

Integrated farming system model for livelihood security and doubling the Income of small-and marginal-farmers under changing climate scenario

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Integrated farming is a sustainable and effective tool for improving rural economy due to its cost effectiveness, low investment and higher profitability. It optimises the farm productivity per unit area through recycling wastes, by-product and residues from one farming system to the other with due environmental consideration. Integrated Farming systems involving crop –livestock (dairy, poultry and duckery)- biogas production –fishery-agroforestry-composting-medicinal and nutritional garden generated a gross and net returns of ₹ 8,12,984 and 3,40,787, respectively with generation of employment equivalent of 675 mandays from 1 ha area in a year (2016-17). Such model can help in attracting rural youth towards agriculture as an entrepreneur venture and livelihood security to small-and marginal-farmers.

Key words: Climate, Farmer, Income, Integrated Farming System

FARMING slaps represents a complex inter-related matrix of soil, plants, animals, implements, power, labour, capital and other inputs controlled in parts by farming families and influenced to varying degrees by political, economic, institutional and social forces that operate at many levels. An integrated farming system (IFS) represents multiple crops (cereals, legumes, oilseeds, tree crops, vegetables etc.) and multiple enterprises (livestock, bee-keeping, fish farming etc.) in a single farm in an integrated manner. For the small-and marginal-farmers of India, who constitute more than 85% of the total farming community, IFS plays a vital role for enhancing their economy and livelihood. Under the gradual shrinking of land-holding, it is necessary to integrate land-based enterprises like dairy, fishery, poultry, duckery, apiary, field and horticultural crops, mushroom, agroforestry etc. within

the bio-physical and socio-economic environment of the farmers to make farming more profitable and dependable. No single farm enterprise is likely to be able to sustain the small-and marginal-farmers without resorting to integrated farming systems for the generation of adequate income and gainful employment year round. Farming systems approach, therefore, is a valuable approach to address the problems of sustainable economic growth of farming communities in India.

Considering the above background a study was undertaken to develop IFS model at the research farm of Indian Agricultural Research Institute, New Delhi with the objectives:

- To develop IFS model to meet the food, fodder, energy, and cash need of the farmers for improving livelihood.
- To generate a net income of ₹ 3.0

to 3.5 lakh/year for small-and-marginal farmers from an area of 1ha.

- To enhance income and resource use efficiency and reduce production cost through recycling of wastes and by-products within the system.
- Promote biodiversity and sustainability through inclusion of variety of crops (and crop variety) and enterprises.

Outline of IFS model

The structure/composition of the integrated farming system (IFS) model, conducted from 2015 to 2017, is shown in Table 1.

Integrated Farming systems: An integrated farming system (IFS) represents multiple crops (cereals, legumes, oilseeds, tree crops, vegetables etc.) and multiple enterprises (livestock, bee-keeping, fish farming etc.) in a single farm in an integrated manner. The level of

Table 1. Enterprise details for the on-station integrated farming systems model (crop-livestock-fishery-poultry-biogas-agroforestry) under irrigated conditions.

Enterprises	Area allocated (m ²)
<i>Integrated Farming System</i>	
<i>Crop enterprise:</i> Field crops (wheat, maize, cotton and mustard)	6,250
<i>Horticultural crops</i>	
<i>Fruits</i> (mango, lemon, guava, papaya and banana)	1,000
<i>Vegetables</i> (okra, brinjal, bottleguards, pea, onion, radish, countrybean, greens: sarsonsag, spinach)	2,000
<i>Floriculture</i> : Marigold	750
<i>Fishery Science</i>	
<i>Composite pisciculture</i> (catla, rohu and mrigal)	1,000
<i>Duckery:</i> Layer purpose (khaki Campbel-35 birds)	10
<i>Poultry</i> : Mostly local birds 50, Aseel 12, Kadaknat 14, Ankleswar 12, and Nikobari 12	10
<i>Dairy</i> (Crossbred cows-3) 3 units of crossbred cows were kept for milk purposes	10x6 = 60
<i>Fodder</i> (Jowar – berseem)	500
<i>Bio-gas plant</i> : 2 m ³ KVIC model to provide cooking gas for 4 to 5 members farm family	
<i>Agroforestry</i> : Moringa (25 plants) (var. PKM-1), Dilenia (2 plants), Neem (2 plants)	100
<i>Medicinal garden</i> : Sarpagandha, Ashwagandha, Aloe vera, Tulsi, Citronella grass, Brahmani, and Mint	100
<i>Nutritional garden</i> : Papaya, Pomegranate (Bhagwa), Custard apple, Sapota, Kaintha, Bael, Guava	100
<i>Compost pit</i> : Compost making from crop residues, farm bio-wastes to produce 5.0 tonne compost round the year from 4 pits (2 cycles)	20
<i>Conventional cropping system</i>	1,000
Maize–wheat	500
Cotton–wheat	500

