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# Development of Sustainable Integrated Farming Systems for Small and Marginal Farmers and Ecosystem Services -A Comprehensive Review

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## ABSTRACT

This review article shows a holistic approach regarding integrated farming system (IFS) for livelihood security and sustainable development of small and marginal households in India. Integrated farming systems are being developed for location specific because enormous problems are being aroused in the agriculture and allied sectors such as declined factor productivity, profitability, unscientific management of farm resources, decreases in crops and livestock productivity due to climate change, changes in food habits of the people, deprived soil health, low inputs use efficiencies, declined in crop diversification and biodiversity, increased cost of production, utilization of high energy inputs, produces low energy outputs and other problems are also coexisted in current farming system. The integrated farming system includes different components like crops, livestock, poultry, beekeeping, fisheries, mushroom, kitchen garden, boundary plantation and others to cultivate in an integrated way for efficient utilization of limited farm resources. Moreover, imperative need to resolve these ablaze issues with the help of development of location-specific integrated farming system modules/models. IFS is a tool of sustainable strategies for the meeting of assorted agrarian anxieties along with ensured food and nutritional security and conserved ecosystem services. The standardized and upscale IFS models increased the productivity and profitability of the farmers more than mono-cropping and single-farm enterprises. The conducted studies emphases about enhance soil quality indicators, recycling and saving plant nutrients by around 55.6% through proper management of farm-based waste and byproducts. A total of 265.18 kg nitrogen, 48.91 kg phosphorus and 269.48 kg potassium can be saved through recycled farm-based waste or byproducts of a 1.5 ha model which comprises nine components. In conclusion, IFS modules/models are emission-negative or low GHG emitters, paving the way for promoting of climate-friendly farming in India. IFS emerges as a holistic approach to increase climate-resilient, greenhouse gas emissions can be reduced, it is a potential for sustainable agriculture development requiring continued research, policy support and innovative strategies for widespread adoption. As regards to livelihood security, the IFS approach has adapted to meet the home-grown family needs of cereals, pulses, oils, fruits, milk, meat, eggs, and vegetables. The future direction for research includes vertical farming, climate-smart farming systems, and improving the quality and sustainability of the farming systems, especially for underprivileged farm householders.

**Key words:** Climate, Employment generation, Ecosystem services, Livelihood, Nutritional security, Productivity, Profitability, Soil health, Sustainability.

Agriculture steers the Indian economy as 54.6% of the country's population is engaged in agriculture and allied activities for their livelihood security (GoI, 2020-21). But in present years income per capita has gone down due to expenditures on the daily used commodities hiking at an alarming rate. Therefore, finding a viable and adaptable alternate solution is the need of the hour, so that our food production system is sustainable, given the country's population growth (Bahadur *et al.,* 2024). Thus, augmenting the income of the people can be possible through diversified enterprises instead of mono-cropping or single enterprise, and integrated farming systems were introduced among Indian small and marginal farmers (Meena *et al*., 2018). Several components like dairy, horticulture, fishery, apiary, mushroom, kitchen gardening, vermicompost and boundary plantation was inducted into the diversified cropping systems. The main focus was to garner the technological packages for the overall improvement of farming community by generating all possible avenues of income at the farm itself (Gill and Singh, 2007). Integrated

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farming system (IFS) involves the integration of multiple agriculture and allied enterprises, guided by the principles of scientific agriculture. This approach aims to optimize the individual component and management of available resources, facilitate the recycling of waste and byproducts, engage family labour to reduce cultivation costs, enhance input use efficiencies, *etc*. The ultimate goal is to maximize production, productivity and income generation from a unit of land area over a stipulated period (Dash *et al.*, 2015). Furthermore, IFS contributes to nutrient recycling, reduces dependency on external inputs, enhances soil quality indicators, and ensures environmental safety. Hence, adaption of a developed location-specific IFS model plays a vital role in biodiversity conservation, improves soil carbon, and contributes to reduction of greenhouse gas emissions (GHGs) (Meena *et al.,* 2023). Our country's population is anticipated to reach 1370 million by 2030 and 1600 million by 2050 (Gupta *et al*., 2020). Developed IFS models gave higher net returns and benefit: cost ratio to the tribal farmers as compared to traditional farming in hilly region of Manipur as reported by (Ansari *et al*., 2013).

## What is the farming system

The farming system is the scientific integration of different interdependencies and interactions of farm enterprises for the efficient use of land, labour and other resources of a farm family which provides year-round income to the farmers especially those found in the handicapped/ underprivileged zone.

