BOOK CHAPTER

INTEGRATED FARMING SYSTEMS FOR SUSTAINABLE AGRICULTURE

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Background of Integrated farming systems

In the mid-1960's, there was little interaction between technical scientists (who were mostly on experiment stations) and social scientists (who tended to be concentrated in planning units). The Green Revolution was beginning to have a great deal of success in Asia and Latin America, being based on good climate (i.e., plenty of water) and soils; very homogeneous and favourable production environments; and the adoption of improved varieties of wheat, maize, and rice that were very responsive to fertilizer. Improved inputs were also readily available and there was an accessible market for the products. However, in most of Sub-Saharan Africa, and certain parts of Latin America and Asia, there has been no Green Revolution. This is because climatic conditions are often not as favourable (i.e., too much or too little rainfall and limited amounts of irrigation), soils are generally poor, production environments are very heterogeneous and poor, and the input and output markets are poorly developed. Not surprisingly, there has been great difficulty in developing improved technologies that are attractive to farmers in such areas.

In Green Revolution areas, farmers were able to benefit from the improved technologies even if they did not do things quite right and the inputs they used were very divisible (e.g., they could use a little or a lot of improved fertilizer or seed). However, in areas with less hospitable environments (e.g., low rainfall areas that are found in many countries in Africa and Latin America), farmers have to do things exactly right if they are to benefit (e.g., planting in good soil moisture) and also they need lumpy inputs (e.g., control over traction). In addition, yield increases are not so good -- they tend to involve incremental rather than major (i.e., revolutionary) changes in yields.

Thus, in the Green Revolution areas, because of the spectacular nature of the technology, experiment-station based technical scientists were very successful in their work. However, the lack of success in using a similar approach in poorer agricultural areas (i.e., with resource poor farmers), led to the evolution of the FSR approach, in which there is close cooperation between technical and social scientists (Norman, 1993).

Integrated Farming Systems (IFS) seem to be the possible solution to the continuous increase of demand for food production, sustainability, stability of income and improvement in nutrition for the small and marginal

farmers with limited resources. Integration of different agriculturally related enterprises with crop activity as base will provide ways to recycle produces and waste materials of one component as input through another linked component to bring in improvement in soil health and reduce the cost of production of the products which finally raise the total income of the farm.

Farming system is a resource management strategy to achieve economic and sustained agricultural production to meet diverse requirements of the farm household while preserving the resource base and maintaining high environmental quality. The advantages of integrated farming systems include pooling and sharing of resources / inputs, efficient use of family labour, conservation, preservation and utilization of farm biomass including non-conventional feed and fodder resources, effective use of FYM, regulation of soil fertility and health, income and employment generation for many people and increase in economic status by utilization of under-utilized resources in an efficient and remunerative manner. Population pressure on land leading to division and fragmentation of land holdings necessitates identification and adoption of suitable farming systems (Korikantimath and Manjumath, 2008).

Farming system models of different situation could enhance the productivity of the farm, improve the profitability of the farmer and sustain the productivity of the soil through recycling of organic source of nutrients from the enterprises involved. IFS also helps to realize money round the year by sale of milk, egg, meat, edible mushroom, bee keeping, etc. to the resource poor farmers. Unlike crop activity, where the involvement of laboures for individual operations are bulky with limited number of operations at wider interval. The enterprise linkage provides good opportunity for day to day operations with limited labourers. This helps the family labourers of the rainfed farmers to work for the farm round the year. The standard of living of the farmer will also improve substantially by the linkage of biogas, quality food commodities for the family use, availability of money round the year etc.

Farming system approach envisages the integration of agroforestry, horticulture, dairy, sheep and goat rearing, fishery, poultry, pigeon, biogas, mushroom, sericulture, apiculture and by-product utilization of crops with the main goal of increasing the income and standard of living of small and marginal farmers. The challenge is to upgrade the technological and social disciplines on a continuous basis and integrate these disciplines to suit the region and the farm families in a manner that may ensure increased production with stability, ecological sustainability and equitability.

Research studies carried out in different situations viz., low land, irrigated upland and upland have demonstrated the technical feasibility and economic viability of the integrated farming systems. Besides facilitating cash income, these farming system models generate additional employment

for family labour and minimize the risk associated with conventional cropping system.

