Status of Agricultural Development in Eastern India
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CHAPTER 3.6

Integrated Farming System for Improving Agricultural Productivity

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CONTENTS

Introduction

An agricultural system is synthetic (man-made) system, embedded in the natural and social systems. It is defined as "an assemblage of components which are united by some form of interaction and interdependence" (Mc Connel and Dillon, 1997). There is consensus that agricultural research must move beyond the boundaries of disciplines, commodities, experimental farms and laboratories, and embrace system perspective (ICAR, 2000). However, despite nearly 30 years of rhetoric, not much headway has been made. Confusion about the concept, apprehension regarding rigor and scientific validity, as well as organizational and operational rigidities perpetuates a status quo. An attempt is being made to introduce the concept of an agricultural and farming system, narrate the Indian experience in this context, and offer some ideas on how to integrate the farming system perspective in the national research system.

Farming System research is an approach to agricultural research and development that view the whole farm as a system and focus on 1) the interdependencies between the components under the control of members of the household and 2) how these components interact with each other in respect of physical, biological and socioeconomic factors not under the household's control (Shaner *et al.*, 1982). Indian economy is predominantly rural and agriculture oriented where the marginal and small farmers constitute 76.2% of farming community. Due to failure of monsoon, the farmers are forced to judicious mix up of agricultural enterprises like dairy, poultry, pigeon, fishery, sericulture, apiculture etc., suited to their agro-climatic and socio-economic condition.

Farming System Research Experiences in Indian Context

Integrated fish farming

Integrated fish farming systems utilize the organic waste of live stock, poultry and agriculture by-products for fish production. The organic waste to the tune of 40-50 kg is converted into one kg of fish. The pond silt becomes rich in nutrient due to ongoing fish culture and this is utilized as fertilizer for fodder crops for raising livestock and poultry or as fish feed. In fish-cum sericulture system, pupae are used as fish feed, while worm faeces and wastewater from silk extraction processing plants are used as pond fertilizers. Thus a complete recycling of waste is achieved in these systems. The opportunities in this system are, considerably wide. Ducks and geese are raised in ponds. Pond dykes are used for horticulture and agricultural crops and animal raising. In addition to fish, the system provides meat, milk, eggs, fruits, vegetables, mushroom, fodder, grains etc. This system utilizes water body, water surface, land and pond silt to increase food production for human consumption. Thus this system holds great promise and potential for augmenting production, betterment of rural economy/household nutrition security and employment generation. In India, this has a special significance, as it can play an important role in improving the socio-economic status of a sizeable section of weaker rural community, especially the tribal.

Horticulture-fish system

Fruits and vegetables are rich in nutritive values and contain carbohydrates, fats, proteins, vitamins, minerals etc. An average American consumes 250 g of fruits and 500 g of vegetables, where as 150 g fruits and 350 g vegetables, is needed by an average Japanese. In India, per capita consumption of fruits and vegetables is 47 g and 142 g per day as against the recommendation of Indian Council of Medical Research which is 85 g and 300 g, respectively.

In India, it is a booming industry for lose and cut flowers. Horticulture as well as its related industries is excellent avenues for employment generation and as a whole by earning foreign exchange. These crops can be increased by bringing more area under cultivation. Ponds are well suited for this purpose. The top, inner and outer dykes of ponds as well as adjoining areas can be best utilized for horticulture crops. These crops are fertilized by pond silt and fertile pond water is used for watering. The success of the system depends on the selection of plants. Ideal management involves utilization to the middle portion of the dyke covering about 2/3 of the total area for intensive vegetable cultivation and the rest of the area along the length of the periphery for fruit bearing plants. Semi intensive farming is done where the dykes are not good. Such system provides large quantities of leaves of cauliflower, cabbage, turnip, radish at the farm site which is fed to the fishes as feed. Grass carp is one of the ideal fish for this purpose. A mono culture of grass carps with stocking density of 1000 ha^{-1} will give a production of 2 t ha^{-1} yr^{-1}. The system, though labour intensive, generates 30% returns to investments annually which is quite high.

Duck-fish integration

This system utilizes the mutually beneficial biological relationship between fish and duck. Asia is considered to be the land of domesticated ducks, but the best breeds and strains currently available have been developed for their excellent egg and meat production in Europe and America, through systematic breeding, feeding, management and disease control. In West, duck meat is considered to be a delicacy. Duck eggs are an important source of food in eastern India. These are cheap to produce and can play an important role in balancing the diet of the India people. Consumption as well as production of duck eggs in India is mostly done by the socially weaker sections of the community. Ducks are of several types such as of the egg type, meat type and the ornamental type. Khaki Campbell, a prolific layer with an annual average production of 310 eggs, is recommended for duck-fish integration.