### Definition of Sustainability

Sustainability by definition means 'the use of natural resources or the application of a practice or technology in a manner in which the long-term net impact on natural resource is not negative' (Vepa *et al*., 2001). The other common definition is 'the use of any resource by the next generation to the use of any resource by the next generation to the same degree as that of the present generation'.

### Advantages of integrated farming

In the face of multidimensional challenges of the new millennium, integrated farming is a multi-enterprise system that offers following advantages.

- ❖Regular income generation around the year from different enterprises/components.
- ❖Maintaining soil fertility and soil and water conservation
- ❖Residue recycling on farm.
- ❖Fulfilment of social and cultural obligations.
- ❖Utilization of marginal land and nonmarketable produce greatly offsets economic risk.
- ❖Fully utilization of surplus family labour on the farm.
- ❖Favourable income generation prospects in rural areas can slow down migration from rural to urban areas.
- ❖Production of saleable products and byproducts.
- ❖Risk reduction from diseases, crop failures and climatic failures or hazards.
- ❖Energy production and consumption.
- ❖Increased populations of beneficial insects and fishes and migrant birds.
- ❖Availability and consumption of a variety of products at a farm that reduces problem of malnutrition of family members.

### Strategies to enable adoption of IFS

The following strategies are to be implemented to enable farmers to adopt integrated farming systems.

- ❖The large number of training and demonstrations on site-specific IFS models need to be conducted by involving research institutions, extension agencies, NGOs, and farmers.
- ❖Popularizing success through a variety of media mixes may be done by government extension machinery to enhance awareness and knowledge levels.
- ❖The agencies should be identified and linked with IFS farmers to procure their farm produce.
- ❖Panchayati Raj Institutions need to be empowered to take up infrastructure work like reclamation of village water bodies (ponds), promotion of village common lands for livestock grazing and setting up of common facilities. Integrated farming system models are being developed for location-specific or for different agriculture situations as mentioned below.

### Rice +fish +poultry based farming system

In the Tungabhadra district of Karnataka where canal irrigation facilities are available, farmers favour growing rice-rice cropping system, but this system is extremely expensive in terms of requirement of huge inputs, henceforth scientific research outcomes suggested for replacement of conventional cropping system through acceptance of a suitable rice+fish+poultry based farming system in response to tackling the contempered problem of the farmers in study area as illustrated by (Channabasavanna and Biradar, 2007 and Reddy *et al*., 2018).

### Fish + poultry+ horticulture- based farming system

This integrated farming system (IFS) model was developed using fish, poultry and horticulture components that play a significant role in increasing manifold production, nutrition, profits, and employment generation to marginal farmers of Udham Singh Nagar district of Uttarakhand as reported by (Sharam *et al*., 2016). Another study conducted reveals that the integration of fish culture with a rice-wheat cropping system can attain the maximum profit in western Uttar Pradesh. Similarly, a fish-based IFS model was developed on 0.9 ha of land (fish cum horticulture on pond dyke (0.5 ha) + rice-wheat (0.4 ha), where fish as a major component was promoted to maximize the farm income and efficiently utilized farm resources. For this purpose, a farm was selected based on its strategic location, water availability, low land condition, *etc.* (Sunil *et al.,* 2023). Besides, fish culture pond dykes were chosen for the development of horticulture module (vegetable cultivation). Existing management practices (low input-based aquaculture) like fishes fed with rice polish and intermittent spread of mustard oil cake in pond (Bahera *et al*., 2004). The existing productivity of fish ponds was less than < 20 q/ ha. As a result of adoption of improved management practices, the fish pond production rose up to 35 q/ha (75.0%).

**Crop + livestock- based farming system**

Climate change, nutritional security, land shrinkage and increasing human population are the most concerning factors in agriculture and a further complicated by deteriorating soil health. Among several ways to address these issues, the most important and cost-effective means are to be adopted in integrated farming system (IFS). Integrating farming systems with livestock enables a way to increase economic yield per unit area per unit of time for farmers under small and marginal categories (Shanmugam *et al*., 2024). This system effectively utilized the waste materials by recycling them via linking appropriate components, thereby minimizing pollution caused to the environment. Further, the integration of livestock component with crops, the production of eggs, meat and milk leads to nutritional security and stable farmer's income generation. So, there is a dire need to develop a eco-friendly, ecologically safe and economically profitable IFS model in western Uttar Pradesh (Palsaniya *et al.,* 2021).