integration can be easily measured with the level of resources, wastes and by-products recycled within the system. This helps in better utilization of various resources available within a system and enhances the resource use efficiency. More the recycling of the resources/by-products/wastes, the better is the integration. Such resource flow within the farming system makes the system self-reliant, less dependent on external inputs and sustainable. In the integrated farming system model developed for small-and marginal-farmers with 1.0 ha area involving the enterprises – crop –livestock (dairy, poultry and duckery)- biogas production –fishery-agroforestry-composting-medicinal and nutritional garden efforts have been made to recycle the by-product and wastes of one enterprise as the in-pot of other enterprise. This has helped in enhancing the resource use efficiency and reducing the production cost. Besides, the farming systems become more self-reliant and less dependent on external inputs. The natural mechanisms of the farm are explored.

The followings are the

components and their composition and roles in an IFS.

Pond as water-harvesting structure: A pond with 50 m length and 20 m width and 2.0 m depth was constructed having a capacity of storing water of 10,00, 000 litres (keeping depth 1.0 m). Pond was having a dyke width of 3.0 m and a catchment area of 456 m², where the excess rainwater comes to pond. Besides around 100 m road of 3 m width serves as a catchment for the pond, the water from the road are harvested in to the pond, thus pond serves as a water harvesting structure. Around 6.0 lakh litres water is harvested depending on the rainfall. This helps in meeting around 30% of the water requirement for the pond round the year. Thus, the pond system serves as a water harvesting structure.

Fish-duck integration: Fish pond with aquatic animals and plants, provides excellent disease-free environment for ducks. Duck droppings go directly in pond, which in turn provide essential nutrients to stimulate growth of natural food. Most common breed used is ‘Khaki

Campbell’ and ‘Indian runners’. Around 300 to 350 ducks/ha can provide 500 to 600 kg meat and 18,000 to 18,500 eggs year. In the integrated forming system unit, we maintained 35 Khaki Campbell ducks in a low-cost duck house having 70 square ft area. In the fish pond, around 100-120 cm water depth is maintained round the year, in which composite fish production is taken. Three species of fish – catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) who feed on surface, column and bottom layer, respectively is taken for best utilization of pond water. Fish and duck integration/link has been explored. For fish production the major production cost is feed. Similarly for duck raising, the major production cost is feed. If we integrate duck with fish, the excreta of the ducks serves as feed of fish through promotion of zoo- and phyto-plankton. Duck also helps in aeration of the pond water. Duck rear in the pond system and eat upon the insect and grass of the pond, thus the feed requirement of duck is partly met from pond system. This integration is very useful for reducing the production cost.

