

Integrated farming system and agriculture sustainability

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ABSTRACT

There are 115 million operational holdings in the country and about 80 % are marginal and small farmers. To fulfill the basic needs of house hold including food (cereal, pulses, oilseeds, milk, fruit, honey, meat, etc.), feed, fodder, fiber, etc. warrant an attention about Integrated Farming System (IFS). Undoubtedly, majority of the farmers are doing farming since long back but their main focus was individual components but not in a integrated manner. At the ICAR and State Agricultural Universities level, lot of efforts have been made aiming at increasing the productivity of different components of farming system like crop, dairy, livestock, poultry, piggery, goat keeping, duckery, apiculture, sericulture, horticulture, mushroom cultivation etc. individually but lacking in their integration by following farming system approach. The integration is made in such a way that product of one component should be the input for other enterprises with high degree of complimentary effects on each other. The fodder fed to the cattle produces milk. The dung, urine and litter produce farmyard manure and energy used for crops and fish pond. The siltation of fish pond is utilized as manure to crops. The farmyard manure can substitute about 25% of recommended N P and K for crops, besides improving the physical and biological properties of soil. The fish pond water can be used by gravity method while there is breakdown in electricity supply. Oilseeds provide nectar for honeybee, edible oils for human and oilseed-cake for animal feed. Integrated nutrient management can enhance the productivity of cereals by 0.5 to 1.0 t/ha. Processing of different products enhances the value addition to the extent of 25 to 50% besides generating 50-75-man days/ family/ year of employment. The fish pond embankment comprising 20-30% can be used for growing cucurbits and fruit trees which provide effective soil cover to checks the soil erosion and also make the system economically viable. The apportionment of farm land involving different enterprises, viz., cereal (40%), pulses (10%), oilseed (10%), horticulture (15%), fishery (10%), livestock (10%), poultry/piggery/goatry (2%), storage, threshing floor, implement shed, vermicompost, straw storage and farm building etc. (3%) for the efficient use of resources available and to enhance the input use efficiency. The preliminary research investigations advocated the benefits of productivity improvement by 30-50% depending upon the number and kind of enterprises and their management. The information on farming system in a systematic way is presented here. The methodology is explained keeping in mind the work done so far to realize better productivity, profitability and sustainable production systems that would help to solve the fuel, feed and energy crisis, create more employment avenues, ensure regular income and encourage agricultural oriented industry.

Key words: Employment, Integrated farming system, Profitability, Resource management.

Indian economy is very much linked to the advancement of agriculture and that too of resource poor marginal and small farmers who constitute 80 % of >115 million farm families cultivating only 29 % of the consolidated and scattered arable land. Sustaining house-hold food security has been an issue of prime importance to majority of the farmers. Farmers under small and marginal categories farmers are economically poor, work in diverse, location specific, risk prone environment invite attention to develop technologies for interdisciplinary enterprises as farming system research. During last five decades, agricultural research emphasized mainly component and commodity based research involving development of animal breed, crop varieties, farm implements, and machinery,

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fertilizer use, and other production and protection technologies mostly conducted in isolation and at the institute level which enabled the farmers to grow more but at the same time over exploited the resources. It resulted in decreasing factor productivity, resource use efficiency and ultimately less farm productivity and profitability. It further coupled with the national problems like environmental degradation, groundwater contamination and entry of toxic substances in to the food chain has become a significant problem. To tackle such problems, farming system approach has been widely recognized and advocated as one of the tool for harmonious use of inputs and their compounded response to make the production system sustainable. In developing countries, poor farmers work hard to feed themselves and try to make a living from their limited land, with some livestock and crops. The livestock

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manure fertilizes the crops, and the crop residues feed the livestock. The more recent integration of fish with the livestock and crop has helped to improve the fertilizer and feed supplies, plus the higher market value of fish as feed and/or food increasing the income substantially. Technically, this important addition of a second cycle of nutrients from fish wastes has benefited the enhanced integration process, and has improved livelihoods of many small farmers considerably. Those who added fish to the livestock-crop system have made a big step forward, not only increasing the fertilizer from the fish wastes, but also enhanced their income from the bigger and quicker yield of fish and their relatively higher market prices. Several studies conducted in different parts of the country have revealed that Integrated Farming System approach besides increase in systems productivity manifold also envisage harnessing the complementarities and synergies among different agricultural sub-systems/ enterprises and augmenting the total productivity, profitability, sustainability and gainful employment for a household. In other words, farming system is a resource management strategy to achieve economic and sustained production to meet diverse requirements of farm households while preserving resource base and maintaining a high level environmental quality (Lal and Miller, 1990). An efficient farming system is an integration of appropriate viable technologies within the enterprise and/ or integration of one or more additional enterprises at a farm according to the availability of resources and to sustain and satisfy as many necessities of the farm owner as it is possible. Farming system aims for enhanced productivity, profitability, sustainability, balanced food, clean environment, recycling of resources, adoption of improved technology, regulate the farm income, create employment opportunities, high input-output ratio, solving feed, fodder, fuel crisis, encourage afforestation, promoting agricultural oriented industry and ultimately standard of living of farming community.