**Integrated farming system under coastal agro-ecosystem**

The long-term projections prove that by 2030, about 40 % of the dietary demand has to be met from livestock-based commodities other than food grains (Kumar *et al*., 2018). At present, improvement in the productivity of crops is being examined from their sustainability viewpoint not only by agricultural scientists, planners and environmentalists but also by progressive farmers, who are switching over from modern insensitive farming to ecologically protective farming (Ponnusamy and Gupta, 2009). The coastal ecosystem faces a lot of problems like flash floods, water logging, seawater intrusion, salinity and pollution due to continued expansion of urbanization, industrialization, tourism and other activities. However, it offers growth opportunities to explore natural resources and different commodities to develop sustainable alternative farming packing. About 10.78 million hectares of land resources of coastal ecosystems support the livelihood security of several million rural poor and also contribute to the national economy in a larger measure (Swarnam *et al.,* 2024). Considering land capability in the coastal ecosystem, the increase in land productivity primarily depends on popularization of alternative land use systems like dairy, fishery, apiary, duckery, mushroom, tree plantation, *etc*. Therefore, the research focus needs to be reoriented toward developing integrated farming system options, well matched with land and water regimes in coastal areas for sustainable increase in productivity and conserved coastal ecosystem (Sunil *et al.*, 2023).

**Enlarge agrotourism farming**

Agrotourism is a way of developing the rural location as part of developing these tourism areas sustainably with a concern to increase the living standard of the farm and rural people by providing them the additional avenues of income. Of late, agro-tourism has emerged as an unconventional way of increasing farmer's income. Hence, the farmers should adopt agrotourism to diversify agricultural goods and explore new markets to generate more money through agrotourism, rural tourism provides an option for visitors to experience uncover rural life, their farm and other related activities, and social and cultural practices which ultimately help the people sustainably living in that locality. The agrotourism development based on local wisdom concerns tourism development and subsequent conditions of sustainable development, as stated by Sriyadil and Eni Istiyanti (2021).

**Livelihood Security analysis in IFS**

'The livelihood of the integrated farming system model was analyzed. The model generated Rs. 672276 as gross production with a marketable surplus of (Rs. 468364) and family savings of Rs. 251794 from the 1.5 ha of land. However, in integrated farming system model, the crop module had gross production of Rs. 241185 out of which the family consumed (B) of produce worth Rs. 26000, from the cropping system waste or byproducts could be recycled (C) of worth Rs. 8172 with a net market surplus (A-B-C=D) of Rs. 207013. Therefore, net family saving was of (D-CP) Rs. 101313 followed by dairy (Milch animals) with a total produce (A) of Rs. 226574 out of which family consumption (B) was Rs. 21285 and recycled value worth of Rs. 48380. The marketable surplus of dairy was Rs. 156909 with family savings of Rs. 58409 followed by horticulture module with a marketable surplus of Rs. 67400/year and net savings of Rs. 38850/year (Meena *et al*., 2022). Vermicompost also gave net savings of Rs. 38600. The fishery component contributes Rs. 10800/year towards net savings; Value addition of fruits could enhance the net savings in the tune of Rs. 3200/year. KG and poultry could add Rs. 1900 and Rs. 1340, respectively. The total quantity of mushroom produced was entirely used for family consumption. Improving the farming system to attain household-level self-sufficiency, land utilization efficiency (LUE) and sustainable livelihood security depends upon the better socioeconomic and ecological aspects of the systems practiced by small farmers in the semi-arid ecosystem of India. There was no integrated index developed for evaluation of farming systems by taking into consideration of ecological, economic efficiency and social equity dimensions. Hence, parameters of farming systems for the application of sustainable livelihood security index (SLSI) were tested using the on-farm research data and methodology for the analysis in terms of component-wise and number of components was developed by combining the ecological security index (ESI) economic efficiency index (EEI), and social equity index (SEI) to develop Sustainable Livelihood Security Index (SLSI). The parameters used for assessing the farming systems include (manure application rate), organic carbon and number of legume crops grown for ecological security, per capita land, total food grain production, milk yield and gross cropped area for economic efficiency and literacy rate, food grain production per capita, milk production per capita, cereal consumption per capita, pulses consumption per capita, oilseeds consumption per capita, milk consumption per capita and fruits consumption per capita for social equity (Table1). Overall, about 73% of considered households were attained an SLI below 0.5, with a mean of 0.47 (Kamaruddin and Samsudin, 2014). The livelihood of households can expand by improving nutrition, income and employment generation (Swarnam *et al*., 2014).