A fish pond being a semi-closed biological system with several aquatic animals and plants which provide an excellent disease free environment for ducks. In turn ducks consume juvenile frogs, tadpoles, dragonfly etc. Thus, makes a safe environment for fishes. Duck droppings find their way into the pond and decompose. This process provides essential nutrients such as carbon, nitrogen and phosphorus for production of natural fish feed organism. Duck cum fish integration has two advantages: First of all there is no loss in the availability of manure and secondly fertilization of the pond is homogenous. Ducks also aerate the pond water along with bottom raking effects. About 500 nos. of ducks can take care of fertilization schedule of 1 ha water body. This saves the cost involved for fertilization and in addition to fish it provides eggs, meat for human consumption.

Poultry-fish integration

An economically viable, simple and well tested poultry-fish integration utilizes poultry droppings of fully built-up poultry litter recycled into fish ponds with fish production levels of 4.5-5.0 t fish ha^{-1}. Broiler production provides immediate returns to the farmers. It is essential to study the market demand of the products which will be available for sale, before taking up the venture. Success of the system depends mainly on the efficiency of farmers, his experience, aptitude and ability in the management of the flock. This involves procurement of good live stock, housing, feeders water trays and management practices, which also include prevention and control of diseases.

The left over animal feeds and excreta is utilized to enhance the biological productivity of water. The poultry litter is applied to the pond in daily doses and is deferred on the days when algal bloom appears in the pond. One adult chicken produces about 25 kg of compost (poultry manure) in one year, 1000 birds would provide "sufficient litter for fertilization of 1 ha water body.

Cattle-fish integration

Fish farming using cow manure is well established practice, It is most abundant one in terms of availability. A cow of about 400 kg body weight excretes about 8 t of dung and about 5000 liters of urine annually. Cow manure particles sink at the rate of 2-6 cm min^{-1} as against 4.3 cm min^{-1} in the case of pig manure. This provides enough time for the fish to consume the edible portion available in the dung. The BOD of cow manure is comparatively lower than that of other live stock manures as it is partly decomposed by micro-organism in the rumen. The fasces and urine are extremely beneficial for filterfeeding and omnivorous fishes such as silver carp, catla etc. A unit of 5-6 cows can provide sufficient input for 1 ha water body. These types of system not only provide fish to the farmer but on daily basis he gets milk which increases revenue for his household security and also reduces working capital. Cow sheds should be built in the vicinity of the fish ponds to simplify the handling of the cow manure.

Goat-fish integration

Goat farming is an age-old practice but its integration with fish farming has not been explored. The solid excreta of goats are several times richer in nitrogen content and phosphoric acid than the excreta of other animals. Goat urine is equally rich in both nitrogen and potash. Goat droppings have the advantage of direct application into grow-out fish ponds as the size of droppings is of around 6-7 mm pellet, coated with mucus and floats in semi dried state. The droppings have been observed to be consumed by the fish. Goats can be kept under a house constructed on the elevated portion of the dyke for facilitating the waste disposal into the ponds.

Rabbit-fish integration

Recently rabbit was considered as a pet animal but it is emerging as an alternate meat source for health conscious meat consumers as it contains low fat in comparison to chicken, mutton, beef and pork. Further among the animals, rabbit has the highest reproduction rate and is comparable to broiler chicken with regard to growth. Approximately 60 individual breeds and varieties of rabbits are popular all over the world viz., Soviet Chinchilla, Grey Giant, White Giant, Newzealand White, Russian Angora, German Angora, etc. It can be reared in three ways: 1. Cage system, 2. Hutch system, 3. Floor system.

The manurial potentials of rabbit excreta were evaluated through studies on its composition and effects on hydro biological conditions, in comparison with the traditional organic manure, cow dung. The high nitrogenous rabbit excreta (10 times higher than that of cow dung) was found to be releasing nutrients gradually, sustaining high plankton production over a long period of time. It is evident from the above fact that rabbit excreta, low in moisture and high in nitrogen content, is quality manure for sustained plankton production and hence rabbitary can be efficiently integrated with fish farming.

Rice-Fish Farming System

Rice-fish integration

The practice of incorporation of fish in rice fields was introduced in the south-east Asian countries from India about 1500 years ago. Planned rice-fish system ensures higher productivity, farm income and employment in these areas. Rice fish system needs modification of rice-fish plot, digging of peripheral trench, construction of dykes, pond refuge, sowing of improved varieties of rice like Panidhan, Tulsi, CR 260-77, manuring, stocking of fish at the rate of 10,000 ha^{-1} and finally feeding of stocked fish with rice bran and oil cakes @ 2-3% of the body weight, etc. Harvesting is done when fish attains table size. Vegetables, fruits, ground nut etc. can be grown on follow land for additional production. Such system provides a net annual income of about ₹ 35,000 ha^{-1} yr^{-1}, which is much higher compared to traditional practice. This facilitates crop diversification, thereby reducing investment risk and also generating year round employment in the farm.

In rice-fish farming, primary producers and consumers (phytoplankton, bacteria and zoo-plankton) at different tropic levels compete with rice for material and energy, decrease over all productivity. However, fish culture in paddy fields can convert and recycle the available material and energy into fish production, accelerate the productivity and rice equivalent yield of the system. Further, it would also enhance the use of land and water without bringing about environmental degradation. In addition to enhanced productivity, this system could further generate employment opportunity, increase income of farmers and provide a better nutritional security.

