Original Research Article

EVALUATION OF FARMING SYSTEM MODULES FOR IMPROVINGPROFITABILITY OF SMALL FARMERS IN COASTAL ODISHA

ABSTRACT

The study evaluated the profitability, sustainability and environmental impact of integrated farming system (IFS) modules, including cropping systems, horticulture, dairy, poultry and fishery in an area of 1.20 ha, in coastal Odisha. This research, part of the sixth production cycle under the All India Coordinated Research Project on IFS, was conducted at the Central Research Station, Odisha University of Agriculture and Technology, Bhubaneswar, during the 2022-23 agricultural year. The experiment integrated five major modules: cropping systems (0.32 ha), horticulture (0.31 ha), dairy (2 cross-bred cows), poultry (500 coloured chicken for meat) and fishery (0.40 ha). Productivity was assessed using rice equivalent yield (REY) and economic returns were calculated for each module. Sustainability was evaluated through sustainable yield indices and carbon footprint assessments, while soil quality parameters, such as bulk density, *p*H, organic carbon and available macronutrients, were monitored over six years. Dairy emerged as the most productive module, yielding the highest REY (15.14 t) and gross return (Rs.3,27,040). Horticulture recorded the highest net return (Rs.1,40,627) and benefit-cost ratio (3.61). The cost of production was mainly influenced by external inputs (52%), followed by labour (33%) and system-recycled inputs (15%). The system generated 399 man-days annually, with over half contributed by dairy. Environmental sustainability was achieved through agroforestry and compost application, making the model carbon-negative. Dairy was the largest greenhouse gas emitter, while horticulture and biomass contributed significantly to carbon sequestration. Over six years, soil quality improved, with reduced bulk density, increased water-holding capacity and enhanced organic carbon levels. Sustainable yield indices for four modules were above 0.6, with dairy showing the highest sustainability. Poultry performance required further improvement to enhance overall system sustainability. In conclusion, the integrated farming system enhanced overall productivity, profitability and environmental sustainability for smallholder farmers in coastal Odisha, showcasing its potential for resource optimization and resilience.

Keywords:Integrated Farming System; Profitability; Sustainability; Environmental impact; Coastal Odisha; Cropping systems; Rice Equivalent Yield; Carbon footprint.

1. INTRODUCTION

Agricultural production in India is increasingly confronted with challenges arising from rapid population growth, limited land availability and changing economic dynamics. The continuous decline in average farm size, coupled with the conversion of agricultural land for non-agricultural purposes, has constrained opportunities for horizontal expansion. In light of this, vertical expansion, through the adoption of sustainable farming systems such as Integrated Farming Systems (IFS), has become crucial for improving food production and securing livelihoods. IFS integrates diverse agricultural enterprises - such as crop production, livestock, fisheries and horticulture - creating synergies that enhance productivity, reduce costs and promote sustainability.India generates substantial quantities of agricultural residues, estimated at 500–550 million tons of crop residues and 1000 million tons of animal waste annually (Bhuvaneshwari *et al*., 2019). When scientifically managed and integrated into IFS, these organic materials can significantly improve soil health, reduce reliance on external inputs like fertilizers and contribute to overall cost savings in farming. IFS, by fostering resource recycling and improving soil fertility, offers a promising solution to the rising demand for food and income stability, particularly for small and marginal farmers who are the backbone of the Indian agricultural sector.IFS has shown considerable potential in enhancing soil organic carbon levels, promoting carbon sequestration and reducing greenhouse gas emissions, contributing to climate-resilient agricultural practices (Paramesh *et al*., 2021). However, despite its clear benefits, the adoption of IFS remains limited due to factors such as insufficient awareness, lack of technical knowledge and inadequate policy support. Therefore, research on the productivity, profitability, resource recycling and environmental impact of IFS is essential to develop effective strategies that can be applied to smallholder farming systems.This study, conducted at the Central Research Station, OUAT, Bhubaneswar, Odisha, aims to assess research are to evaluate the productivity and profitability of individual IFS modules, examine the efficiency of resource recycling within the system, assess employment generation potential and estimate the greenhouse gas emissions associated with these practices. The findings of this research will contribute to the development of sustainable farming systems that enhance food security, improve farmer livelihoods and mitigate environmental impacts, providing valuable insights for policymakers, agricultural practitioners and researchers working towards the betterment of Indian agriculture.

