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Economic Evaluation of the Integrated Farming System (IFS) Model: A Pathway to Sustainable Rural Livelihoods in India

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ABSTRACT

The Integrated Farming System (IFS) approach has emerged as a holistic solution for achieving Sustainable Rural Livelihoods (SRL) and fostering inclusive growth. This paper reviews the region-specific suitability and successful implementation of IFS models across India. It specifically presents an economic evaluation of the IFS model (1 ha-Irrigated) developed by ICAR-IARI, New Delhi, focusing on the empirical feasibility of implementing this innovative system. A financial feasibility analysis was conducted using three indices: Net Present Worth (NPW), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR), based on a primary survey of nine distinct enterprises within the IFS model. Additionally, scenario analysis assessed three different project durations. India's diverse agro-climatic regions have led to various IFS models, each tailored to specific regional needs. The IFS model by ICAR-IARI, developed for small and marginal farmers, has been found financially feasible, assuming a discount rate of 10 percent and a project life of 15 years. This model also provides significant year-round employment opportunities. As the project life extends, overall performance and outcomes for individual components improve. Despite challenges, the IFS model shows substantial potential for future exploration, offering a promising solution for sustainable growth in Indian agriculture and contributing to sustainable rural livelihoods.

Keywords: Integrated farming system, sustainable rural livelihood, financial feasibility analysis, rural economy

JEL codes: Q01, Q12, Q14, Q18, R11

I

INTRODUCTION

India is predominantly a rural country with 68.8 per cent of the country's population and 72.4 per cent of the workforce residing in rural areas (GoI, 2011). Besides producing almost all agricultural produce, rural areas contributed around one-third of non-farm output and 48.7 per cent of non-farm employment in the country (Chand et al., 2017). Population projections indicate that India will continue to be predominantly rural till the year 2050, after which the urban population is estimated to overtake the rural population (United Nations, 2012). In making the Indian economy a 5 trillion-dollar economy by the year 2025, the role of the rural economy will be of utmost importance (Abdin and Kumar, 2020).

After 2004-05, rural areas witnessed negative growth in employment despite a 7.45 per cent annual increase in output (Chand et al., 2017). The main reason behind this is the withdrawal of females from the labour force (Chand and Srivastava, 2014) due to an increase in the statutory minimum wage, manufacturing jobs being relocated away from habitation, a lack of skills and rising tension between labour and employers (Chand et al., 2017). Besides, Indian agriculture is faced with multifaceted

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challenges such as declining trends in average size of land holding (GoI, 2015-16), small farm holdings, limited access to essential farm resources, poor resource use efficiency, stagnant productivity and non-profitability of agricultural entrepreneurs (Rathore et al., 2019).

The concept of Sustainable Rural Livelihood (SRL) is an attempt to go beyond the conventional definitions and approaches to poverty eradication through different livelihood capitals such as human capital, social capital, natural capital, physical capital and financial capital to cope with shocks and stresses and maintain or enhance the individual's capabilities and assets both in present and in the future without degrading the natural resource base (Dadabhau et al., 2013). Achieving SRL in India calls for a holistic approach, such as an integrated farming system (IFS), that can address many challenges which small and marginal farmers face, and who constitute more than 86% of small farm holders (Kashyap et al., 2015; Singh et al., 2019). In IFS, an output from one subsystem, which otherwise may have been wasted, becomes an input to another subsystem, resulting in a greater efficiency of output of desired products from the land/water area under a farmer's control (FAO, 2010).

An IFS model of one hectare has been developed at ICAR-Indian Agricultural Research Institute, New Delhi, with the potential to ensure the livelihood security of small and marginal farms. Several studies on IFS have been conducted, but most of them have predominantly focused on agronomic analyses, and insufficient attention has been given to a comprehensive economic assessment of IFS models. In response to this gap, the present study explores the economic aspect of the IFS model of IARI and its potential for attaining SRL in rural India.

II

METHODOLOGY

The study is based on both primary and secondary data. Primary data were collected in consultation with the scientist in charge of the Integrated Farming System (IFS) Model at ICAR–IARI. The variables covered included detailed descriptions of each enterprise, cost components, and returns from both main products and by-products. Comprehensive data were compiled for the IFS model, which consists of nine modules as described below.