The eastern region of the country is blessed with plenty of rainfall, most of which occurs during June to September. Rice is, therefore, the predominant crop of this region during monsoon. During this period, about 50% of the annual rainfall comes from few intense storms. To increase the productivity from unit volume of water and unit area of land, conservation of rain water both in- situ and ex-situ and integration of fish/prawn culture is found to be a viable, low input based and easily adaptable technology for small and medium farmers. This technology is most suitable for irrigated rice ecosystem of Bhubaneshwar. In the system, a height of 12.5 cm and refuge area of 9% of rice field resulted in highest return (4.22 to 4.55 t ha^{-1} REY) without using any pesticide. Stocking density of fish and prawn @ 25,000 ha^{-1} is recommended for this short duration (about 120 days) fry to fingerling stage of rearing. Rice-fish integration not only helps to compensate the economic loss in rice production brought about by natural calamities but also enhances the land and water productivity without bringing about environmental degradation. The system could generate employment opportunity, increase income for farmers and provide nutritional security (Mohanty and Mishra, 2003).

Rice-fish system can be conceptualized by: 1) creation of micro watershed-cum-fish refuge in 10-20% area for effective land use, 2) raising of strong and wide dykes all around using up to 20% of area that will protect the micro environment and accommodate integration of different components like vegetables, fruit crops, birds, livestock, agro-forestry, mushroom, floriculture, apiculture etc. 3) ultimately aiming at an environment that promotes synergism between components resulting waste recycling among one another leading to higher and sustainable farm produce, income and employment without degrading the ecosystem (Sinhababu, 2003).

Rice-fish farming is practiced by the farmers mostly in rainfed and some irrigated areas mainly in Midnapore and 24 Parganas districts of West Bengal by improved methods. In this case the farmers deepen the pond refuge up to 10 to 12 ft and widen the bunds to accommodate vegetables, fruits crops (banana, papaya), betel vines, besides eucalyptus. Farmers grow two crops of high yielding rice; kharif rice Jaya cross is grown and is harvested during middle of October in 2-3 ft of standing water. Then the standing water in the field is pumped out and collected in the pond in the field or adjacent ponds. Boro rice (IET 4786) is seeded in sprouted condition or planted in December and grown with lift irrigation from the collected rainwater in which fish is also grown. Farmers raise some vegetables on the bunds and creepers on platforms over pond. Ducks are also integrated in this system (Sinhababu, 2003).

At Cuttak, the CRRI design (pond refuge connected with two side trenches), rice cv. Gaytari, Tulsi, CR-1014, Durllav are cultivated with grain yield 3.5-4.5 t ha^{-1}. Among fish Catla, rohu, mrigal, silver carp species and freshwater prawn (*M. rosenbergii*) are grown. On the bunds coconut, banana, vegetables, black gram are grown besides and agro-forestry plants (eucalyptus, acacia). The net income is ₹ 60,000- 70,000 ha^{-1} (Sinhababu and Venkateswarlu, 1998).

In Maharajganj district of Uttar Pradesh, farmers are having a fish farm with a hatchery and rice-fish with the area of 1.2-3.6 acres. Design of the pond refuge and also all around trenches type. Rice-fish seed (fingerlings) is mainly practiced in irrigated and shallow lowlands. The rice varieties are Shambha, Masuri, Basmati, Hybrid (PA 6201) with the yield performance of around 22 q/acre. The fish spp. are catla, rohu, mrigal and common carp and the productivity is up to 300 kg ha^{-1} $season^{-1}$ with income of ₹ 30,000. Fish farming can also be integrated with sugarcane. On the bunds pigeon pea, teak, and siso trees are also grown.

In Kamrup district of Assam, farming system is practiced by small farmers with an farm area of 0.5-1 acre. Design of one pond refuge covering 20% area and rice field of 50% area and rest for all around bunds and uplands adjacent to the farm. Farm has tube well irrigation facilities. The major component of the farming system in this case is rice, fish, goat, vegetables, fruit crop (banana), bamboo, gamar. Income is around ₹ 20,000/ $acre^{-1}$ yr^{-1} (Sinhababu, 2003). In Assam on-farm farming system research programme is in operation since 1999- 2000.

The Eastern India Rainfed Rice Project, which is supported by the Ford Foundation, has concentrated its efforts on: i) Crop and varietal identification, their agronomic management , mixed and sequential cropping practices have been initiated for the upland ecosystems; ii) Varietal identification for tolerance to submergence and intermittent drought, their suitable agronomic requirements and opportunity for sequential cropping form part of the research agenda for lowland and deep water situations. Deep water rice areas provided opportunities for aquaculture with common carp and fresh water prawn when supplemented with fish feed. Vegetable farming on dykes of the deep water areas was instrumental in augmenting the income of the rice farmers (Biswas, 1990). The conventional transfer of technology model of component technology testing on farmers' fields dominates their on farm testing process.

