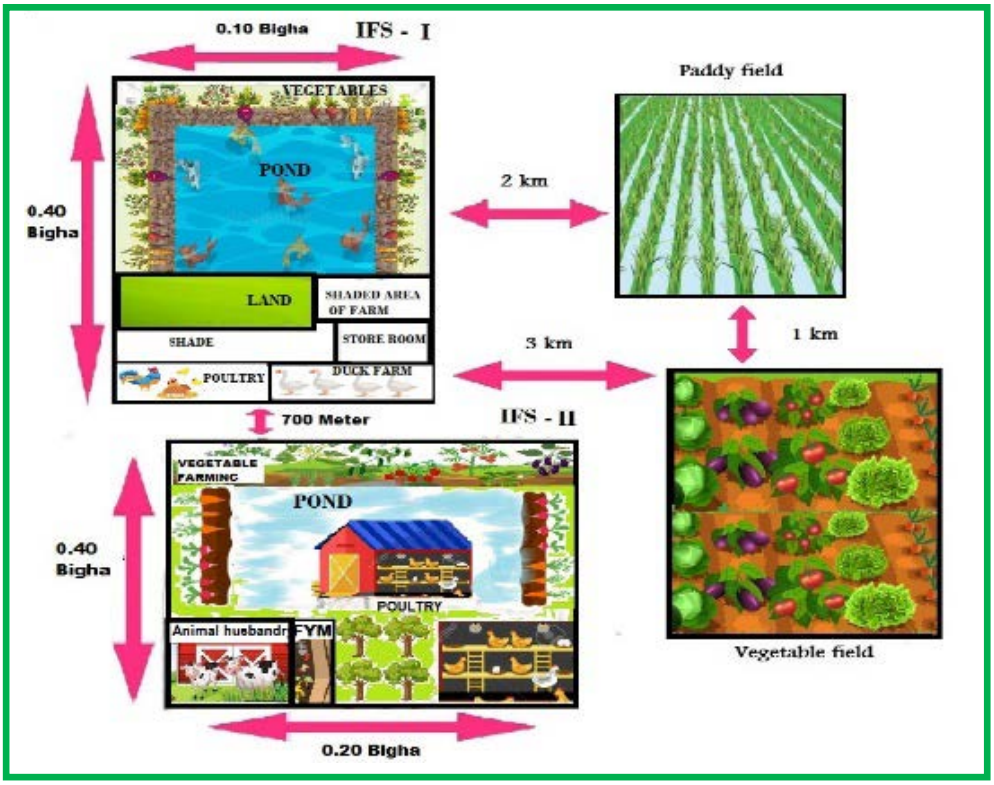


Figure 119: A farm layout with different components

Capital cost with financial assistance, if any

The capital cost invested in land is 12.38 lakhs is shown in Table 91.

Table 91: Capital cost for developing the IFS

Item	Cost per unit (Lakh Rs.)	Total cost (Lakh Rs.)	Subsidy/Govt. contribution (if any) (Lakh Rs.)
Poly house.	10 Lakh/ Unit Of 1000 m^2	10.00	5.00
Pond excavation	0.90 / bigha	1.60	1.60
Vermi compost unit	0.10/ unit	0.10	0.10
Micro sprinkler	0.10/ 3 bigha	0.10	0.10
Drums	-	0.08	0.08 from SSKVK
Shovels	-	0.04	0.04 from SSKVK
Tanks	-	0.26	0.26 from SSKVK
Polythene sheets	-	0.10	0.10 from SSKVK
Fertilizer	-	0.10	0.10 from SSKVK
Total Cost		12.38	

Bio-economic circularity of the farm

The integrated system functions as a recycling system by using the trash produced by one system in another. While Smt. Suniti Mondal isn't familiar with the term "integrated farming", but she is aware of how to maximize productivity, cut costs associated with farming, and reduce environmental pollution by using waste from one component as an input to another. The excreta of animals is used to prepare organic manure which is then used in agricultural fields to grow crops. It helps in reducing the cost of buying chemical manure for agriculture. Livestock animals and poultry are fed on leftover of crop and vegetables that greatly reduce the cost of purchased formulated feed from market. The animal excreta and cattle manure are also utilized as fertilizer for fish ponds, and the cycle continues as a self-sustaining, a self-complementary sustainable system (Fig.120). As reported by Smt. Suniti Mondal, an amount of Rs. 28,300.00 is being circulated in the form of bio-economics in the farm.