- **Module 1 – Crop Production:** This module covers 0.7 ha and integrates six components (cereals, pulses, oilseeds, vegetables, fruits, and flowers) under nine diverse cropping systems. The cropping systems ensure year-round utilization of land and resources.
- **Module 2 – Pisciculture:** A 0.1 ha pond (50 m × 20 m, 2 m depth) was constructed for composite fish culture. Catla (*Catla catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*), and Grass carp (*Ctenopharyngodon*

idella) were stocked in a 3:4:3:2 ratio at a density of 12,000 fingerlings/ha. Fish farming was integrated with duckery for efficient nutrient recycling.

- **Module 3 – Duckery:** A cost-effective duck shed was constructed on the pond embankment, accommodating 35 Khaki Campbell ducks (32 females and 3 males). Birds were fed with a wheat–pearl millet mixture (3:2) at 100 g/bird/day, while their droppings contributed to pond manuring, enhancing pisciculture productivity.
- **Module 4 – Poultry:** A raised poultry house supported on iron pillars above the pond was constructed to accommodate 50 Kadaknath birds. The birds were fed the same wheat–pearl millet mixture (3:2, 100 g/bird/day). Integration with the pond ensured recycling of droppings into the aquatic system.
- **Module 5 – Apiary:** Four boxes of *Apis mellifera* were maintained, with nectar primarily sourced from seasonal flowering crops. Sugar syrup was provided only during lean flowering periods.
- **Module 6 – Agroforestry:** Twenty-two trees were planted on 0.012 ha boundary land at 4 m spacing, including 21 moringa (*Moringa oleifera*) and one neem (*Azadirachta indica*), providing biomass for food, fodder, and medicinal use.
- **Module 7 – Composting Unit:** Four vermicompost pits (3 m × 1 m × 1 m) were established using *Eisenia foetida* earthworms for decomposing crop residues and cow dung. This ensured sustainable nutrient recycling through organic manure production.
- **Module 8 – Biogas Plant:** A Khadi and Village Industries Commission (KVIC) model biogas plant of 2 m^3 capacity was installed. The digester was charged with cow dung and water in a 1:1 ratio, generating biogas for energy needs and slurry for soil nutrient management.
- **Module 9 – Dairy:** A cattle shed was constructed with three crossbred cows (two Holstein Friesian and one Jersey), supported by a paddock and dung/urine tanks. Animals were fed crop residues and weed biomass, contributing to milk production, dung, and overall nutrient cycling.

The detailed production outputs from each module are presented separately in *Annexure 1.*

2.1 Economic Feasibility Analysis

In this study, for each of the components as well as for the whole model, feasibility analysis has been done using the discounted cash flow measure, taking a 15-year project life and a 10% discount rate. Under this measure, three indices have been calculated, i.e., Net Present Worth (NPW), B:C Ratio (BCR) and Internal Rate of Return (IRR) (Scandizzo, 2021).

B_t and C_t are the benefit and cost at time t, respectively, T is the project life, and r is the discount rate. A project with a positive NPW is preferred over a negative NPW, and NPW=0 makes the investor indifferent.

$$NPW = \sum_{t=0}^{T} \frac{(B_t - C_t)}{(1+r)^t}$$

If the BCR exceeds one, then the project is viable.

$$BCR = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}}$$

IRR is the annual growth rate that an investment is expected to generate, and evaluate the desirability of investments. IRR is the discount rate at which the present value of total benefits equals the present value of total costs:

$$PV(Benefits) - PV(Costs) = 0$$

Thus, these measures collectively provide a robust framework for assessing the economic feasibility of the IFS model at both the enterprise and system levels.

III

RESULT AND DISCUSSION

3.1 Regional Evaluation and Tailored Approaches for Integrated Farming Systems (IFS) in India

Numerous studies across the country have been undertaken to develop customized IFS models suitable for specific agro-ecoregions. These provide a good understanding of the challenges and opportunities faced by IFS in each region (Patidar and Dhiman, 2020). The list of these studies is given as follows:

3.1.1 Northern and Central Zone

Singh et al. (2011) highlighted the popularity of the Crops + Dairy model among farmers in Meerut, UP, and suggested additional components like poultry, apiary, floriculture, and vegetables. Choudhary et al. (2012) highlighted the importance of crop husbandry, horticulture, and livestock rearing in Mandi district, Himachal Pradesh. Meshram et al. (2019) in Mandla, Madhya Pradesh, bring out the employment potential of the Crops + Dairy model, and suggested additional components for sustainability. Sharma et al. (2021) explored economic opportunities under rainfed regions through livestock, poultry, mushroom, and traditional farming systems in Samba and J&K. These studies underscore the importance of diversified farming tailored to the needs of smallholders and marginalized farmers.