**Carbon footprint from the IFS model**

Climate change and its impacts on agriculture are relatively well documented at the global and regional levels, while adaptation measures to sustain food production are mostly location- specific. Such measures integrated into a production system as a farming practice will become robust based on its performance at smallholder. The huge use of agricultural chemicals in crop production resulted in immense GHG emissions from crop fields and other linked enterprises. In the present study, results revealed that under different cropping systems, rice-wheat system had produced higher GHGs than other cropping systems *i.e*. (1304 kg CO2-e from 1800 $m^2$ area) followed by sugarcane-ratoon-wheat system (641 kg CO2-e from 3500 $m^2$ area). The total sources from the 1.5 ha model were 6638 whereas the total sink was 44028 from the same piece of land. Thus, GHG from the IFS model was negative (-37390 kg CO2-e) from 1.5 ha of the model. The higher carbon sink in the IFS model was due to fruit trees and boundary plantation due to which the GHG emission is negative, so more intensification of crops or enterprises can be done. Therefore, an integrated farming system approach may be one of the possible ways to mitigate the effect of climate change as reported by (Yadav *et al.,* 2019) and (Meena *et al*. 2022). The climate smartness practices were witnessed

**Table 1:** Livelihood analysis of integrated farming system developed on (1.5ha).

| Farm enterprises | (A)Value of all the farm commodities produced (Rs.) | (B) Value of farm commodities consumed in the family (Rs.) | (C) Value of all the farm commodities recycled within the system (Rs.) | (A-B-C)= D Marketable surplus (Rs.) | (D-CP) Family savings (if any) (Rs.) |
|---|---|---|---|---|---|
| Crop and cropping system | 241185 | 26000 | 8172 | 207013 | 101313 |
| Dairy (Milch animals) | 226574 | 21285 | 48380 | 156909 | 58409 |
| Horticulture (Fruit crop) | 72500 | 5100 | - | 67400 | 38850 |
| Fishery | 28800 | 5400 | - | 23400 | 10800 |
| Poultry | 15025 | 7200 | 625 | 7200 | 1340 |
| Mushroom | 11042 | 7200 | 1200 | 2642 | -3118 |
| Boundary plantation (fruit trees) | 5400 | 2300 | 300 | 2800 | 500 |
| Vermicompost/ FYM | 64000 | - | 64000 | - | 38600 |
| KG | 3250 | 3250 | - | - | 1900 |
| Value addition | 4500 | 4500 | - | - | 3200 |
| Total of all the farm produces (GR) | 672276 | 146235 | 122677 | 468364 | 251794 |

CP: Cost of production.

**Table 2:** Recycling farm waste and byproducts in integrated farming system model (1.5ha).

| Recyclable farm by produces | Quantity (kg) dry weight basis | Nutrient content (%) and recyclables nutrients (kg) | | | Total NPK (kg) | Economic value (Rs.) |
|---|---|---|---|---|---|---|
| | | N | P | K | | |
| Green manures | 875 | 1.27 (11.11) | 0.36 (3.15) | 1.64 (14.35) | 28.61 | 544.0 |
| Pulses dry matter | 870 | 0.52 (4.52) | 0.21 (1.83) | 1.06 (9.22) | 15.57 | 316.0 |
| Spent mushroom | 800 | 1.50 (12.0) | 3.65 (29.2) | 0.61 (4.88) | 46.08 | 542.0 |
| Tree leaves | 320 | 1.29 (4.13) | 0.36 (1.15) | 1.62 (5.18) | 10.46 | 198.0 |
| Poultry manure | 125 | 0.9(1.12) | 0.6(0.75) | 1.6(2.00) | 3.87 | 74.0 |
| Crop residues | 1250 | 0.56(7.0) | 0.09(1.13) | 1.20(15.00) | 23.13 | 493.0 |
| FYM | 6500 | 0.60 (39.0) | 0.18 (11.7) | 1.35 (87.75) | 138.45 | 2911.0 |
| Vermicompost | 11500 | 1.62 (186.3) | 0.23 (26.45) | 1.26 (144.90) | 357.65 | 6318.0 |
| Total | 22240 | 265.18 kg Nitrogen | 48.91 kg Phosphorus | 269.48 kg Potassium | 623.82 kg Nitrogen, phosphorus and potassium | 11394.0 |

Source: Meena *et al*., 2022.

in reduced greenhouse gas (GHG) emissions and expanded carbon sink that resulted in mitigation benefit of 5.40 Mg CO2eq/ha/year. Crop residue mulching, agroforestry, and organic waste recycling contributed to enlarging the C sink and minimizing net GHG emissions (Shanmugam *et al.,* 2024). Based on these findings, we demonstrated that a crop-livestock- based IFS model is the best climate-smart strategy to enhance the productivity and food security of small farmers in a sustainable way against the consequences of climate change and to increase the mitigating potential through carbon stocking (Rangaswamy *et al.*,1996).

