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Review Article

Integrated Farming System Models Development for Small and Marginal Households for Sustainable Production and Livelihood Improvement in India: An Overview

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Abstract

At present, 121 million agricultural holdings are in India; out of these 99 million holdings are small and marginal (87%). Small holdings are not well suited to farm mechanization, coupled with poor economic condition of farming community and lack of resources; these factors are exclusively responsible for the slow growth of Indian Agricultural. Hence, there is immense need to develop area specific integrated farming system models to resolve multi-dimensional problems prevailing related to agriculture and allied sectors. Integrated farming systems approach is one of the most powerful tools for enhancing productivity, profitability, nutritional security, livelihood improvement, employment generation and sustainability of the farm households, particularly small and marginal farming communities, presently they have constituted more than 87% of the total farm households. In India, increasing population demands coupled with decreasing availability of farm resources resulted declining in productivity which warrants an immediate attention of researchers to tackle these problems and there is urgent need to reorient agriculture research programs from individualistic enterprise approach to need developed holistic approach of integrated farming system. The concept of integrated farming system research integrates various enterprises and resources (inputs) at the farm level into consideration for planning production of crops, selecting cropping systems and combining various enterprises to develop integrated farming systems having sustainable agriculture production systems. Similarly, inclusion of horticulture, dairy farming, bee keeping, fisheries, poultry farming, sheep and goat rearing, sericulture, mushroom cultivation under two or three tier system of integrated farming can give substantial additional high energy food without affecting production of food grains. Soil, water, climate, marketing, labour, transport and local demands are the main criteria to select the farming systems for any working place. Moreover, integrated farming system is a biologically integration system, which integrates mechanism into farming activities to achieve utmost replacement of off- farm inputs and sustain farm profits through decease of costs of production and augment productivity of the entire system towards vertical horizon. As regards to livelihood security, the IFS approach adopted in the model met almost all the homegrown family demands of cereals, pulses, oil, fruit, milk, meat, vegetables, and value-added products. Moreover, integrated farming systems also pave the needed socially acceptable, environmental hygiene and economically viable to large growing population of India. Therefore, now the need of develop an agro-ecology based integrated farming system which would augment soil health, ecological balance, employment generation and fertilizers cost reduction through recycled farm-based by-products. Further, most of the inputs being used in agriculture becoming costlier and go out of reaches to common man which results in farming becoming unviable and unsustainable enterprise particular to small and marginal households of India.

Hence, it is clear that adoption of allied enterprises enhanced the net return sizably over the arable farming. Thus, whole farming system approach is very constructive in solving the various problems of farmers in India.

Keywords: Enterprises; Employment generation; Environment safety; Farming system components; Farm family; Farm based waste; Food security; Integrated farming system; Livelihood; Marketing; Nutritional security; Productivity; Profitability; Recycling; Sustainability

Introduction

In India, different types of farming systems co-exist depending upon available resources, agriculture practices and location specific needs of humans to meet the requirements of food, fodder, fuel and fiber. Integrated farming system (IFS) is a complex interrelated matrix of soil, plants, animals, implements, power, labour, capital and other inputs controlled in part by farming families and influence to varying degree by political, economic, institutional and other factors that operate at farm level. Small farm holders including marginal (0.40 ha) and small (1.20 ha) category farmers represent more than 86% of Indian farm families and are expected to increase to the level of 96% in coming decades are also living in risk prone diverse climatic conditions. The income of average farmers from cropping alone is hardly sufficient to sustain his family. Integrated farming system approach is not only a reliable way of obtaining a fairly high productivity with substantial fertilizer economy but also a concept of ecological soundness, leading to sustainable agriculture (Swaminathan, 1987). Different farming systems have been developed and being practiced by the farmers indigenously without any rationale for utilizing the residues arising out of cropping/animals and other associated enterprises at farm dairy, irrespective of kind of animals and their breeds, has been an integral part of prevailing farming system in whole India(Mahapatra and Bapat, 1992).The intensive efforts have been made by the scientists and farmers to brining radical changes in agriculture scenario and country as a witnessed of several agricultural revolutions for increasing production of different farm produces including crops (green revolution), milk (white revolution), oilseeds (golden revolution) and lastly fish (blue revolution) which enabled us to reach the level of self-sufficiency in most of food commodities and also exporter of many of them. However, all such advancements could benefit well-endowed rich farmers only and small farm holders remained deprived of it. Further, agricultural research in India emphasized mainly commodity-based researches involving development of animal breed, crop varieties, farm implements and machineries, 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 most of the resources and natural heritage as well. This all resulted in decreasing factor productivity, declining resource use efficiency and ultimately less farm productivity and profitability. It further coupled with the environmental problems like global warming, environmental degradation, ground water contamination and entry of toxic substances in to the food chain and it has become significant problem and major concern of the future. Different agricultural practices and agriculture as a whole contribute 17-20% in global warming and the situation will become worst if proper conservation and management measures are not adopted.