Possible output of integrated farming system

Since Integrated Farming System (IFS) is an interrelated complex matrix of soil, water, plant, animal and environment and their interaction with each other enable the system more viable and profitable over the arable farming system. It leads to produce the quality food. To strengthen the food chain, it is essential to eliminate nutritional disorder which has been realized on account of appearing deficiency of mineral nutrients and vitamins in food being consumed. Horticultural and vegetable crops can provide 2-3 times more energy production than cereal crops on the same piece of land and will ensure the nutritional security on their inclusion in the existing system.

Similarly inclusion of bee-keeping, fisheries, sericul-

ture, mushroom cultivation on account of space conservative also give additional high energy food without affecting production of food grains. The integration of these enterprises will certainly help the production, consumption and decomposition in a realistic manner in an ecosystem.

Likewise, it is pre-requisite in farming system to ensure the efficient recycling of resources particularly crop residues, because 80-90% of the micronutrients remains in the biomass. In the Indo-Gangetic plains, where rice straw is not recycled in an effective way and even in Punjab where rice cultivation is practised on 2.6 m ha produces about 16 m tonnes of paddy straw which is destroyed by burning. To curtail such precious input loss, the use of second generation machinery for efficient crop residue management to conserve moisture, improve soil micro-organism activities, regulate soil temperature, check soil erosion, suppress weed growth and on decomposition improves soil fertility. Its beneficial effect can also be accrued by incorporating with the soil. The crop residue can be used as floor thatch for cattle shed, composting, growing mushroom and for dry fodder also.

Multiple use of water for raising crops, fruits, vegetables, and fishery may also enhance the water productivity. Likewise, in villages, the sewerage water can be purified through *Hydrilla* biomass before its release to fish pond. Besides, the community land in the villages, which are accessible to better use, must be used for productive purpose. Therefore, adoption of concept like social forestry, water harvesting and recycling fishery, and stall feeding to the animals (goatery / piggery) will add to the profit margin with other numerous indirect benefits of employment and improved ecology of the area. Such types of enterprise integration generate additional income varying from Rs 20, 000- 25,000/ha under irrigated and Rs 8,000-12,000 under rainfed ecosystem. The income enhancement due to integration of processing and on-farm value addition by 25-50%, yield improvement on account of improved soil health by 0.5-1.0 tonne/ha, cost reduction by Rs.500 - 1,000/ha and employment generation by 50-75 man days/household have also been observed.

Present status of farming system research

The preliminary investigations clearly elucidated that integration of agricultural enterprises viz., crop, livestock, fishery, forestry etc. have great potential towards improvement in the agricultural economy. These enterprises not only supplement the income of the farmer by increasing the per unit productivity but also ensure the rational use of the resources and further create employment avenues. The following of suitable crop choice criteria having deep and shallow root system, inclusion of legume crop as catch , cover and fodder crops and adoption of bio-intensive com-

plementary cropping system along with other enterprise will certainly prove as a self sustained production system with least cost of production. The farming system is governed by various forces viz., physical environment, socio-economic conditions, political forces under various institutional and operational constraints and above all government favorable policies, which may keep the food security intact and livelihood fully protected. A brief account of the present status of farming system in the country and elsewhere is highlighted below.

In traditional Chinese system, the animal houses were constructed over a pond so that animal waste fell directly into the water fueling the pond ecosystem, which the fish could then feast on for food. Not only were the fish harvested but the pond water, now with extra nutrients was used for irrigation in crops. The maximum return (Rs 79,064/ha) was earned from fisheries + piggery + poultry as compared to Rs 5,33,221 from the rice-wheat system and registered 48.6% gain. This also generated additional employment of about 500 man days/ha/annum (Gill *et al.*, 2005). Even a buffalo in Gujarat plain and hilly region and changing the pattern of cultivation of fish and rice in rice+fish culture in Western plain and Ghat region brought about a radical change in productivity and profitability. There are many examples of situations where indigenous breeds and local feed resources have proved to be more appropriate than exotic types and imported technologies. Crossbred (F1) Holstein-Zebu cattle were more efficient producers of milk and meat in a tropical environment in Brazil (Madalena, 1989) and in Colombia (Rodriguez and Cuellar, 1994) than the pure, breed Holstein. Leaves from the jackfruit tree (*Artocarpus heterophyllus*) supported higher live weight gains in indigenous goats in Vietnam than the more digestible foliage from *Trichanthera gigantean* (Keir *et al.*, 1997). Hybrid broiler chickens quickly succumbed to disease and malnutrition when they were put in an environment where "scavenging" local chickens were able to produce normally. The use of sap (or juice) from the sugar palm tree (*Borassus flabillifer*) as feed for pigs is another excellent example of a technology developed from indigenous knowledge (Khieu Borin and Preston, 1995). Various studies demonstrated that the appropriate use of local feed resources and indigenous livestock breeds requires close integration between crops and livestock within the system. The excreta are recycled on the farm to produce energy and the effluent is used for fertilizer to produce protein supplements for the livestock.

