

Integrated farming system for productivity and sustainability in agricultural production

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With 16.8% of the world's population and less than 2.4% of world's arable land, India is confronted with several challenges in agricultural development. Food security, employment, income generation, resource conservation and environmental protection have emerged as major world concerns. Within the sustainable agriculture framework, Integrated Farming System (IFS) is one approach towards transforming the idea of sustainable development from concept to reality. Integrated farming system can ensure the highest standard of food production with the minimum environmental impact and thereby, improving the the quality of life of farmers. More importantly, IFS helps to maintain sustainability in farm production and productivity even under highly vulnerable climatic conditions with the available resources accessible to the farmer. The goal of attaining social equity and inclusive growth can't be achieved without providing livelihood and nutritional security to the most vulnerable sections of the indian population which consist of mostly scheduled tribes and castes. The population of tribal farmers is high in the central tribal belt in the middle part of the country which includes southern Rajasthan, Madhya Pradesh, North eastern Gujarat, Vidarbha region of Maharashtra and Chhattisgarh.

Keywords: Employment, Food security, Resource conservation, Resource saving, Sustainable development goals

IN India, the growth rate of Agriculture in the recent past is very slow in spite of the rapid economic growth. The country's population is expected to reach 1660 million in the year 2050 for which 349 million tonnes of food grains will be required. It is anticipated that the land area available in 2050 would be around 137 million hectares. To meet this requirement there is a need to double the productivity of agricultural crops from the existing level of productivity. The current scenario in the country indicates that the area under cultivation may further dwindle and more than 20% of the current cultivable area will be converted for non-agricultural purposes by 2030. Because of the declining per capita availability of land in India, there is hardly any scope for horizontal expansion of land for food production. Only vertical expansion is possible by integrating appropriate farming

components that require lesser space and time to ensure periodic income to the farmer. Integrated farming systems, therefore, assumes greater importance for sound management of farm resources to enhance the farm productivity and reduce the environmental degradation, improve the quality of life of resource-poor farmers and maintain sustainability. To sustain a positive growth rate in agriculture, a holistic approach is the need of hour. This approach can be transformed into a farming system that integrates crops with enterprises such as-agroforestry, horticulture, animal (cow, sheep and goat) rearing, fishery, poultry, pigeon rearing, mushroom production, sericulture, and biogas production-for increasing the income and improving the standard of living of small and marginal farmers. The challenge of such an integrated farming system (IFS) is to upgrade

technological and social disciplines continuously and integrate these disciplines to suit the region and the farm families in a manner that will ensure increased production with stability, ecological sustainability and equitability.

An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high production levels, while minimizing the negative effects of intensive farming and preserving the environment. Based on the principle of enhancing natural biological processes above and below the ground, the integrated system represents a winning combination that

- Reduces erosion;
- Increases crop yield, soil biological activity and nutrient recycling;
- Intensifies land use, improving profits; and

- Can therefore help reduce poverty and malnutrition and strengthen environmental sustainability.

IFS for sustainable productivity

In recent years, food security, livelihood security, water security as well as natural resources conservation and environment protection have emerged as major issues worldwide. Developing countries around the world are promoting sustainable development through sustainable agricultural practices which would help them in addressing socioeconomic as well as environmental issues simultaneously. Within the broad concept of sustainable agriculture IFS holds special position as in this system nothing is wasted, the byproduct of one system becomes the input for another. Integrated farming system are often less risky, if managed efficiently (Table 1).

Possible output of Integrated Farming System

Since Integrated Farming System (IFS) is an interrelated complex matrix of soil, water, plant, animal, environment and their interaction with each other enabling the system to be more viable and profitable over the arable farming system. It leads to produce the quality food. 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 of their inclusion in the existing system. Similarly inclusion of bee-

keeping, fisheries, sericulture, mushroom cultivation on account of space conservation also provides additional high-energy food without affecting the production of food grains. The integration of these enterprises will certainly help the production, consumption and decomposition in a realistic manner of an ecosystem.

Productivity enhancement by IFS

Considering serious limitations of horizontal expansion of land for agriculture, the only alternative left is vertical expansion through various farm enterprises requiring less space and time but giving high productivity and ensuring periodic income especially for the small and marginal farmers.