The benefits of advancement in agriculture were harnessed mainly by small group of large and medium categories of farmers who were endowed with resource. Small land holdings are not well suited to mechanize farming coupled with poor economic condition and lack of resources are responsible for slow growth rate in agricultural sector. The soil, water, climate, marketing, labour, transport and local demands of people are the main criteria to select the farming systems. Small and fragmented land holdings do not allow farmers to keep independent farm resources like draught animals, tractors, bore wells/tube wells and other sophisticated farm machineries for various cultural operations. To fulfill the basic needs of household including food (cereals, pulses, oilseeds, milk, fruit, honey, eggs, mushroom, vegetables, fish meat etc.) for human, feed and fodder for animals, fuel & fiber for domestic purposes and overall improvement in livelihoods warrant an attention about Integrated Farming System (IFS).

Concept and Essence of IFS

Integrated farming system is an integration of appropriate viable technologies within the enterprises and integration of one or

more enterprises with prevailing farming system at a farm according to the availability of resources and farmer's choice to satisfy the necessities of a household as well as for livelihood security of a family which simultaneously leads to better utilization of resources, increased productivity per unit area, efficient recycling of farm wastes, generation of more employment, reduced risk and ensured environmental safety and finally sustainability. It is a holistic approach bringing all the disciplines together, executed by multidisciplinary team of scientists and starting from the level of the farmer ends. The essence of IFS approach lies in livelihood improvement of small farm holders, economic and nutritional security, increased employment, agricultural sustainability and environmental safety. With rising population, declining land to man ratio and increasing mechanization in farm operations, agriculture alone is not able to provide adequate income and employment to all households in India. Integration of farm enterprises provides better livelihood in terms of increased food production, higher net income, improved productivity and reduced income imbalance between agricultural labour and urban factory worker. Introduction of appropriate farming systems has been one of the approaches to achieve better growth in agriculture and livelihood. Increase in non-farm employment has also become essential for improving income and living standard of rural population. Farming systems has been elaborated differently by various workers. Farming system as a holistic approach broadly addresses itself to different components of the farm enterprises and inter-relationship among themselves and farm environment.

Farming Systems Research (FSR) in India

Indian agriculture is predominated by small farms. Over the last 40 years (1971-2011) number of holdings has grown to more than 2% annum^{-1} while area operated has increased by about 0.1%. Thus, average farm size has gone down (Table 1). All these data indicate decline in farm size, continuing inequality in distribution of basic resource e.g., land. Landlessness is the logical culmination of this process. The number of landless agricultural labour household has grown to 144 million in 2011 from 107 million in 2001 (from 13 million in 1972). Consequently, there will be increasing number of food deficit households in rural areas, more land locked in self-consumption. It is expected that a declining surplus for rapidly growing urban population will arise aggravating food insecurity in future. The data are presented on the share of small farms in production of crops and on ownership of livestock clearly shows the significance of small farm holding in favour of farming system research (FSR).

Cattery of land holding	*2001*	*2011*
Holdings <1 ha	>62% (>77 million)	>67% (>90 million)
Holdings <2 ha	>80%(>100 million)	>85%(>115 million)
Holdings >4 ha	7%	5% (7 million)
Area on farms <2 ha	>35% of net cropped area	>44% of net cropped area
Area on farms <4 ha	>39% of net cropped area	>68% of net cropped area

Table 1: Distribution of operational land holdings in India during 2001 and 2011.

Present scenario of integrated farming system research in India

Farming system approach is a bottom to top approach where in all research and developmental activities of the farm revolved around the farmer. The real beneficiary and are planned and executed accordingly, keeping in view of farm resources, economic status and family's annual household food and fodder demand. In addition to this social and political aspects also play key role in selection of system of farming in respective zones. The integration is made in such a way that product of one component should be input to another enterprise with high degree of complimentary effects on each other. Such as fodder fed to cattle produces milk, dung, urine and litter produce farmyard manure and energy used for crop and fishpond. The FYM can substitute about 25% of recommended NPK for crops, besides improves physical and biological properties of the soil. When cow dung mixed with crop residues and other farm wastes may convert into nutrient rich and termite free vermicompost. The fish pond dykes comprising of 20-30% can be utilized for planting of perennial grasses, vegetables and even some time for fruit plants cultivation and these provides effectively soil cover in order to check the water and wind erosions and make the system more economically viable. The silt (nutrient rich soil) of fish pond should be utilized as manure to crops. The fishpond water should be recycled by gravity and lift method as supplement irrigation at most critical growth

stages while there is breakdown in electricity supply and long dry spell prevails. Oilseeds crop in integrated farming system (IFS) provides nectar for honeybee, edible oil for human being and oilseed cake as animal feed. Integrated nutrient management can enhance the productivity of cereals up to 0.5 to 1.0 tha^{-1}. Processing of different products enhances the value addition to the extent of 25 to 50% besides generating 50-75 man-days $family^{-1}$ $year^{-1}$ of employment.