Adoption of different integrated farming system models in varied farming situations of the country enabled to enhance total production (REY) ranging from 9.19% in Eastern Himalayan Region to as high as 366% in Western plains and Ghat Region when compared to prevailing farming systems of the region. Even a simple intervention of replacing traditional breed of milch animal by cross bred cows and buffaloes in Gujrat plain and Hill Region and changing pattern of cultivation of fish and rice in Western plain and Ghat Region brought about a radical change in productivity. The strength of Eastern region lies in its livestock population. The population of the livestock in all the seven states of Eastern region is high, however, the productivity is low, much below the national average. Standardized technologies developed by ICAR such as crossbreeding, improving feed quality, animal health coverage, enhancing meat and egg production can easily double the productivity and production of animal products (DG, ICAR,2005).

Rice+fish+goat/buffalo/bullock

A diagnostic survey made in the North Eastern Plain Zone of Uttar Pradesh by Singh *et al.* (2004) revealed that the average size of the land holding is small in this region as over 83.3% of farmers in Varanasi and 55.6% of farmers in Chandauli district own majority of farmers in this region. Rice and wheat are the predominant crops in this region as 86.1% and 82.4% of the farmers are growing rice and wheat respectively, followed by pulses, oil seeds and vegetables. Fertilizer use in this region is unbalanced, as only 33.3% of the farmers of Varanasi and 22.2% farmers of Chandauli district use the recommended fertilizer dose in rice while 40.7% of the farmers of Varanasi and 22.2% of Chandauli are only adopting the recommended fertilizer dose. Cattle's rearing is more common in Varanasi district where as farmers of Chandauli districts were more interested in buffalo rearing. Only few farmers in this region on small scale practiced the rearing of goats and bullocks. Poultry rearing were adopted only by the farmers of Varanasi district and none of the farmers of Chandauli district were interested in poultry rearing. The farmer's unawareness, less diversification of enterprise and small size of land holding has made them unable to generate more production potential.

Agri-horti-silviculture based cropping system

Many fruit trees can also be combined with arable crops i.e. agri-horticulture in order to reduce the gestation period and use the soil and rain fall more efficiently. This system has the highest potential for income enhancement. Fruit crops like ber, guava, pomegranate and amla can be grown with short duration inter planted crops like cow pea, green gram, black gram and Dolichos. The success of these systems lies in the management practices to achieve higher biomass and yield as a compatible system. A number of such systems have been identified for both Alfisol and Vertisol areas that gave a benefit-cost ratio of 3-4 folds as compared to arable crops. Both dry land agriculture and agri-horticulture are successful in relatively deeper soils and availability of protective irrigation facilities.

Silvipasture is a system where trees are grown along with the pasture, which may be a grass or a legume". This system is particularly suitable for marginal lands where arable, cropping is not remunerative. Marginal lands put under this system for 6-8 years improve soil fertility and physical characteristics due to biomass recycling- and nutrient addition. One such successful model is the growing of *Cenchrus ciliaris* and *Stylosantlies humata* as pasture species in alleys formed by planting *Leucnena leucoccphala* on contour furrows 7.5 m apart. On an average, Stylosantlies and Cenchrus yield 4.0 and 2.5 tonnes dry mass/ha/year and the tree accumulates a biomass of 12-14 t ha^{-1} after eight years. The overall cost-benefit ratio of this system works out to be 2.45 as against 1.6 for sorghum.

On the basis of research findings, Baishya *et al.,* (2004) emphasized the following : i) mushroom production with the use of paddy straw after harvest, ii) planting of som/soaglu and scientific rearing of Eri and Muga silk worm, iii) cultivation of flowers as inter crop with field crops or as mono culture, iv) scientific rearing of fish and pig together, v) inclusion of pigeon as another enterprise with very less recurring expenditure, vi) by-product utilization viz. (a) silk worm pupa (pupa cake left after extraction of oil for commercial purpose to be used as fish meal) (b) silk worm litters to be used as composting (c) use of castor seed for oil purpose.

Crop+fish+duckery/poultry based farming system

Pisciculture and duckery with crops were also practiced in Bhelura Rampur and Dosiyatola villages of Vikram block in Patna district. The fish production was found remunerative. In this case the av. net profit was ₹ 60,000 year^{-1}. Apart from increased fish yield, 20-30% higher yield and improved quality of berseem fodder was also obtained. Ducks were used mainly for better aeration in the field pond and for egg purpose. Backyard poultry and duck farming along with livestock and crops were also found profitable for small farmers (Gautam *et al.*, 2004). Some of the major projects/programmes that incorporated the FSR principles into their programme include:

The Rajendra Agricultural University (RAU) has chosen the flood-prone complex and high risk *Chaur* lands of North Bihar lying between the natural drainage courses of river systems to implement farming system research and extension related activities. Man-made interventions downstream have affected natural drainage and hydrological balance in such a way that the earlier practiced indigenous technologies have become unpredictable due to change in water regimes. For solving the production constraints of Chaur areas, the on-station research technologies were not considered appropriate as they were not developed to address the problems arising from variations in monsoon rains, flash floods and impeded drainage (Saran *et al*.,1982). Implementation of FSR related activities in the flood-prone complex and high risk chaur lands of North Bihar by the Rajendra Agricultural University (RAU) has led to the development of rice varieties suitable for shallow water, semi deep water and deep water ecosystems.