2. MATERIAL AND METHODS

2.1 Location of Experimental Site

The experiment was conducted at the Central Research Station of the Odisha University of Agriculture and Technology, Bhubaneswar during 2022-23. The study confined to sixth production cycle of a long-term field experiment on "Sustainable resource management for climate smart IFS" under the AllIndia Coordinated Research Project (AICRP) on Integrated Farming Systems. The experimental site was situated at 20º15′ N Latitude and 85º 52′ E Longitude at an elevation of 25.9 m above the mean sea level and at about 64 km away from the Bay of Bengal. The station comes under the East and South Eastern Coastal Plain Agroclimatic Zone of Odisha.

2.2 Soil Characteristics

Soil samples (0–15 cm depth) were collected in May 2023 and initial analyses from June 2017 revealed sandy loam texture in both systems, with higher sand content in the horticultural system (75.4%) than the cropping system (68.3%). Bulk density was similar (1.42 Mg/m³ vs. 1.41 Mg/m³), while water-holding capacity was higher in the cropping system (38.4% vs. 35.8%). Both systems had slightly acidic pH, with the cropping system at 5.98 and horticultural at 5.72. Organic carbon, nitrogen, phosphorus and potassium were slightly higher in the horticultural system. Electrical conductivity was low in both, indicating non-saline conditions. These differences reflect variations in soil fertility and nutrient dynamics across the systems.

2.3 Cropping History of the Experimental Plot

The present study represents the sixth crop cycle of a long-term experiment initiated in 2017-18, comprising five major farming system modules: cropping systems, horticultural systems, dairy, poultry and fishery. Prior to 2017-18, three additional modules-mushroom, duckery and apiary-were part of the system from 2011-12 but were discontinued thereafter.

2.4 Climate and Weather

The experimental region experiences a sub-tropical climate with hot, humid summers (March to June), a wet monsoon (late June to mid-October) and mild, dry winters (November to February). Annual rainfall averages 1454.5 mm, with the majority occurring during July (317.6 mm) and August (359.3 mm). May is the hottest month (36.7°C), January the coldest (14.0°C) and December the driest (5 mm rainfall). Relative humidity peaks in September (93%) and is lowest in December (42%). Bright sunshine hours are highest in February (9 hours/day) and lowest in July (4.2 hours/day). Weather conditions during the production cycle (June 2022–May 2023) were typical of the region, with maximum temperatures ranging from 28.0 to 40.4°C and minimum temperatures from 13.4 to 27.6°C.

2.5 Soil Parameters

Soil analysis revealed a bulk density of 1.42 Mg/m³, water holding capacity of 38.4% and pH of 5.98. Organic carbon was 6.8%, with available nitrogen, phosphorus and potassium levels at 290 kg N/ha, 13.8 kg P/ha and 196 kg K/ha, respectively. Electrical conductivity was recorded at 0.25 ds/m. These parameters indicate a soil environment conducive to supporting diverse farming system modules.

2.6 Details of Experiment

The experiment was designed with five major modules such as cropping systems, horticulture, dairy animals, poultry and fisheries. The total value of all the produce from a module was expressed in terms of rice equivalent yield (REY) per year. The field experiment comprised various modules with specific areas allocated to each: Cropping systems included 0.16 ha each for paddy-green gram (*Oryza sativa* - *Vigna radiata*) and paddy-rapeseed (*Oryza sativa* - *Brassica napus*). Horticultural module consisted of 0.18 ha for coconut and fodder grass, 0.10 ha for mango, guavaand vegetables and 0.03 ha for a nutritional garden. Livestock modules included 0.01 ha each for dairy animals (one cross-bred Jersey and one cross-bred Holstein Friesian cows) and poultry (500 colored birds rotated at 100 birds per rotation). The fishery module utilized an area of 0.40 hawhich consisted of 0.32 ha water body for fish farmingand 0.08 ha pond dyke area for growing seasonal vegetables.An area of 0.03 ha was diverted for vermicompost and compost units. Additionally, 0.12 ha area was allocated forother purposes such as including a threshing floor, farm building and roads.