For poor people, it starts small with ducks and chickens; then a few goats are kept for milk or fattening and to slaughter for a day of sacrifice; next a milch cow; then a bullock for ploughing in cooperation with another one-buffalo family; then two bullocks. These can be used to

plough the fields of others- a very lucrative business in the planting season. In India, one would add a milch buffalo at the apex of desirable animals on the farm. In the Vietnamese concept, the pigs will be the second step in the ladder. The concept means to start with small livestock and women and then the household will step by step get out of poverty. The poorest households kept only poultry and these households were those most dependent on common property resources for their living (e.g. use and sale of firewood from the forest). A similar stratification has been reported in several studies from Asia (Lasson and Dolberg, 1985). Survey on farming systems in the country as a whole revealed that milch animals; cows and buffaloes irrespective of breed and productivity is the first choice of the farmers as an integral part of their farming system. However, from economic point of view, vegetables and fruits (mango and banana in many parts of the country) followed by bee keeping, sericulture, mushroom and fish cultivation was the most enterprising components of any of the farming systems prevalent in the country.

The average yield gaps between 27 pre-dominant and 37 diversified farming systems were examined across the agro-climatic zones through detailed survey on characterization of on-farm farming systems. Diversification of farming system by integration of enterprises in varied farming situations of the country enabled to enhance total production in terms of rice equivalent yield ranging from 9.2% in eastern Himalayan region to as high as 366% in Western-plain and Ghat region when compared to prevailing farming systems of the region. A number of success stories on IFS models including Sukhomajari Watershed of Chandigarh, Fakot Watershed in hilly areas of Uttarakhand. Jayanthi models for almost all the situations of Tamil Nadu, WTCER model for coastal and irrigated alluvial lands of Orissa, Darshan Singh Model for irrigated conditions of Punjab, PDCSR model, for western Uttar Pradesh. and many more in different parts of the country suggest that farmers' income can be increased manifold by way of diversification of enterprises in a farming system mode for sustainability and economic viability of small and marginal category of farmers (Table1).

In Tamil Nadu, the IFS increased the net return on an average of Rs 31,807/ha/year over the arable farming (Rs 19,505/ha/year). While in Goa, when coconut was integrated with crop, vegetables, mushroom, poultry and dairy enabled to enhance Rs 17,518/ha/annum over the cashewnut cultivation alone. In Madhya Pradesh, the integrated farming gave a margin in net return of Rs 17,198/ha/year over the arable farming. In Uttar Pradesh, the average enhancement in return was Rs 45,736/ha/annum over the existing crop-based farming system. Similar trend was observed at other locations. These preliminary inves-

Table 1. Economic viability of Integrated Farming System Research models developed in different states of the country

State	Prevailing system	Net return (Rs./ha/year)	Integrated Farming System	Net return (Rs./ha/year)	References
Tamilnadu	Rice-rice-blackgram	8,312	Rice-rice-cotton +maize	15,009	Shanmugasundaram <i>et al.</i> (1995) Shanmugasundaram and Balursamy (1993)
	Rice-rice	15,299	Rice-rice-cotton +maize+poultry/fish Rice-rice- <i>Azolla/Calotropis</i> +Fish	17,209 17,488	
	Rice-rice-rice-fallow-pulses	13,790	Rice-rice-rice-fallow-cotton+maize+ duck cum fish	24,117	Ganeshan <i>et al.</i> (1990) Jayanthi <i>et al.</i> (2001)
	Cropping alone	36,190	Cropping+fish+poultry Cropping+fish+pigeon Cropping+fish+goat	97,731 98,778 13,1118	
	Rice	22,971	Rice+fish Rice+ <i>Azolla</i> +fish	28,569 31,788	
Goa	Cashew	36,330	Coconut+forage +dairy Rice-brinjal (0.5 ha) + Rice-cowpea (0.5 ha)+mushroom +poultry	32,335 75,360	Manjunath and Itnal (2003)
Madhya Pradesh	Arable farming	24,093	Mixed farming + 2 cow Dairy (2cows) +15 goats+10 poultry+10 duck+fish	37,668 44,913	Tiwari <i>et al.</i> (1999)
Maharashtra	Cotton (K) + Groundnut (S)	(-) 92	Blackgram(K)-Onion (R)-Maize+cowpea Crop+dairy+sericulture Crop + dairy	1,304 3,524 5,121	Shelke <i>et al.</i> (2001)
Punjab	Crops (Rice-wheat)	81,200 (Gross)	Crops (rice-wheat) + dairy Fish + piggery	1,54,000(G) 1,13,200(G)	Gill (2004)
Uttar Pradesh	Crops (Sugarcane-wheat) Crops alone	41,017 66,371	Crops (Sugarcane+wheat)+dairy Crop + dairy Crop + dairy + horticulture Crop + dairy+ apiary Crop+dairy+vermicomposting	47,737 1,03,615 1,07,467 1,34,382 1,39,472	Singh (2004) Singh <i>et al.</i> (2006)

tigations substantiate the monetary benefits to the farming community. It further leads to many indirect benefits over the coming time which remained hidden.

Productivity enhancement by IFS

In view of serious limitations of horizontal expansion of land for agriculture, only alternative left is vertical expansion through various farm enterprises requiring less space and time but give high productivity and ensuring periodic income especially for the small and marginal farmers. The highlights about the research investigations carried out in India towards farming system outcome are discussed to conceptualize its significance towards farming community livelihood.