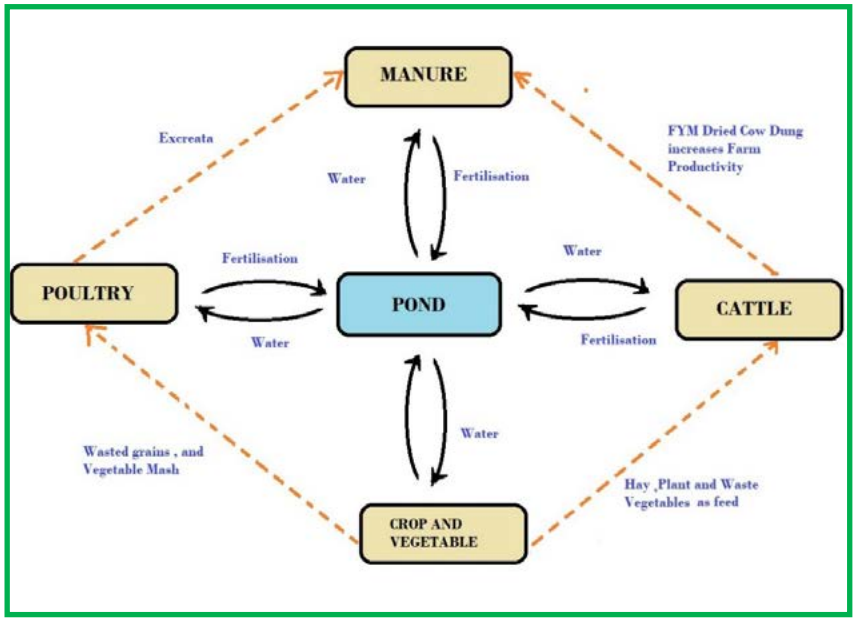


Figure 120: Resource recycling system at the farm of Smt. Suniti Mondal

Farm economic viability

Smt. Suniti Mondal concentrates on IMC, Tilapa, Chithala, and air-breathing fish in her aquaculture-based integrated farm; the net profit from this fishery sector is Rs. 22,92,000.00 which is followed by grain production (Rs. 1,83,000.00), animal husbandry (Rs. 1,15,600.00), vegetable production (Rs. 1,00,350.00), and spice production (Rs. 23,500.00), thus indicating to the fact that it is truly fishery based integrated farm. Smt. Suniti Mondal estimated that the typical household expenses were Rs. 38,000.00 per year on things like food, health care, education, and other things. Fig 121 shows the ratio of net income to the sum of the component incomes. Fishery provides the highest net income (84.0%) followed by cereal (7.0%), vegetable (4.0%), livestock (4.0%) and spices (1.0%). The income analysis shows that an aquaculture-based integrated farm in 4.0 ha area can provide a benefit cost ratio (B:C) of 2.46. An investment of Rs. Rs. 18,56,900 can result an annual net income of Rs. 27,14,450.00 from a 4.0 ha area.

Table 92: Annual economics of Smt. Suniti Mondal's integrated farm

Components	Production	Gross Income (Rs.)	Net Income (Rs.)
Vegetable	18050 kg	242100.00	100350.00
Spice	1800kg	49000.00	23500.00
Duck	2000 eggs, 235 kg meat	74750.00	22100.00
Poultry	1500 egg 150 kg meat	34500.00	13500.00
Cattle	3600 l Milk	126000.00	74000.00

Components	Production	Gross Income (Rs.)	Net Income (Rs.)
Fishery	32460 kg	3715000.00	2292000.00
Fodder Cultivation	200 kg	4000.00	3000.00
Goat	30 kg meat, 2 kid	23000.00	6000.00
Cereal	9000 kg	306000.00	183000.00
Total		**4574350.00**	**2717450.00**

