

Resilient integrated farming system

models in irrigated agriculture

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Indian economy relies heavily on agriculture with small and marginal farmers constituting 85% of the farming, possessing 44% of the total operational land. However, the per capita availability of land is found declining from 0.35 ha in 1961 to 0.12 ha in 2015 and projected further decline of 0.09 ha in 2050. The declining per capita availability of land and vagaries of nature poses serious threat to profitability and sustainability of farming and provides no scope for horizontal expansion of land for food productivity. The solution for increased productivity and to have resilience agriculture lies with vertical expansion of land i.e. integrated farming system. This system with appropriate farm component integration requires lesser space and time for providing periodical farm income, employment, livelihood and nutritional security with an answer of sustenance and resilience. Over the years scientists have developed different integrated farming system models suitable for low land and irrigated dryland ecosystems, thus meets the goals through multiple uses of natural resources such as land, water, nutrients, energy in the era of climatic change in a complimentary way thereby giving scope for realizing the physical indicators of farming system, a suitable system for small holders' farming.

Keywords: Integrated farming systems models, Irrigated dryland, lowland, Resilience

IT is estimated that, about 80% of the total area is under cultivation to feed the ever increasing population of the world. Globally, the demand for food products increases by 70% and expected to be doubled by 2050. The changing climate scenarios such as increasing temperatures, changes in rainfall pattern in terms of frequency and intensity has resulted in yield loss of most of the agricultural crops. Hence, the Food and Agriculture Organization, emphasizes on concepts that gives importance for improving the resilience of agricultural systems against these environmental factors and can offer increased food production in the face of changing climate, environmental variability and improves nutritional outcomes and reduce cost of farming and its contribution to green house gas emissions.

Integrated farming system results

in increased agricultural productivity, reduce greenhouse gas emissions, supports global food demand and nutritional security. As the farming system ensure stability against the uncertainties and possesses the capacity to adopt for a particular situation, can be conceptualised for resilient agriculture. Resilience can be attained through lesser reliance on external inputs, enhanced nutrient cycling and increased natural resource use efficiency. This has the ability to cope with climatic variability and other changes either positive or negative, with its adaptive strategy to maintain ecosystem stability in the face of stress or disturbances.

Concept of farming system

Indian agriculture is characterized by small farm holdings and the average farm size is only 1.57 ha. Around 93% of farmers have land

holdings smaller than 4 ha and they cultivate nearly 55% of the arable land. Majority of Indian farmlands can be classified under low land ecosystem, irrigated dry land and rainfed ecosystem. Therefore, even a small change in the production system could jeopardize the balance of food production and agriculture which demands country like India to adapt more robust approach in achieving climate resilience in agriculture. Location-specific IFS models have the potential to double the farmer's income besides providing year-round employment. Integration of different agriculturally related enterprises with crops provide ways to recycle the products and by products of one component as input to another and reduce the cost of production and increase the total income of the farm (Fig. 1).

- In general, the concept of farming

- system
- Involves best utilization of the growing space through the integrated farming approach
- Ensures nutritional and economic security for better health of the farm family as they get different products and cash crops from their own land, boosting food security through local production, consumption and helps in reducing migration

Improves soil's physical and chemical properties, its nutrient status and biological components. Such interactive systems affect the microclimate and provide a strong base to good agricultural practices for sustained increased productivity. Hence, the farming system practices address the capacity to transform internally in response to endure stress and thus obtaining the required function.

Suitable IFS models for resilience in irrigated agriculture

India constitutes a significant quantity of lowland, irrigated and dryland ecosystem where resilience towards change of environmental conditions and other factors are very much important. One of the most credited ways of achieving resilience in these areas is through adapting practices such as IFS, and also the most recognized practice among various researchers as well. Some of the most notable researches in irrigated agriculture done for different ecosystems. The location specific IFS models are validated based on the biophysical indicators such as productivity, profitability, employment generation and resource