In Haryana, Singh *et al.* (1993) conducted studies of various farming systems on 1 ha of irrigated and 1.5 ha of unirrigated land and found that under irrigated conditions of mixed farming with crossbred cows yielded the highest net profit (Rs 20,581/-) followed by mixed farming with buffaloes (Rs 6,218/-) and lowest in arable farming (Rs 4,615/-). In another study conducted with 240 farmers of Rohtak (wheat-sugarcane), Hisar (wheat-cotton) and Bhiwani (*gram*-bajra) districts in Haryana which represented zones of different crop rotations revealed that maximum returns (Rs/ha) of 12,593, 6,746 and 2,317 were obtained from 1 ha with buffaloes in Rohtak, Hisar and Bhiwani, respectively. The highest net returns from Rohtak was attributed to the existence of a better soil fertility type and of irrigation facilities coupled with better

control measures compared to other zones. In terms of total man days, Rohtak had the highest employment potential followed by Hisar and Bhiwani. The employment potential under mixed farming conditions was predominantly from livestock rather than crop production (Singh *et al.*, 1999).

The results of a study on IFS conducted in Punjab in a farmer participatory mode describe the beneficial effect of this approach. At the farm of Smt. Surender Kaur, the rice-wheat system gave net returns (Rs/ha) of 66,465 while rice-wheat + dairy showed an advantage of Rs.8,733/ha. Rice-wheat + dairy + fishery further supplemented the net return up to Rs 13,822 and when it was strengthened with piggery, the net advantage/ha was of / Rs 20,068. In addition, the dairy enterprises generated 138 mandays and piggery generated 28 mandays employment over rice-wheat system. The cost benefit ratio was also in the viable range 1.74 to 1.83 (Table 2).

The average of 2 years at the farm of Shri Mohender Pal Singh of village Anihar, the dairy enterprises gave Rs 7,383 over rice-wheat system and the net profit margin (Rs/ha) enhanced to 16,906 when it was coupled with fishery enterprise. The integrated approach generated 70 mandays/annum over rice-wheat system and the benefit cost ratio varied from 1.86-2.00 (Table 2).

Similarly at the farm of Bhupinder Singh at village birk, the dairy enterprise could give Rs 10,761/ha and poultry also enhanced the margin to Rs 11,546/ha. These enterprise could generated additional manpower of 173

Table 2. Economics ($\times 10^3$ /Rs/ha) of various farming systems

Systems (Area)	REY (t)	Total cost	Net return	Employment generated (man hours)	(In Rupees)	
					Employment generation ovr rice-wheat (man days)	B:C ratio
Surinder Kaur Farm						
Rice-wheat (2.0)	18.0	39.67	66.47	-	-	1.67
Rice-wheat (1.78) + (0.22) dairy	29.7	101.03	75.20	-	138.2	1.74
Rice-wheat (1.22) + (0.22) dairy + fishery (0.56)	30.4	99.98	80.29	-	136.6	1.80
Rice-wheat (1.14) + dairy (0.22) + fishery (0.56) + piggery (0.24)	32.2	104.28	86.53	-	171.9	1.83
Shri Mahinder Pal Singh, village- Anihar						
Rice-wheat (2.0)	17.8	43.40	63.32	34.2	-	2.45
Rice+wheat (1.4) + dairy (0.6)	27.2	81.83	70.70	155.4	69.3	1.86
Rice-wheat (0.4) + dairy (0.6) + fishery (1.0)	29.9	80.67	80.22	154.3	70.4	2.00
Shri Bhupinder Singh, (Village- Birk)						
Rice-wheat (1.0)	12.5	26.40	47.97	12.8	-	2.82
Rice+wheat (0.6) + dairy (0.4)	25.0	90.03	58.73	171.5	158.8	1.65
Rice-wheat (0.6) + dairy (0.4) + poultry (100)	25.5	92.39	59.51	175.1	162.3	1.64

*REY: Rice Equivalent Yield

mandays/annum (Table 2). The profit margin increase is directly linked with the management at the farmer level. After 3-4 years, the progeny of milch animals also add to the profit margin.

Another study involving cropping, poultry, pigeon, goat and fishery was conducted under wetland conditions of Tamil Nadu. Three years results revealed that integration of crop with fish (400 reared in 3 ponds of 0.04 ha each), poultry (20 babkok layer bird), pigeon (40 pairs), and goat (Tellichery breed of 20 female and 1 male in 0.03 ha deep litter system) resulted in higher productivity, higher economic return of Rs 1,31,118 (mean of 3 year). Integration of enterprises created the employment opportunities where in comparison to 369 mandays/year generated in cropping alone system, cropping with fish and goat created additional 207 mandays/annum (Table 3). The resources were recycled in such a way that fish were fed with poultry, pigeon and goat dropping. Similarly, extra poultry, pigeon and goat manure and composted crop residue of banana and sugarcane were applied to the crops. The four conventional cropping system tried were rice-rice-blackgram, maize-rice-blackgram, maize-rice-sunhemp and rice-rice-sunhemp.

In India, about 43 m ha of land is under rice cultivation and there are many situations where low land submerged conditions prevail and water remained ponded for a long with 10-30 cm depth. Balusamy *et al.* (2003) explained that rice + *Azolla*-cum-fish culture is one of the economical option in such type of area. Monoculture system rely mainly on external inputs while in integrated system, recycling of nutrients takes place that help in reducing the cost of production for economic yield. 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 data (Table 4) clearly advocated the beneficial effect of *Azolla* on rice+fish. The gross income obtained in rice + *Azolla* + fish was 25.7 % more over the rice crop and 6.9 % more over the rice + fish. The net income followed the same trend. Thus rice + *Azolla* + fish on an average gave Rs 8,817/ha more over the rice monoculture and Rs.3,219/ha over the rice + fish. This model was proposed for extensive scale adoption in Tamil Nadu.