3.1.2 Eastern Zone

In Bihar, Kumar et al. (2012) identified seven farming systems, with Paddy + Fish + Duck + Goat being the most productive. Chatterjee et al. (2015) in Nadia, West Bengal, highlighted crop diversification's economic benefits. Burman et al. (2015) in Ranchi, Jharkhand, analysed IFS economics, with Paddy + Fishery + Poultry + Dairy, most commonly observed. Dash et al. (2015) demonstrated IFS benefits in Khordha, Odisha, focusing on pond integration. Poonam et al. (2019) developed Rice-Fish models for Eastern India, emphasizing their suitability and effectiveness. These studies highlight the role played by rice-fish based IFS models for sustaining the livelihoods in the eastern region.

3.1.3 Southern Zone

In Karnataka, Kiresur et al. (2010) found FS-II (Horticultural crops + Dairy) outperforms FS-I (Field Crops + Dairy + Drought animals) economically. In Rangareddy, Telangana, Rao et al. (2017) discovered RF+LS+I (Rainfed crop + Livestock + Irrigated Crops) yields the highest household income while reducing market dependency. In Visakhapatnam, Andhra Pradesh, Rao et al. (2020) identified rice or sugarcane-based systems with dairy as most profitable. Saravanakumar et al. (2020) examined major farming systems in Coimbatore and Erode, Tamil Nadu and found fruit-based and turmeric-based systems most profitable.

3.1.4 Western Zone

Patel et al. (2016) identified the most suitable IFS model for North Gujarat as a combination of crops, horticultural units, boundary plantation, livestock, and vermicompost. In Southern Rajasthan, Singh et al. (2017) evaluated four farming systems across Chittorgarh and Banswara districts, and highlighted FS-I (Crop + Vegetables) and FS-IV (Crop + Poultry) as economically viable options under irrigated and rainfed conditions, respectively. Sonawane et al. (2020) documented nineteen different IFS models in Pune and Solapur, Maharashtra, with the Agriculture + Horticulture + Value-addition model emerging as the most promising among farmers.

The ICAR-AICRP on IFS has also recommended specific IFS models for different agro-ecoregions (Table 1) to harness local resources efficiently, optimize agricultural productivity, and enhance sustainability.

TABLE 1. RECOMMENDED IFS MODELS ACROSS VARIOUS AGRO-CLIMATIC ZONES OF INDIA

Agro-climatic region (No. of IFS Models)	Locations (State)	Prevailing Farming System	Suggested IFS Model	Increase in profit (%)
Western Himalaya (3)	Chatha (Jammu & Kashmir)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Poultry + Agroforestry + Apiary	254
	Palampur (Himachal Pradesh)	Livestock + Cereals based	Crop + Dairy + Horticulture	306
	Pantnagar (Uttarakhand)	Crop + Dairy + Tree plantation	Crop + Dairy + Horticulture + Agroforestry	92
Eastern Himalaya (2)	Jorhat (Assam)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Apiary	669
Trans Gangetic Plains (2)	Hisar (Haryana)	Crop + Dairy	Crop + Dairy + Horticulture +	257
	Ludhiana (Punjab)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Agroforestry + Apiary	144
Upper & Middle Gangetic Plains (7)	Modipuram (Uttar Pradesh)	Crop + Dairy	Crop + Dairy + Horticulture + Mushroom + Biogas	373
	Varanasi (Uttar Pradesh)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Poultry + Mushroom	431
	Patna (Bihar)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Goat/Poultry/Duckery + Mushroom	184
	Sabour (Bihar)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Goat + Duckery	296
Lower Gangetic Plains (1)	Kalyani (West Bengal)	Crop + Dairy + Vegetable/Goat/Poultry	Crop + Dairy + Horticulture + Fishery	109
Eastern Plateau and Hills (2)	Raipur (Chhatisgarh)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Poultry + Mushroom	134
	Ranchi (Jharkhand)	Crop + Dairy /Goat + Pig	Crop + Dairy + Horticulture + Fishery + Mushroom	298
Western Plateau and Hills (3)	Akola (Maharashtra)	Crop + Goat + Horticulture + Poultry	Crop + Dairy + Horticulture + Goat/Poultry	216
	Rahuri (Maharashtra)	Crop + Dairy	Crop + Dairy + Horticulture + Poultry	226
Southern Plateau and Hills (4)	Coimbatore (Tamil Nadu)	Crop + Dairy	Crop + Dairy + Horticulture + Goatery	88
	Rajenderanagar (Telangana)	Crop + Dairy + Horticulture	Crop + Dairy + Horticulture + Fishery + Poultry	222
	Sriguppa (Karnataka)	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Goat	118
East Coast Plains and Hills (1)	Bhubaneswar (Odissa)	Crop + Dairy + Horticulture	Crop + Dairy + Horticulture + Apiary + Fishery + Poultry/Duckery + Agroforestry + Mushroom	265
West Coast Plains and Hills (7)	Goa	Crop + Dairy	Crop + Dairy + Horticulture + Fishery + Mushroom	643
	Karjat (Maharashtra)	Crop + Livestock	Crop + Dairy + Horticulture + Goat/Poultry	26
Western dry (1)	Kota (Rajasthan)	Crop + Dairy	Crop + Dairy + Horticulture + Goat/Poultry	78
Gujarat Plains and Hills (1)	S K Nagar (Gujrat)	Crop + Dairy	Crop + Dairy + Horticulture	354

