E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(11): 28-32
Received: 15-07-2024
Accepted: 24-08-2024

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Integrated farming system for resource recycling, sustainability, and employment generation among the small and marginal farmers in Vidarbha region of Maharashtra

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i11a.1916

Abstract
Integrated farming system (IFS) assures efficient resource recycling, long-term sustainability, and regular employment generation which are prerequisites for the sustainable livelihood of small and marginal farmers. The present research was conducted at All India Co-ordinated Research Project on Integrated Farming System Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Kharif-rabi* season of 2023-24. The model was designed for a 1 ha area with crop, dairy, poultry, horticulture, vermicompost, kitchen garden, and boundary plantation. The results revealed that the system had generated a total of 22490 kilograms of recyclable products and by products out of which 9283 kilograms of products and by products were recycled resulting in a marketable surplus of ₹ 36756. The total quantity of nitrogen, phosphorus, and potassium recycled within the system through cow manure (FYM), poultry manure, and vermicompost were 25.84 kg, 11.22 kg, and 19.32 kg respectively from 2803 kg of total organic manure. The system recorded a sustainability yield index (SYI) value of 0.85. Employment generation in the integrated farming system model was 285 man-days/year.

Keywords: Integrated farming system, sustainability, nutrient recycling, employment generation

Introduction
In the Indian economy, the focus lies predominantly on rural areas and agriculture. Small (Holding land between 1 and 2 ha) and marginal (Owning less than 1 ha) farmers play a vital role as the backbone of the rural economy. They make up about 86% of the total farming community, despite only having possession of 44% of the arable land in 2015–16. Over the years, the average operational land holdings have significantly decreased from 2. 28 ha in 1970–71 to 1. 08 ha in 2015–16. Due to 80% of farm families being small and marginal farmers, a financial limitation arises that hinders higher investment in agriculture. The increasing need for food on limited land can be met by boosting agricultural efficiency (Smith, 2013) [16]. Considering these facts, the country will have to increase food production by over 32% from current levels to feed the estimated population of approximately 1. 6 billion by 2050. (Ngachan & Das, 2018) [15].

Furthermore, as the agriculture sector has modernized, energy consumption has significantly risen because of factors such as animal feed, fossil fuels, chemical fertilizers, electricity, mechanization, and more. Resulting in ecological imbalances and numerous health issues for humans. (Kumar *et al*., 2019; Martinho, 2016) [8, 12]. The increasing concerns over the adverse effects of intensive and industrial agriculture have led to a call for environmentally conscious sustainable methods. (McKenzie *et al*., 2016) [13]. Hence, in addressing the multitude of challenges arising in agriculture, it is essential to adopt an environmentally friendly holistic strategy, like the integrated farming system (IFS). An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained production levels while minimizing the negative effects of intensive farming and preserving the environment. (Lal and Miller, 1990; Gupta *et al*., 2012) [10, 7].

The Integrated Farming System is a mixed farming approach where crop and livestock elements are harmoniously integrated to supplement and complement each other. In this system, an interrelated set of enterprises is utilized where the "waste" from one component is transformed into an input for another part of the system, resulting in reduced costs and enhanced production and/or income. IFS operates as a network of interconnected systems. IFS guarantees that waste from one component transforms into a valuable resource for another component. By utilizing waste as a resource, we can eliminate waste and enhance overall productivity for the entire agricultural system. IFS farms incorporate low-input energy and agricultural waste as a means of efficient resource recycling. (FAO, 1977) [4] stated that "there is no waste," and "waste is only a misplaced resource which can become a valuable material for another product" in an integrated farming system.

Materials and Methods

The present study entitled “Integrated Farming System for Resource Recycling, Productivity and Employment Generation among the Farmers of Vidarbha Region” was conducted at All India Co-ordinated Research Project on Integrated Farming System Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during Kharif-rabi seasons of 2023-24. The integrated farming system model encompassed a total area of 1.00 hectare with 4 cropping systems *viz*, Bt cotton + green gram (0.2 ha), soybean + pigeon pea (0.20 ha), sweetcorn + clusterbean (0.20 ha), hybrid sorghum – lucerne multicut (0.15 ha), livestock (0.03 ha) with 1 Sahiwal breed cow and 800 Kaveri birds and vermicompost, horticulture (0.20 ha), kitchen garden and boundary plantation (0.02 ha). To assess the soil's chemical composition, samples were collected from randomly selected spots across the experimental area at depths of 0-30 cm before sowing, revealing pH 7.88, electrical conductivity (0.20 dSm^{-1}), organic carbon content of (0.53%), available N (180.24 kg ha^{-1}), P (10.51 kg ha^{-1}) and K (310.15 kg ha^{-1}). The farming system was analysed for resource recycling, sustainability, and employment generation. Recyclable residues from each component were quantified in kilograms, and the value of each recycled product and by product within the system was determined based on market prices with animal by products utilized as nutrient sources in crops and remaining product and by product as marketable surplus. The sustainable Yield Index was calculated by using the formula suggested by Singh *et al*., 1990 [17]. The different components mentioned are in (Table 1).