Farming System Research (FSR) has emerged as a new theme in international agricultural research (IAR) and rural development for over two decades. Although, the idea that an understanding of existing farming systems (EFS) is an essential pre-requisite for formulating sensible innovations came to prominence only recently, but it is not new. The incorporation of FSR ideas into agricultural research, however, is more recent. In fact the term 'Farming Systems Research' began to be applied in the mid-1990th to technology development activities for small scale and limited resource farmers. The growing perception of the failure of mainstream agricultural research and extension institutions to generate and disseminate technologies widely adopted by small scale resource poor farmers resulted in evaluation of FSR in the post green evolution era, while reviewing the historical perspective of the development of Farming Systems Research in India over the past 60 years stated that FSR with a farmer's perspective occupies pride place in India's agricultural research agenda. Most appropriately the farming systems research may be defined as "as highly location specific research, which represents appropriate combinations of farm enterprises *viz*. cropping systems, livestock, fisheries, forests, poultry and means available to the farmers to raise them for profitability". FSR is a relatively new area of research in India but is considered to be extremely relevant for accelerating agricultural development

Significance of Integrated Farming System Research

To meet growing demands of food, feed, fodder and fuel for ever increasing human and animal population and to provide gainful employment, IFS has several advantages over the arable farming such as;

Increased food supply: Horticultural and vegetable crops can provide 2 to 3 times more calories than cereal crops on the same piece of land and will provide food and nutritional security. Similarly, inclusion of bee keeping, fisheries, sericulture, mushroom cultivation under two tier and three tier systems of integrated farming can give substantial additional high energy food without affecting production of food grains.

Recycling of farm residues: proper collection & utilization of cow-dung and urine of animals in the form of farm yard manure (FYM) and vermicompost (VC) alone can save about 50% of NPK requirements of the crops. Vermicompost containing 3 to 4% more N content than farm yard manure (FYM) can be produced from crop residue mixed with cow dung for restoring soil fertility. Further, if we utilize even 1% of annually available 200mt crop residue for mushroom cultivation then we can produce 2 lakh t mushrooms against only 40 t of president day production. Crop residue management includes green manure of legume crops in rotations. On an average, organic manures like farm yard manure and compost contain 0.5%-1.0% N, 0.6% P and 0.5% K, respectively. These can supplement the fertilizer and reduce cost of cultivation.

Use of marginal and wastelands: combination of forestry, fishery, poultry, dairying, mushroom and bee keeping can be combined more with crop production and all these activities can be undertaken on marginal to wastelands.

Employment generation: Studies conducted in India and elsewhere, indicated that 200 to 400 % increase in gainful employment after adopting of integrated farming system as compared to existing farming system and additional income to farm families to increase their standard of living. Comparatively diversified and rather intensive nature of multifarious activities related to different enterprises included in the integrated farming system (IFS) provide a lot of opportunities of employment and keeps farmers and their family engaged whole the year and as such can help in solving unemployment problem in India. The man days required for the production of crops alone was 182ha^{-1} $annum^{-1}$ wherein under IFS this number was 2.91 times more (795-man days) than crops alone. In this way farming system approach not only ensures the livelihood of small farm holders but also diversified nature of IFS approach requiring significantly a greater number of man days increases more opportunities of employment particularly in rural areas. More number of enterprises integrated in to existing farming system requires a greater number of labour engagements (Table 2).

State	*Prevailing system*	*Net return (Rs.ha^{-1})*	*Integrated Farming System*	*Net return (Rs. ha^{-1}year^{-1})*
Tamil Nadu	Rice-rice-black gram	8312	Rice-rice-cotton+maize Rice-rice-cotton+maize+poultry/fish	15004 17209
	Rice-rice	15299	Rice-rice-Azolla/Calotropis+Fish	17488
	Rice-rice-rice-fallow-pulses	13790	Rice-rice-rice-fallow-cotton+-maize+duck cum Fish	24117
	Cropping alone	36190	Cropping+fish-poultry Cropping+fish-pigeon Cropping+fish-goat	114665 118462 126564
	Rice	22971	Rice+fish Rice+Azolla+fish	28569 31788
Goa	Cashew	36330	Coconut+forage+dairy Rice-brinjal (0.5 ha)+ Rice-cowpea (0.5 ha)+ Mushroom + poultry	32335 75360
Madhya Pradesh	Arable Farming	24093	Mixed farming + 2 cow Dairy (2cows) +15 goats+10 poultry+ 10duck+fish	37668 44913
Maharashtra	Cotton(K)+Groundnut (S)	(-)92	Black gram (K)-Onion (R)- maize+cow-pea Crop+Dairy+Sericulture Crop+Dairy	1304 3524 5121
Punjab	Crops (Rice-wheat)	81200 (Gross)	Crops (Rice-wheat)+dairy Fish+piggery	154000 113200(G)
U.P.	Crop (Sugarcane-wheat) Crops alone (Diversi-fied)	41017 66371	Crops(Sugarcane+wheat)+Dairy Crop+Dairy Crop+Dairy+Horticultrue Crop+Dairy+Apiary Crop+Dairy+Vermicomposting	47737 103615 107467

Table 2: Development of integrated farming system models in different states of India.

