AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly e Newsletter
Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

CROP BASED INTEGRATED FARMING SYSTEMS FOR SUSTAINABLE PRODUCTION, NUTRITIONAL SECURITY AND ENVIRONMENTAL SAFEGUARD

Article Id: AL202066

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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, 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 a varying degree by political, economic, institutional and rest factors that operate at farm level. The farm holding size in India has been declining over the years, and about 86% (126million) out of 146 million operational holdings are marginal and small. Presently, India comprises of 18% human and 15% livestock population of the world which is maintained on 2.3% land and 4.2% water, 1% forest land and 0.5% pasture and grazing land resources of the globe. Thus, these exist tremendous pressure on available resources to meet domestic needs. The burgeoning population and rising income levels have, however, consistently increased the demand for basic food items and value-added food products also. This increased demand for food from the limited resources available in India can possibly be met by integrating farming systems which offers a whole farm policy and whole systems approach to farm management. The income of average farmers from cropping alone is hardly sufficient to sustain his family. An integrated farming system approach is not only a reliable way of obtaining 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 practised by the farmers indigenously without any rationale for utilizing the residues derives from crops/animals and other associated enterprises at the farm. Dairy animals are an integral part of the prevailing farming system across the country. With rising population, declining land-man ratio and increasing mechanization in farm operations,

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

agriculture alone are not able to provide adequate income and employment to 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 the agricultural labourer and urban factory worker. Increase in non- farm employment has also become essential for improving income and living standard of the rural population (Chadha, 1993; and Kumar *et al*., 2003). The farming system is the integration of farm enterprises to which a farm family allocates its resources in order to efficient utilizes the existing enterprises for enhancing the productivity and profitability of the farm. The farming system, as a holistic approach broadly addresses itself to different components of the farm enterprises and inters-relationship among themselves and the farm environment. Despite different researchers in India and elsewhere generally, restrict themselves to the crop sub-system while referring the farming system without farming adequate attention to the other farm enterprises and socioeconomic conditions in which the farmer operate.

The main objective of opting different kinds of farming was to reduce dependency on external sources. However, following industrialization, farming became commodity-based depending upon agro-climatic conditions of the area and proximity to industries like sugar factory, soya processing plant, rice mill, oil mill, ginning mill, dal mill etc., similarly poultry farming, dairy farming, piggery, beekeeping, fish cultivation, vegetable farming, fruit-farming, floriculture, mushroom farming gained popularity in the peri-urban areas also to exploit the market of the produce available in the city (Meena *et al*.2018). However, with the pace of time, the sustainability of single commodity based farming became questionable because of fluctuating market trends and dependency on external inputs. The 'green revolution' further intensified the crop-based farming system with indiscriminate use of fertilizers leading to a situation of fatigued land and reduced crop production. In IFS, farmer seeds to provide efficient and profitable production which is economically viable and delivers safe, wholesome and quality food through the efficient management of livestock, fish, forage, fresh produce and arable crops, while conserving and enhancing the environment at the same time. Thus, the integrated farming system is adoption and integration of wide rages of a resource-saving package of practices, which ensures an acceptable level of profits/income, make the whole system economically sustainable, ecologically renewable, socially acceptable, minimizes the negative impacts of intensive farming and preserve as well as improve the environment (Gill *et al*. .2009).

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

Farming systems: definition and importance

Farming system though is not a new concept and is defined by different persons in their own way. However, most practicable and meaningful definitions are documented hereunder:

The 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).

"Farming system" is a complex inter-related matrix of soil, plants, animals, implements, power, labour, capital and other inputs controlled in parts by farming families and influenced in varying degrees by political, economic, institutional and social forces that operate at many levels (Mahapatra, 1992).