The FSR efforts by the Birsa Agricultural University (BAU) in the tribal belt of the plateau region of Chotanagpur tract of Jharkhand has assisted the scientists in the identification of rice and finger millet varieties suitable for different ecological situations such as uplands, midlands and lowlands. The facilitative role played by the linkman and link woman, who served as an effective interface between the FSR practitioners and the co-operating farmers, has been an interesting observation made in this study. Attempts at crop-livestock integration and agro forestry are in progress in the second phase (Singh, 1990).

In the FSR programme implemented by the Bidhan Chandra Krishi Vishwa Vidyalaya (BCKVV) in West Bengal to identify suitable rice varieties for the upland and lowland situations, as well as to develop rice-based farming systems, the scientists have observed the displacement of female labour by the modern technology from performing the agricultural operations to processing and supervision activities.

Alley cropping

It is an agroforestry system in which food crops are grown in alleys formed by hedgerows of trees or shrubs. During the rainy season the hedgerows are cut close to the ground to reduce the competition. The advantages of this system are (i) it provides higher total biomass per unit than arable crop alone, (ii) utilizes off season precipitation, (iii) provides green fodder during the lean season, (iv) provides additional employment opportunities during the off season, and (v) when planted along the contours on a sloppy land, acts as barrier to run off water, holds the silt, and conserves moisture (Rao *et al.,* 1991) and improves micro climate for crop growth.

Major Case Studies in Different States

1. **State: Bihar** (*Kumar et al., 2010*)
   - Agricultural growth : -20 to + 30%
   - Population BPL : 42.60%
   - Gross irrigated areas : about 50%
   - Av. Ground water exploitation : 39%
   - Water logged area : about 9.41%
   - Small and marginal farmers : about 85%
   - State's GDP from agriculture : 40%
   - Av. Size of land holdings : 0.32 to 0.5 ha
   - Av. Annual Rainfall : > 1000 mm.

Agriculture is the bedrock of Bihar's economy, employing 80% of the workforce and generating nearly 40% of GDP. Agriculture in Bihar is faced with major challenges like low productivity, regional disparities and low level of diversification of agriculture into non-food crops and commercial crops. The State requires an action-oriented policy for rejuvenating its agriculture sector. Bihar is a true example of a 'resource rich state' inhabited by 'poor people' and 'high potential low productivity' state. This poses challenge for researchers in agriculture and natural resource management to evolve new, effective strategies for delivering rural services and for implementing local institutional arrangements to improve livelihoods of the rural poor through agriculture based activities.

Land holdings in Bihar consist predominately of small and marginal farm holdings with a high degree of fragmentation. About 85% of the farmers are small and marginal but sharing only 50% of the land. The average size of the holding is 0.83 ha, with that of small and marginal farmers range from 0.32 to 0.5 ha. These tiny holdings are fragmented and scattered and land tenure system does not enable private investments for permanent improvement of land and infrastructure. With the average size of land holdings shrinking as a result of increasing fragmentation, many marginal farms are becoming economically non-viable and oriented towards subsistence. This has slowed the diversification into commercial crops from low value-added cereals that continue to dominate cropping.

Whole Bihar lies under Middle Gangetic Plains of India and Bihar has been divided into three types of sub- ecological zones:

a) North Bihar Plains
b) North-Eastern Bihar Plains, and
c) South Bihar Plains

North Bihar Plains

The most dominant cropping system of the area is Rice- maize followed by rice- wheat. High population of cattle (85-125 km^{-2}), buffalo (60-90 km^{-2}) and goat (50-150 km^{-2}) is observed. People of this region mostly depend on cattle and buffalo for milk production and draught purpose. Goat is reared mostly for meat production. High goat population in this region is due to availability of quality fodder and grazing land. Pig population in this region is also very high (15-20 km^{-2}). Productivity of most of the enterprises like crop, fish and animals is quite low. There is high input cost and lack of proper recycling of resources, which result into meager net income. This forces rural migration as postal economy through poor quality job and thus very poor livelihood. There is need to develop location specific IFS modules which could be able to fill the gap. The major possible IFS intervention could be:

Crop + Horticulture
Crop + Fish
Crop + Fish + Cattle

North Eastern Bihar plains

Currently horticultural crops account for around 4% of cropped area and show strong promise for growth in several districts. It is clear from cropping patterns that a shift towards non-food grain crops is already taking place. Litchi cultivation is one such success story where there is potential for further expansion if the right investment climate for agri-business is established. Bihar produces 70% of India's litchi crop, which is high in terms of both quality and yield per acre. In makhana cultivation Bihar has monopoly and it accounts for nearly 85 percent of production. Apart from these, the production of mangoes, pomegranates, spices and other crops show great promise.