Global perspective

Population in the most tropical countries is pressing hard for producing more food from the limited areas available for cultivation. The goal of sustainable agriculture can be achieved by seeking the optimal use of internal production inputs in a way that provide acceptable levels of sustainable crop productivity and livestock production resulting in economically profitable return. Integrated farming system approach is not only a reliable way of obtaining fairly high productivity, but also a concept of ecological soundness leading to sustainable agriculture

The Technical Advisory Committee of the CGIAR defined sustainable agriculture as successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources. Sustainable agriculture is ecologically sound, economically viable, socially just, Humane, adaptable.

Farming system approach is therefore, designated as a set of agricultural activities organized into functional unit(s) to profitably harness solar energy while preserving land productivity and environmental quality and maintaining desirable level of biological diversity and ecological stability. The emphasis is more on a system rather than gross output. In other words 'farming system' is a resource management strategy to achieve economic and sustained production to meet diverse requirement of farm household while preserving resource base and maintaining a high level environment 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 part by families and influenced to varying degrees by political, economic institutional and social forces that operate at many levels.

The components of IFS include Agriculture, fish farming, horticulture, duck rearing, forestry, pigeon rearing, mushroom cultivation, sericulture, *Azolla* farming, dairy, kitchen gardening, poultry, fodder production, goat rearing, nursery, sheep rearing, seed production, piggery, vermiculture. The different IFS are: i) crop-livestock - forestry farming system, ii) crop-fish-poultry farming system, iii) crop-livestock-poultry-fishery farming system and iv) Labour intensive system for small area.

Country scenario

India is the second most populous country in the world. With the population growth rate of over two per cent, the population is increasing year after year. Therefore, the challenge of meeting the basic requirements of this

increasing population is a major concern. The green revolution, a follow-up of modern agriculture has helped to solve the problem to a great extent. But the exploitative tendency of modern agriculture aimed at higher production per unit area, by using chemical fertilizers and pesticides is infact, rapidly degrading the basic production capacity of the ecosystem. During the past few years, in many situations, over exploitation of natural resources initially did have short term gains, but has resulted in degradation of soil fertility and productivity and ecological imbalance. It has created serious problems of salinity, water logging, soil erosion, host of complex pests and diseases, menace and degradation of environment including air and water pollution. Therefore, to maintain the productivity of the land even after harvesting higher crop yields, on a sustainable basis and also to increase the productivity of the land year after year, a sound integrated farming system has to be developed. Such an integrated farming system should have the objective to produce enough to meet the genuine demand and needs of the society, be profitable to the farmer, conserve natural resource base and provide healthy and safe environment in the long run. Considering the large variations that exist in soils, climatic situations in- different locations and economic and social conditions of the farmers, alternate integrated farming systems are to be developed (Nadagouda, 2000).

The future of Indian agriculture depends heavily on the development of appropriate farming system as applicable to resource poor farm families and as suited to different agro ecological zones. The endowment of abundant sunshine, long growing season, responsive soil types and combination of surface water, ground water and seasonal rains and above all a progressive peasantry, offer vast scope for an intensive farming system though multiple cropping and diversified farming including animal husbandry, forestry, sericulture, fisheries and the like (Patil *et al*., 2008).

Integrated farming systems- profitability and sustainability

Integrated systems are about bringing crops and livestock into an interactive relationship with the expectation that together, as opposed to alone, they will generate positive effects on outcomes of interest, such as profitability overall productivity, and conservation of non-renewable resources. It is, however, much more than this. The “system” includes the environment, soil characteristics, landscape positions, genetics, and ecology of plant and animals. It involves management practices, goals and lifestyles of humans, social constraints, economic opportunities, marketing strategies and externalities including energy supplies and costs and impacts of farm policies. Systems also reflect natural resources available and the impact on their use, wildlife issues, target and non-target plant and animal species, micro-organisms, and indeed all of the definable and indefinable factors that ultimately interact to result in an outcome that is never constant (Allen *et al*., 2007).