Poultry-fish-crop integration: The poultry fish system is common in Indian and foreign countries. In the farming system unit a low cost poultry house of 8.9m³ (3.30m × 2.70 m) is established over the pond with the support of pond dyke, in such a way that the poultry droppings fall in to the pond directly. In the poultry unit of IFS, 50 layer poultry birds are taken. Besides to egg production, which contributes to net income, the valuable poultry droppings (around 1.0 tonne/year) serves as fish feed through promotion of zoo- and phyto-plankton. Poultry manure is rich in nitrogen (N) and phosphorus (P), which fertilize the fish pond. Fish production of 4,500-5,000 kg/ha/yr is obtained by recycling chick droppings into fish ponds is possible. Layer production provides both eggs and meat both on regular and long term. Around 300-500 broiler/layer/ha can provide 70,000 eggs and 1,250 kg of chicken. Around 6-10 tonnes/ha/year manure

is produced. Periodically, the water quality is analysed for N and dissolved oxygen. When the N content in pond water exceeds more than 2.5 to 3.0 ppm, the water is used for irrigating the crops. This nutrient rich water helps in manuring the crops grown in the system, thus multiple use of water is possible, which helps in reducing the manure requirement for crop production and enhancing water productivity also.

Dairy-biogas-crop integration: This is a common feature in Asian agriculture. By-product of dairy industry-cowdung is recycled through biogas plant and biogas plant digested slurry is utilized for fertilization of the crop plant. In a year around 20.0 tonne of cowdung produced from 3 cross-bred cows is recycled through biogas plant to manure the crop plants in the system. This helps in enhancing the nutrient status of the field and soil-health. The integration of dairy with crop is an index of sustainability. Besides, modern form of energy biogas is produced from this integration which supports the gas requirement of 4-6 members of the farm family. Besides crop and dairy integration is vital. In crop enterprise, the fodder, berseem during *rabi* and sorghum or baby corn during *kharif* help in meeting the green fodder requirement of dairy cows. Baby corn helps in generating the income and also providing valuable fodder. Baby corn can be grown round the year. Similarly, other crops like maize and sweet corn stovers after harvest is utilized as a good source of fodder to dairy and grasses from pond dykes and fruit crop areas are also utilized as fodder to dairy animals.

Apiary-crop integration: Bee-keeping is an enterprise which blends perfectly with other components of an ideal integrated farming system. Honey-bees provide valuable pollination service to cross pollination dependent crops of the farming system thereby enhancing their productivity. Bee-keeping helps in realizing higher crop productivity. It adds to farm profitability mainly through increased cross pollination. It has been estimated that the value of increase in crop yields through

pollination is more than the value of honey produced by honey bees. Apiculture also generates employment opportunities or leads to effective utilization of family labour. Beekeeping can be started with very little investment and less labour when compared with other livestock. Apiculture is women friendly enterprise as it involves less drudgery in accomplishing the activities. Beekeeping can fit in any of the multi-crop based cropping system that assure the availability nectar and pollen resources for the bees.

Composting-crop integration: The IFS unit has the provision of composting using pit method of composting (4 units: 3×1×1 m³). The crop residues, weeds and grasses which are removed from the crop enterprise are recycled in to the compost pit and around 5.0 tonne of manure is produced round the year in 2 cycles. The manure is utilized for manuring the field.

Medicinal garden : There are several types of gardens such as medicinal, garden which may double farmers income. India has been considered as a major store house of various indigenous plants that are used to cure disease and disorder of various kind. Small-and marginal-farmers of India usually prefer such plants, since these are safe, economical and easily available to them. A small medicinal garden in 100 to150 m² area is maintained in Integrated farming system unit consisting of medicinal plants such as: *sarpagandha* (*Rauvolfia serpentina*), *ashwagandha* (*Withania Somnifera*), *aloevera* (*Aloe barbadensis*), *tulsi* (*Ocimum tenuiflorum*), lemon grass/citronella grass (*Cymbopogon citratus*), *ajwain* (*Trachyspermum amni*), *brahmani* (*Bacopa monnieri*), mint (*Mentha piperita*), *hadajod* (*Cissus quadrangularis*), insulin plant (*Costus igneus*), soursop fruit plant (*Annona muricata*), *harida* (*Terminalia chebula*), *kalmegh/Green chiretta* (*Andrographis paniculata*), *harsingar* (*Nyctanthes arbor-tristis*), *Giloy* (*Tinospora cordifolia*), *sadabahar* (*Catharanthus roseus*), *pathharchata* (*Kalanchoe kinnata*), small cardamom (*Elettaria cardamomum*),

curry leaf (*Murraya koenigii*), and shatavari plant (*Asparagus racemosus*). These plants were raised considering the family need of a farmers, which can help the farmers to cure their health problems a natural way. Besides, curry leaf is a regular use in the family and lemon grass is useful in making tea.