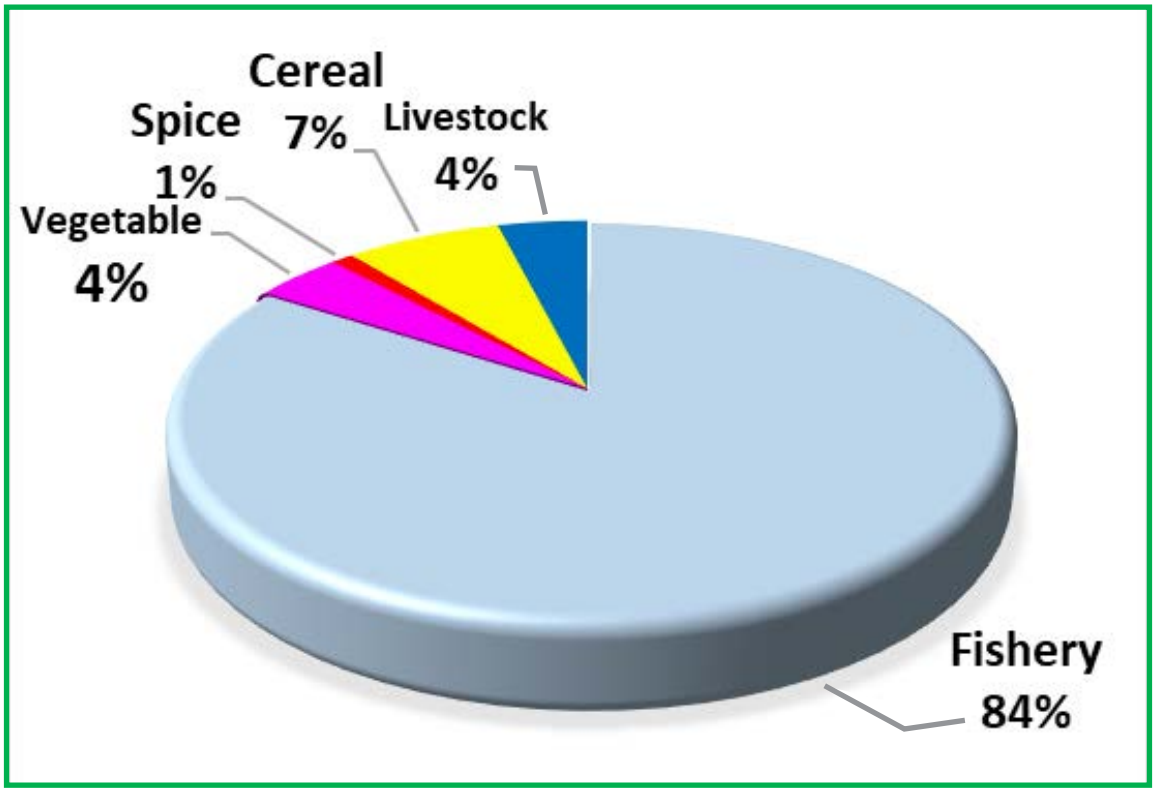


Figure 121: The percentage net income generated from each of the component in integrated farming

Conclusion

Smt. Suniti Mondal uses only 4.0 ha of her land for integrated farming, which generates a significant profit for her. Reliance on a self-complementary system, farming with a range of crops (cereal, vegetables, animal husbandry, fisheries, fodder production, and spices) has rendered the environment green and agriculture sustainable. For effective agricultural practices, employing organic manure to increase soil fertility is essential. Smt. Suniti Mondal uses rainwater collected in ponds as well as sewage water to irrigate her crops and vegetables, decreasing the burden on the wetland's limited groundwater supply. Smt. Suniti Mondal is able to meet the dietary needs of his three-person household by producing enough grain, vegetables, milk, meat, fish, and eggs from her farm. Smt. Suniti Mondal wishes to keep expanding the scope of integrated farming by looking at the potential integration of a number of new elements, such as pearl culture and mushroom cultivation. She is excited to impart her integrated farming expertise to the local farmers in order to advance the local agricultural practices. She is a proud farmer who is quite happy with her line of work. Smt. Suniti Mondal is concerned for her next generation who should continue farming. Hence, she wants to educate her child with higher levels of farming practices. With a net return of Rs. 27,17,450.00 from 4.0 ha of land, Smt. Suniti Mondal's narrative vividly demonstrates the technical and financial viability of building an integrated farm based on aquaculture. Nonetheless, having access to farm fresh and healthy food for feeding one's family is better than purchasing the same thing from a store.