**Food and nutritional security**

Overall monitoring and livelihood analyses of the IFS model revealed that by eliminating constraints these were accountable for the yield gaps and optimum integration of farm eco-friendly enterprises consequences saved 77.31% cereals, 48.71% oilseed, 75.57% pulses and 97.90% sugar, respectively. Similarly, a dairy component of IFS model produced 58.89% of milk as surplus for selling in the market. Vermicompost prepared from animal excreta and crop residues was entirely used in the crops and fruit production. The third furthermost component of IFS model is horticulture, in which fruit and vegetables were twisted more than household obligation (92.69% and 92.62%). Therefore, household supplies of these commodities have been met through other enterprises of the model. Fishes produced in pond can be used in the diet of farm households and at the same time, these can also be sold in nearby markets to earn some money for the purchasing of other essential commodities which are obligatory for the households. Hence, 86.66% of fish were sold in the market and the rest were used in farm family food. The mushroom enterprise of IFS model has an axillary potential because mustard and paddy straws were recycled for mushroom production. They were traded in the market at higher rates and remains were used by mushroom growers because they were a good source of proteins. However, 100% (172 kg/year) of extra mushrooms were sold in the market (Table 1).

**Nutrient budgeting under IFS**

Recycling of farm- based waste or byproducts has elevated nutrient values within the system for reducing the use of chemical fertilizers. Maximum Nitrogen (N) content was found in Vermicompost (1.62%) followed by mushroom spent (1.50%) and tree leaves (1.29%), respectively. However, utmost phosphorus (P) content was seen in mushroom spent (3.65%) followed by tree leaves 0.36% and green manure (0.36%). While the highest potassium (K) content was found in green manure crop *dhaincha* (1.64%) followed by tree leaves (1.62%) and FYM (1.35%), respectively. Maximum total NPK (nitrogen, phosphorus and potassium) content was found in decreasing order in Vermicompost (357.65 kg), FYM (138.65 kg) and mushroom spent (46.08 kg). Recycled by-produce increasing net income Rs. 11394/ year from the entire system (Table 2).

**Employment generation**

The IFS has created more working hours in the system owing to more enterprises than the cropping system alone. The model generated 525 man-days/ha/year. The IFS model has provided employment opportunities throughout the year due to the involvement of more manpower than used in one module of the system. Diversification of farming including multifarious activities of different enterprises included in the IFS model paved to set of employment opportunities and intact households with farming and their family members were always engaged throughout the year in this business. Rathore *et al.,* (2019) also reported that integrated farming systems under arid and semi-regions increased employment opportunities than adopted single farming system. Thus, IFS model helped in solving the problem of unemployment of farm families. The total man-days required for the crop component was 251 man-days /ha/ year followed by dairy (155 man-days/year) and horticulture (153 man-days/year) on the mean data of three years.

**Energy budgeting under IFS**

A farming system is a resource management strategy to ensure the maximum efficiency of a particular system. Studies conducted at Goa revealed the higher energy use efficiency of IFS with rice. Integration of poultry and mushroom enterprises with rice-brinjal system required the highest energy input, whereas the rice cropping alone recorded the least requirement of energy. The energy output was maximum under rice-brinjal+mushroom+poultry. The output of multi-rice based enterprise was reasonably good varying from 100.91 to 105.63 MJ/ha. It is thus, evident that efficient utilization of scarce and costly resources is the need of the hour and can be accrued by following the concept of IFS through supplementation of allied agro-enterprises (Korikanthimath and Manjnath, 2009).