Nutritional garden: A small nutritional garden in 150 to 200 m² area was maintained in the integrated farming system unit consisting of papaya (*Carica papaya*), pomegranate (*Punica granatum*), custard apple (*Annona reticulata*), sapota (*Manilkara zapota*), kaintha (*Limonia acidissima*), bael (*Aegle marmelos*), guava (*Psidium guajava*), coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophyllus*), banana (*Musa paradisiaca*) star fruit (*Averrhoa carambola*), elephant apple (*Dillenia indica*) and *aonla* (*Phyllanthus emblica*). There are certain unique fruit plants very useful for health point of view such plants are kaintha, star fruits, elephant apple, and custard apple. By maintaining a nutritional garden, the care has been taken how a farm family can get fruits round the year for better nutrition to the family members. Besides this, other fruit plants such as kinnow, lemon, guava, sweet orange, mango are grown in dykes of pond and boundary of the farming system, which also contribute to income and family requirement of fruits.

Resource recycling in IFS

The major objectives of the study were to enhance the income of farmer by integrating different land-based enterprises, and reduce production cost by recycling farm by-products and wastes within the system. The by-product of dairy, i.e. cowdung, forms a major raw material for biogas. Digested slurry of biogas forms a major part of feed of pisciculture for increasing plankton growth as well as supplying valuable manure to raise the productivity of crops. The by-product of poultry, i.e. poultry dropping, forms an important ingredient of pisciculture for increasing the plankton growth and also increases the fertility of land.

Even an item like apiary has lot of indirect bearing on crop enterprise by increasing yield and quality through improvement in pollination, apart from giving a wholesome product like honey to the farmers. Farmers like to have flowers which add to the aesthetic sense of farm family and flowers serve as foraging plants for honey-bees. The by-product of crops like wheat-straw and other crop residues and weeds are utilized for compost making and valuable compost is utilized for production of vegetables, fruits and other crops.

Biodiversity and ecosystem services

Agrobiodiversity can be used as a resilient crop production system due to its useful in self-sufficiency, erosion control, carbon sequestration, soil fertility build up, drought resistance, functional biodiversity and organic production systems. Agrobiodiversity and its links to ecosystem properties have cultural, intellectual, aesthetic and spiritual values that are important to society. In this farming systems – 10 field crops (wheat, maize (grain purpose), sweetcorn, cotton, greengram, redgram, groundnut, mustard, babycorn, pea); 10 vegetables (Okra, brinjal, garden pea, tomato, cowpea, broccoli, pumpkin, bottlegourd, radish, cowpea) and 15 fruit crops (mentioned above) and 20 medicinal plants (mentioned above), 2 fence crops (country bean and spine gourd (*Momordica dioica*), 4 spices crops (corriender, ginger, turmeric, chilly), 4 green vegetables (*palak*, raddish, *sarso ka sag*, basella), 2 fodder plants (sorghum, berseem) are grown. It is more than 65 plants/crops are grown in 1ha area. Besides, other organisms/ livestock- crossbred cows, 3 to 4 species of fish (as mentioned above), 2 breed of poultry birds (Rhode Island Red, Kalinga Brown) (previous year, local *deshi* birds, Aseel 12 number, Kadaknatl4 number, Ankleswar 12 number, Nikobari 12 number were taken) and one breed of duck (Khaki Campbell) is maintained in the Integrated Farming System unit, which aids to the agro-biodiversity of the system. Such a diversity not only serves as strong pillar to sustainability, risk

minimization and climate resilience, but also provides ecosystem service for the farm family to maintain a healthy life by meeting around 80% of the farm family requirement for various products including modern form of renewable energy (biogas). The produces are of better quality due to no or minimal use of chemicals.