The main purpose of the integrated farming system is to bring self- sufficiency in farmer's requirement of food and cash; increased income and employment opportunity; recycling of farm wastes and byproducts and increasing resource use efficiency through efficient management of resources (Mahapatra and Bahera, 2004). The land-based enterprises such as dairy, poultry; mushroom, biogas etc. were included to complete the cropping program in order to fetch higher income and employment, thus leading to higher social and economic upliftment. The philosophy of such an integrated farming system revolved around better utilization of time, money, resources and family labourers. The farm family gets scope for gainful employment round the year, thereby ensuring good income and a higher standard of living. The income analysis of such studies revealed that from a small farm piece of 1.0 ha area, the net return of Rs. 3,04,465/ha could be realized from an investment of Rs.1,02,350 generating 356 man-days of employment with a resource use efficiency of Rs. 2.97 per rupee invested.

Principles of Integrated Systems

Principles behind the Integrated Farming System approach as described by several workers as summarized below:

1. The integrated farming system is a farmer-centric bottom-up approach wherein all research and developmental activities of the farm revolved around the farmer-the real

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

beneficiary and are planned and executed accordingly: keeping in view his/her farm resources, economic status and family's annual household food and fodder demand.

2. Social and political environment plays a key role in the selection of the system of farming in respective areas/zones and are considered during the process of planning.
3. IFS is a multi-enterprises and multidisciplinary holistic approach combining all related field of agriculture and subject specialization for maximum synergetic impact and outcome with less input energy.
4. Knowledge of farmers resources, a system of farming and constraints analysis are the pre-requisites for successful planning of any IFS activities.
5. All the farm resources are allocated, keeping in view the households needs, market availability and demand of different commodities.
6. Diversification of existing cropping and farming systems through complementary combination of proven cost effective technologies and less resource requiring farm enterprises.
7. The integration is made in such a way that the product of one component should be the input for other enterprises with a high degree of complementary effects on each other.
8. All farm wastes and crop residues etc. are properly collected, composted and or recycled in-situ and nothing goes waste promotion to vertical farming with multiple uses of resources.
9. Adoption of resource conservation technologies for maximizing resource use efficiency.
10. More emphasis is given to lowering a chemical load and thus promoting organic farming with the ultimate goal of environmental protection.
11. Being more diversified in nature, the approach is more employment generative, particularly for rural unemployed youths.
12. More emphasis is given for on-farm processing and adding product value before use at farm and marketing of surplus produces (if any).

Farming Systems Scenario of Small Farm Holders in India

The marginal and small categories of farmers, in general, are literally illiterate, financially handicapped (more than 30% are below poverty line), small and scattered land holding not suited for high-tech agricultural machinery, work in resource-poor and risk-prone

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

diverse conditions. Further, these farmers most after are laggards and practice whatever their neighbours do and because of wide spread poverty among these categories of farmers, they cannot take much risk to adopt new innovations in the field of agriculture and hence could not achieve advantages of several commodity based revolution took place (Mahapatra and Bapat,1992). Even after six decades of independence and eleven five year plans completed, the economic conditions of small farm holders is still bad to worst. It is because the efforts made so far were in favour of resource rich and large holding farmers and not planned according to real conditions of these categories of farmers representing 4/5th of the total farm holding of the country. A detailed analysis for these categories of farmers is given in the Table1 below;

Table1: SWOT analysis of small farm holders.

Strengths	Weaknesses	Opportunities	Threats
The only strength of these category of the farmers is sufficient available man power	1. Small & fragmented land holdings 2. Wide spread poverty 3. Lack of resources 4. Illiteracy 5. Laggardness	1. Loans on low interests 2. Subsidies on implements, milch animals and new enterprises like fish production, horticulture and a number of small scale industries. 3. Free trainings for agriculture related enterprises. 4. Research oriented technologies to increase the productivity and profitability of existing On-Farm farming systems.	1. Any type of technological and methodological failures can affect the economic condition of the family. 2. Small farmers' works in risk prone diverse conditions. 3. Environmental factors such as climate and weather adversities are beyond the control of small economically handicapped farmers 4. High risk to introduce any new technology.