In a study conducted at ICAR Research Complex, Goa, it was revealed that with the integration of mushroom and poultry production (based on the resources availability within the system) in rice-brinjal crop rotation the system productivity was increased to 21,487 kg/ha especially with rice-brinjal rotation leading to an additional returns of ₹30,865/ha. In addition, the system approach was found to be sustainable as reflected from the changes in soil organic carbon and indicated by the sustainability yield index. In Tamil Nadu, the IFS increased the net return on an average of ₹31,807/ha/year over the arable farming (₹19,505/ha/year). While in Goa, when coconut was integrated with the crops, vegetables, mushroom, poultry and dairy enabled to

enhance ₹17,518/ha/annum over the cashew cultivation alone. In Madhya Pradesh, the integrated farming gave a margin in net return of ₹17,198/ha/year over the arable farming. In Uttar Pradesh, the average enhancement in return was ₹45,736/ha/annum over the existing crop-based farming system.

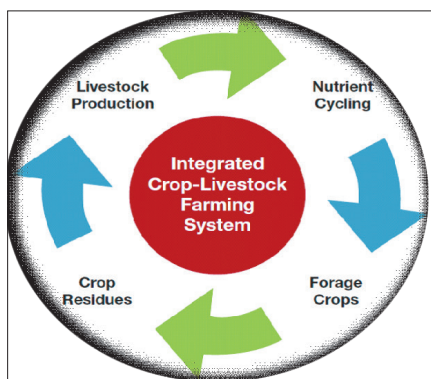
Monoculture systems rely mainly on external inputs while in an integrated system, recycling of nutrients takes place that help in reducing the cost of production for economic yield. The fish in the rice field utilizes the untapped aquatic productivity of the rice ecosystem. The rice bottom is highly fertilized on account of the production of zoo and phytoplankton and these resources are fully utilized by the fish. The gross income obtained in rice + *Azolla* + fish was 25.7% more, over the rice crop and 6.9% more, over the rice + fish. Thus rice + *Azolla* + fish on an average gave ₹8,817/ha more return over the rice monoculture and ₹3,219/ha over the rice + fish.

Integrated crop-livestock farming system

In an integrated crop-livestock farming system the waste of one enterprise becomes the input of another for making better use of resources. For example, crop residues can be used for animal feed, while manure from livestock can enhance agricultural productivity by intensifying nutrients that improve soil fertility as well as reducing the use of chemical fertilizers.

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

State	Prevailing system	Net return (₹)	Integrated Farming System	Net return (₹)
Tamil Nadu	Rice-rice	15,299	Rice-rice- <i>Azolla</i> / <i>Calotropis</i> + Fish	17,488
	Cropping alone	36,190	Cropping+fish+poultry	97,731
			Cropping+fish+pigeon	98,778
			Cropping+fish+goat	13,1118
Goa	Cashew	36,330	Coconut+forage +dairy	32,335
			Rice-brinjal (0.5 ha) + Rice-cowpea (0.5 ha)+mushroom +poultry	75,360
Madhya Pradesh	Arable farming	24,093	Mixed farming + 2 cow	37,668
			Dairy (2 cows) +15 goats +10 poultry+10 duck+fish	44,913
Uttar Pradesh	Sugarcane-wheat	41,017	Crops (Sugarcane+wheat)+dairy	47,737
Karnataka	rice – rice system	21599	Rice-fish (pit at the center of the field) – poultry (reared separately)	62, 977
			Rice-fish (pit at one side of the field) – poultry (shed on fish pit)	49, 303

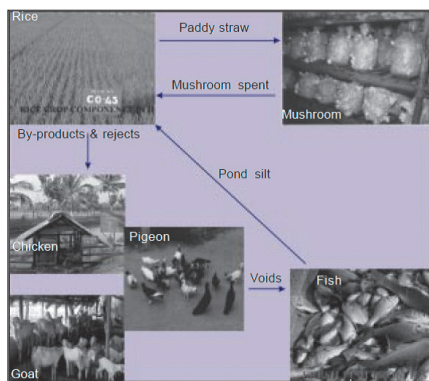


Integrated crop-livestock farming system – key aspects (integrated farming includes combined growth of the crop, livestock, poultry, fish, tree crops, plantation crops or other systems)

Integrated Farming System under irrigated condition

The biggest edge such farming systems have on other types of farming systems is the abundance of water available for crop growth. This makes it possible for the cultivators to expect a decent harvest, thus earning a reasonable income from cropping enterprises. But if other enterprises were taken along with crop husbandry in properly selected combinations, it would increase the productivity of the farm many folds and thus would virtually change the economic scenario of the place. In low-land rice areas there is considerable scope for growing fish along with rice. They observed that the inoculation of *Azolla* with rice + fish farming system enhanced the income and the nutrient uptake of low-land rice.