ECONOMICS

Taking the performance of different components of the whole farming system into consideration, it revealed that dairy enterprise comprising of 3 crossbred cows gave the maximum gross and net return of ₹ 4,46,040 and ₹ 1,52,324, respectively. This enterprise also involved maximum production cost of ₹ 2,93,716 and generated employment opportunities of 365 man-days. Other next promising enterprise was crop production, which generated a gross and net return of ₹ 1,65,354 and ₹ 93,198, respectively. This enterprise covering maximum area of 0.7 ha, involved a production cost of ₹ 72,156 and generated employment opportunities of 150 man-days. The performance of multilayer pisciculture stood next to crop production where the magnitude gross and net returns were ₹ 90,000 and ₹ 44,456 with investment of ₹ 45, 544 creating employment opportunity to the extent of 26 man-days (260 man-days/ha). The other enterprises – duckery, fruits, agroforestry and crops grown in fence were also promising by contributing to gross and net

returns, though the area covered in these enterprises are less (Table 2). Resource-use efficiency (₹/₹ invested) depicted a different picture in comparison to net and gross returns. Though dairy enterprise generated maximum gross and net returns, resource-use efficiency was the minimum from it, reverse was true for agroforestry.

Despite these differences in the magnitude of aforesaid indicators, the overall success was commendable from the integrated farming system model comprising of land-based enterprises: crops (horticultural, medicinal and field crops) + dairy + fishery + duckery + poultry + biogas + agroforestry in 1.0 ha area. The IFS model generated a gross and net returns of ₹ 8,12,984 and 3,40,787, respectively were obtained with generation of employment equivalent of 675 mandays (Table 2). IFS model helped in providing gainful employment for the farm family members round the year and earning a wage/salary of 2.25 to 2.50 lakh/year. Such IFS models are potential to double the farmers income and to diversify monoculture of rice-wheat cropping system (creating environmental and other resource degradation problems), where a net income of around ₹ 60,000/ha/year is achieved.

FOCUS OF IFS MODEL AND POLICY ISSUES

Dominance of small-and marginal-farmers

Indian agriculture is dominated

Table 2. Economic of 1 ha IFS model for small-and marginal-farmers under north Indian situations

Enterprise	Area/unit	Gross returns (₹)	Production cost (₹)	Net returns (₹)	Labour (man-days)	Resource-use efficiency (₹/₹ invested)
Crops	0.7 ha	1,65,354	72,156	93,198	150	2.29
Fishery	0.1ha	90,000	45,544	44,456	26	1.98
Duckery	35 birds	50,590	30,781	19,809	52	1.64
Dairy	3CB (11,151 litres milk)	4,46,040	2,93,716	1,52,324	365	1.52
Biogas	KVIC model (2m ³)	9,000	4,000	5,000	12	2.25
Fruits	Lemon + Kinnow 0.03 ha	16,000	6,000	10,000	15	2.67
Fence area	Country bean (0.03)	30,000	18,000	12,000	50	1.67
Agro-forestry		6,000	2000	4000	5	3.0
Total		8,12,984	4,72,197	3,40,787	675	1.72