Integration of various farm enterprises in a farm ensures growth and stability in overall productivity and profitability. It also ensures recycling of residues, optimization of resources, minimization of risk and generation of employment. Various enterprises that could be included in farming system are crops, vegetables, fruits, flower cultivation, dairy, poultry, fish, goat, pig, sericulture, mushroom cultivation, agroforestry, bee keeping, silviculture, agro-based industries and food processing. A judicious mix of enterprises complementary to cropping and suited to the given farm situation and farmer's preference would bring overall prosperity.

Under farming system, the farm is viewed in a holistic manner. Farmers are subjected to many socio-economic, bio-physical, institutional, administrative and technological constraints. Farming system conceptually is a set of elements or components that are inter-related which interact among themselves. At the centre of the interaction is the farmer exercising control and choice regarding the type and results of interaction (Lal and Millar, 1990).

Role of integrated farming system

IFS approach as a biophysical and socio-economic capsule has immense potential to address instability of income, food and nutritional insecurity, unemployment, vulnerability and poverty of farmers as well as landless laborers. The urgency for addressing issues of livelihood security mainstreaming rural poor to the benefits of production technologies and development process in an integrated manner in the target districts needs no emphasis. This calls for establishing synergy and complimentary to both at production system levels and beyond production, farm activities to non-farm activities. IFS for optimizing economic returns from resource allocation under different agro-ecological scenarios such as, totally rainfed, rainfed farming supported by WHS and rainfed farming supported by underground water extraction are the need of the hour. In this action research study, the IFS will be used to pave the way for growth and sustainable development for larger uptake.

Objectives of integrated farming systems

i) To identify existing farming systems in specific area and assess their relative viability;

ii) To formulate farming system models involving main and allied enterprises for different farming situations;

iii) To ensure optional utilization and conservation of available re-sources and effective recycling of farm residues within system;

iv) To maintain sustainable production system without damaging resources base environment; and

v) To raise overall profitability of farm household by complementing main allied enterprises with each other.

vi) Analysis of existing farming systems in terms of resource use efficiency, production and productivity, income, employment and sustainability across different agro-climatic zones.

vii) Evaluation and identification of farming system through participatory approach that ensures threshold level of income for the livelihood security.

viii) Development and evaluation of synergic effects and their actions associated with different farming systems.

ix) Developing appropriate institutional and market linkage including value addition for enhancing sustainability.

x) Imparting training and capacity building of various stakeholders on IFS.

Goal of IFS

The goals of IFS are maximization of yield of all component enterprises to provide steady and stable Income rejuvenation/amelioration of system's productivity - and achieve agro-ecological equilibrium. A void build-up of insect-pests, diseases and weed population through natural cropping system management and keep them at low level of intensity. Reducing the use of chemicals (fertilizers and pesticides to provide chemical I free healthy produce and environment to the society.

Components of IFS

The components of IFS include Agriculture, fish farming, horticulture, duck rearing, forestry, pigeon rearing, mushroom cultivation, sericulture, *Azolla* farming, dairy, kitchen gardening, poultry, fodder production, goat rearing, nursery, sheep rearing, seed production, piggery, vermiculture. The different IFS are: i) crop-livestock - forestry farming system, ii) crop-fish-poultry farming system, iii) crop-livestock-poultry-fishery farming system, and iv) Labour intensive farming system for small area (Patil *et al*., 2008).

Food and fodder security through integrated farming system approach

Sustaining household food has been an issue of prime importance to majority of the farmers belonging to the categories of small and marginal holdings. Farmers under these categories are economically poor, work in diverse, location specific, risk-prone environment invite attention to develop

technologies for inter-disciplinary enterprises as farming system research. It envisages development of technologies by integration of allied enterprises with existing crop components for harnessing the productivity and profitability of each enterprise by taking into account the farmer priorities, socio-economic conditions and resource available with them. Thus farming system is the appropriate combination of farm enterprises viz., crops, livestock, fishery, poultry, mushroom, bee keeping and the means available to the farms serve as valuable manures for recycling within the system. It further ensures interaction with the environment without dislocation of the ecological and socio economic balance on one hand and attempt to meet the national goals on the other. Integration of economically viable, socially accepted and environmentally safe enterprises, along with existing farming systems has been found enterprising in many of the states including TamilNadu (Jayanthi *et al*., 2007), Maharashtra (Shelke *et al*., 2001), Punjab (Gill, 2001) and Uttar Pradesh (Singh *et al*., 2006). While assessing the need of farming system approach in Indian context (Swaminathan, 1990) described that having attained food security for the nation, the future strategy would necessitate a change in priorities through diversification to encompass farm level horticulture, agro-forestry, animal production and fisheries etc. in to the subsistence level farming avocation. This calls for holistic configuration of different farm enterprises (Singh *et al*., 2008).