Harmonising insights: A holistic view of integrated farming in West Bengal

Based on the highest net income from specific components (agriculture, horticulture, livestock, or fishery) and their corresponding scores, the 60 Integrated Farming Systems (IFS) under study are categorized into four groups. The analysis reveals that the majority of IFSs are horticulture-based (35.0%), followed by livestock-based (25.0%), fishery-based (21.7%), and agriculture-based (18.3%). This document presents 24 case studies on IFSs in West Bengal, spanning six agro-climatic zones. These case studies offer valuable insights into sustainable agricultural practices, economic viability, livelihood enhancement, employment opportunities, and environmental conservation, providing a comprehensive approach to developing and managing IFSs across the diverse agro-climatic zones of West Bengal.

Key words:

Agro-climatic zone, Cereal, Horticulture, Livestock, Agroforestry, Aquaculture, Bio-economic circularity, Sustainability, Employment generation.

Introduction

The diverse agro-climatic zones of West Bengal present unique challenges and opportunities for farming. To harness the full potential of these zones, integrated farming systems (IFSs) that combine horticulture, livestock, fisheries, and other agricultural practices have emerged as sustainable solutions. These systems not only improve farm income, but also promote environmental sustainability, food security, and employment generation. This synthesis explores the successful implementation of various integrated farming systems across different agro-climatic zones in West Bengal, demonstrating the versatility and resilience of these approaches.

Hill Agro-climatic Zone

In the Hill Agro-climatic Zone, particularly in the Kalimpong hills, horticulture-based integrated farming has become a cornerstone for sustainable agriculture. Combining spice cultivation with other horticultural practices has maximized income for farmers, leveraging the unique climatic conditions of the region. Additionally, the integration of livestock, such as piglet production systems, has brought wealth and prosperity to farm families. This synergy between livestock and crop production further strengthens the sustainability of agriculture in the Kalimpong hills.

Terai Agro-climatic Zone

Moving to the Terai Agro-climatic Zone, horticulture-based integrated farming continues to provide a sustainable revenue source, particularly in the Jalpaiguri district. Fishery-based integrated farming has also set a notable example for augmenting income, while intercropping fruit plants and vegetables in Uttar Dinajpur maximizes farm income. In Alipurduar, poultry farming has emerged as a key component of livestock-based integrated farming, contributing significantly to income generation.

Old Alluvial Agro-climatic Zone

In the Old Alluvial Agro-climatic Zone, goat-based agroforestry farming has proven to be a game-changer, maximizing income and generating employment, particularly in Dakshin Dinajpur and Murshidabad districts. Fishery-based integrated farming has provided tribal farmers in Dakshin Dinajpur with sustainable alternatives to traditional farming practices, while livestock-based systems have played a vital role in sustainable employment generation.

New Alluvial Agro-climatic Zone

The Burdwan district has seen success with vegetables-based integrated farming, guided by Good Agricultural Practices (GAP), offering a beacon of hope to the farmers. Livestock-based integrated farms, like those managed by Fazla Haque, have inspired new aspirations among livestock keepers. In North 24 Parganas, the integration of fishery with vegetable farming has optimized income in traditionally vegetable-growing areas, and smallholders in Nadia district have found sustainability and profitability through horticulture-based integrated farming.