Crop + Goat + Fish integration was tried in Tamil Nadu by allocating 0.32 ha, 0.04 ha and 0.04 ha for crop, fodder and fishpond, respectively. Inclusion of one unit of goat (20 females + 1 male) could enhance the net income by ₹36,000 per year and productivity of ₹98 per day. The goat unit would provide 11 tonnes of valuable manure apart from supplementing the feed requirement of fish (400 fingerlings). It also helped in generating employment opportunities for the family labour to the tune of 182.5 workdays per year, distributed uniformly over the year. About 10 kg of rice straw or crop wastes could be effectively utilized as substrate for producing 5 kg of edible mushroom per day. The cost



Component integration and resource recycling in lowland ecosystem

of production per kg of mushroom in IFS was ₹12 as compared with a commercial venture where the production cost is ₹20. Thus, at an annual production of 1,460 kg of edible mushroom, IFS offers an additional net income of ₹11,680. It also helps in supplementing the crop activity with high-value organic manure (mushroom spent compost) up to 3 tonnes. Employment opportunities were enhanced at the rate of 1/2 workday per day, or 182 workdays per year, to the family of the labour. Recycling the no-cost/low-cost material of one enterprise as input to another enterprise helps reduce the unit cost of production of output.

Integrated Farming System in dry land

The selection of enterprises must be based on the cardinal principle of minimizing the competition and maximizing the complementarity between the enterprises. In Uttar Pradesh, it was observed that crop + dairy + goat farming followed by crop + goat farming had the maximum potential. Integration of dairy + biogas + silviculture for garden land condition and cropping + goat under rainfed situation were the best model for the western zone of Tamil Nadu. Through IFS, there is a possibility of raising small breeds of livestock and poultry in rainfed uplands of eastern India where cereal and grain legume crop formed an integral part of the farming system.

Pond-Based IFS

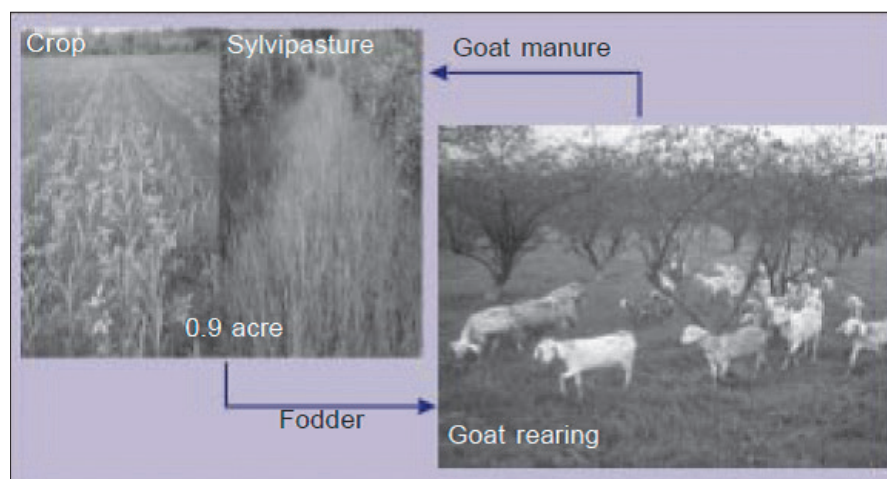
Pond-based farming is beneficial in increasing farm income, creating

employment opportunities and improving soil health. The system is useful in minimizing risk, encouraging biodiversity and improving the ecosystem as a whole. Farmers can get fresh, nutritious and balanced food for a healthy lifestyle. Promotion of a large number of such systems may act as a series of miniature water and nutrient harvesting structures for harvesting the costly plant nutrients, organic matter, soil and water, which would otherwise be dumped into the sea. For efficient use of pond water, paired row bed planting of okra and mulching of water melon and bottle gourd with decomposed paddy straw were found effective. Integration of cropping in 0.90 ha with fishery in 0.10 ha, 50 layers of poultry and 5 kg oyster mushroom production per day would result in a higher net return of ₹35,000/ha/year. Integration of Rice-Gingelly-Maize and Rice-Soybean-Sunflower in 0.90 ha with 0.10 ha polyculture fish rearing, 100 pairs of pigeon and 5 kg mushroom production per day could result in a higher return of ₹88,700 in 1 ha farming with additional employment of 300 man days/year. The highest net return of ₹1,31,118 could be possible by the integration of goat (20 female + one male), fish (400 numbers of polyculture), along with improved cropping system for wetlands.