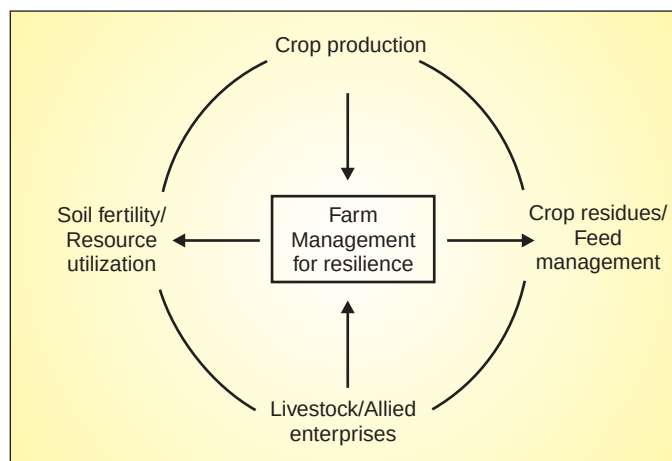


Fig. 1. IFS for resilient agriculture.

use efficiency for soil fertility improvement.

Lowland ecosystem

Experimental results on enterprise linkage for wetland farming systems revealed that rice-soybean-sunflower and rice -gingelly- maize cropping systems (each in 0.18 ha) with pigeon (40 pairs), fish (400 polyculture fingerlings in 0.04 ha of pond water) and mushroom (2 kg/day) was best in obtaining higher productivity in the system as a whole than the conventional cropping system with rice-green gram-maize in 0.20 ha and rice-sunhemp- maize in 0.20 ha. An integration of crop, pigeon, fish and mushroom gave better per day returns and higher benefit cost ratio. Integration of poultry, fish, mushroom, and crop applied with recycled poultry manure sustained the productivity of soil. The growth of fish culture fed with poultry and pigeon droppings was comparable to that of growth achieved with artificial feeds. Net returns and benefit cost ratios were higher with fish production with poultry or pigeon droppings. The outcome of the study indicated that to enhance the

productivity of lowland farmers having one hectare farm, economic returns, employment generation for the family labour round the year and soil fertility with environmental protection.

Institutional research on farming system with rice + azolla + fish culture was found promising for viable economics in low land conditions of Tamil Nadu. Field trenches were provided with 1.0 m depth and 1.5 m width occupying 10% of the rice

area, for sheltering the fish. *Azolla microphylla* was grown in rice field throughout the cropping period. The fish in rice field utilized the untapped aquatic productivity of rice ecosystem as the rice bottom is highly fertilized on account of the production of zoo and phytoplankton and these resources are fully utilized by the fish. The rice + azolla + fish model recorded higher gross income (25.7%) over rice monoculture and rice + fish (6.9%). Thus rice + azolla + fish on an average gave ₹ 8,817/ha more over the rice monoculture and ₹ 3,219/ha over the rice + fish integration.

A study was carried out with cropping, poultry, pigeon, goat and fishery enterprises in all possible combinations during 1998-2001, with a view to recycle the residue and by- products of one component over the other. Three systems, viz. crop+fish+poultry, crop+ fish+ pigeon and crop+fish+goat were tried in one hectare area. The study revealed that integration of cropping with goat and fish (Table 1) recorded higher system productivity (37,679 kg/ha), net return (₹ 1,31,118) and per day return (₹ 511/ha).

Table 1. Productivity and economic analysis of integrated farming system and components

Farming systems	Component Productivity (kg) & (%)					System productivity (kg/ha)	Net return (₹/ha)	Per day return (₹/ha)
	Crop	Poultry	Pigeon	Fish	Goat			
Crop	12995	-	-	-	-	12995	37153	178
Crop + Fish + Poultry	26,352 (89.0)	1205 (4.1)	-	2052 (6.9)	-	29609	97731	400
Crop + Fish + Pigeon	24,854 (85.2)	-	2545 (8.7)	1774 (6.1)	-	29173	98778	400
Crop + Fish + Goat	25,725 (68.3)	-	-	1975 (5.2)	9979 (26.5)	37679	131118	511

A study conducted on IFS at Agricultural Research Station Karnataka, with crop component (rice-rice, maize-sunflower, vegetables), fishpond and goat including fodder area was compared with conventional rice-rice system. Model of crop+fish+poultry+goat recorded the 26.3% higher productivity and net returns by 32.3% than conventional cropping system. The benefit cost ratio was higher (1.97) in IFS than conventional system (1.64). Among the components, higher net returns were recorded with crop (63.8%), followed by goat (30.9%), fish (4.0%) and poultry (1.3%), respectively. Employment generation was reduced by about 40% in this system but distributed throughout the year. Specific energy was low in IFS (3.09 MJ/kg). IFS model required lower water requirement which consumed 47.4% less water (1247 mm) compared to conventional rice-rice system (2370 mm).