Crop + Horticulture + Bee Keeping
Crop + Horticulture + Livestock
Crop + Fish + Livestock

The northern part of Bihar is also characterized with large number of water bodies like ponds, lakes and rivers etc. Water stagnates in these water bodies up to 6-7 months. Some water bodies are perennial in nature in which water impounds round the year. Northern Bihar is also prone to flood. These seasonal and perennial water bodies could be a boon for the north India by growing aquatic crops. Amongst the aquatic crops, Makhana is highly productive, nutrious, fully organic non-cereal food and remunerative crop grown in stagnant water. Concerted efforts are required to develop makhana based production system by integrating makhana with crop, fish and horticultural enterprises under aqua-terrestrial eco-system. The major possible Integrated farming systems of the area may be:

- Makhana + Fish
- Makhana + Trapa + Fish
- Deep water rice + Fish
- Crops + Goat
- Crop + Fish + Dairy

South Bihar Plains and Hills

The predominant cropping system of the area is rice- wheat. The average productivity of major crops are quite low than the national average like rice (2.05 t ha^{-1}), wheat (2.26 t ha^{-1}), pulses (1.02 t ha^{-1}), Potato (15.9 t ha^{-1}) and sugarcane (77.03 t ha^{-1}) while productivity of maize surpassed the national average. The soil is fertile and region has enough natural resources. There is scope to increase the productivity as well as income of the farmers by farming in integrated mode. The major possible Integrated farming systems of the area may be:

Crop+Horticulture, Crop+Fish, Crop+Dairy, Crop+Goat, Crop+Goat+Poultry
Crop+Horticulture+Fish etc.

Except these plains some hilly lands are also available under this category where rainfed agriculture is being done. Soils of these areas are red and yellow, susceptible to erosion and falls into late rite group. Soil erosion is the main problem of this area. There is a greater scope of horticultural crops by water harvesting. According to the population and geographical situation following farming system can be undertaken:

Crop+Pig
Crop+Goat/Dairy/Sheep/Rabbit
Agroforestry+Goat/Dairy
Horticulture+Pig+Poultry
Crop + Horticulture+Poultry+Apiary etc.

Keeping above points in view, ICAR Research Complex for Eastern Region, Patna has developed two Integrated Farming Systems Modules for small and marginal farmers of Eastern region for lowland and midland irrigated ecosystems. The details of the module are given as:

A) Two acre IFS module (for lowland situation)

Components:
Crop + Livestock + Fishery
Allied: Duckery / Vermicomposting / Bee keeping/ FYM
Details of land allocation are presented in Fig 1.

1) Cereal crops (50% area)
Kharif: Rice
Rabi: Wheat/Maize/Lentil/Mustard

2) Horticultural crops (Fruits + Vegetables): 12.5 % area

Vegetables
Kharif: Cucurbits/Brinjal/Okra
Summer: Brinjal/Boro/ Okra/ Bitter gourd / Cucumber etc.

Fruits
Papaya (On pond's dike and field bunds)
Banana (On pond's dike)
Lemon (On pond's dike and Horticultural block)
Guava (On pond's dike and Horticultural block)

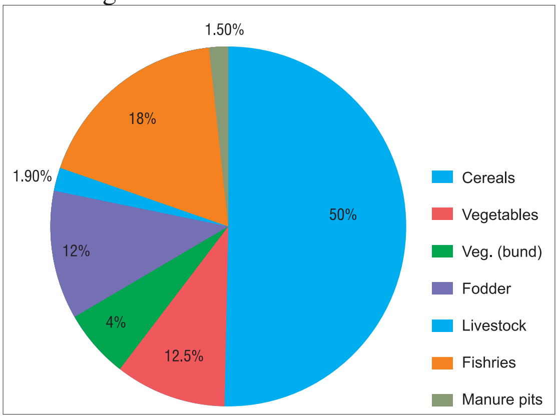

Fig 1. Land allocation to different enterprises 2 Acre IFS module

3) All around the field bunds cucurbits or seasonal vegetables having lesser water requirement may be raised by making wire fences.

4) Fish + Duck integration (17.8% area)
   i) Mix carp culture: Rohu (20% as column feeder), Catla (30% as surface feeder), Mrigal/common carp (50% as bottom feeder)

ii) Duck: For 1000 m^2 water area 40 number of ducks are sufficient
Khakhi Campbell breed of duck is right choice for this area (Dual purpose)
A thatched hut of 10 x 15' size is optimum for 40 ducks above the water or on the pond's dike.

5) Livestock (1.80% area)
A size of 3 adult cows + 3 calves is optimum for two acre land in respect of FYM requirement for the fields and fodder requirement for the livestock. A thatched hut of 20' x 30' with sufficient paddock space is sufficient for above no. of animals. The Cow shed should be connected with the pond with a drainage channel so that urine and water can move into the pond. A storage hut for storing of animal feed should be also made near the animal shed.