2.7 Employment generation

Labours employed to carry out various activities in cropping systems,horticultural systems, dairy,poultry and fishery were recorded and expressed in mandays. A person working for 8 hours in a dayis considered as one-man day. Labourrequirement for each module and for each month wasrecorded.

2.8 Energy use

Energy input and output for each farming system module were calculated in Mega Joules (MJ), based on energy values for human, animal, machinery, diesel, seed, fertilizers and pesticides. Energy-use efficiency was determined by dividing energy output by energy input. Energy output efficiency was calculated as the daily energy output and energy productivity was calculated as rice-equivalent yield per unit of energy input.

$$\text{Energy use ef iciency} = \frac{\text{Total energy output}}{\text{Energy input}}$$

$$\text{Energy output ef iciency of a farming system module} = \frac{\text{Total energy output of the module (MJ)}}{\text{365 (days)}}$$

$$\text{Energy productivity} = \frac{\text{Rice equivlent yield (kg)}}{\text{Total energy input } (MJ)}$$

2.9 Estimation of green-house gas emission

Greenhouse gas (GHG) emissions from the farming system modules were estimated using activity data and IPCC (2006) emission factors in an excel-based calculation. The formula employed was:

Emission = A × EF

Where:

Emission = Annual emissions (kg CO_2-eq)

A = Activity data (e.g., kg of nitrogen used, liters of fuel consumed)

EF = IPCC default emission factors (e.g., CO_2-eq per kg N or per litre of fuel)

Carbon sequestration by trees was assessed based on IPCC (2006) guidelines, accounting for carbon stored in leaves, branches, stems, bark and roots through photosynthesis. Net emissions were calculated by subtracting carbon sequestered by trees (sink) from total emissions generated by farm activities (source).

2.10 Quantification of recyclable waste

Crop by-products, including paddy straw, greengram haulms, rapeseed stalks and horticultural waste, were used for livestock feed and in the production of compost and vermicompost. Paddy chaffy grains served as bedding material in poultry houses. Livestock dung and urine, collected daily, were utilized for composting, organic manure production and as fish feed in ponds. Poultry excreta, along with bedding materials, were also collected daily and used as fish feed or as manure for horticultural crops. Records of the production and utilization of all waste materials were maintained.

2.11 Economics

The economics of production for each farming system module were evaluated based on the prevailing market costs of inputs and the prices of produce. Gross returns were calculated using farm gate prices, while net returns were determined by subtracting the total cost from the gross returns. To analyse the production economics of each module, data on labor force power and input utilization were recorded. The cost of production for each module was categorized into three components: (1) cost of externally purchased inputs, (2) cost of recycled inputs within the system and (3) cost of labour used in production.

2.12 Sustainable Yield Index

The Sustainable Yield Index (SYI) and Sustainable Value Index (SVI) are derived from actual yields and net returns over a long period. These indices were calculated using data from the past five years (2018-19 to 2022-23) based on rice equivalent yields (REY) and net returns, respectively.

$$\text{Sustainable yield index} = \frac{\text{Mean REY} - \text{Standard deviation}}{\text{Maximum REY}}$$

$$\text{Sustainable value index} = \frac{\text{Mean net return} - \text{Standard deviation}}{\text{Maximum net return}}$$

2.13 Data Analysis

Data collected throughout the experimental year were compiled for each module and compared. The total value of all produce from a module was expressed in terms of rice equivalent yield (REY). The relative contribution of each module to total production costs, gross returns and net returns was calculated. Benefit: cost ratios were determined by dividing the gross return by the production cost. These ratios were analyzed using various cost scenarios: total cost, cost excluding recycled input cost, cost excluding family labour and cost based on purchased inputs alone. Additionally, month-wise production, returns and employment generation were also assessed.