Irrigated dryland ecosystem

Many studies conducted across India, proved successful in achieving higher productivity by adapting IFS systems, besides resilience.

A Field experiment was conducted to identify and optimize the component linkages in IFS for irrigated upland of North Eastern Zone of Tamil Nadu. Cropping system versus IFS models with dairy and Japanese quail were evaluated. IFS model recorded higher benefit cost ratio (2.47), per day return (₹ 602), employment generation (374 man days), partial budgeting (higher net benefits of ₹ 1,83,366/ha). In nutrient recycling, vermicompost component produced a quantity of 5642 kg with a nutrient potential of 118.4, 51.9 and 84.6 kg of NPK. Dairy component added 10000 kg of farmyard manure which has a potential of 53, 25, and 58 kg NPK. Japanese quail produced 1243 kg of manure with 27.3, 19.3 and 18.4 kg NPK which reduced the cost of production and improved the soil health and yield.

Further, in Bhubaneswar, an IFS model developed with cropping

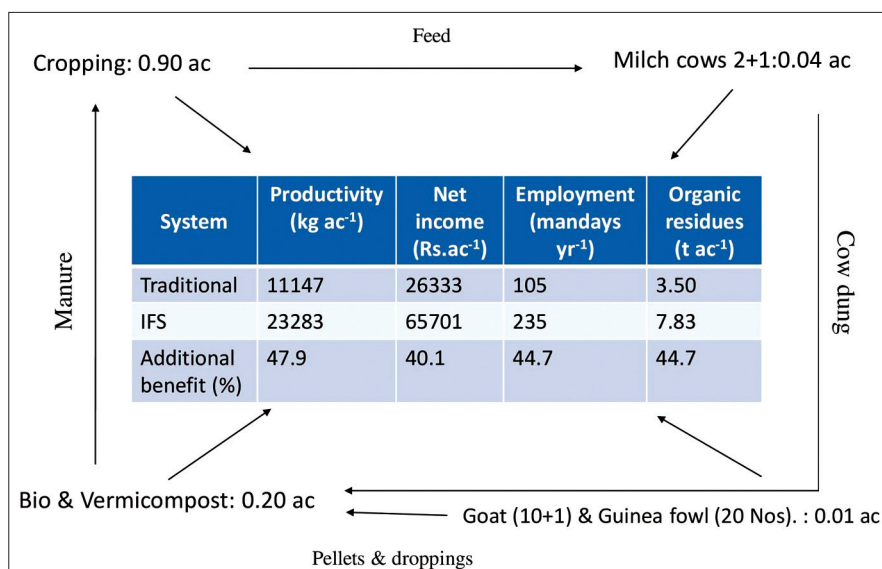


Fig. 2. Farmer participatory farming system for Irrigated dryland.

systems + horticulture + dairy (2 cows) + fishery + poultry (380 nos.) + duck (20 nos.) + agroforestry + vermicompost + mushroom + biogas + apiary gave higher equivalent yield of 22.8 t/ha and net return of ₹ 75,129/year.

The results of IFS research conducted across India showed climate resilience and the results were carried forward through farmer participatory research. The crop activity in integrated farming system consisted of field, vegetable, and fodder crops. The livestock kept were two cross bred milch cows and a calf, ten female tellicherry does + one buck and twenty guinea fowls (Fig. 2). The manure obtained from milch cows along with field and fodder crop residues were used for bio compost. Vegetable wastes, goat and guinea fowl manure were used for vermicomposting. Improved farming system gave the maximum maize grain equivalent yield of 57 t/ha/year which was 48% higher than the traditional farming system. The improved system was able to generate employment of 588 man days/ha which was higher than traditional farming system (263 man days/ha). Through recycling of crop residues and livestock manure about 3.7 tonnes of bio-compost and 1.6 tonnes of vermicompost were obtained from one acre land area. An estimated supply 26 kg of N, 22 kg of P and 26 kg of K to field and fodder crops were made through

biocompost. Application of vermicompost enriches the soil with 39, 11 and 18 kg NPK to vegetable crops. The returns per rupee of investment from the ratio of gross value of output to total cost was 3.62 and ratio of net value of the products to total cost was 2.80, which demonstrated on the ability of improved farming system to generate more returns when compared to the traditional system and efficiency of IFS towards sustainability and resilience.