6. Fodder production (12.5% area): For feeding of 3 cows and 3 calves 1000 m² land is sufficient if year round fodder production is carried out. In addition to green fodder, straw, leaves, stems of different cereals and vegetables can be also used as animal feed.
Kharif: M.P. Chari/Sudan grass/ Napier/Maize
Summer: Boro/Lobia/Maize/Sudan grass
Rabi: Berseem/Oat/Maize etc.

7. Spices: In the sheds or where light intensity is less like orchards, spaces between the huts etc. turmeric, ginger or guinea grass can be taken.

8. FYM/ vermi-composting pits: (1.4 % area)
Optimal sizes pits for preparation of FYM and vermi compost should be made depending upon land available near the cowshed so that required raw materials for making manures should be made available nearby for convenience and to avoid transportation charges.

Details of nutrient recycling in the model are given in Fig 2, economics of IFS models are presented in Table 1-3 and employment generation in Table 4.

Note: Cattle shed should be always constructed away from birds to avoid attack of any transmissible or contagious diseases to animals or vice-versa.

Out of above mentioned income, we get about 27.8 t Cow dung and 1.2 t vermi-compost which is equivalent to 482 kg Urea, 400 kg of SSP and 396 kg of MOP. In other words we can curtail the cost of cultivation up to ₹ 8,000-9,000/year by recycling these organic wastes into the system.

Table 1. Economics of two acre IFS module (complete one year)

Components	Gross income (₹)	Net income (₹)
Cereals	39,335	19,010
Vegetable	42,180	29,647
Fruits	14,505	10,000
Dairy + Income from calves	1,44,280	96,870
Fishery	19,700	14,172
Duckery (egg)	15,000	10,800
Total ₹	2,75,000	1,80,499

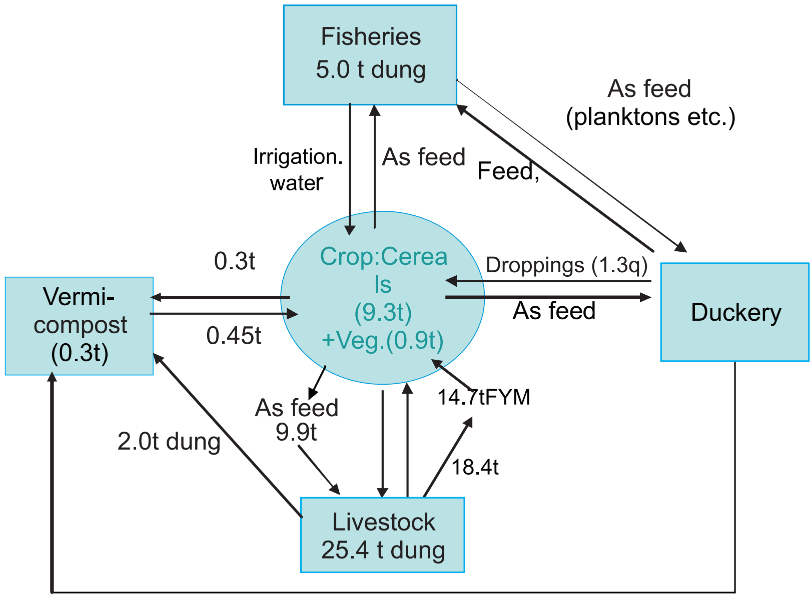

Fig 2. Nutrient recycling and interdependence of components under 2 acre IFS module

Table 2. Establishment, income and expenditure statement of two acre IFS module

Components	Establishment cost	Gross income(₹)	Net income (₹)
Crop (0.4 ha)	-	20325	19010
Horticulture Crops (0.15 ha)	2500	17785	39647
Fodder Crop (0.1 ha)	-	6224	Used within the system
Fishery (0.1 ha)	70000	5528	14172
Duckery (pond's bund)	18000	4200	10800
Dairy (0.016 ha)	70000	62500	81870
Vermicompost & FYM pits	15000	3300	Used within the system
Total ₹	175500	119862	180499

Table 3. Economic analysis of different components and system under two acre IFS module

Farming system	Rice-Wheat	Vegetable	Fishery	Duckery	Cattle	Net income (₹)
Rice-Wheat system	46122	-	-	-	42290	46122
Rice-Wheat +Dairy	43815	-	-	-	42290	86105
Rice-Wheat + Dairy + Fishery	38050	-	22500	-	42290	102840
Rice-Wheat + Dairy+ Fishery+Duckery	38050	-	22500	18000		144165
Rice-Wheat + Dairy+Fishery +Duckery	38050	-	22500	18000	42290	134130
Rice-Wheat + Vegetable + Dairy	32285	53790	-	-	42290	128365
Rice- Wheat+ Vegetable+ Dairy+ Fishery	32285	53790	22500	-	42290	150865