Of late farming community in India has been facing new challenges of food and nutrition security, human health and structural adjustments to comply WTO stipulations on the one hand and the sustainable environment on the other. The slow growth of the agricultural sector is mainly due to stagnation in productivity growth and a grave concern for policy makers and planners. The key challenges to Indians agriculture lies in designing, developing and managing farming systems that enabled farmers to be efficient, equitable and sustainable in the bio-economic, bio-physical and socio-cultural environment.

The existing resource base of large segment of farming community does not permit them to derive full benefit of modern technology. Hence the concept of strengthening resource base and optimum allocation of resources is of crucial importance. Therefore it is imperative to evolve suitable strategy for undertaking more than one enterprise in the farm to increase productivity and supplement the income. This can be effectively achieved by determining optimum sustainable farming systems, resulting in increasing the farm income. “Farming” is the process of producing economic and animal products, and “System” implies set of interrelated practices organized in to the functional entity. “Farming system” is resource management strategy to achieve economic and sustained agricultural production to meet diverse requirements of the farm household and preserving resource base for future generation and maintaining high environmental quality. Within an agro-ecological zone several farming systems will typically be found with

variations in resource endowments, preferences and socio-economic positions of the rural households.

Implementation of IFS for distinct protection systems with weak livelihood security such as totally rainfed farming, rainfed farming with Water Harvesting Structures (WHS), rainfed farming with WHS and ground water irrigation and Landless labourers household with livestock, will substantially improve the livelihood security on a sustainable basis. Infrastructural support to facilitate IFS, Soil and Water Conservation (SWC), will enhance economic security, employment opportunities, reducing drudgery and enhancing livelihood security. Appropriate institutional linkages will improve market orientation, efficiency, value addition and livelihood security. Human resource development through capacity building in IFS and Income Generating Activity (IGA) enables to counter the challenges of vulnerable areas in the state. Social capital formation builds collective action, cooperation, trust, social cohesion required for improving livelihood security through IFS.

Farming system concept

In farming system, all the activities, decision, management, input/output, purchase/sale and resource (s) utilized make the matrix which interacts with socio-economic and bio-physical environment. Farm activities interact with market forces (socio-economic) and ecosystem (bio- physical) for purchasing inputs and disposing outputs by utilizing and degrading natural resources (land, water, air, sunshine, etc.). Sustainability is the objective of the farming system where production process is optimized through efficient utilization of inputs without infringing on the quality of environment with which it interacts.

The overall objective is to evolve technically feasible and economically viable farming system models by integrating cropping with allied enterprises for irrigated, rainfed, hilly and coastal areas with a view to generate income and employment from the farm.

Scope of farming system

Farming enterprises include crop, livestock, poultry, fish, tree crops, plantation crops, sericulture, etc. A combination of one or more enterprises with cropping, when carefully chosen, planned and executed, gives greater dividends than a single enterprise, especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of the enterprises to be combined with crop production activity. Integration of farm enterprises depends on many factors such as,

1. Soil and climatic features of the selected area.
2. Availability of the resources, land, labour and capital.
3. Present level of utilization of resources