Table 1: Details of the components in the IFS model

Sr. No.	Components	Area (ha)
A	Cropping system	-
1	Bt cotton + green gram (1:1)	0.60
2	Soybean + pigeon pea (6:1)	
3	Sweetcorn + cluster bean (2:2)	
4	Hybrid sorghum – lucerne multicut	0.15
B	Horticulture	-
5	Custard apple (Balanagar grafts)	0.20
C	Livestock	-
6	Dairy (1 Sahiwal cow)	0.03
7	Poultry (800 Kaveri birds) 400 birds per batch	
D	Others	-
8	Kitchen garden (okra, cowpea, spinach, coriander, carrot)	0.02
9	Boundary plantation (karonda)	
	Total	1.00

Results and Discussion

Resource recycling: Under the integrated farming system products and by products from one component can be used as input in another component. These products and by products are recycled and reused within the different components, with their quantities quantified and converted into marketable values. Within the crop component, a total of 15409 kilograms of by products were recycled these included low-grade grains used as poultry feed, crop straw utilized as dry fodder for livestock, and materials for vermicomposting. The total market value of recycled products from the crop component amounted to ₹ 11595, whereas in the livestock component and vermicompost unit, a total of 2803 kilograms of by products, such as farmyard manure, poultry manure, and vermicompost applied to various crops within the system, were recycled. The total market value of recycled products from these components was ₹ 15950. The system generated a total of 22490 kilograms of recyclable products and by products out of which 9283 kilograms of products and by products were recycled, valued at ₹ 27545 in the mark*et al*ong with a marketable surplus of ₹ 36756 (Table 2).

The gross expenditure included on-farm, off-farm, and daily wages. Savings from on-farm inputs obtained from other components amounted to ₹ 32570, representing 10.16% of the total recycled products within the system. Off-farm costs, reflecting the price of inputs purchased externally, totalled ₹ 202658, contributing 63.19% to the overall expenditure. The total investment in daily wages reached ₹ 85500 contributing 66.66% to the gross expenditure (Table 3).

Table 2: Recycled products in integrated farming system model its total quantity and market value

Farm enterprises and related products used for recycling within the system (kg)	Quantity produced (kg/lit/No.)	Intermittent use of recycled farm produce and by-products (kg)						Total products recycled (kg) with their market value (₹)	Marketable surplus (₹)
		Crop unit	Horti. unit	Dairy unit	Poultry unit	Vermi unit	KG & BP unit		
Low-grade Grains (used as feed)	50	-	0	-	50	-	-	900	0
Fodder (lucerne)	6375	-	-	1980	120	-	-	4200	8550
Crop straw	8984	-	-	1330	-	3000	-	6495	6981
Total (A) Crop component	15409	-	-	3310	170	3000	-	11595	15531
FYM	4100	500	700	-	-	600	65	3730	4470
Total (B) Dairy	4100	500	700	-	-	600	65	3730	4470
Poultry manure	1574	-	135	-	-	-	50	925	6945
Total (C) Poultry	1574	-	135	-	-	-	50	925	6945
Vermicompost	1407	700	-	-	-	-	53	11295	9810
Total (D) Vermicompost	1407	700	-	-	-	-	53	11295	9810
Grand Total (A+B+C+D)	22,490	1,200	835	3310	170	3600	168	27,545	36,756

Table 3: Contribution of different farm enterprises in resource recycling and overall saving in production cost

Components	On-farm (₹)	Off-farm (₹)	Daily wages (₹)	Total (₹)
Crop	11500	32476	23400	67376
Horticulture	7100	3890	7200	18190
Dairy	5955	31785	31200	68940
Poultry	1140	130250	13500	144890
Vermicompost	5700	3000	4200	12900
Kitchen garden & Boundary plantation	1175	1257	6000	8432
Total	32570	202658	85500	320728
Percent gross expenditure	10.16	63.19	26.66	100

Sustainability

From different integrated farming system models highest sustainable yield index (SYI) value was recorded from integrated farming system model T_6: crop + horticulture + dairy + poultry + vermicompost + kitchen garden + boundary plantation (0.85) which is due to the integration of all the components. It was followed by T_3: crop + dairy + vermicompost (0.63), T_2: crop + horticulture (0.52), T_4: crop + poultry (0.49), T_5: crop + kitchen garden + boundary plantation (0.49) and lowest in sole crop component T_1: crop (0.43) **(**Table 4). A sustainability index close to unity/1 shows higher sustainability reflecting that the system is highly sustainable. The trend of the yield sustainability index was $T_6 > T_3 > T_2 > T_4 > T_5 > T_1$.