Source: AICRP on Integrated Farming Systems, Annual Report 2016–17, ICAR–IIFSR, Modipuram, Meerut.

TABLE 2. SUCCESSFUL IFS MODELS FOR DIFFERENT AGRO-CLIMATIC ZONES ACROSS INDIA

States	IFS Models	Area (ha)	Annual Net Return*
	Zone-I (Ludhiana)		
Punjab	Crop+Vegetables+Agro-forestry	2.42	4.37
Himachal Pradesh	Crop+Dairy+Mushroom+Sericulture	1.00	2.46
Uttarakhand	Crop+Dairy+Fodder+Fisheries+Poultry+Mushroom+Vermi-pits+Biogas	1.00	3.06
Jammu & Kashmir	Crop+Vegetables+Fruit+Dairy+Fisheries+Poultry+Mushroom+Vermi-pits+Biogas	4.04	1.73
	Zone-II (Jodhpur)		
Rajasthan	Crop+Vegetables+Spices+Dairy	6.00	10.00
Haryana	Crop+Vegetables+Dairy	5.50	6.50
Delhi	Crop+Vegetables+Dairy+Apiary	8.00	32.50
	Zone-III (Kanpur)		
Uttar Pradesh	Crop+Vegetables+Dairy+Fisheries	1.00	3.21
	Zone-IV (Patna)		
Bihar	Crop+Dairy+Fisheries+Poultry+Vermi-pits	0.60	5.29
Jharkhand	Crop+Dairy+Fisheries+Poultry+Ducks	2.02	7.80
	Zone-V (Kolkata)		
A & N Islands	Fisheries+Ducks+Horticulture	0.10	0.29
Odisha	Fisheries+Dairy+Horticulture	1.60	5.11
West Bengal	Fisheries+Ducks+Horticulture+Dairy+Poultry	0.47	1.22
	Zone-VI (Guwahati)		
Assam	Crop+Fisheries+Ducks+Horticulture	1.00	5.10
Arunachal Pradesh	Crop+Fisheries+Piggery+Horticulture	1.00	1.52
Sikkim	Crop+Vegetables+Dairy+Poultry+Vermi-pits	1.00	2.40
	Zone-VII (Barapani)		
Manipur	Crop+Poultry+Piggery	0.87	7.20
Meghalaya	Horticulture+Fisheries+Poultry+Vermi-pits	0.13	1.25
Mizoram	Horticulture+Fisheries+Livestock	1.25	6.55
Nagaland	Fruit+Piggery+Poultry	0.70	3.12
Tripura	Horticulture+Agriculture+Livestock	1.05	4.60
	Zone-VIII (Pune)		
Maharashtra	Fisheries+Horticulture+Poultry+Sericulture	1.30	6.33
Gujarat	Fisheries+Horticulture+Dairy+Poultry+Vermi-pits	3.20	2.30
Goa	Horticulture+Livestock+Apiary	6.00	40.77
	Zone-IX (Jabalpur)		
Madhya Pradesh	Crop+Vegetables+Dairy+Poultry+Goatry+Vermi-pits	1.00	2.27
Chhattisgarh	Crop+Vegetables+Dairy+Poultry+Goatry+Ducks+Piggery+Vermi-pits	1.50	1.13
	Zone-X (Hyderabad)		
Andhra Pradesh	Rice+Livestock+Poultry	2.22	4.64
Telangana	Crop+Horticulture+Dairy+Poultry+Goatry+Vermi-pits	0.78	2.33
Tamil Nadu	Crop+Horticulture+Dairy+Poultry+Goatry+Bio-gas	2.00	7.76
	Zone-XI		
Karnataka	Coconut-based IFS model	1.00	4.90
Kerala	Coconut-based IFS model	1.00	6.25