4. Economics of proposed integrated farming system.

5. Managerial skill of the farmer

For any sustainable and economically viable farming system, *in-situ* conservation of rain water to the maximum possible extent (which automatically takes care of soil conservation) and build up of soil fertility and productivity largely through the incorporation of organic manures but only supplemented by minimum extent of need based chemical fertilizers/amendments are the primary considerations. *In situ* rain water harvesting and conserving can be achieved by appropriate bunding followed by land levelling and strengthening of the bunds by planting trees and grasses on the bunds. Regular maintenance of bunds and interbund management practices such as carrying out all cultural operations across the slope, compartment bunding, mulching, application of organic manures to improve the infiltration rate of soils etc. will help to conserve soil and water. Soil fertility build up and its regular maintenance can be achieved on sustainable basis only through the application of organic manures such as FYM, compost, vermicompost, crop residues and green manures. Building up of soil fertility through organics is very important since with such a practice, stability of increasing trend in crop yields can be achieved as compared to sudden rise and fall of crop yields when chemical fertilizers are used. Regular use of organics encourages multiplication of beneficial soil microbial population and the soil borne pathogens are controlled. Organics such as vermicompost also make the plant resistant to certain pests and diseases. Moreover, quality of the produce from such a crop will be superior as compared to the produce obtained when chemical fertilizers are used. In irrigated agriculture, after few years of irrigation, degradation of soil is very common. But, wherever green manuring is practiced as a regular feature, degradation of soil has not taken place. At present, it has been the experience of most of the farmers that the farming under the existing situation is not a profitable enterprise. The major reason for such a situation is the high cost of cultivation which is increasing year after year. Therefore, any effort to reduce the cost of cultivation by avoiding/minimizing the use of chemicals and middlemen in agriculture will definitely bring in stability of agricultural production and farming will be a profitable concern.

Crop management practices such as crop rotation, mixed cropping, INM and IPM need to be incorporated in all the farming situations. Crop rotation and mixed cropping have many advantages. Build-up of pests/diseases and depletion of plant nutrients from the soil can be avoided by following the simple practice of crop rotation. It will also help to build soil fertility when a legume crop is involved in the crop rotation. Mixed cropping when followed in an appropriate manner will increase total output under normal situations but will act as an insurance against failure of crops under abnormal conditions. When a legume is involved as one of the

component crops, in mixed cropping, it will improve soil fertility. Mixed cropping is also advantageous in minimizing the spread of pests and diseases and is efficient in the utilization of soil moisture, nutrients and sunlight. Instead of depending solely on chemical fertilizers and amendments, a combination of organic manures, biofertilizers and chemical fertilizers is always better to maintain good soil health and at the same time to harvest higher crop yields. In case of plant protection, sole dependence on chemicals and their indiscriminate use has resulted in making the insect pests resistant to chemical pesticides, thereby increasing the dosage of pesticides for the control of pests year after year. Moreover specific pesticides are to be used for particular pest at its particular stage. Many farmers have very little knowledge of such specific plant protection measures which is again complicated by almost frequent changes in the plant protection schedules. Under such situations, IPM has definite advantages, but complete elimination of chemicals in a phased manner from the IPM schedule and developing plant protection methods with appropriate cultural practices, cropping systems and use of bioagents and plant products will be ideal.

Mixed farming involving allied enterprises which are complementary to agriculture, such as dairy, apiculture, sericulture, inland fisheries, sheep/ goat rearing and poultry will provide employment and additional income to the farmer throughout the year. It will also act as an insurance against crop failures due to climatic vagaries and will help to build soil fertility when animal wastes are properly utilized for preparation of manures.

Integrated Agro-forestry system

Agro forestry is a land use system that involves deliberate retention, introduction of tree or woody perennials in crop/animal production to benefit from the resultant ecological and economic intersections. (Nair, 1993). Agro-forestry based production system are capable of yielding leaf fodder, wood and food at the same time besides conserving and rehabilitating the ecosystem. The woody perennial/tree is one of the components in such a system. Agro-forestry, an important part of integrated farm production systems in four major agro-ecosystems, determining the system productivity and profitability. Area under agro-forestry can be covered depending upon the land capability classification. Land capability classification is the systematic arrangement of different kinds of land according to properties which determine the ability of land to produce virtually on permanent basis. The classification is based on land feature and inherent potentials. Land classes I-III or IV are categorized for agricultural or arable land use whereas land classes IV/V -VIII are categorized for non-agricultural or non-arable land use. It is being increasingly realized that in order to derive maximum benefits from the available resources and prevailing patterns of agriculture, a land use planning is essential to achieve a sustainable use of land, water and vegetation. In India 175 m ha low productive wasteland is the potential areas

for agroforestry developmental activities (Shrotriya *et al.*, 2000)..