Red and Laterite Agro-climatic Zone

In the challenging terrain of the Red and Laterite Zone, agriculture-based integrated farming has improved income and nutrition in upland areas of Birbhum. Fishery-based integrated farming in the undulating terrain of Bankura and horticulture-based systems in

Jhargram have similarly enhanced income. In Purulia, sustainable poultry-centric livestock systems have fostered entrepreneurship and bolstered rural economies.

Coastal Saline Agro-climatic Zone

In the Coastal Saline Agro-climatic Zone, fish-based integrated farming has emerged as a sustainable livelihood strategy in South 24 Parganas. Innovations such as land shaping and rainwater harvesting have opened new vistas for sustainable agriculture, while the cultivation of vegetables on land embankments has proven to be both profitable and sustainable. The region's wetlands have also found eco-friendly, profitable uses through fishery-based integrated farming ventures.

Key Takeaways

These case studies on IFSs unfold the recognition of their potential to transform agriculture into a more sustainable and diversified system and offer the following takeaways.

Learning from real-world examples: The case studies provide insights into actual implementations of IFSs in specific contexts, considering factors such as climate, soil type, market demand, and socio-economic conditions. By examining real-world experiences, readers can understand the approaches within IFSs, innovative practices, successes, and lessons learned from these initiatives. The readers realize the complexity of the real world in which the farmers and farm families operationalized IFS.

Holistic approach: The present case studies on IFSs emphasize the interconnectedness of various agricultural components such as crops, livestock, fisheries, and agroforestry. Understanding this holistic approach can lead to improved resource utilization, enhanced productivity, increased farm income and environmental sustainability.

Resource optimization: West Bengal faces challenges related to small land holdings and limited irrigation facilities. These case studies on IFSs showcase how limited resources can be optimally utilized through practices such as intercropping, crop rotation, efficient water management techniques and recycling of bio-resources.

Diversification for resilience and income sources: IFSs typically involve the integration of crops, livestock, fisheries, and other allied activities. Such diversification can help farmers mitigate risks associated with mono-cropping, climate variability, market fluctuations, and pest outbreaks and enhance resilience and stability in the face of uncertainties by providing multiple income streams.

Nutritional security: IFSs contribute to nutritional security by promoting dietary diversity, producing nutrient-rich foods, and providing culturally appropriate food sources to local communities. IFSs empower local communities with the knowledge and skills to produce their own food sustainably as well as, reduce vulnerability to external shocks such as price fluctuations or supply chain disruptions.

Agricultural sustainability and environmental stewardship: West Bengal is primarily an agrarian state with a diverse range of crops and farming practices. These case studies demonstrate how sustainable agricultural practices can be implemented to ensure long-term productivity while contributing to environmental conservation through practices such as organic farming, conservation tillage, biodiversity enhancement and the use of biopesticides and biofertilizers. This can help in preserving soil fertility, water conservation, and biodiversity preservation.

Livelihood improvement: The present case studies on IFSs offer opportunities for income generation, employment, and livelihood improvement, particularly for smallholder farmers.