**in lakh rupees*

ICAR has endorsed successful IFS models for different agro-climatic zones across India based on the studies conducted by IIFSR, Modipuram. These models vary based on the state and specific area, focusing on combining various agricultural activities for optimal productivity and profitability. Among all the successful models, the highest position in terms of per-hectare annual net return has been secured by Meghalaya under Zone-VII Barapani, followed by Bihar under Zone-IV Patna and Mizoram under Zone-VII Barapani with an annual net return of Rs. 9.62 lakh/ha, 8.82 lakh/ha and 8.28 lakh/ha, respectively. Below is a summary of zone-wise all the recommended successful IFS models, their areas in hectares, and annual net returns for each zone (Table 2).

3.2 Financial Feasibility Analysis and Employment Opportunities of the IFS Model Recommended by ICAR-IARI, New Delhi

Table 3 presents the feasibility analysis of various modules along with the entire IFS model of ICAR-IARI by considering a project life of 15 years with a discount rate of 10%.

TABLE 3. FEASIBILITY ANALYSIS OF DIFFERENT COMPONENTS OF IFS MODEL, ICAR-IARI (VALUES IN LAKH RUPEES)

Modules	Fixed Cost	Variable Cost	Total Cost	Gross Return	NPW	B:C Ratio	IRR (%)
Pisciculture	11.50	7.51	19.01	28.35	3.43	1.29	16
Duckery	2.50	6.43	8.93	11.52	0.93	1.19	21
Poultry	7.34	14.02	21.36	34.01	5.31	1.45	45
Apiary	0.64	1.83	2.47	3.97	0.66	1.49	75
Vermicompost	0.57	0.65	1.22	1.80	0.09	1.11	4
Biogas Unit	0.28	1.54	1.82	2.06	0.02	1.02	2
Crop Unit	18.00	12.41	30.41	52.43	8.45	1.47	27
Dairy	10.39	42.17	52.56	74.25	8.69	1.31	33
Horticulture	1.60	4.90	6.50	28.39	6.59	2.75	19
IFS	51.99	87.51	139.50	212.30	27.86	1.35	28

Source: Authors estimate based on primary data

For computing costs, different components of fixed and variable costs were considered. For estimating gross return, both the main product and the by-product were measured. Notably, the dairy module exhibits the highest NPW of rupees 8.69 lakh, followed closely by the crop production unit with 8.45 lakh, and the Horticulture module with 6.59 lakh. In terms of B:C ratio, the Horticulture module secures the top position with 2.75, followed by the Apiary module with 1.49, and the Crop Unit with 1.47. Regarding IRR, the Apiary module again leads with 75%, trailed by the Poultry module with 45%, and the Dairy module with 33%. These rankings highlight the profitability and financial viability of various modules within the integrated farming system demonstrating notable performance across different metrics**.** The IFS model as a whole exhibits NPW of rupees 27.86 lakh, a B:C of 1.35, and an IRR of 28%, showcasing its economic viability.

Across India, Singh *et al.* (2011) in Meerut, Uttar Pradesh, and Kumar *et al.* (2012) in Patna, Bihar, both found that Crop and Dairy based IFS models yielded higher net returns and employment compared to conventional systems. Rao *et al.* (2017) in Rangareddy, Telangana, demonstrated economic advantages with Rainfed Crop+Irrigated Crop+Livestock IFS model. Saravanakumar *et al.* (2020) in Coimbatore and Erode, Tamil Nadu, found fruit-based farming systems more profitable. Lastly, Bussa *et al.* (2023) in New Delhi highlighted IFS profitability, showing marketable surplus for all components. These studies collectively underscore the economic and environmental benefits of integrated farming across diverse agricultural contexts in India.

Figure 1 depicts that the IFS model, ICAR-IARI demonstrates significant employment generation, totalling 628 man-days. The Dairy module stands out as the highest contributor, generating 365 man-days, followed by the Crop module, which provides 150 man-days of employment. Additionally, the Poultry, Pisciculture, and Duckery modules collectively contribute the third highest employment generation, providing 26 man-days. This highlights the diversified nature of employment opportunities within the IFS model, emphasizing its role in promoting livelihoods and economic sustainability. Netam *et al.* (2019) in Uttar Bastar Kanker, Chhattisgarh, reported significant returns and employment through IFS, especially with organic manure recycling.