Restoration of soil fertility and conserving environment: with efficient recycling of crop and animal residue in crop-livestock-poultry-fishery system, at least half of the nutrient can be saved along with restoration of soil fertility and cleaner environment be maintained. Preparation and large-scale use of vermicompost will further help in decreasing dependence on chemical fertilizers and will also help in keeping clean and healthy environment. The leguminous crops like Pigeonpea (*Cajanus cajan*), pea (*Pisum sativum*), moongbean (*Vigna radiata*) and urdbean (*Vinga mungo*) in crop diversification lead to enhanced soil fertility. Use of organic manures result in influencing physical, chemical and biological properties of the soil which will lead to increase the crop yields.

Farming systems scenario of small farm holders in India

Under the existing agrarian structure, most of the rural farm families are small and marginal in nature they are living below the poverty line with the continued threats to their livelihood security characterized by low in food security and income, unemployment,

health problems, education etc. Due to this reason, these categories of farmers are poorly adopted to the changed farming scenario especially in rain fed areas (<750mm fain annum^{-1}) as reported by Lal and Miller, 1990. Further, this section of farming community is very much susceptible from the natural vagaries like drought and flood and resulting in large scale migration to urban areas for seeking livelihood opportunities. Keeping in view of these constraints IFS ensures the consolidation of the natural resource base at farm level and offers better opportunities for adoption of improved technologies with the target of enhancement of overall production and productivity of the farm. It also provides an opportunity to arrive at appropriate combination of the enterprise through interlinking of different farm enterprises for the effective use of natural resources available at farm level and for recycling of nutrients on the farm. This technique ensures in the creation of better awareness on the adoption of technologies which can lead to sustainable production process with on-farm employment creation to support livelihood of the rural farm families. Based on need, choice and resources available on the farm, different allied activities such as horticulture, dairy and vermicompost unit are correctly incorporated into the production system with an aim of generating income and employment for the farm family through economically friendly model to get regular income, employment and livelihood security. The crop and animal residues are recycled for vermicomposting for use in the crop field. The productivity enhancement after intervention and stability in crop productivity will result in higher sustainable yield index (SYI) in crops. The change in productivity is variable and in constraint farming situations the interventions have greater impact and bring greater increase in yield (38 to 80%). The impact of whole farm demonstration of integrated faring system (IFS) is significant because of improvement in natural resource base of the farmer and risk reduction. The new vegetable crops and varieties introduction in to the farms is one of the important interventions which enhance the income of farm families with increase in cropping intensity, employment generation and nutritional security among farm families and surrounding rural households. Gill et al. (2009) opined that, 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. The emphasis will be given for the incremental changes with seasonal crops and with the other activities, with the introduction of new technologies, forcing the farmers to re-organize substantial portions of their activities. Economic analysis was done by recording cost and income involved in crop production activities and for other farm enterprises. The monitory values used for comparing the alternatives that includes only those outputs sold for cash are those inputs purchased with cash.

Yields gaps prevailing in integrated farming system components

The data of All India Coordination Research Project (AICRP) on Integrated Farming Systems(IFS) revealed that there is vast scope to enhance the productivity and profitability of existing farming systems in the India through bridging the yield gaps pertaining to major farm enterprises including crops and animals. There is also enormous scope of intensification and diversification in existing farming systems through minimizing production constraints those are responsible for yield gaps. The economic returns can be increased many folds through adoption of farming system approaches. Existing farming system characterization was done throughout India; it reveals that there is a big yield gap between farmer yield and achievable yield. The yield gaps were as high as 200% in castor crop at Rajendera nagar, Hyderabad (A.P.), 140% in buffalo milk at Kanpur (UP), 172% in cow milk, and 150 to 160% in poultry & goats at Sabour (Bihar), 200% gap in cow milk at Jorhat (Assam) and 40-90% in other enterprises like fish and birds in different parts of the India. However, in major crops rice, wheat and maize their yield gaps were around 40-70%, respectively.

Technological interventions for augmenting production

There is urgent need to generate low cost holistic farm technologies involving agricultural diversification focusing enterprises like crop (crop diversification with drought resistance crops/varieties and remunerative crops), dairy, goatry, apiary, agro forestry and agro-processing units etc. driven by market demand and opportunities (Lightfoot et al., 1993). Many scientists has advocated farming system analysis and multi-disciplinary research for the development of small farms (Devendra, 2002 and Prein, 2002). Hence, development of suitable integrated farming system (IFS) models for the small landholders in different agro-ecological regions of the India is major concerned. The basic aim of integrated farming system (IFS) is to derive a set of resource development and utilization practices,

which lead to substantial and sustained increase in agricultural production. Farming system studies involving a number of enterprises and taking the physical, socio-economic and bio-physical and environments into consideration are very complicated, expensive and time-consuming. There exists a chain of interactions among the components within the farming systems and it becomes difficult to deal with such inter-linking complex systems (Behera and Mahapatra, 1999 and Shekinah et al., 2005). This problem can be overcome by construction and application of suitable whole farm models.