3. RESULTS AND DISCUSSION

3.1 Production and economics of the IFS model

System yield: The integrated farming system's yield, measured in rice equivalent yield (REY), is influenced by module productivity and market prices. Cropping systems contributed 2.69 t REY, focusing on cereals, pulses and oilseeds, crucial for family nutrition (Mahapatra and Behera, 2011). Milk production was the main revenue driver, with the dairy module yielding 15.14 t REY. Integration of dairy enhances system productivity (Ravisankar *et al*., 2007). Horticultural systems contributed 9.00 t REY, emphasizing the importance of vegetable cultivation for productivity, profitability and sustainability (Kachroo*et al*., 2014; Patra *et al*., 2019). Fishery and poultry modules contributed 3.26

and 6.96 t REY, respectively, diversifying agricultural activities and enhancing overall productivity. Integrated poultry-cum-fish production systems outperform conventional methods (Alam *et al*., 2009; Hartman, 2012; Das *et al*., 2005; Abdelghany and Ahmad, 2002). Continued monitoring and management are crucial for sustainability (Table 1.).

Economics: The total cost of production was Rs.3,89,108, with dairy accounting for over 50%. However, cropping systems had the lowest net return (Rs.26,711), while horticultural systems yielded the highest net return (Rs.1,40,627). Horticultural systems also had the highest benefit-cost ratio (BCR) of 3.61. The lowest net return was realized from cropping systems (Rs.26,711) with its share of 6.5% in the system net return. Similar results were also reported by Kachroo*et al*. (2014) and Patra *et al*. (2019) [8,9] (Table 1.).

Table 1. Production and economics of the IFS model of 1.2 ha farmland at Bhubaneswar, 2022-23

Components	Production (t REY)	Cost of production (Rs.)	Gross returns (Rs.)	Net returns (Rs.)	BCR	Relative contribution (%)		
						Costof production	Gross returns	Net returns
Crops	2.69	31447	58158	26711	1.85	8.08	7.27	6.50
Dairy	15.14	200068	327040	126972	1.63	51.42	40.86	30.87
Horticulture	9.00	53813	194440	140627	3.61	13.83	24.29	34.20
Fishery	3.25	27130	70300	43170	2.59	6.97	8.78	10.50
Poultry	6.96	76650	150420	73770	1.96	19.70	18.79	17.94
Total	**37.05**	**389108**	**800358**	**411250**	**2.06**	**100**	**100**	**100**

3.2 Resource recycling in the system

Resource recycling is a key objective of the integrated farming system (IFS), contributing significantly to farm sustainability and resource efficiency by reducing the need for external inputs, improving soil health and enhancing productivity. Intermittent use of recycled products was quantified across modules, as presented in Table 2. highlighting their economic value. In the cropping system, 29 kg of grains were used as seeds, 2060 kg of paddy straw and green gram haulm as dry fodder in the dairy module and 384 kg of rapeseed residue for composting, while 490 kg of unfilled paddy grains were utilized as poultry bedding. The dairy module recycled 18,000 kg of cow dung, with 17,200 kg used for compost and 800 kg for fishery, amounting to Rs.9,000 in value. Horticulture produced 24,000 kg of green fodder worth Rs.30,000, recycled in the dairy module and 2,000 kg of crop residue worth Rs.2,000 used for compost. In the poultry module, 900 kg of litter, valued at Rs.1,600, was recycled in horticulture, while fishery recycled 400 kg of crop residues worth Rs.400. The IFS also produced 6,200 kg of farmyard manure (FYM) and 1,100 kg of vermicompost, with portions recycled across cropping, horticulture and fishery modules and the surplus sold, generating additional income. As shown in Table 4.19 and illustrated in Figures 5.1, 5.2 and 5.3, the highest contribution of cost inputs generated and recycled was in the horticulture module (32%), followed by dairy (16.6%) and cropping systems (10.5%), as these relied primarily on organic manures produced within the system. The lowest contribution was in poultry (1.9%), as most inputs were market-procured. These recycling practices underline the IFS's role in sustainable and efficient resource management (Table 2).