While the rice–wheat cropping system exhibits a labour productivity of ₹1,411 per man-day, as computed in this study, the Integrated Farming System (IFS) model recommended by ICAR-IARI, New Delhi, demonstrates a substantially higher labour productivity of ₹11,477 per man-day. This marked difference highlights the efficiency gains achievable through diversified production, where crop, horticulture, livestock, and fishery components collectively generate higher returns per unit of labour. The multi-component nature of the

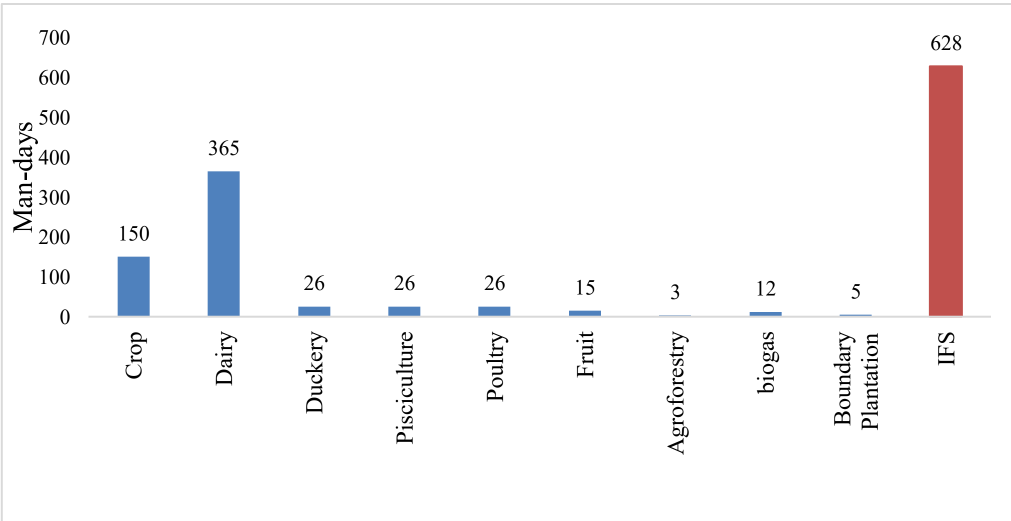

FIGURE 1. EMPLOYMENT GENERATION FROM DIFFERENT ENTERPRISES OF IFS MODEL, ICAR-IARI (1HA)

TABLE 4. COMPARISON OF LABOUR PRODUCTIVITY BETWEEN RWCS IN IGP AND INTEGRATED FARMING SYSTEM (IFS) MODEL AT ICAR-IARI

System	Net Return (₹ /ha)	Human Labour (Man-days)	Labour Productivity (₹ /man-day)
RWCS – IGP	135,816	96	1,411
IFS (ICAR-IARI, New Delhi)	7,207,647	628	11,477

Note: The Rice–Wheat Cropping System (RWCS) values have been computed across five states (Punjab, Haryana, Uttar Pradesh, West Bengal, Bihar) of Indo Gangetic Plains (IGP) for the year 2021–22, as reported by the Directorate of Economics and Statistics.

IFS not only enhances farm income but also provides greater employment opportunities throughout the year, thereby reducing seasonal underemployment common in traditional monocropping systems. These findings underscore the potential of the IFS model to improve both economic and labour-use efficiency for farmers, making it a viable alternative to conventional rice–wheat systems in terms of financial returns and sustainable livelihood generation (Table 4).

The IFS model generates strong backward linkages by creating sustained demand for diverse inputs (*Annexure 2*). It annually requires 255.2 kg of seed, 154 kg of fertilizers, 5 kg of pesticides, 1,050 m³ of irrigation water, substantial quantities of livestock and fish feed, 60 litres of diesel, and 120 hours of machine use, thereby supporting allied enterprises and input markets.

3.3 Scenario analysis of the IFS model under three different project lives developed by ICAR-IARI, New Delhi

Table 5 incorporates a comprehensive scenario analysis of the IFS model developed by ICAR-IARI, evaluating its feasibility over three distinct project

TABLE 5. SCENARIO ANALYSIS OF THE IFS MODEL, ICAR-IARI UNDER DIFFERENT PROJECT LIFE (VALUES IN LAKH RUPEES)