Research results of cropping systems

Studies conducted in All India Coordinated Research Project (AICRP) on Cropping Systems (CS) based on survey through resource characterization in different States by Agricultural Universities (SAUs) elucidate that there are 14 predominant farming systems in the India. The results of held research clearly pronounced the sizeable increase in the net return by following integrated farming system approach. The net profit margins were directly linked with the number and kind of enterprises. The maximum net profit of Rs.143625ha^{-1} year^{-1} in coconut + banana, vegetable, horticulture, crops and dairy. It was followed by Rs. 118225ha^{-1} year^{-1} with crops + dairy + fishery in agro-climatic zone 3. Out of 14 farming systems, 10 farming systems gave net return in the range of Rs. 50000 to Rs. 15000ha-1year-1. Similar, studies on development of region specific integrated farming system modules including Dairy, Duckery, Poultry, Horticulture, Apiary and Fishery conducted in different states of India has been found to increase profit as compare to cropping system alone (Table 1).

Case studies of IFS conducted in various states of India

Tamil Nadu

Study involving cropping, poultry, pigeon, goat and fishery was conducted under wetland conditions of Tamil Nadu state of India. Three years results revealed that integration of crop with fish (400 numbers reared in 3 ponds of 0.04 ha each), poultry (20 babkok layer bird), pigeon (40 pairs), and goat Tellichere breed of 20 female and 1 male in 0.03 ha deep litter system) resulted in higher productivity, higher economic return of Rs. 131118 (mean of three year) was obtained by integrating goat + fish + cropping applied with recycled fishpond silt fed with goat dropping. Integration of enterprises created the employment opportunities where in comparison to 369 man-days year^{-1} generated in cropping alone system, cropping with fish and goat created additional 207 man-days year^{-1} (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(Jayanthi etal., 2003). The four conventional cropping system tried were ric (*Oryza sative*)-rice(*Oryza sativa*)-black gram(*Vigna mungo*), maize(*Zea mays*)-rice(*Oryza sativa*)-black gram(*Vigna mungo*), maize(*Zea mays*)-rice(*Oryza sativa*))-sunhemp (*Crotalaria juncea*) and rice(*Oryza sativa*)-rice(*Oryza sativa*)-sunhemp(*Crotalaria juncea*).

Farming systems	*System productivity (Rice-equivalent yield t ha^{-1})*	*Net returns (Rs. ha^{-1})*	*B:C ratio*	*Per day return (Rs.)*	*Employment generation (man-days)*
Cropping alone	13.0	37153	2.43	178	369
Cropping + fish + poultry	29.6	97731	3.02	400	515
Cropping + fish + pigeon	29.2	98778	3.06	400	515
Cropping + fish + goat	37.7	131118	3.36	511	576

Table 3: Productivity and economic analysis of integrated farming system model in Tamil Nadu.

In India, about 43mha of land is under rice cultivation and there are many situations where low land sub merged conditions prevail and water remained in pond for a long period of time with 10-30cm depth. Balasamy et al., (2003) explained that Rice (*Oryza sativa*) + Azolla (A*zollapinnata*)- cum fish culture is one of the economical options in such type of area. Monoculture system rely mainly on external inputs while in integrated system where recycling of nutrients takes place help to reduce the cost of production for economic yield. The fish in rice (*Oryza sativa*) 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 results showed an increase in net profit from Rs.37153ha^{-1} year^{-1} in cropping alone to Rs. 98778/ha/annum in Cropping + Fish +Pigeon, Rs. 131118ha^{-1} year^{-1} in Cropping + Fish + Goat system of farming. Wherein net profit increased form Rs.22971 ha^{-1} year^{-1} in Rice (*Oryza sativa*) alone to Rs. 31788 ha^{-1} year^{-1} in Rice + Fish + Azolla (Balasamy et.al., 2003). The data given in Table 3 clearly advocated the beneficial effect of Azolla on Rice (*Oryza sativa*) + Fish. The gross income obtained in rice (*Oryza sativa*) + Azolla (*Azolla pinnata*) + Fish was 25.7% higher over the rice (*Oryza sativa*) crop and 6.9% higher over the rice (*Oryza sativa*) + fish. The net income followed the same trend. Thus Rice (Oryza sativa) + Azolla (Azolla pinnata + Fish on an average gave Rs. 8817ha^{-1} additional over the rice monoculture and Rs. 3219ha^{-1} over the rice (*Oryza sativa*) + fish. This model was proposed for extensive scale adoption in Tamil Nadu.