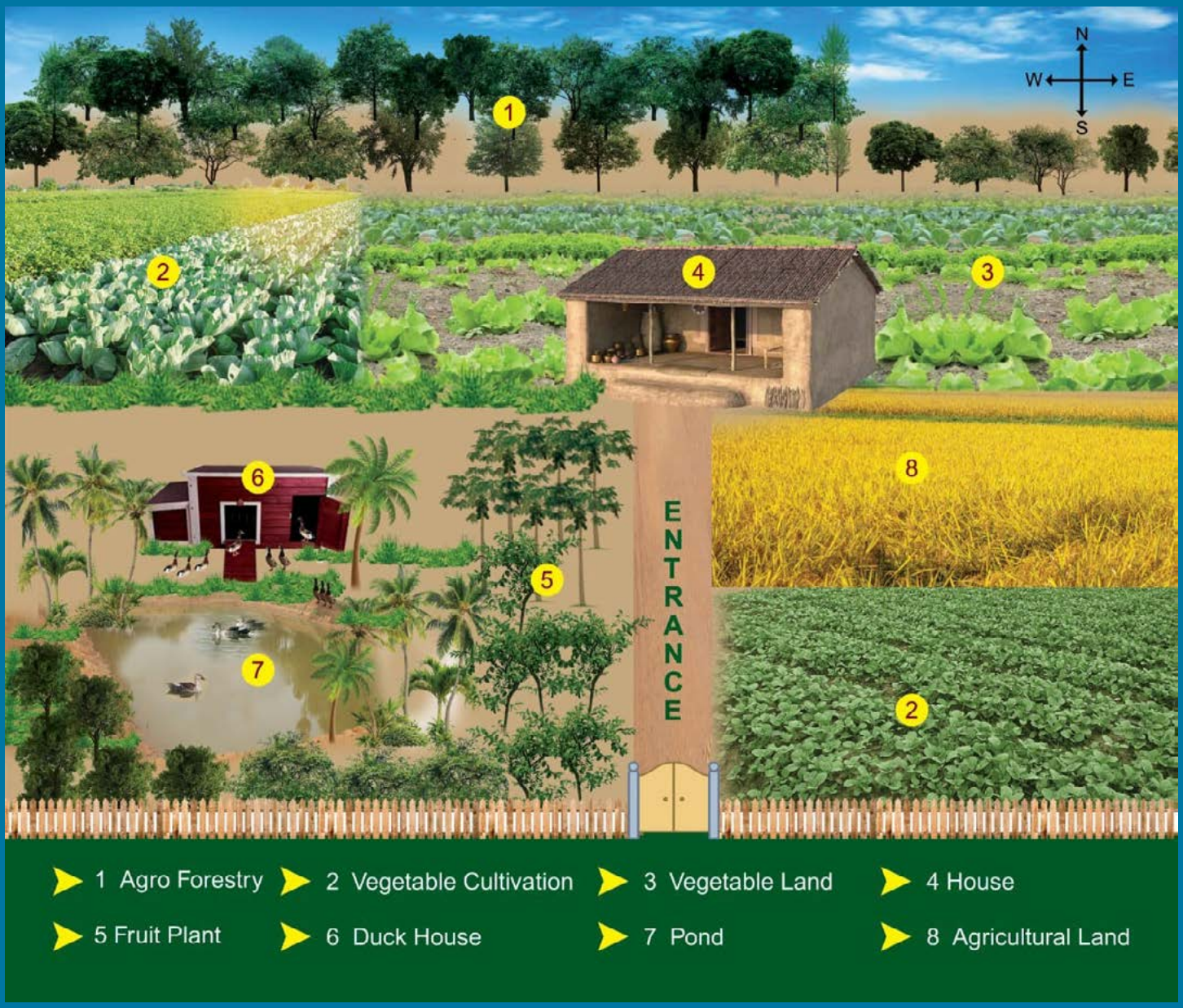
Community engagement and knowledge sharing: The documented case studies depict knowledge exchange among farmers, researchers and extension agents, and networking with different institutions.

Bankable project formulation: The current case studies on IFSs across six agro-climatic zones of West Bengal can serve as a valuable resource for formulating bankable projects or area development schemes. These case studies provide evidence of technical feasibility with best practices and economic viability including financial returns and financial plan, thereby increasing the likelihood of securing funding and achieving project success.

Policy implications: Case studies offer valuable insights to the policymakers, researchers, and development practitioners for targeted policy formulation, program design, and resource allocation. Policies that support and incentivize the adoption of integrated farming practices can foster sustainable agriculture, food security, and rural development. Policymakers may leverage insights into driving factors to replicate successful integrated farming initiatives on a larger scale. Overall, studying case studies on IFSs underscores the potential of this approach for making a pathway towards a more resilient, equitable, and environmentally friendly food system.

Conclusion

Across diverse agro-climatic zones of West Bengal, integrated farming systems have shown their potential to transform agricultural practices, improve farm incomes, and promote sustainability. By integrating traditional knowledge with modern techniques and fostering community engagement, these systems ensure the long-term viability of agriculture and the well-being of rural communities. These case studies underscore the importance of tailored, zone-specific approaches in addressing the unique challenges faced by farmers, ultimately contributing to a more resilient and prosperous agricultural sector.



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