Existing and Integrated Farming Systems

The benefits of advancement in agriculture are harnessed mainly by small group of large and medium category of the farmers who are resource endowed. At present about 86% farmers are marginal and small in India. Small-land holdings are not well suited to mechanize farming coupled with poor economic condition and lack of resources is responsible for slow growth rate in agricultural sector. Pigeonpea, urd bean and moong bean are the second choice of the farmers after sugarcane-ratoon-wheat cropping system in western plain zone of Uttar pradesh. However, the legume crops like cowpea and *dhaincha* arebeing used asgreen fodder

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

and green manuring crops. The predominant existing farming systems are in India: crop alone, crop dairy, crop dairy+ horticulture, crop plantation+ dairy horticulture etc.

There is urgent need to optimize the limited available resources with farmers and cut down the cost of production through integration of different enterprises at one place to use them as byproducts and supplementary for getting higher benefits. Thus, we can save inputs purchased from the market by 70-80% and rest 20-30 % will be required. The farming system research is considered to be a powerful tool for natural and human resource management in developing countries like India. This is a multidisciplinary whole–farm approach addressing the constraints of small and marginal farmers. The main aims of increase income and employmentfrom small holdings by integration of various farm enterprises and recycled of crop residues and byproducts within the farm system. The small and fragmented land holdings are forbidden in the way of mechanization and hence the whole crop operations are carried out by the farm family resulted in meagre farm production which is consumed by the farm family itself. The interaction of biophysical, technological, institutional and socioeconomic conditions are leading to temporal and spatial variability among the farming systems which are not only help in enhancing productivity and profitability but also contribute in creation of available balanced diet. Under the existing agrarian structure, most of the rural farm families are of 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 rainfed areas (Lal and Miller, 1990). Further, this section of farming community is very much susceptible to the natural vagaries (drought & flood) and resulting in large scale migration to urban areas for seeking livelihood opportunities. Keeping in view of these problems, the innovation on IFS developed by ICAR-IIFSR, Modipuram, Meerut, Uttar Pradesh, India. To ensures the consolidation of the natural resource base at farm level and offers better opportunities for adoption of improved technology/ies with the target of enhancement of overall production and productivity of the farm. To 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. And this technique ensures in the creation of better awareness on the adoption of technology/ies 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

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

available on the farm, different allied activities such as horticulture, dairy and vermi compost should be included in 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 can be recycled for vermicomposting for applying in the field crops. The productivity enhancement after intervention and stability in crop productivity was noticed as indicated by higher sustainable yield index in crops adopted in all farms. The change in productivity is variable and in constraint farming situations the interventions have greater impact and brought greater increase in yield (38 to 80 %) and stability in yield was noticed. This shows the impact of whole farm demonstration of IFS is significant because of improvement in natural resource base of the farmer and risk reduction. The new vegetable crops and varieties are to be introduced in the farms, one of the important interventions which enhanced the income of farm families, increased the cropping intensity, boost employment and increase nutritional security for the farm families and surrounding rural households. Gill (et al. 2009) also reported 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 farming system. The emphasis was given for the incremental changes with seasonal crops and with the other activities, with the introduction of new technologies, forced the farmers to re-organize substantial portions of their activities. Economic analysis was done by recording and the 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.

The important components of IFS model are includes vegetables crops like cabbage, cauliflower, okra, french bean, tuber crops, floriculture, medicinal, aromatic and forest plants (used for timber /fuel/ fodder), grasses and fodder crops and hence alternatives suitable farming systems for different farming situation in the India are: Crop alone, Crop+ dairy, Crops+ dairy + horticulture, Crops+ plantation+ dairy and Crop + horticulture.

AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly e Newsletter
Volume 2 – Issue 5
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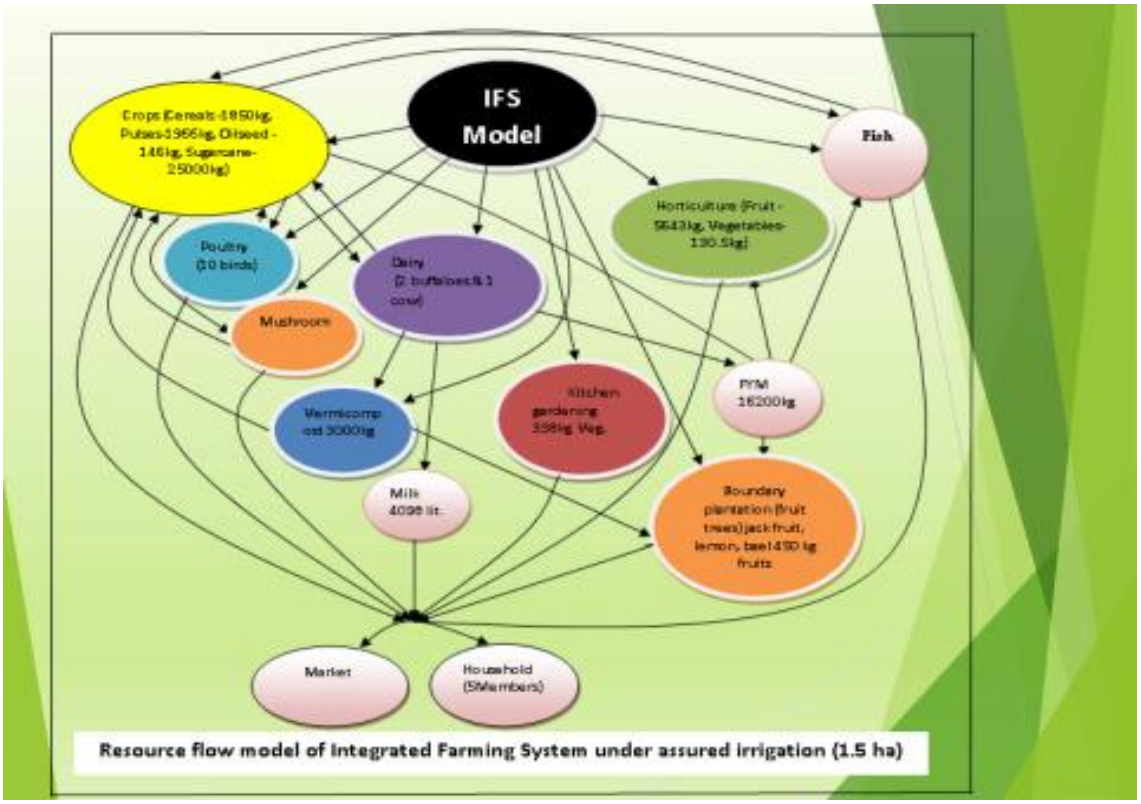
www.agriallis.com



The soil, water, climate, marketing, labour, transport and local demands are the main criteria to select the farming systems. For example in western plain zone of Uttar Pradesh irrigation facilities are ample, hence farmers has preferred to grow sugarcane as a remunerative crop thereafter rice, wheat and maize are the another important crops. Apart from this, pulses like pigeonpea, urd bean and moong are grown by the farmers. While, the legume crops like cowpea and dhaincha are taken for green manuring, fruit crops *viz.* mango, guava, jackfruit, jamun and oilseeds such as mustard, toria, vegetables crops like potato, cabbage, cauliflower, okra, potato, French bean, tubers (sweet potato) , floriculture, medicinal, aromatic and forest plants (used for timber, /fuel/ fodder), grasses and fodder crops. Thus, all available natural resources indicate that number of potential, profitable and feasible farming system enterprises and their alternatives are available in the region. The various potential, profitable and sustainable of farming systems. The integration of location specific suitable and socio-economically acceptable farming system enterprises can help to achieve sufficient food and nutritional security, farm resource recycling to enhance the farm income and employment opportunities in general and improve livelihood in different states of India as given in Table2.