In a study conducted at Goa to assess the effect of different recycled manure on rice based crops under residual soil moisture in rice fallow system. The maximum crop residue for recycling was available from rice-sunhemp (14.11 t/ha/year) which was 2.95, 2.86 and 3.5 folds more than rice-groundnut, rice-cowpea and rice-brinjal cropping systems, respectively (Table 5).

Among the enterprises where rice-sunhemp was supplemented with mushroom and poultry, it further enhanced the potential quantity for recycling by 14.9% over the rice-sunhemp because the rice straw was used as substrate for mushroom cultivation. It is, thus evident that adoption of intensified cropping systems helped to recycle the crop residue more efficiently than the rice crop alone. The organic manure farmyard manure, poultry manure, mushroom residue smeared fully intact for reuse but the crop residue available under different system is about 62% and rest is used for dry or other purpose.

India is considered as the land of spices and the glory of Indian spices are known world over. Spices used in

Table 3. Productivity and economic analysis of integrated farming system in Tamil Nadu (1998-2000)

Farming systems	System rice-equivalent yield (t/ha)	Net returns (Rs./ha)	B:C ratio	Per day return (Rupees)	Employment generation (mandays)
Cropping alone	13.0	37,153	2.43	178	369
Cropping + fish + poultry	29.6	97,731	3.02	400	515
Cropping + fish + pigeon	29.2	98,778	3.06	400	515
Cropping + fish + goat	37.7	1,31,118	3.36	511	576

Source: Jayanthi *et al.* (2001).

Table 4. Economics of rice-*Azolla* fish integrated farming system

System	Gross income (Rs.)			Total expenditure (Rs.)	Net income (Rs.)
	Crop	Fish	Total		
Rice	43,291	-	43,291	20,320	22,971
Rice + fish	39,447	11,422	50,869	22,300	28,569
Rice + azolla + fish	40,752	13,649	54,401	22,613	31,788

Source: Balusamy *et al.* (2003).

Table 5. Quantification of recyclable manorial resources (t/ha/year) from rice based farming systems

Crop/ Enterprise	Recyclable manorial resource	Quantity produced			Potential quantity for recycling		
		1999-00	2000-01	Pooled	1999-00	2000-01	Pooled
Rice alone	Paddy straw	3.90	5.47	4.69	1.95	2.74	2.34
Rice-groundnut	Paddy straw+ groundnut haulm	6.24	7.99	7.12	4.29	5.26	4.78
Rice-cowpea	Paddy straw + cowpea haulm	6.83	7.74	7.29	4.88	5.01	4.94
Rice-brinjal	Paddy straw + brinjal stalks	5.83	6.91	6.37	3.88	4.18	4.03
Rice-sunhemp	Paddy straw + sunnhemp biomass	19.26	13.63	16.45	17.31	10.9	14.11
Mushroom-cultivation	Mushroom spent substrate	0.68	0.72	0.70	0.68	0.72	0.70
Poultry rearing	Poultry manure	1.40	1.40	1.40	1.40	1.40	1.40
Dairy (2 milch cattle)	Farm yard manure	5.33	4.08	4.71	5.33	4.08	4.71
Rice-groundnut+mushroom-poultry	As above	8.32	10.11	9.22	6.37	7.38	6.88
Rice-cowpea+mushroom-poultry	As above	8.91	9.86	9.39	6.96	7.13	7.04
Rice-brinjal+mushroom-poultry	As above	7.91	9.03	8.47	5.96	6.30	6.13
Rice-sunhemp+mushroom-poultry	As above	21.34	15.75	18.55	19.39	13.02	16.21
Rice-alone+mushroom-poultry	As above	5.98	7.59	6.79	4.03	4.86	4.44

Source: Korikanthimath and Manjunath (2005).

foods impart flavour, pungency and colour. In Kerala, each home is having small land, in which coconut, banana, jack fruit, mango, pepper, nutmeg, cloves, cinnamon, ginger, turmeric are commonly cultivated for their requirement in a multi-storey or multi-tier cropping. To achieve high resource use efficiency, multi-storey or multi tier system are adopted where crops ranging from tall trees to low growing annual form different canopy layers are grown together that normally have different rooting pattern with complimentarity to each other. Results of a study conducted in Kerala clearly advocate the supremacy of multi-storied cropping where coconut + ginger and coconut + clove system gave 3.52 and 3.70 folds more net

Table 6. Economics and employment generation in coconut + spice system

System	Net return (Rs/ha/year)	Additional employment (man days/ ha/ year)
Coconut alone	10,400	-
Coconut + Ginger	36,590	500
Coconut + Clove	38,500	NA

Source: Parthasaraty *et al.* (2004).

Table 7. Relative profitability of the selected farming systems in north coastal zone

Farming system	Small				Medium			
	No. of farmers	Crop (ha)	Allied enterprise	Net returns (Rs. lakhs)	No. of farmers	Crop (ha)	Allied enterprise	Net returns (Rs. lakhs)
Agricultural + Poultry	17	12.0	5,030 birds	3.04 (0.18)*	20	32.4	10,300 birds	10.47 (0.52)
Agricultural + Sheep	12	7.2	228 sheep	5.17 (0.43)	11	13.6	270 sheep	8.38 (0.76)
Agricultural + Sericulture	11	4.4	520 layers	1.11 (0.10)	9	11.2	2,200 layers	4.18 (0.46)

Source: Viroji Rao and Bose (2002).