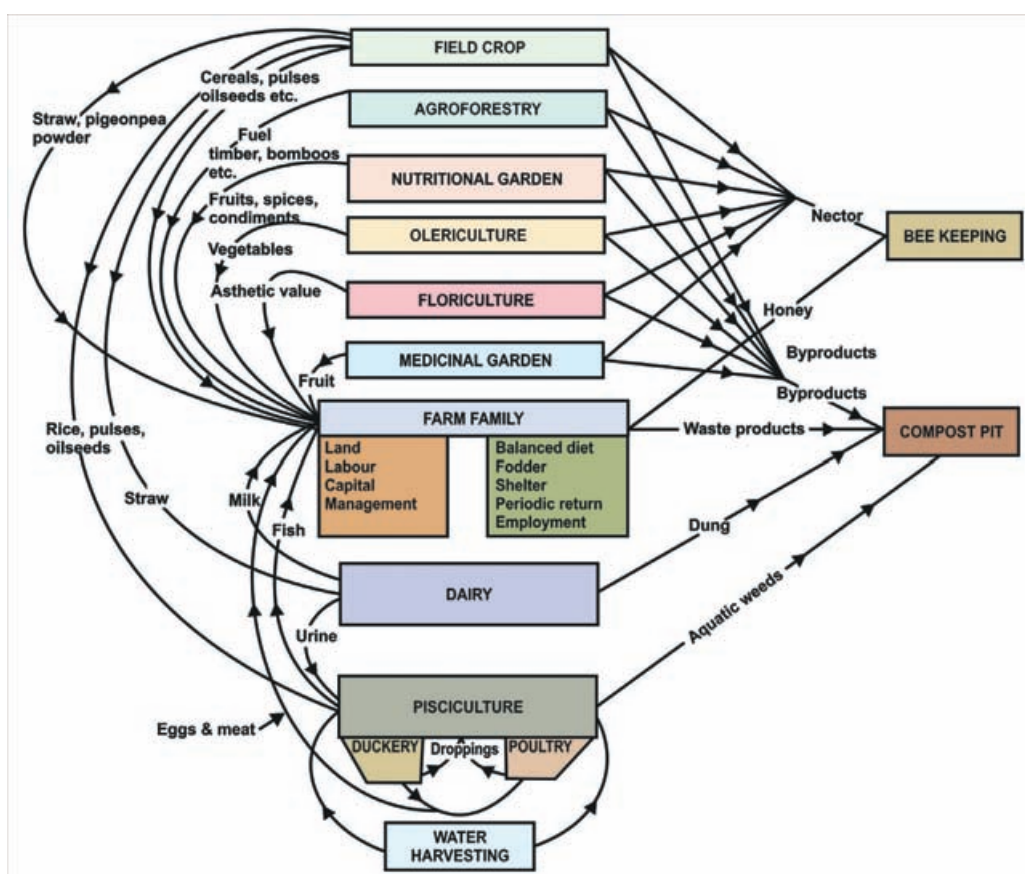


Fig. 1. A close examination of resource recycling indicated the interdependence of the different components of the total farming system to make the farmer self-sufficient in terms of ensuring the family members a balanced diet for leading healthy life and also making farm-self-sufficient through recycling of by products/wastes.

with > 85% small-and marginal-farmers. Developing of an integrated farming system with the objective of enhancing the livelihood security of small- and marginal-farmers has been a timely effort in a premier institute like IARI, New Delhi. This has benefitted the students and researchers from India and abroad for carrying the information for future planning of small farm system of the country in a more viable and sustainable manner.

Demonstration of a system and holistic approach

The development of vast small-and marginal-farmers is possible through system and holistic approach. However, agriculture in south Asia including India and other developing countries is suffering from the disciplinary and component approach and not allowing proper growth particularly growth of small-and marginal-farmers. Under the situation, such an IFS model demonstrate the system and holistic approach, from which the clients

from India and other developing countries get the message for promotion of system approach.

Attracting Rural Youth to Agriculture

IFS model of IARI, New Delhi has attracted rural youth from Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Odisha, Mizoram, Manipur, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab and Uttarakhand. These youth are attracted for making IFS as an entrepreneurial venture for gainful employment. Some of them have partly/fully implemented also. In future, such an approach may help in creating employment for the rural youth of our country.

Variants of IFS

IFS is a holistic and system approach, in which natural mechanism of the system is explored by establishing compatible linkages among the various components, which make it sustainable. Such a system approach is very much needed for developing sustainable model for E-IFS (Energy self-sufficient IFS),

organic farming, natural farming, Natu-eco farming and conservation farming systems.

SUMMARY

The entire philosophy of integrated farming system revolves round better utilization of time, money, resources and family labourers of farm families. The farm family gets scope for gainful employment round the year, thereby ensuring good income and better standard of living. It is high time that the scientists, administrators and planners should think on such lines and provide adequate facilities and encouragement to the small and marginal farmers and rural youth to go ahead with the integrated farming systems with a sense of commitment for the rural development in totality.

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