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

Table 2: Prevailing system and integrated farming systems in different states of India

State	Prevailing systems	Integrated Farming Systems
Tamil Nadu	Rice-Rice-Black gram	Rice-Rice-Cotton+Maize Rice-Rice-Cotton+Maize+Poultry/Fish
	Rice-Rice	Rice-Rice-Azolla/Calotropis+Fish
	Rice-Rice-Rice-Fallow-Pulses	Rice-Rice-Rice-Fallow-Cotton+Maize+Duch cum Fish
	Cropping alone	Cropping+Fish-Poultry Cropping+Fish-Pigeon Cropping+Fish-Goat
	Rice	Rice+Fish Rice+Azolla+Fish
Goa	Cashew	Coconut+Forage+Dairy Rice-Brinjal (0.5 ha)+ Rice-Cowpea (0.5 ha)+ Mushroom + poultry
Madhya pradesh	Arable Farming	Mixed Farming + 2 Cow Dairy (2cows) +15 Goats+ 10 Poultry+10 Duch+Fish
Maharashtra	Cotton(K)+Groundnut(S)	Black Gram (K)-Onion (R)- Maize+Cowpea Crop+Dairy+Sericulture Crop+Dairy
Punjab	Crops (Rice-Wheat)	Crops (Rice-Wheat)+Dairy Fish+Piggery
Uttar pradesh	Crop (Sugarcane-Wheat) Crops alone (Diversified)	Crops(Sugarcane+Wheat)+Dairy Crop+Dairy Crop+Dairy+Horticultrue Crop+Dairy+Apiary Crop+Dairy+Vermicomposting

Major Focus 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 socioeconomic 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).

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

FSR is farmer-oriented: FSR views small farmers as clients for research and technology development (Jayanthi et al.2007).Therefore, its fundamental objectives are to generate technologies relevant to their goals, needs and priorities. Several mechanisms are employed to attain these objectives: (i) farmers are integrated into research process, the existing farming system is studied before proposing technological solutions and (iii) 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 (Rhoades and 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.

Technological Interventions for Integrated Farming Systems

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, goatory, apiary, agroforestry and

Volume 2 – Issue 5
Online ISSN: 2582-368X
www.agriallis.com

agro-processing etc. diren by market demand and opportunities (Lightfoot *et al.* 1993; Prein 2002).

Many researchers advocated farming system analysis and multidisciplinary research for the development of small farms (Devendra, 2002; Prein, 2002). Hence, development of suitable IFS models for the small farmer in different agro-ecological regions of the state is of major importance. The basic aim of an 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, socioeconomic and bio-physical environments into consideration are very complicated, expensive and time-consuming (Mahapatra and Behera, 2004). 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; Shekinah *et al*., 2005). This problem can be overcome by construction and application of suitable whole farm models.

Conclusion

In brief, the system agriculture is based on the idea of enhancing peoples' capacity to mange change by developing their ability to learn, how to learn, to improve problem situation and to communicate effectively. It draws on the concept of experiential learning and on systems thinking and practice as well as scientific method and encourages intuitive, creative activity, as well as logical, systematic thinking. It envisages agriculture as complex interaction between natural and social phenomena. In India, the increasing population demands coupled with decreasing resources base and declining productivity warrants an immediate attention of researchers to attend to these problems and there is urgent need to reorient agriculture research programmes from individualistic enterprise approach to holistic (System oriented) approach in agricultural system. The concept of integrated system research takes various enterprises and resources inputs at the farm into consideration for planning production of crops, selecting cropping systems and combining various enterprises to develop integrated farming systems having sustainable agriculture production.

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Volume 2 – Issue 5
Online ISSN: 2582-368X
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Volume 2 – Issue 5
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