Success stories in achieving resilience by adapting IFS around various parts of India under irrigated conditions are appended.

Tamil Nadu

The farmers of Cauvery New Delta region, Tamil Nadu are pleased in establishing IFS models in their fields through NADP -IFS scheme. The trained farmers willingly adopted IFS and experienced the positive goals. Family members were engaged throughout the year for maintaining fish cum poultry farming. By using vermin-bag technology, started producing vermicompost within farm and could able to produce approximately 1.5-2.5 tonnes and applied these for the coconut, mango trees planted on the bunds and nearby areas of fish pond. They said that excess quantity if any will be applied for rice crop thereby to reduce the fertilizer cost. In terms of employment, income generation,

waste recycling, reducing input usage, selling eggs and fish for getting extra additional income, they expressed their happiness in implementing this scheme.

Haryana

For Ms. Amarjeet Kaur, a well-known progressive farmer in Adhoyi village, agriculture is the main source of income to fulfill the basic requirement of her family. She possesses 3.4 ha land with irrigation facility. She practiced cropping system alone. But the yield and income were low. After introduction of IFS components, viz. cropping system, dairy and vermin compost, net income recorded was ₹ 6.7 lakhs/year. Due to climate change, she shifted rice cultivation to maize that reduced the water requirement which improved the productivity and yield.

Karnataka

Ms. Hemalatha from Mandya district of Karnataka practiced IFS, viz. crops + dairy + vermicompost + poultry/duck + kitchengarden + silviculture. Among different components, from dairy she earned higher net income of ₹ 25,200/month. The waste generated from silviculture and dairy unit used for vermin compost preparation, marketed to local farm and nurseries,

earned ₹ 20,000/month. Also rears Silkworm, sells at local cocoon market, earned ₹ 15,000/month. Overall, through IFS earned ₹ 65,000/month, generated more employment throughout the year with best natural resource utilization.

Tripura

Sri Prasenjit Das, a progressive farmer of Pekucherra village of North Tripura is a successful IFS practitioner, associated with farming for over 30 years, normally practices traditional methods of crop cultivation and could not get more yield and profit. With introduction of horticultural crops and livestock components, earned ₹ 1,00,000 from crops followed by fishery (₹ 88,000), dairy (₹ 70,000), horticulture (₹ 4,51,400) and goat (₹ 12,000). On a whole, IFS improved the farmer's status and generated employment opportunities throughout the year for the family.

suitable interventions, for example introduction of fodder component in the system increases forage availability, leads to improved productivity of animals within the system. Further, the direct and indirect effect of fertilization for enhancing productivity provides clearly the synergistic dimension of crop livestock integration. The targeted feeding intervention of soil and livestock component increases energy production, gross income and soil fertility improvement. The location specific strategic adoptive agronomic interventions employed in crop livestock integration helps in strengthening physical, chemical and biological environment. Adoption of farming system could able to endure shocks or stress due to biotic and abiotic factors through various interventions. Thus, IFS attempts to formulate proxies of resilience that characterise towards stress or to respond to favourable conditions.

SUMMARY

The farm diversifications with crops and livestock components were found to have synergies in the system in term of productivity, profitability and sustainability. The integration is source for providing food and nutritional security of the ever increasing population. Adopting

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Integrated Farming Systems (IFS) models

Four integrated farming system models were established for round the year income and employment. A 0.56 ha wetland IFS model comprising of field crops (rice, maize, sorghum (grain and fodder), redgram, greengram) + horticulture (banana, papaya, Guava, Pomegranate, apple ber, rosewood, pomelo citrus vegetables), livestock (Ongole cow, kadaknath and Aseel poultry) + fish (rohu/Indian carp and grass carp) have been developed for Andhra Pradesh. Similarly two IFS models for Gujarat and Rajasthan comprising of crops, horticulture and livestock have been established.



Integrated Farming System model for wetland ecosystem of Andhra Pradesh. Source: ICAR Annual Report 2020