Table 4: Sustainable yield index of different integrated farming system models

IFS models	Components yield (kg)						Total (kg)	SYI
	Crop (C)	Horti. (H)	Dairy (D)	Poultry (P)	Vermicompost (VC)	Kitchen garden & boundary plantation (KG & BP)		
T_1: C	10525	-	-	-	-	-	10525	0.43
T_2: C+H	10525	1625	-	-	-	-	12150	0.52
T_3: C+D+VC	10525	-	2310	-	1407	-	14242	0.63
T_4: C+P	10525	-	-	1186	-	-	11711	0.49
T_5: C+KG+BP	10525	-	-	-	-	1055	11580	0.48
T_6:C+H+D+P+ VC+KG+BP	10525	1625	2310	1186	1407	1055	18108	0.85
	-	-	-	-	-	SD	2762	-

Employment generation: Employment opportunities generated under an integrated farming system from various components *viz*, crop cultivation (78 man-days/year), dairy (104 man-days/year), poultry (45 man-days/year), horticulture (24 man-days/year), kitchen garden and boundary plantation (20 man-days/year) and vermicompost (14 man-days/year) (Fig. 1). Employment generated from dairy was highest among all components this may be due to the stall feeding of cows which involves labour for various operations like feeding, watering, and cleaning, which is followed by crop cultivation due to peak labour demand during on season (Table 5).

Among different IFS models' the highest employment generation was observed in treatment T_6: crop + dairy + poultry + horticulture + kitchen garden + boundary plantation + vermicompost (289 man-days/year) this may be due to the Integration of other components with cropping which increases labour requirement round the year without much lean and peak demand for labour, which is followed by T_3: crop + dairy + vermicompost (196 man-days/year) and lowest in T_1: crop (78 man-days/year) **(**Table 6) (Fig. 2).

Table 5: Employment generation of different components in integrated farming system model

Components	Employment generation (man-days/year)
Crop	78
Horticulture	24
Dairy	104
Poultry	45
Vermicompost	14
Kitchen garden & Boundary plantation	20

Table 6: Employment generation in different integrated farming system models

IFS Components	Employment generation (man-days/year)
T_1: C	78
T_2: C+H	102
T_3: C+D+VC	196
T_4: C+P	123
T_5: C+KG+BP	98
T_6: C+H+D+P+VC+KG+BP	285

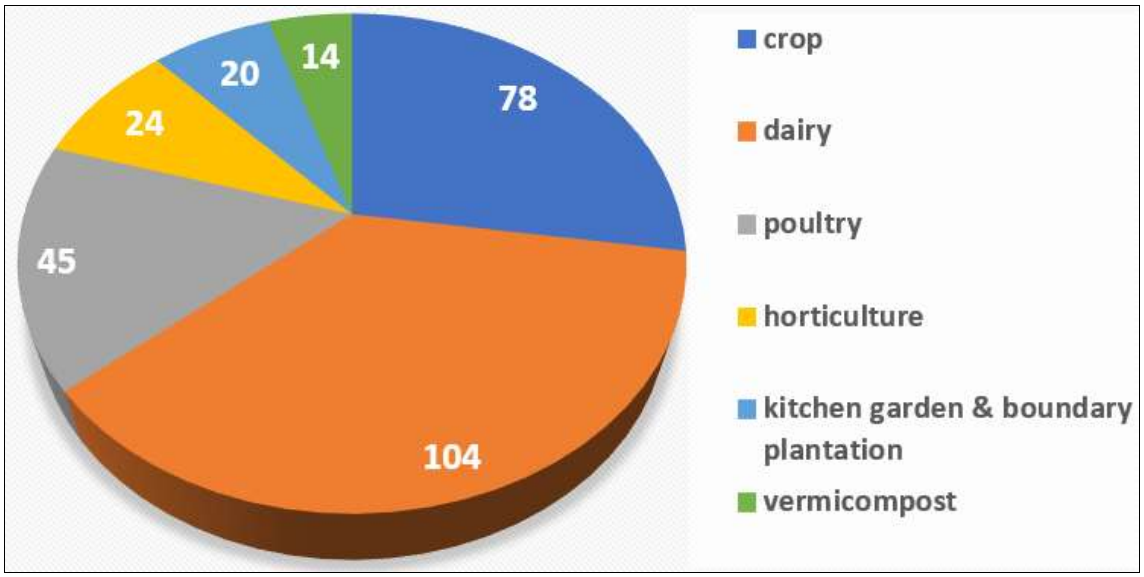

Fig 1: Employment generation (Man-days/year) of different components in the integrated farming system model