Table 2. Recycled products and their market value

Products used for recycling within the system	Quantity produced (kg)	Intermittent use of recycled farm produces (kg)						Market value of the recycled products (Rs.)
		Crops	Horti-culture	Dairy	Vermi-compost/ compost	Fishery	Poultry	
Cropping systems								
Grains	1796	29	-	-	-	-	-	898

Crops straw	2444	-	-	2060	384	-	-	4018
Paddy chaffs	490	-	-	-	-	-	490	1470
Dairy								
Cow dung	18000	-	-	-	17200	800	-	9000
Horticulture								
Green fodder	24000			24000				30000
Crop residue	2000				2000			2000
Fishery								
Crop residue	400				400			400
Poultry								
Poultry litter	900	-	320	-	-	-	-	1600
FYM/ Vermicompost								
FYM	6200	1300	4400			500		9300
Vermicompost	1100	-	450	-	-	50	-	10000

Table 3. Module-wise cost of production and their relative contribution, 2022-23

Components	Value of inputs (Rs.)				Relative contribution (%)		
	Purchased frommarket	Generated and recycledwithin farm	Man days	Total cost	Purchased frommarket	Generated and recycledwithin farm	Man days
Crops	8589	3298	19560	31447	27.3	10.49	62.21
Dairy	100640	33250	66178	200068	50.3	16.62	33.08
Horticulture	5317	17200	31296	53813	9.8	31.96	58.16
Fishery	15200	2150	9780	27130	56.0	7.92	36.05
Poultry	71920	1470	3260	76650	93.8	1.92	4.25
Total	**201666**	**57368**	**130074**	**389108**	**51.8**	**14.74**	**33.43**

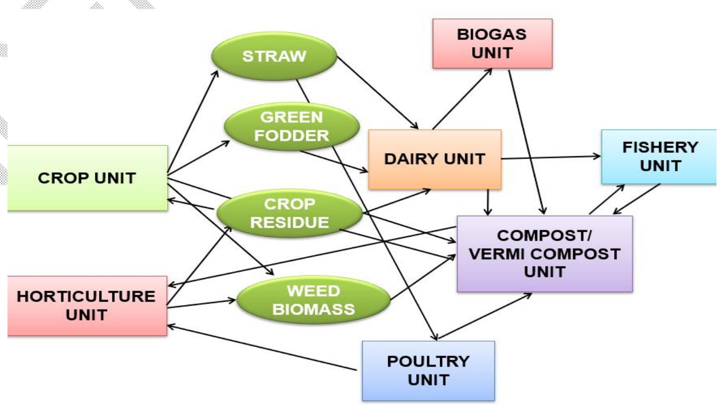

Fig:1. Resource recycling: 2022-23

3.3 Employment generation through the modules in IFS

One of the major objectives of the Integrated Farming System (IFS) is to create employment opportunities for the farm family throughout the year. In this study, the system generated 399 man-days annually, with the dairy module being the most labor-intensive, contributing more than 50% (203 man-days) of the total. This module required significant labor for tasks such as intensive care of animals, harvesting and feeding green fodder, cleaning cowsheds and milking. The horticulture module also played a vital role, creating 96 man-days (24.1% of the total), as activities like manuring, regular harvesting, grading and selling vegetables and fruits demanded considerable workforce engagement. In contrast, the poultry module required the least manpower, generating only 10 man-days (2.5%). Thus, IFS ensures year-round employment for farm families, with dairy and horticulture making substantial contributions (Table 4.).