Agro forestry /Agri-horticulture is a very important component in an integrated farming system. Inclusion of tree component in the farming has many advantages. Some of the important advantages of the agro-forestry system are:

a. It meets the human needs of food, fuel, fodder, timber and pesticides (eg. neem).
b. It provides sustainable income with low cost of cultivation and returns are higher as compared to any cropping system involving only annual crops.
c. It controls soil erosion and improves soil fertility and productivity by regular leaf fall and tapping the nutrients from lower regions of the soil.
d. It very well adjusts with any vagaries of nature. Efficient use of erratic rainfall is possible by trees.
e. Trees act as resting place for birds, which are relatively beneficial for agriculture, since harm done by birds is more than compensated by their action for control of insect pests.
f. Shade created by trees is beneficial in raising certain shade loving crops and horticulture nursery and for vermiculture.

Summing up, it can be said that an integrated farming system involving annual crops, tree crops (beneficial MPTS and fruit trees), dairy, poultry, inland fisheries, goat/sheep rearing, apiculture, sericulture and organic farming by minimizing the use of chemical fertilizers and pesticides is a profitable, sustainable and eco-friendly agriculture which needs to be practiced by each and every farmer (Nadagouda, 2000).

Integration of Enterprises

In agriculture, crop husbandry is the main activity. The income obtained from cropping is hardly sufficient to sustain the farm family throughout the year. Assured regular cash flow is possible when cropping is combined with other enterprises. Judicious combination of enterprises, keeping in view of the environmental conditions of a locality will pay greater dividends. At the same time, it will also promote effective recycling of residues/wastes.

Choice of Enterprise: The basic points that are to be considered while choosing appropriate enterprise in Integrated farming system (IFS) are:

1. Soil and climatic features of an area/locality
2. Resource availability with the farmer
3. Present level of utilization of resources

4. Return/income from the existing farming system
5. Economics of proposed integrated farming system
6. Farmer's managerial skill
7. Social customs prevailing in the locality

Enterprise integration

Livestock is the best complementary enterprise with cropping, especially during the adverse years. Installation of a biogas plant in crop-livestock system will make use of the wastes, at the same time provides valuable manure and gas for cooking and lighting. In a wetland farm, there are greater avenues for fishery, duck farming and buffalo rearing. Utilizing the rice straw, mushroom production can be started. Under irrigated conditions (garden lands), inclusion of sericulture, poultry and piggery along with arable crop production is an accepted practice. The poultry component in this system can make use of the grains produced in the farm as feed. Pigs are the unique components that can be reared with the wastes which are unfit for human consumption. In rainfed farming, sheep and goat rearing form an integral part of the landscape. Sericulture can be introduced in rainfed farming, provided the climatic conditions permit it. Agro- forestry (silviculture and silvi-horticulture) are the other activities which can be included under dryland conditions. In the integrated system, selection of enterprise should be on the cardinal principle that there should be minimal competition and maximum complementary effect among the enterprises.

Integrated farming system meets spread out demand for food, income and diverse requirements of food grains, vegetables, milk, egg, meat etc., thereby improving the nutrition of small-scale farmers with limited re sources. Integration of different agriculturally related enterprises with crops provides ways to recycle the products and by products of one component as input to another and reduce the cost of production and increase the total income of the farm.

Choice of crops and allied activities

Integrated farming system focuses around a few selected, interdependent, interrelated and often inter-locking production systems, Normally, they are based on crops, livestock, and related subsidiary professions. This integrated nature involves the utilization of primary and secondary produces of one system as basic input of the other systems, making them mutually integrated as one whole unit. This incidentally helps to reduce the dependence on procurement of inputs from open market, making the system sustainable on long term basis in the development of sustainable farming system models, the concepts of intensification, diversification and value addition must be kept in view. The interaction would also help to improve productivity in various activities