Note: *Figures in parenthesis indicate Rs Lakhs/farmer

return over pure crop of coconut. Likewise, developed substantial additional employment (Table 6).

In a recent study conducted in North-coastal zone of Andhra Pradesh on farming system in terms of per cent contribution of allied enterprises on the annual net income of the small farmer; agriculture with sheep ranked first followed by agriculture with poultry and agriculture with sericulture enterprise (Table 7). In case of medium farmers, agriculture + poultry ranked first followed by agriculture + sheep and agriculture + sericulture. In this community based study, the large-sized poultry farm could be managed by the medium-sized farmers and it gave more profit owing to specific market outlets, availability of loans, availability of maize grain as feed, no weather abnormalities and use of poultry litter as manure for crops. Contrary to this, small farmers take less interest in extension programmes, feel difficulty in taking loans and market non-awareness motivate them for sheep rearing. They maintain flocks under extensive system with zero input management and get good profit margin. It is thus clear that adoption of allied enterprises enhanced the net return sizably over the arable farming (Rao and Bose, 2002).

The major crops grown in the northern Telangana zone (NTZ) are rice, maize, jowar, groundnut, sugarcane and cotton and other components include buffalo, goat, sheep and poultry. The results of a study conducted on survey based with 3 agricultural and livestock based farming systems viz., dairy, poultry and sheep rearing clearly revealed that all the farming systems generated more than 3 folds additional employment over arable farming (Radha *et al.*, 2000). The net returns (Rs/ha) were higher in agriculture + dairy (35,293) followed by agriculture + poultry (26,830) and agriculture + sheep rearing (14,665). Among different farming systems, agriculture + dairy proved to be more promising than other (Table 8). The main reason for high return is that stover of maize/jowar is used for fodder and their grains for feed as well as sugarcane crops to feed cattle, buffalo were available at the farm.

Farming system is a resource management strategy to avail maximum efficiency of a particular system. Studies conducted at ICAR Research Complex for Goa revealed the higher energy use efficiency of IFS with rice (Manjunath, 2002). The mean total energy input varied considerably among the systems. Integration of poultry and mushroom enterprise with rice-brinjal system required highest energy input (52,030 MJ/ha) and followed by rice-groundnut system integrated with mushroom and poultry (46,077 MJ/ha). However, rice cropping alone without any rice based crops or enterprises recorded the least requirement of energy (Table 9). The energy output was maximum (1,65,334 MJ/ha) under rice-brinjal + mush-

Fig. 1. Benefit : Cost ratio of different alternate land use systems. (Narain and Bhati, 2005)

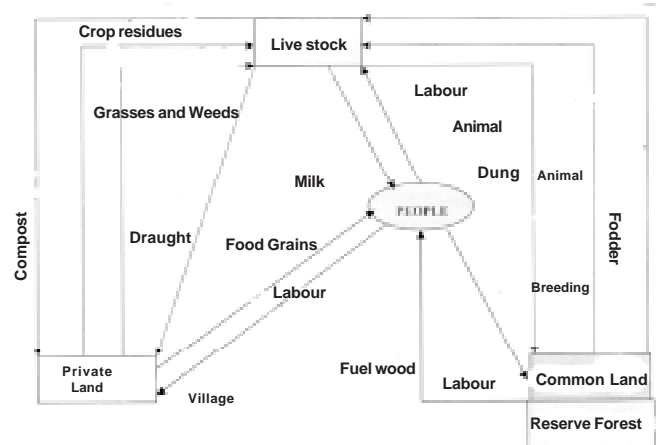


Fig. 2. A conceptual model showing close link between land- live-stock and people in hilly area (Thakur and Badiyala, 2005)

Table 8. Income and employment generation under different farming systems of northern Telengana.

Farming system	Human labour (MWDs)	Net returns (Rs.)	Additional employment over agriculture (MWDs)	Additional net returns over agriculture (Rs.)
Agriculture + dairy	521	35,293	359	27,842
Agriculture + poultry	528	26,830	366	19,379
Agriculture + sheep rearing	486	14,665	324	7,214
Agriculture alone	162	7,451	-	-

Source: Radha *et al.* (2000). MWD : Man Working Days.

Table 9. Energy budgeting (MJ/ha) for rice based IFS.

Farming system	Input (MJ/ha)	Output	Efficiency
Rice-fallow	11,563	78,182	6.76
Rice-groundnut+mushroom+ poultry	46,077	1,02,857	2.24
Rice-cowpea+mushroom+poultry	43,792	1,05,627	2.41
Rice-brinjal+mushroom+poultry	52,030	1,65,334	3.18
Rice-sunnhemp+mushroom+poultry	41,439	1,00,911	2.44

Source: Manjunath (2002).

room + poultry with 3.18 system energy efficiency mainly due to the lesser energy input involved in contrast to energy rich output enterprises. The output of all multi - rice based enterprise was reasonably good varying from 1,00,911 to 1,05,627 MJ/ha excluding brinjal crop based farming system. It is thus evident that efficient utilization of scarce and costly resource is the need of the hour and can be accrued by following the concept of IFS through supplementation of allied agro-enterprises.