Table 4. Employment generation by different components and their relative contribution to total employment generation by the system

Components	Employment generation	Relative contribution(%)
Crops	60	15.0
Dairy	203	50.9
Horticulture	96	24.1
Fishery	30	7.5
Poultry	10	2.5
Total	**399**	**100**

3.4 GHG emission by the IFS modules

An integrated farming system (IFS) serves as a significant sink for greenhouse gases (GHGs) through agroforestry, biomass addition and compost, making it environmentally sustainable. The total GHG emissions from the IFS were 3232 kg CO_2-e, with the dairy module being the largest contributor, accounting for about 77% (2474 kg CO_2-e) of the total emissions. This high contribution is attributed to enteric fermentation in ruminant animals, which produces methane (CH_4), a potent GHG, as well as CH_4 emissions from cow manure. Studies estimate that livestock production contributes approximately 20% of CH_4 and 35% of N_2O emissions globally (Hartung, 2003; Hartung and Monteny, 2000). Despite the emissions, the IFS model demonstrated robust carbon sequestration capabilities, with trees in horticultural systems and biomass contributing 2214.8 and 1166.8 kg CO_2-e, respectively, to the total sink, resulting in a carbon balance of -139.6 kg CO2-e. This carbon-negative balance indicates that the farm absorbed more GHGs than it emitted, highlighting its environmental sustainability and potential for further diversification and intensification (Adhikari *et al*., 2012; Dutta *et al*., 2017) (Table 5.).

Table 5. Net GHGemission in IFS model (CO_2-e in kg) 2022-23

Components and items	CO_2-e in kg
Paddy-greengram	89.1
Paddy-rapeseed	78.5
Fodder crops	66.3
Horticultural systems	48.2
Dairy	2473.8
Poultry	64.6
Kitchen garden	10.7
Pond	261.3
Total source	**3092.4**
Agro-forestry sink	2214.8
Total biomass/ compost added-sink	1166.8
Total sink	**3371.6**
GHG-IFS	**-279.2**

3.5 Energy use efficiency by various components

The energy input, output, energy use efficiency and energy productivity of various Integrated Farming System (IFS) modules varied significantly, reflecting their resource use patterns and sustainability. The dairy module recorded the highest energy input (57,540 MJ) due to the high-energy feeds required for cross-bred milch cows, while the fishery module had the lowest input (1,288 MJ) due to minimal resource requirements. Horticultural systems demonstrated the highest energy output (81,631 MJ), attributed to substantial production of fruits, vegetables and fuelwood, while fishery exhibited the lowest output (5,870 MJ) due to limited production. Among the modules, horticulture had the highest energy use efficiency (10.37) and energy output efficiency (1,070 MJ/day), highlighting its capacity to generate significant outputs with moderate inputs, whereas poultry showed the lowest energy use efficiency (1.63) and output efficiency (16 MJ/day) due to its relatively low energy outputs. Fishery was the most energy-productive (2.53 kg REY/MJ) because of its low input requirements, while the dairy module was least productive (0.26 kg REY/MJ). These results underscore the sustainability and efficiency of horticultural and fishery systems, emphasizing the need for optimized input management in dairy and poultry modules to enhance their energy efficiency(Table 6.).

Table 6. Energy use efficiency by various components

Components	Energy input (MJ)	Energy output (MJ)	Energy use efficiency	Energy output efficiency (MJ/day)	Energy productivity (kg REY/MJ)
Crops	6,522	65,017	9.97	178	0.41
Dairy	57,540	64,560	1.12	177	0.26
Horticulture	7,871	81,631	10.37	224	1.14
Fishery	1,288	5,870	4.56	16	2.53
Poultry	6,616	10,771	1.63	30	1.05
Total	**79,837**	**2,27,849**	**2.85**	**624**	**0.46**

3.6 Sustainability of Individual Module in IFS, 2018-19 to 2022-23

The integrated farming system has demonstrated a positive trend in production and gross returns, reflecting growth and expansion in agricultural activities since 2017-18, with consistent increases in net returns generating positive income (Table 7). The substantial improvement in net return per rupee invested highlights efficient resource utilization and enhanced resource recycling within the system. Sustainability indices, such as the sustainable yield index (SYI) and sustainable value index (SVI), calculated based on rice equivalent yields and net returns from individual IFS modules over the past five years (2018-19 to 2022-23) (Table 8), provide valuable insights into optimizing resource allocation. All modules, except poultry, had SYI values of 0.6 or higher, indicating sustainability in yield, with dairy emerging as the strongest module in both indices, underscoring its sustainability and productivity. Horticulture showed relatively lower sustainability indices, suggesting potential for improvement in yield and value generation, while poultry, with the lowest scores, requires more focus to enhance its sustainability and productivity. Overall, the system achieved a high sustainable yield index (0.74), signifying good yield performance across the farming system.