IFS-expected outcome

Enhanced income : IFS provide opportunity to make use of the produce of one component as input on another component at the least cost. By reductions the cost of production, the profitability per rupee invested is enhanced by eliminating the interference of middleman in most of the inputs used. Small ruminants like goats and sheep form an important economic and ecological niche in Asian mixed farming systems. Approximately, 60% of goats and 20% of sheep population are in Asia. The sale of goats contributes 30% of the total farm income in India. The IFS research in Tamil Nadu provides interesting research results. In a small farm of 2 ha, goat component added an additional income of Rs 12,000/- with 6 goats. In north-western and deltaic districts. In the rainfed black soil areas in Southern Tamil Nadu tree legumes like *Leucaena leucocephala* (Subabul), *Acacia senegal* (Gum Arabic tree), *Prosophis cineraria* (Khejri) and perennial fodder grass with inclusion of six goats yielded an additional income of Rs 12,500 per year from a farm area of 1.6 ha. Reports state that for farm households, the average net income is shared between crops and livestock in the ratio of about 3:1.

Livestock keeping was more suited to small land holders to fetch additional income to the farm family. Reports show that, there was an increase in the return to the tune of 148% due to the introduction of poultry cum dairy based integrated farming systems over cropping alone.

Employment generation

Gainful employment is one of the major considerations for evolving any farming system. IFS under dryland with sorghum + cowpea, *Leucaena leucocephala* + *Cenchrus ciliaris* (Anjan grass), *Acacia senegal* + grasses with goat rearing generated an additional employment I of 113 mandays/ha annually in a farm size of 1 ha. Maintenance of four milch cows with cropping could generate an additional employment of 274 man days as against cropping alone in Thanjavur delta in Tamil Nadu. Integration of crop - dairy - biogas - silviculture I - spawn production could generate an additional employment of 562 mandays than cropping alone under lift irrigated garden lands. Integration of duck cum fish culture and dairying could generate 396 and 702 mandays, respectively, as against 252 man days with rice based cropping alone in Cauvery delta region of I Tamil Nadu. Cropping with poultry + fish + mushroom' generated the highest employment of 798 mandays. The allied enterprises added employment to the tune of 423 mandays providing opportunity for 1.16 family members to be employed per day round the year.

IFS study at Bhubaneshwar for a period of two years comprising of field and horticultural crops, fishery, poultry, duckery, apiary, mushroom, dairy and agro-forestry generated an additional employment of 573 man days on a small piece of land of 1.25 ha. At Kasargode, one hectare of coconut

gardening required 150 man days and it increased to 1000 man days on introduction of dairy based integrated farming. Cropping alone generated 400 mandays as against 904 in integrated farming systems with six buffalo. Cattle and buffalo rearing involved intensive use of family labour and offered significant employment opportunity for small and marginal farmers. A herd of 200 goats under integrated farming systems provIded full time employment for two persons throughout the year. Labour utilization was found to increase by 182% in integrated farming systems by the introduction of 270 poultry birds in a crop cum poultry enterprise. Cropping alone generated I 245 man days and integrated farming systems with sericulture in one hectare generated 598 man days in a year.

Nutrient recycling

Replenishment of soil fertility status through substantial improvement in the post harvest available NPK nutrients could be achieved even with higher removal of nutrients through crop uptake by the application of recycled or composted pigeon and poultry manure combined with inorganic fertilizer. Application of 50% nitrogen through fertilizer and 50% through goat manure enhanced the soil fertility status and provided better opportunity for recycling of manure to the crops. Continuous dairy based- farming system increases organic carbon and available status of nutrients.

Alternate land use options

IFS provides alternate land use systems which are more appropriate in areas where subsistence farming is practiced in fragile ecosystems and it possess more potentiality and flexibility in land use than the traditional crop production systems.

Agrisilvicultural system – lesser risk

Agro-forestry is an integrated self sustained land management system, which involves woody perennials with agricultural crops including pasture/livestock simultaneously or sequentially on the same unit of land and meeting ecological as well as socio economic needs of the people. Due to low initial cost and ensured seasonal income through inter cropping and supply of different kinds of raw materials to support cottage industries, tree farming could certainly offset the risky farmering especially under dryland conditions.

Agri-horticultural system – higher income

Fruit-based cropping systems are not only known for their economic viability but also generate employment and give assurance against crop failure during drought years. Maize, sorghum and cowpea are compatible

with trees like *Psisdium gujava, Eugenia jamolana* and *Annona squamosa.* Under rainfed conditions in alfisol, agrihorticulture systems give the highest benefit cost ratio compared to annual cropping.