An economic evaluation of alternative land use systems over 18 years (Fig.1) showed 1.41-1.87 benefit-cost ratio over 1.24 under arable farming. This proves worth of grasses-trees-animal system over arable farming under arid ecosystem. The best system under arid situation is agri-pasture followed by agroforestry, silvo-pastoral, agri-horticulture and lowest in crop production. Therefore, under arid ecosystem, integrated management of natural resources invoking traditional and innovative alternative farming systems keeping water as control issue viz., diversification of crops and cropping systems, agri-silvo-horti-pastoral production systems.

Hill farming is a self contained system in which land, livestock and people are closely linked (Fig. 2). The system is predominantly sustained by flow of organic material and plant nutrients from uncultivated land and adjoining forests. Supply of this crucial source is getting jeopardized due to over felling and over grazing with the result crop and fodder production/unit time have decreased over the years. However, the fragile eroded hill soils are extremely low in available nutrients and organic matter content, incapable of sustaining increasing demand for food and fodder caused by increased population of both human and animals. As a result, at present an average farmers' family produces food grains just sufficient to meet 4-5 months its requirements. The hilly regions of the country are today confronted with multiple of soil and water re-

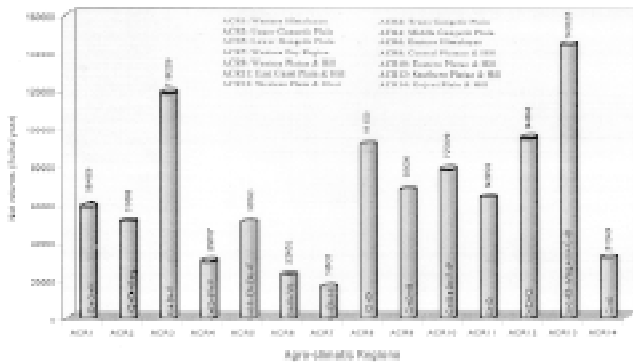
sources related problems like increased sedimentation of rivers and water bodies, recurring floods, drying up of water sources and above all the deteriorating socio-economic status of the people. Therefore, the above-depicted model is very common for subsistence agriculture.

Economic analysis of different micro-watershed based farming systems namely dairy farming, agro-pastoral and agri-horti-silvi-pastoral systems (Table 10) have shown the economic viability of these systems as an alternative to shifting cultivation. In agri-horti-silvipastoral, about 77 % of the net return comes from the livestock unit with pigs as a component. From these observations it could be said that livestock components particularly pigs, could be important in any farming system which is socially acceptable in the north-eastern hill regions. It is worth to mention here that NEH region accounts for 60 % of the total pig population of India and a majority of the tribal people being non-vegetarian, pork forms an important item of their food (Bijarbarva *et al.*, 2005).

A study conducted by the AICRP on Cropping System based on survey through resource characterization in different State Agricultural Universities elucidate that there are 14 pre-dominant farming systems in the country and their economic detail is given in Fig. 3.

The results clearly pronounced the sizeable increase in the net return by following IFS approach. The profit margins were directly-linked with the number and kind of enterprises. The maximum net profit (Rs 1,43,625/ha/annum) in coconut + banana + vegetable + horticulture + crops and dairy. It was followed by crops + dairy + fishery (Rs 1,18,225 ha/year) in agro-climatic zone 3. Out of 14 farming systems, 10 farming systems gave net return in the range of Rs 0.5 to Rs 1.5 lakh/ha/annum.

Another study conducted at Project Directorate for Cropping Systems Research, Modipuram for ascertaining the livelihood security of marginal and small farmers under irrigated ecosystem advocated beneficial effects of IFS on productivity, profitability and sustainability. A model developed on 1.5 ha area comprises of crops (0.72 ha), dairy (0.32 ha), horticulture (0.22 ha), fishery (0.10 ha) and miscellaneous (0.14 ha) which was used for goat, apiary, vermicompost, threshing floor and farm building. Net returns (Rs/ha) from the crop, dairy, horticulture, fishery and apiary was 53,183, 27,515, 7,168, 1,445 and 3,372 respectively. The relative contribution from the dairy, horticulture, fishery and apiary towards net return was 52, 14, 3 and 6 % where crops were taken as 100 %. It is thus clear that the contribution of different enterprises strengthened the crop component and showed a margin of Rs 39,498/ha/annum and their contribution rated about 35 %. The goatery enterprise was the new intervention and gave net return of Rs.15,180 in one year mainly from the sale of



C, crops; D, dairy; H, horticulture; F, fish; Veg, vegetable; P, poultry; B, Banana; G, goat; Coc, coconut

Fig. 3. Potential Farming Systems of different Agro-climatic regions of the country

Table 10. Economics of micro-watershed based agro-pastoral, dairy and agri-horti-silvopastoral systems

Economic parameters (Rs/ha)	Dairy farming	Agro-pastoral system	Agri-horti-silvo-pastoral system 1990-91
Input	23,184	29,675	10,604
Output	37,384	50,882	20,943
Net return	14,200	21,207	10,339
Input: output ratio 1993-94	1:1.61	1:1.71	1:1.97
Input			
With livestock	45,030	38,201	11,406
Without livestock	-	17,366	9,197
Output			
With livestock	93,992	78,692	24,468 +22,275* + 8,750**
Without livestock			
Net return			
With livestock	48,960	40,490	13,061+ 22,275* + 8,750**
Without livestock		14,575	3,922 + 22,275*
Input: output ratio			
With livestock	1:2.08	1:2.05	1:2.14
Without livestock		1:1.83	1:1.42

*Price of wood tree at harvest after 10 years planing.