Goa

A study was conducted at Goa state of India to find out the effect of different recycled manure on rice(*Oryza sativa*) based crops under residual soil moisture in rice fallow system. The maximum crop residue for recycling was available from rice(*Oryza sativa*)-sunhemp (*Crotollaria juncea*) i.e. 14.11 t ha^{-1} year^{-1} which was 2.95, 2.86 and 3.5 times higher than rice(*Oryza sativa*)-groundnut (*Arachis hypogaea*), rice(*Oryza sativa*)- cowpea (*Vigna sinensis*) and rice (*Oryza sativa*)-brinjal (*Solanum melongena*) cropping systems, respectively. Among the enterprises where rice (Oryza sativa) + Sunhemp (*Crottalaria Juncea*) was supplemented with mushroom and poultry, it further enhanced the potential quantity for recycling by 14.9% over the (*Oryza sativa*) + Sunhemp (*Crottalaria Juncea*) because the rice (Oryza sativa) 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 (*Oryza sativa*) alone crop. The organic manure, farm yard manure (FYM), 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 dairy or other purpose. 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 integrated faming system with rice (Oryza sativa) based systems (Manjunath, 2002). The mean total energy input varied considerably among the systems. Integration of poultry and mushroom enterprise with rice (*Oryza sativa*)-groundnut (*Arachis hypogaea*) system integrated with mushroom and poultry (46077 MJha^{-1}). However, rice (Oryza sativa) cropping alone without any rice (*Oryza sativa*) based crops or enterprises recorded the least requirement of energy (Table 4). The energy output was maximum (165334 MJ ha^{-1}) under rice (*Oryza sativa*) – brinjal (*Solanum melongena*) + mushroom + poultry with 3.18 system energy efficiency was 6.76 mainly due to the lesser energy input involved in contrast to energy rich output enterprises. The output of all multi rice (*Oryza sativa*) based enterprise was reasonably good varying from 100911 to 105627 MJha^{-1} excluding brinjal (*Solanum melongena*) 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 followed the concept of integrated farming system through supplementation of allied agro-enterprises. Dazhong, W. and Pimental (1984) recommended that energy utilized through inputs and energy produced as products by each component in the farming systems should be work out for energy budgeting.

System	Gross income (Rs.)			Total expenditure (Rs.)	Net income (Rs.)
	Crop	Fish	Total		
Rice	43291	-	43291	20320	22971
Rice + Fish	39447	11422	50869	22300	28569
Rice + Azolla + Fish	40752	13649	54401	22261	32140

Table 4: Economics of rice + azolla+ fish integrated farming system.

Kerala

In Kerala state of India, each home is having small hand, in which coconut (*Cocos nucifera*), banana(Musa), jackfruit (*Artocarpus heterophyllus*), mango (*Mangifera indica*), pepper (*Capsicum annuum*), nutmeg (*Myristica fragrans*), turmeric (*Curcuma longa*) are commonly cultivated for their multistory 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 complimentary to each other. Results of a study conducted in Kerala coconut (*Cocos nucifera*) + clove (*Syzygium aromaticum*) system gave 3.52 and 3.70 times more net return over pure crop of coconut (*Cocos nucifera*). Likewise, developed substantial additional employment (Table 5).

Farming system	Pooled mean energy		
	Total input ($MJha^{-1}$)	Total output ($MJ\ ha^{-1}$)	Efficiency
Rice-follow	11563	78182	6.76
Rice-groundnut+ mushroom+poultry	46077	102857	2.24
Rice-cowpea+mushroom+poultry	43792	105627	2.41
Rice-brinjal+mushroom+poultry	52030	165334	3.18
Rice-sunnhemp+mushroom+poultry	41439	100911	2.44

Table 5: Energy efficiency of different farming systems.

Andhra Pradesh

In a recent study conducted in North-coastal zone of Andhra Pradesh on farming system in terms of % 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. In case of medium farmers, agriculture + poultry raked first followed by agriculture + sheep and agriculture + sericulture. In this community-based study, the large size 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 (*Zea mays*) 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 programs, 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.

Telangana

The major crops grown in the Northern Telangana Zone are rice (*Oryza sativa*), maize (*Zea mays*), jowar (Sorghum bicolor), groundnut (*Arachis hypogaea*), sugarcane (*Saccharum officinarum*) and cotton (*Gossypium hirsutum*) and other components include buffalo, goat, sheep and poultry. The results of a study conducted on survey based with three agriculture and livestock-based farming systems viz. dairy, poultry and sheep rearing clearly revealed that all the faming system generated more than 3 times additional employment over arable farming. The net returns were higher in agriculture + dairy (Rs.35293) followed by agriculture + poultry (Rs.26830) and agriculture + sheep rearing (Rs.14665). Among different farming systems the agriculture + dairy was proved to be more promising than other (Table 6). The main reason for high returns that stover of maize (*Zea mays*) and jowar (*Sorghum bicolor*) for fodder and their grains for feed as well as sugarcane (*Saccharum officinarum*) crops to feed cattle buffalo were available at the farm.

System	Net return (Rs.ha^{-1}year^{-})	Additional employment (man days ha^{-1}year^{-1})
Coconut alone	10400	-
Coconut + Ginger	36590	500
Coconut + Clove	38500	-

Table 6: Economic and employment generation in coconut + spice system.