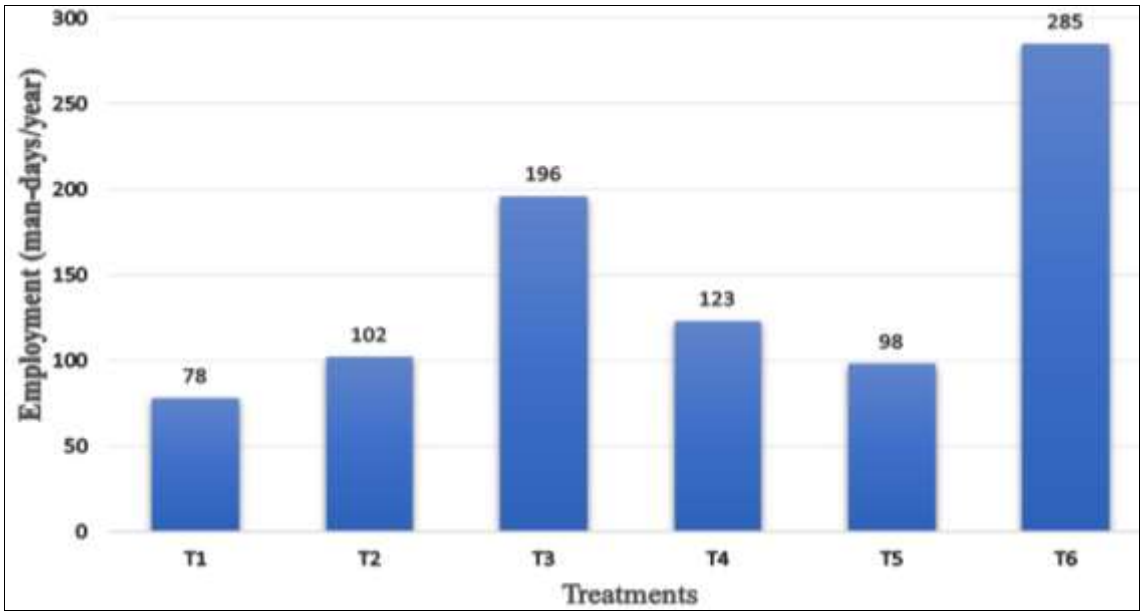

Fig 2: Employment generation in different integrated farming system models

Nutrient recycling

The total quantity of product through livestock components was 2050 kg. The amount of nutrients recycled in cow manure (FYM) and poultry manure was 12.44 kg N, 8.58 kg P, and 13.45 kg K. The total quantity of product through the vermicompost unit was 753 kg. The amount of nutrients recycled in compost units was 13.40 kg N, 2.63 kg P, and 5.87 kg K. The total quantity of nitrogen, phosphorus, and potassium recycled within the system through cow manure (FYM), poultry manure, and vermicompost were 25.84 kg, 11.22 kg, and 19.32 kg, respectively from 2803 kg of organic manure (Table 7).

Recycling of crop residues has enormous potential in improving soil health as reported by Kumar *et al*. (2012) [9]. The most notable advantage of utilizing by-products at the farm level for recycling is that it will certainly reduce the production cost and ultimately improve the farm income considerably (Desai *et al*. 2013) [3].

Table 7: Nutrient recycling through organic manures in an integrated farming system model

Organic source	Quantity of manure (kg)	Nutrient content (%)			Nutrient supplied (kg)		
		N	P	K	N	P	K
FYM	1865	0.4	0.25	0.6	7.46	4.66	11.19
Poultry manure	185	2.69	2.12	1.22	4.98	3.92	2.26
Vermicompost	753	1.78	0.35	0.78	13.40	2.63	5.87
Total	2803	-	-	-	25.84	11.22	19.32

Conclusion

From this study, it can be concluded that the adoption of the IFS models not only ensured sustainability, and efficient recycling of products and by products but also generated regular income. Integration of multiple components including crop + dairy + poultry + horticulture + vermicompost + kitchen garden + boundary plantation resulted in maximum employment generation. The system has attained a higher sustainable yield index value which indicates greater sustainability. The various products and by products that are recycled and reused within the different components have reduced the overall expenditure incurred on production costs and increased the efficiency of the farming system. Nutrient recycling highlights the self-sustainability of the system, reducing dependency on external inputs and saving costs on expensive chemical fertilizers which ultimately leads to sustainability.

Acknowledgements

The authors are thankful to the AICRP on Integrated Farming System Research unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for their facilities and great support for this study.

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