Silvi/hortipastural system - improved) sustainability

Horticulture is one of the agroforestry systems which involve integration of fruit trees with pasture. *Cenchrus ciliaris* and *Cenchrus glaucus* are grasses and *Prosopis cineraria* and *Acacia senegal* are the trees suited for the system. *Stylo* and *Cenchrus* are compatible fodder crops with guava, custard apple and mango. In Southern zone of Tamil Nadu, the gross income and B : C ratio obtained from sorghum + tamarind, sorghum + neem, blackgram + neem, blackgram + tamarind were found sustainable.

IFS - solution to energy and fodder crisis

Solve energy crisis : It is expected that the entire world is going to suffer for want of fossil fuel from 2030 AD. So it becomes inevitable to identify an alternative source to solve our energy crisis within a span of 3 to 4 decades. In IFS, by way of effective recycling techniques the organic wastes available in the system can be utilized to generate biogas. Though this may not be a source for complete supplementation, to certain extent of the energy crisis can be solved.

Solve fodder crisis : In IFS, each and every piece of land area is effectively utilized. Growing of perennial fodder trees in the borders and water courses only helps in supplementing legume fodder but also enriches soil nutrients by fixing the atmospheric nitrogen. In the cropped land, IFS envisages intensification of cropping by including legume fodder like cowpea either as second tier or as third tier in the system. These practices relieve the crisis of non-availability of quality fodder to the animal component linked.

Solve fuel and timber crisis : The national demand of fuel wood in 2020 AD is 400 million m^3, whereas the current production is only 20 million m^3. Similarly, the requirement of industrial wood in 2020 AD is 64.4 million m^3 and the current production level is just 11 million m^3. The present level of production should be increased to twenty folds in case of fuel wood and six folds in industrial wood. This could be possible to certain extent by afforestation programme in the shrub jungles and sparse forest areas. In IFS by linking agro-forestry appropriately, the production level of fuel wood and industrial wood can be enhanced without detrimental effect on crop activity in the field level.

Avoid degradation of forests *:* There is a vast gap between the demand and production level as far as fuel wood and timber are concerned. This naturally induces the users to encroach on the forests nearby illegally to bridge the gap. Right now our forest area is lesser (22%) than the prescribed norm of 33 per

cent, to the geographical area. Even the forest area at present has more than 2/3rd sparse vegetation. By linking Agro-forestry in IFS, the degrading of forest area could be minimized to certain extent by supplementation of fuel and timber wood.

Land Reclamation and Integrated Farming System

It is estimated that about seven million hectare of land in this country is affected by varying degrees of soil salinity and sodicity. Such problematic soils are inhibiting agricultural production in the affected areas. The farmers, generally unaware of the magnitude of the problem, continue to grow crops without soil reclamation measures and harvest very poor crop yields. In the spread of Saline Sodic Soils West Bengal ranks third, after UP and Gujarat, having an area of 0.85 million hectare of salt affected soil distributed mainly in 24-Parganas and Midnapore districts. Sundarbans areas of 24 Parganas district alone constitute about 94 per cent salt affected area of the State.

Constraints

There are certain constraints like heavy investment in the initial stage, especially for the procurement of enterprises, involvement of multi-disciplinary activities likes animal husbandry, fishery, sericulture, horticulture, forestry, agricultural engineering etc, non-availability of improved cultivars/varieties/ breeds of livestock at farm site, lack of know-how especially on the constituents of feed and the possibility of supplementing from their own produces with cheaper rate and lack of marketing for the produces from different enterprises at village level are anticipated in the progress of this technology.

Conclusion

Farming system models at different situations could enhance the productivity of the farm as whole, improve the profitability in terms of additional net return and continuous flow of income to the farmer and sustain the soil health through residue addition and improve the major and micro nutrient supply effective recycling of crop residues and livestock waste results in environmentally safe disposal. The enterprise linkage provides good opportunity for regular and gainful on-farm employment for farm family members with equi-temporal distribution. This also helps for nutrition security through optimized carbohydrate, protein, fat and energy supply by integrating allied enterprises (Jayanthi and Vennila, 2008).

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