Punjab

In Punjab conditions, studies on IFS on farmers' fields revealed that the rice (*Oryza sativa*)-wheat (*Triticum aestivum*) system gave net returns of Rs. 66465ha^{-1}. While rice (*Oryza sativa*)-wheat (*Triticum aestivum*) + dairy showed an advantage of Rs. 8733 ha^{-1} above and over rice (*Oryza sativa*)-wheat (*Triticum aestivum*). Rice (Oryza sativa)-wheat (Triticum aestivum)+ dairy + fishery further supplemented the net return up to Rs.13822ha^{-1} and when it was strengthened with piggery, the net advantages ha^{-1} was of Rs.20068. In addition, the dairy enterprises generated 138 man-days and piggery generated 28 man-days employment over rice (Oryza sativa)-wheat (*Triticum aestivum*) system. The cost: benefit ratio was also in the viable range 1.74 to 1.83 (Table 7). In another study gross income was found to increase from Rs.81200ha^{-1} year^{-1} in rice (*Oryza sativa*)-wheat (*Triticum aestivum*)cropping alone to Rs.154000 ha^{-1} year^{-1} in Crop + Dairy and Rs.11320 in Fish + Piggery system of farming.

Farming system	Human labour (MWDs)	Net returns (Rs.)	Additional employment over agriculture (MWDs)	Additional net returns over agriculture (Rs.)
Agriculture + Dairy	521	35293	359	27842
Agriculture + Poultry	528	26830	366	19379
Agriculture + Sheep	486	14665	324	7214
Agriculture alone	162	7451	-	-

MWD: Man Working Days.

Table 7: Income and employment generation under different farming systems of Telangana.

System	Area under systems (ha)	REY (tha^{-1})	Gross return (Rs.)	Total cost (Rs.)	Net return (Rs.)	Return over rice-wheat system	Employment generation	B:C ratio
Rice-wheat	2.0	18.0	106133	39668	66465	-	-	2.67
Rice-wheat dairy	-	29.7	176231	101033	75198	8733	138	1.74
Rice-wheat	1.78							
Dairy farming	0.22							
Rice-wheat+dairy+fishery	-	30.4	180262	99975	80287	13822	137	1.80
Rice-wheat	1.22							
Dairy	0.22							
Fishery	0.56							
Rice-wheat+dairy+fishery +piggery	-	32.2	190814	104281	86533	20068	172	1.83

Table 8: Economics of various farming systems.

Haryana

In Haryana state of India, studies of various farming systems were conducted on 1.0 ha of irrigated and 1.5 ha of un-irrigated land and it found that under irrigated conditions of mixed faming with crossbred cows yielded the highest net profit (Rs.20581 year^{-1}) followed by mixed farming with buffaloes (Rs.6218 year^{-1}) and lowest in arable farming (Rs. 4618 year^{-1}). In another study conducted with 240 farmers of Rohtak, Hisar and Biwani districts in Haryana which represented zones of different crop rotations wheat (*Triticum aestivum*)-sugarcane (*Saccharum officinarum*) in Rohtak, wheat (*Triticum aestivum*)- cotton(*Gossypium hirsutum*) in Hisar and gram (*Cicer arietinum*)-bajra (*Pennisetum glaucum*) in Bhiwani zone) revealed that maximum returns of Rs.12593, Rs.6746 and Rs. 2317 were obtained from ha^{-1} with buffaloes in Rohtak, Hisar and Bhiwani, respectively. The highest net returns from Rohtakwas attributed to the existence of a better soil fertility 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 conditions of mixed farming was predominantly from livestock rather than crop production (Singh etal., 1999).

Uttar Pradesh

In western plain zone of Uttar Pradesh irrigation facilities are ample; hence farmers had preferred to grow sugarcane (*Saccharum officinarum*) as a remunerative crop. Thereafter rice (Oryza sativa), wheat (*Triticum aestivum*) and maize (*Zea mays*) are the main crops. While, among the pulses crops Pigeonpea (*Cajanus cajan*), urd bean (*Vigna mungo*) and moongbean (*Vigna radiata*) are being grown. The other suitable farming systems are crop+ dairy, crop + dairy + horticulture, crop + plantation + dairy and crop + horticulture etc. Thus, all the available resources canbe utilized efficiently and feasibly under the integrated farming system. Further, studies conducted at ICAR- IIFSR, Modipuram (Uttar Pradesh) indicated that 82.47% higher profit can be earned from the diversified farming system in place of cultivation of crops alone. As regarding of livelihood security, the integrated farming system (IFS) approach adopted in the region had met almost all the domestic family needs of food, fodder, fuel etc. and saves a sizable amount of cash. Further, availability of a variety of products including pulses, oilseeds, vegetables, fruits, milk, eggs and meat were effortless to family members (Gonales and Van Der Veen, 1986).). Recycling of farm wastes and crop residues etc. promote organic farming and besides healthy food to human as reported by Goplan et al. (1976) and it was more congenial to safeguard of environment.

North Eastern Hill region (NEH)

Hill faming is a self-contained type of system in which land, livestock and people are closely connected. The system is predominantly sustained by a flow of organic material and plant nutrients from uncultivated land and adjoining forests. Supply of crucial source is getting jeopardized due to over felling and over grazing with the results crop and fodder production unit-1time have decreased over the years. However, the fragile eroded hill soils are extremely low in available nutrients and organic matter (OM) content, incapable of sustaining increasing demand of food and fodder caused by increased population of both human and livestock. As results, at present and average farmers' family produces food grains just sufficient to meet 4-5 months of its requirements. The hilly regions ofIndia are today confronted with multiple of soil and water resources related problems like increased sedimentation in rivers and water reservoirs, recurring floods, drying up of water sources and above all the deterioration socio-economic condition of people. Therefore, above mentioned model is very common for the subsistence of agriculture in hilly areas.