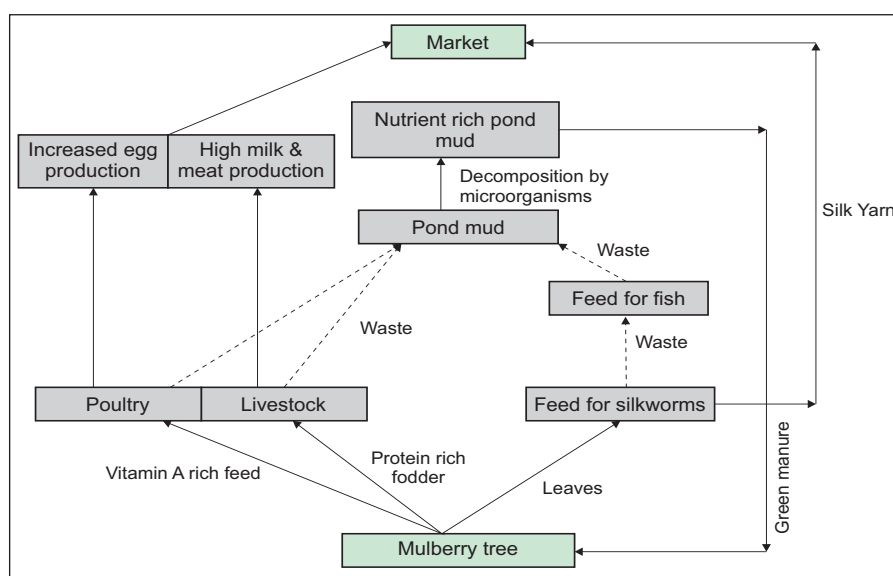
Dyke-Pond systems

In many parts of Asia, the productive use of land and water resources has been integrated by transforming wetlands into ponds separated by cultivable ridges. Thus aquaculture and water management act as an engine driving the sustainability of the entire farming system.

The dyke-pond system serves two major functions: (a) achievement of a general ecosystem balance through the harmonization of well-coordinated activities and functions embedded in the ecosystem, and (b) transformation and regeneration of organic substances based on a multi-layer trophic eco-system structure, which helps contribute successfully to sustainable economic



Resource recycling in rainfed land through crop, sylvi-pasture and goat rearing



Mulberry Dyke-Pond System

development. The system contains two interrelated systems of dyke and pond; the dyke is the land ecosystem for the growth of crops whereas the pond is the water ecosystem, consisting of fish and aquatic plants. The dyke-pond system can be of various kinds depending on the crops planted on the dyke such as mulberry dyke-fishpond, sugar cane dyke-fishpond, banana dyke-fishpond, and so on. The input and output of material and energy in the dyke-pond system are basically balanced.

In this system, the mulberry tree represents the first trophic level. Photosynthesis takes place

in its leaves, which are fed to the silkworms for yarn production (the primary consumers) whose excreta and chrysalises are in turn fed to fish (the secondary consumers). The aquatic organisms in the pond are the reduction agents that decompose fish excreta and algae, break down the organic matter in the pond, and produce nitrogen, phosphorus, and potassium. The pond supplies the dyke with the fertile mud, which after decomposition is used as a primary source of fertilizer for the mulberry trees. Mulberry leaves can also be used in the poultry ration. Incorporation of shade dried mulberry leaves in layer's mash to

the extent of 6% showed an increase in egg production with desirable yolk colour without any adverse effect on body weight and egg quality. Mulberry leaves, owing to their high carotene content, could be form a valuable source of vitamin A for the health of poultry birds and increased egg production.

Empowerment of women through IFS

Women plays an important role in household management including the agricultural operations. This is especially true for hilly and tribal areas. There is a vast scope to improve the household profitability by judiciously utilizing family labour using innovative practices and ensuring multiple uses of various household resources. This is possible through women's empowerment through location specific trainings and critical need based support. With the improvement in educational status in the years to come, the role of women in agriculture and management of household resources will be increasingly important.

SUMMARY

Due to population explosion, the income from cropping alone in small and marginal farm is hardly sufficient to sustain a farmer's family. Also, farmers need regular income for decent living. Hence, the unitary concept of crop, fish or animal husbandry is gradually changing to the integrated system with the view of producing fish, meat, egg, milk, vegetables and other allied products within farm. With global warming and climate change, a further change in frequency, intensity and amount of rainfall is expected and thus, utility of these miniature structures may assume greater importance in future, especially in tropical climatic regions.

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