Modules	Fixed Cost	Variable Cost	Total Cost	Gross Return	NPW	B:C ratio	IRR (%)
Project life of 10 years							
Pisciculture	9.50	5.36	14.86	20.25	1.98	1.19	13
Duckery	1.98	4.29	6.27	7.68	0.59	1.14	19
Poultry	5.81	9.34	15.15	22.67	3.81	1.38	44
Apiary	0.51	1.22	1.73	2.65	0.49	1.43	75
Vermicompost	0.54	0.43	0.98	1.20	-0.01	0.98	-1
Biogas Unit	0.27	1.03	1.30	1.37	-0.02	0.97	-3
Crop Unit	14.25	8.28	22.53	34.95	5.65	1.36	25
Dairy	8.23	27.87	36.10	48.65	6.01	1.26	32
Horticulture	1.26	3.54	4.80	12.75	2.52	1.77	12
IFS	41.30	58.10	100.31	141.16	18.74	1.28	26
Project life of 15 years							
Pisciculture	11.50	7.51	19.01	28.35	3.43	1.29	16
Duckery	2.50	6.43	8.93	11.52	0.93	1.19	21
Poultry	7.34	14.02	21.36	34.01	5.31	1.45	45
Apiary	0.64	1.83	2.47	3.97	0.66	1.49	75
Vermicompost	0.57	0.65	1.22	1.80	0.09	1.11	4
Biogas Unit	0.28	1.54	1.82	2.06	0.02	1.02	2
Crop Unit	18.00	12.41	30.41	52.43	8.45	1.47	27
Dairy	10.39	42.17	52.56	74.25	8.69	1.31	33
Horticulture	1.60	4.90	6.50	28.39	6.59	2.75	19
IFS	51.99	87.51	139.50	212.30	27.86	1.35	28
Project life of 20 years							
Pisciculture	14.50	10.73	25.23	40.50	4.32	1.33	16
Duckery	3.02	8.58	11.60	15.36	1.15	1.21	21
Poultry	8.87	18.69	27.56	45.35	6.24	1.48	45
Apiary	0.72	2.44	3.22	5.30	0.77	1.52	75
Vermicompost	0.59	0.87	1.46	2.40	0.16	1.18	5
Biogas Unit	0.28	2.06	2.34	2.03	0.05	1.05	4
Crop Unit	21.75	16.55	38.30	69.91	10.19	1.52	27
Dairy	12.56	56.46	69.02	99.85	10.35	1.33	33
Horticulture	1.93	6.26	8.19	44.02	9.12	3.24	20
IFS	62.68	116.92	181.52	284.82	33.53	1.39	28

Source: authors estimate based on primary data durations: 10, 15, and 20 years. The analysis reveals that as the project duration increases, both the NPW and the B:C ratio generally improves across the entire IFS model. This improvement can be attributed to the spreading of fixed costs over a longer period and the accumulation of returns, which enhances profitability. For instance, the NPW increases from 18.74 lakh rupees over 10 years to 33.53 lakh rupees over 20 years, while the B:C ratio rises from 1.28 to 1.39. Notably, most enterprises within the model exhibit similar positive trends, with the exception of the vermicomposting and biogas units. These two modules report negative NPW values of -0.01 lakh rupees and -0.02 lakh rupees, respectively, and B:C ratios below 1, at 0.98 and 0.97 when a 10-year project period was considered. The negative returns for these enterprises are attributed to high fixed and variable costs associated with their setup and operational processes, which can limit profitability, particularly in the early years. Additionally, market demand and pricing for vermicompost and biogas products is not yet sufficient to cover these costs, hindering financial viability. The Internal Rate of Return (IRR) also shows an upward trend as project duration extends. However, the shift from 15 years to 20 years reveals only slight changes in IRR for most enterprises, indicating a stabilization in returns. For example, the IRR for poultry remains consistent at 45% across both project durations, while the apiary maintains a high IRR of 75%. This consistent performance across varying project lengths underscores the robustness and viability of the IFS model, suggesting that longer project lifespans can enhance overall economic returns, with specific attention needed for the less profitable vermicomposting and biogas units. Addressing the challenges these enterprises face could improve their financial outcomes in future analyses.

3.4 Adoption Challenges – Lessons from IFS of ICAR-IARI, New Delhi

Several studies have analysed the constraints faced during implementation of IFS models (Choudhury *et al.*, 2019; Ponnusamy *et al.*, 2017; Pushpa, 2010; Ramya *et al.*, 2021). This study also identified a range of challenges expressed by farmers. High initial capital requirements, difficulties in planning, supervision, and maintenance, along with the lack of processing and storage facilities, were commonly cited. Farmers also highlighted the absence of markets for biogas slurry, insufficient tree yields, and difficulties in sustaining vermicompost during extreme weather. Dairy operations demand assured manpower, while fishery units face threats from predatory birds. Duckery and poultry remain vulnerable to disease, and apiary enterprises require scale, with feed shortages during lean flowering seasons. A critical challenge lies in marketing the diverse range of outputs, as the relatively small quantities from each component often fail to meet bulk market requirements. This leads to difficulties in selling perishable produce such as vegetables, milk, fish, or minor crops, compounded by transportation constraints, unorganized collection systems, price fluctuations, and post-harvest losses. Moreover, researchers emphasize the scarcity of skilled labour, the need for scientific knowledge among entrepreneurs, and the importance of training programs, all of which require additional budgetary support.