Economic analysis of different micro watershed-based farming systems namely dairy farming, agro-pastoral and agri-horti-silvi-pastoral systems have shown the economic viability of these systems as an alternative to shifting cultivation. In case of agri-horti-silvi-pastoral, 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 hilly regions. It is worth to mention here that NEH region accounts for 60% of the total pig population of the India and majority of the tribal people being non-vegetarian; pork is an important diet of their food.

Major centre of attention in Farming System Research

In the past few decades farming system research (FSR) has emerged as a popular and major theme in international agricultural research (Sands, 1986). Yet despite the widespread use of the term FSR, substantial ambiguity persists about its meaning and the types of research concepts, objectives, approaches, activities and methods to which it should be applied. FSR integrates the following key activities and concepts into a coherent research process designed to overcome the perceived weaknesses in mainstream agricultural research.

It is problem solving: FSR is an operational research which first identifies technical, biological and socio-economic constraints to improve production in farming systems. It then endeavours to develop solutions which are appropriate for the management conditions of that system (Biggs, 1995).

FSR is farmer-oriented: FSR views small farmers as clients for research and technology development. Therefore, its fundamental objectives are to generate technologies relevant to their goals, needs and priorities. Several mechanisms are employed to attain these objectives; farmers are integrated into research process, the existing farming system is studied before proposing technological solutions and technologies are adapted to local circumstances and needs of a specified group of farmers (Rhoads and Booth, 1982; Chambers and Ghildyal, 1985).

FSR is system oriented: FSR views the farm in a holistic manner and focuses on interactions between components. In practice the whole farming system serves as the frame-work for analysis, but specific components, sub-systems or interventions.

FSR is interdisciplinary: FSR, by nature, cuts across conventional, commodity and disciplinary boundaries. Biological and social scientists must collaborate in order to understand the conditions under which small farmers operated, to diagnose constraints and to develop appropriate and improved technologies (Rhoadesand Booths, 1982; Mahapatra and Behera, 2004).

FSR complements mainstream commodity and disciplinary agricultural research: it does not replace it: FSR draws on the "body of knowledge" of technologies and management strategies, generated by discipline and commodity research and adapts them to the specific environment and socioeconomic circumstances of a target group of relatively homogeneous farmers (Sands, 1986).

On-farm research is central to FSR approach: On-farm research provides the context for collaborations between farmers and researchers (Chambers and Ghildyal, 1985). Researchers get a deeper understanding of the farming system and the decision-making context of the farm family. It revolves round the basic principle that successful agricultural research and development efforts should start and end with the farmers (Rhoades and Booth, 1982). Farmers' participation is ensured at different stages of technology generation and transfer processes such as system description, problem diagnosis, design and implementation of on-farm trials, and providing feedback through monitoring and evaluation.

Conclusions

The farm system research (FSR) needs to be undertaken with greater vigour and persuaded with realistic changes at various levels, which may be called for long term transformation. Farming system research (FSR) is the most suited for the small farmers in less developed and developing countries. The development of such methodologies is an important aspect of farming systems research also at the International Agricultural Research Centres (IARC).

Farming system research is a better approach for allowing better decision making on recommendations to farmers and on priorities for technical research. In most of FSR strategies little attention is paid to components such as livestock, food processing or farm employment. In fact, a framework within which FSR should operate to develop adaptive technologies needs to be clearly understood.

Farmers develop high expectations when something is done on their farm and their curiosity must be satisfied as quickly as possible if their support and assistance is to continue. As such some technologies which provide quick results must be incorporated in farming

systems development. The farming system research particularly important when the impact of the recession is forcing many developing countries into adjustment policy which have a marked effect on the socioeconomic environment of rural areas.

In FSR small farmers should be considered to be clients for agricultural research and development of technology, the farm as whole is viewed in a holistic manner and focus is on interrelations between components and also considered to be problem solving operational research, the FSR nature sounds good for accelerating agricultural development in India. Perhaps the only way in which improvement can be achieved by the construction and application of suitable whole farm models.

The farming system research should be used in formulation of new farming process to test innovation on the farmers field, a wide range of experimental pattern could be pre-screened for compatibility with the existing farm research and the community social and economic structure. The construction and application of suitable whole farm models for examining the profanities of profitability under various resource and constraint conditions are of great importance.

It can complement very well with existing agricultural research by providing new focus on methodological as well as on technical aspects. The technical complementary between FSR and mainstream agricultural research is mainly situated in FSR integration of component and commodity research results into adopted technology at the farmer level.

The most important contribution of farming system research (FSR) is that it provides a focus for all the disciplines involved in agricultural research and development and that it attempts to classify farmers into relevant categories for agricultural research and policy. Its conduct will have a definite impact and relevance to generate research results, which can quickly enhance agricultural productivity and most suited to resource centric holistic research.

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