**Economics analysis**

The productivity of various IFS components was assessed based on prevailing market prices in terms of grains, milk, fish, fruits, vegetables, mushrooms and green fodder. The entire productivity of the model was 260.41t/1.5ha/ year when economic values of main and by-products were converted into sugarcane equivalent yield (SEY/t/ha/year). However, maximum SEY was accrued from the crop module (93.93 t/1.04ha/year) followed by dairy component 3 animals and their dung and urine (61.80 t/year), the three most important enterprise of the model was horticulture in terms of SEY (56.44 t/year) and poultry (20.43 t/year) after selling of eggs and manure from 20 birds and vermicompost (8.66 t/year). The crop residues and other farm wastes generated from the dairy animals, green weeds, dry leaves (boundary plantation), green manure (*dhaincha*), poultry manure, and mushroom spent compost were also taken into account for calculating the physical production from different farm enterprises. The major nutrients (NPK) from the farm-based residues were also saved to the tune of 230.62 kg nitrogen 90.25kg phosphorus and 284.56 kg potassium). Thus, a total of three major nutrients were harvested 605.43 kg from 19837 kg of farm- based waste and green manuring including fish pond water and soil, recycled after a certain interval. The economic values of three chief nutrients (NPK) were Rs.12662/year when nutrient values were compared with market prices of one kilogram of nutrient (N:11.65/kg, P:26.25/kg and K:26.73/kg, respectively). The output of the entire model was calculated on sugarcane equivalent yield(SEY) by converting the main and by-products yields of non-sugarcane crops and economic products of other enterprises into equivalent sugarcane yields on a price basis using the formula:

$$SEY = \frac{(Y\times * P\times)}{P\times}$$

$$SEY = \frac{(Yx * Px)}{Pr}$$

Where

Yx = Yield of non-sugarcane crops (kg).

Px = Price of non-sugarcane crops (kg).

P× = Price of non- sugarcane crops (Rs.kg$^{-1}$).

Pr = Price of sugarcane.

Among the components evaluated, the highest net return was obtained from the crop (36.07%), followed by livestock (23.73%), horticulture (21.67% fishery (7.84%), poultry (2.01%) and mushroom (2.65%), respectively. The average employment generation over five years was 695 man-days/1.5 ha/year under integrated farming system. The gross return obtained from nine components was also higher under this model as compared to existing farming system, with a benefit: cost ratio of 2.53. To improve productivity, economic returns, and employment generation for family labour, integration of all these components should be adopted instead of cultivating the crop alone in western plain zone of Uttar Pradesh (Meena *et al*., 2022). Gross and net returns from the various components of integrated farming system model were dependent on productivity and cost of production. However, maximum gross and net returns were obtained from the crop component of the model (Rs. 380000/ year and 244000/year. The next best enterprise of IFS model was dairy in terms of higher profitability and it gave a total of gross and net returns of Rs. 237200/year and Rs.141000/ year by the sale of milk, Vermicompost, saves the chemical fertilizers. The third component of the model which was more economical was horticulture; it generated revenue of Rs. 105800/year and Rs. 83200/year as gross and net profit over all five years of the study followed by fishery, mushroom, Vermicompost, boundary plantation and kitchen garden. As a whole, the total gross and net returns from all components were obtained of Rs. 612000/1.5 ha/ year and Rs.374000/1.5 ha/year over the five years of data, of the model developed for western plain zone of Uttar Pradesh. Crop + dairy based farming system has been found most profitable enterprise in western Uttar Pradesh as reported by Singh *et al.,* (2009) The sugarcane, wheat, maize, rice, and potato crops grown in different cropping systems and dairy as an integral part of the IFS model which gave the higher income than other enterprises study area but there is a dire need to diversify the existing cropping systems and livestock farming to augment farmers income. They also reported that vegetable- based farming systems were more profitable than livestock- based farming system. Meanwhile, both the enterprises/components were integrated with crop enterprises and gave better results in terms of economic gains for the farmers due to farm-based waste being used as input for animal and animal-based waste being used as input in vegetable farming. The per capita total family income in all the farming systems was found to be higher than poverty estimates.

## CONCLUSION

It can be concluded that diversification of existing farming systems with changes, addition or improvement of crop and livestock components and inclusion of horticulture, kitchen garden, primary and secondary processing, and boundary plantation are essential to improve the income of small and marginal householders of India. Integrated farming system is a powerful tool for improving farm households' productivity, profitability, nutritional security, quality of life, employment generation, and sustainability, especially among small and marginal farming communities. Integrated farming system is also promoting ecological soundness and long-term sustainable agriculture. It is also helpful in employment generation through additional manpower engaged in the various farm activities. Ample production of cereals, pulses, oilseeds, fruits, vegetables, milk, eggs and mushroom shall be regulated throughout year supply to households and augments nutritional security and trails regular income from different enterprises and synergistic interaction between components of the IFS model through use of by-products. Thus, we can reduce the competition for available limited resources in higher production and finally enhance resource use efficiency through recycling. Integration of components is often employed as a livelihood strategy for small landholders.

### Conflict of interest

The authors declare that they have no conflict of interest.

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