Table 7. Profit generated by various components and the system during the last six years

Year	REY(t)	Gross Return(Rs.)	Cost of Production(Rs.)	NetReturn (Rs.)	Net return per rupee invested (Rs.)	Employment generated (man-days)
2017-18	25.15	3,64,732	2,35,661	1,29,071	0.55	463
2018-19	28.53	4,99,311	3,41,276	1,58,035	0.46	495
2019-20	29.03	5,37,252	3,14,980	2,22,272	0.71	423
2020-21	27.51	5,34,658	3,07,513	2,27,145	0.75	389

2021-22	31.26	6,40,808	3,56,476	2,84,332	0.80	390
2022-23	37.06	8,00,358	3,89,108	4,11,250	1.06	399
Mean	**29.76**	**5,62,853**	**3,24,169**	**2,38,684**	**0.75**	**427**

Table 8. Sustainability indices of the components based on last five years performance, from 2018-19 to 2022-23

Components	Sustainable Yield Index	Sustainable Value Index
Cropping system	0.68	0.42
Dairy	0.80	0.54
Horticulture	0.60	0.38
Fishery	0.61	0.48
Poultry	0.44	0.26
System	0.74	0.43

The IFS demonstrated growth, with improved net returns over the years. Sustainable yield indices (SYI) above 0.6 were recorded for most modules, except poultry, which had lower sustainability. The system's overall sustainable yield index was 0.74, indicating strong yield performance.

3.7 Soil physico-chemical properties

Data related to physico-chemical properties of soil in experimental site of cropping systems and horticultural systems are presented in Table 9. Bulk density of soil after six years was more or less reduced from the initial values of 1.42 and 1.44 Mg/m^3 in cropping and horticultural systems. Soil pH also reduced from 5.98 to 5.97 in cropping systems and from 5.82 to 5.74 in horticultural systems after six years of cropping. Water holding capacity in both the cases increased from the initial values. Organic carbon of soil increased in both the systems from the initial value 6.8% to 7.0% in cropping systems and from 7.1% to 7.5%. Available nitrogen, phosphorus and potassium in soil increased over the initial values in both the cases after six years of cropping.

Table 9. Soil physico-chemical properties after completion of production cycle

Parameter	**Cropping system**		**Horticultural system**	
	Initial values (2017)	**Final values (2023)**	**Initial values (2017)**	**Final values (2023)**
Bulk density (Mg/m^3)	1.42	1.40	1.44	1.41
Particle density (Mg/m^3)	2.62	2.61	2.65	2.64
Water holding capacity (%)	38.4	39.6	42.0	43.8
pH	5.98	5.97	5.82	5.74
Organic carbon (%)	6.8	7.0	7.1	7.5
Available Nitrogen (kg N/ha)	290	297	308	312
Available Phosphorus (kg P/ha)	13.8	14.5	17.2	18.0
Available Potassium (kg K/ha)	196	198	200	203

4.CONCLUSION

Integrated Farming Systems (IFS) present a sustainable and holistic approach to farm management by leveraging synergistic interactions among diverse components such as crops, livestock, trees etc. These systems not only enhance resource utilization and recycling efficiency but also contribute significantly to income generation, employment opportunities and environmental conservation, ensuring livelihood security for rural communities. The adaptability of IFS to local resources and family labor makes it a resilient strategy against climate uncertainties while also aiding in carbon sequestration. To fully utilize the potential of IFS in addressing climate change and fostering sustainable agriculture, it is crucial to promote region-specific models through farmer awareness programs and supportive government policies. Future research and development efforts should focus on optimizing component combinations, improving resource recycling and diversifying outputs to enhance the overall effectiveness and scalability of IFS.

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