To address these challenges, potential strategies include the formation of farmer producer organizations (FPOs) and self-help groups (SHGs) for aggregation and economies of scale, contract farming and tie-ups with retail chains for assured markets, and on-farm value addition to extend shelf life and enhance profitability. Further, linkages with digital platforms and cooperative societies can improve timely sales and fair pricing, thereby making IFS adoption more viable and sustainable for small and marginal farmers.

IV

CONCLUSIONS

Financial feasibility analysis of the IFS model developed by ICAR-IARI indicate superior performance of Dairy, Fruit trees, and Apiary modules in terms of NPW, B:C ratio, and IRR respectively. The IFS model significantly contributes to employment generation and longer project lifespans can enhance overall economic returns. Despite facing constraints, the model exhibits resilience. Besides, IFS has emerged as a pivotal climate-resilient technology, offering a stable and sustainable production system that aids in mitigating risks and building resilience against climate change impacts (Ayyappan and Arunachalam, 2014). By integrating diverse components, IFS contributes to developing climate-smart agriculture, presenting an ideal solution to safeguard food security amidst the challenges posed by the ever-increasing global population (Bhatt, 2016). To ensure success of IFS approach, investment in low-cost technologies, assured access to markets will play a crucial role for its sustainability. In nutshell, the IFS model holds significant potential to uplift the rural economy and achieve Sustainable Rural Livelihoods.

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ANNEXURE

ANNEXURE 1. COMPONENT WISE PRODUCTION OF THE INTEGRATED FARMING SYSTEM (IFS) MODEL (1 HA, IRRIGATED CONDITION, ICAR-IARI)

Module (Area/Units)	Sub-component / Species	Annual Production
Crop Production (0.7 ha)	Cereals (Rice, Wheat, Maize, Babycorn, Sorghum)	14,155 kg (grain)
	Pulses (Cowpea, Redgram, Vegetable pea)	2,301 kg (grain)
	Oilseeds (Mustard, Sunflower)	328 kg (seed)
	Vegetables (Potato, Onion, Brinjal, Bottle gourd, Okra)	10,745 kg (vegetable)
	Fodder (Berseem)	7,704 kg (fodder)
	Flower (Marigold)	252 kg (flowers)
Pisciculture (0.10 ha)	Composite fish culture: Catla, Rohu, Mrigal, Grass carp	1,500 kg fish
Duckery (35 ducklings)	Khaki Campbell	240 eggs
Poultry (50 birds)	Kadaknath	160-180 eggs and 65-85 kg meat
Apiary (4 boxes)	European bee	16 kg honey
Agroforestry (0.012 ha)	Neem and Moringa	37 kg leaves
Composting unit (4 pits, 3m × 1m × 1m each)	Red worm	300 kg compost
Biogas plant (2 m^3)	KVIC model	300 kg slurry and 360 m^3 biogas
Dairy (3 crossbreed cow)	Holstein Friesian and Jersey	11, 860 litres milk and 18.25 tonnes cow dung

ANNEXURE 2. ANNUAL INPUT REQUIREMENTS FOR THE INTEGRATED FARMING SYSTEM (IFS) MODEL DEVELOPED AT ICAR-IARI, NEW DELHI

Input Type (Unit)	Annual Requirement
Seed (kg)	≈ 255.2 (Cereals: 37.8; Pulses: 14.1; Oilseeds: 0.8; Vegetables: 68.8; Potato tubers: 132; Fodder: 1.6; Marigold: 0.1)
Fertilizers – NPK (kg/year)	154 (N: 76; P_2O_5: 43; K_2O: 35)
Herbicides / Pesticides (kg/year)	5
Irrigation water (m^3/year)	1,050
Animal feed – Cattle (kg/year)	800
Animal feed – Goat/Sheep (kg/year)	120
Fish feed (kg/year)	350
Poultry feed (kg/year)	180
Fuel / Diesel (L/year)	60
Labour – Human (man-days)	628
Labour – Machine (hours)	120