**Price of goat sold for mutton in 3rd years.

Table 11. Net returns and relative profit margin of 1 ha module of farming system at PDCSR, Modipuram

Enterprises	Net return (Rs./ha/annum)	Relative profit margin (%)
Crops	53,183	100
Dairy	27,515	52
Horticulture	7,168	14
Indian Fishery	1,445	3
Indian Apiary	3,370	6
Total	92,681	-

Table 12. Household security and economic viability of Integrated farming system model at PDCSR, Modipuram

Developmental phases	Cost of production (Rs/ha/year)	Net return (Rs/ha/year)	Net saving after fulfilling 7 members family requirements
First 4 years (2004-2008)	1,09,627	1,00,573	Subsistence
Current year (2008-09)	2,03,442	1,31,661	12,101

Table 13. Nutrient budgeting under Integrated Farming System at PDCSR, Modipuram

Source of nutrients and per cent nutrient content (N:P:K) on dry wt. basis	Available quantity at farm (kg)	Supplied quantity (kg)		
		N	P	K
Green manure crops				
i. <i>Sesbania</i> spp. (1.29:0.36:1.64)	8800	18.9	5.3	24.0
ii. Cowpea (1.29:0.36:1.64)	8500	18.3	5.1	23.2
Crop residues (dry weight)				
i. Sugarcane leaves (0.4:0.18:1.28)	900	3.6	1.6	11.5
ii. Arhar leaves (1.29:0.36:1.64)	232	3.0	0.8	3.8
iii. Potato leaves (0.52:0.21:1.06)	1450	7.5	3.0	15.4
Cow dung (dry weight) (4:1.2:1.9)	17600	704.0	211.0	334.0
Total	-	755.3	226.8	411.9
Considering 30% use efficiency of released NPK through organic sources	-	226.6	68.0	123.6
Nutrient requirement/year (field + plantation crops)	-	285.3	116.3	109.9

new progeny and old animal disposed off (Table 11).

The study has given significant results and it is worthwhile to give the explanation that farming system ap-

proach requires at least 3 years for its establishment. The average net returns of 4 years was Rs 1,00,573/ha/annum and this net return was just equivalent to the 7 family

members subsistence. However, if the family members are 6 then Rs 11,263 was the net gain and the corresponding value for 5 members was Rs 26,148. It indicated that during first 4 years for a larger family size get the income from employment generation a crucial input as is evident from the cultivation cost Rs 1,09,627/ha/annum. Astonishingly in vth year, net return increased up to Rs 1,31,661/ha/annum with cost of production as Rs 2,03,445/ha/annum, which gave Rs 12,101 net saving after fulfilling all the family requirements of 7 family members (Table 14). So the major share of cost of production goes to family labour in the farming system approach. As a result, it ensures the livelihood security for the medium to large family size.

To substantiate the statement made above clearly illustrated in Table 15. The farming system approach makes the system so holistic that fulfill about 90% of the farm nutritional requirement independent. The total N, P₂O₅ and K₂O requirements of the system tried in the Integrated model at PDCSR, Modipuram were 285.5, 116.3 and 109.9 kg/ha, respectively, whereas the corresponding requirement of 226.6, 68.0 and 123.6 was fulfilled from the resource recycling.

This nutrient budgeting clearly advocated the self-sustainability of the system and which will not only reduce the dependency on the external inputs but also provide the balanced and rich nutrition to the system which is the key factor for taking care of sustainability.

Results discussed revealed that IFS enables the agricultural production system sustainable, profitable and productive. About 95 % of nutritional requirement of the system is self sustained through resource recycling. As the number of enterprises are increased, the profit margin increases but simultaneously coupled with increase in cost of production and employment generation though the profit increase was marginal. Further, it is evident that profit margin varied with the ecosystem (rainfed/irrigated), management skill, and socio-economic conditions. On an average profit margin on account of IFS varied from Rs 15,000 to Rs 1,50,000/ha/annum. Simultaneously it takes care of the food and nutritional security of the farming family. The study further revealed improvement in the net profit margin varying from 30-50 %. The resource characterization study revealed that/ha improvement in profitability varied from Rs 20,000 to 25,000 under irrigated condition, resource recycling improve fertility led to 5 to 10 q/ha crop yield increase, generate 50-75 mandays/family/ year and reduce the cost of production by Rs.500-1,000/ha. Therefore, there is an urgent need to promote the IFS concept under all agro-climatic conditions of the country.

The further thrust of IFS are :

- There is a need to create the database on farming system in relation to type of farming system, infrastructure, economics, sustainability etc. under different farming situation.
- Need to develop research modules of farming system under different holding size with varying economically viable and socially acceptable systems.
- The assessment and refinement of the technologies developed at research station at cultivators' field.
- Need to prepare a contingent planning to counteract the weather vagaries/ climate threats under different farming situation.
- Need to prepare a policy draft for the consideration of planners for its promotion at large scale with nominal financial assistance either through short/ medium/ long term loans and other promotional advantage.

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