Table 4. Employment generation under two acre IFS module

Cropping system	Wheat-Rice	Vege-table	Fishery	Duckery	Animal husbandry	Total (₹)
Rice-Wheat system	402	-	-	-	-	402
Rice-Wheat+Dairy	390	-	-	-	160	550
Rice-Wheat+Dairy + Fishery	378	-	42	-	160	580
Rice-Wheat +Dairy + Fishery + Duckery	378	-	42	80	160	660
Rice-Wheat +Vegetable + Dairy	378	148	-	-	160	638
Rice-Wheat +Vegetable + Dairy+Fishery	330	148	42	-	160	680
Rice-Wheat +Vegetable + Dairy+Fishery+ Duckery	330	148	42	80	160	760

B) One acre IFS module (midland situation)

Components:

Crop + Goat + Poultry

Allied: Mushroom/Goat manure/Vermi composting

Land allocation: Details of land allocation or different components in 1 acre model has been given in Fig 3.

Cereal crops (50% area)

Kharif: Rice

Rabi: Wheat/Maize/ Lentil/Mustard

2. Horticultural crops (Fruits + vegetables): 22.5 % area

Vegetables

Kharif: Cucurbits/Brinjal/Okra

Summer: Brinjal/Boro/ Okra/ Bitter gourd/ Cucumber etc.

Fruits

Papaya (On field bunds)

Banana (On field bund)

Lemon (In Horticultural block)

Guava (In Horticultural block)

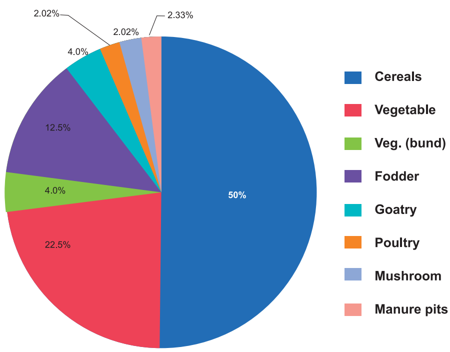

Fig 3. Land allocation to different enterprises under one acre IFS module

3. All around the field bunds cucurbits or seasonal vegetables having lesser water requirement may be raised by making wire fences (about 4 % of total area)

4) Livestock (Goat): 2.5% area

A size of 20 female goat + 1 buck is optimum for one acre land in respect of manure requirement for the fields and fodder requirement for the livestock. A thatched hut of 20’ x 30’ with sufficient fenced paddock space (to move the goats freely as goats have to kept on stall feeding) is sufficient for above no. of animals. The goat shed should be airy and sunny A storage hut for storing of animal feed should be also made near the animal shed. Black Bengal breed of goat is suitable for this region.

5) Poultry (100 birds)
   100-200 birds (broiler) can be reared in an area of 225 sq. ft. by making a thatched hut. All around wire meshing should be done at the inner walls to protect the birds from predators and hunting animals. The hut should be airy and proper arrangement of bulb or other lighting should be done before rearing the chicks.
6) Mushroom: Year round mushroom production can be done in an area of 25 X 20' by making a thatched hut for optimum return. In this shed about 200 mushroom bags can be kept at a time by making bamboo shelves. Selection of the mushroom strains should be done on the basis of climate and humidity in the atmosphere as
   March-September: straw/paddy/milky mushroom
   October-February: Oyster/ Button mushroom
7) Fodder production: (12.5% area)
   For feeding of 20 + 1 unit of goat an area of 600 m^2 is sufficient if year round fodder production is carried out. In addition to green fodder, dry husks, leaves, stems of different cereals and vegetables can be also used as feed.
   Kharif: M.P. Chari/Sudan grass/Maize
   Summer: Boro/Lobia/Maize/Gunea grass
   Rabi: Berseem/Oat/Maize etc.
8) Spices: In the sheds or where light intensity is less like orchards, spaces between the huts etc. turmeric, ginger or guinea grass can be taken.
9) FYM/ vermicomposting pits: (1.4% area)

Optimal sizes pits for preparation of goat manure and Vermicompost should be made depending upon land available near goat shed so that required raw materials for making manures should be made available nearby field and livestock.

Nutrient recycling among different components of the 1 acre IFS model has been presented in Fig, 4. Economics of the system has been presented in Table 5.

In addition to above mentioned income about 5.6 t of goat manure and 0.6 t of vermi compost is also prepared within the system which were recycled within the system. The above mentioned organic manures are equivalent to 100 kg Urea, 170 kg SSP and 40 kg MOP in addition which costs about ₹ 4000/-. The straw available from the crops was recycled into the system in form of mushroom, feed to animals and vermi composting. A total increase in man power employment was also reported from the system (Table 6). Detailed economics of the individual component of the system has been presented in Table 7.

Table 5. Economics of the system (complete one year cycle)

Component	Gross Income (₹)	Total Income (₹)
Rice Crop	13893	8398
Vegetable/Fruits	30240	21015
Goatry	50000	39180
Poultry	52500	32500
Beekeeping	16500	10800
Mushroom Production	22000	16800
Total ₹	185133	128693

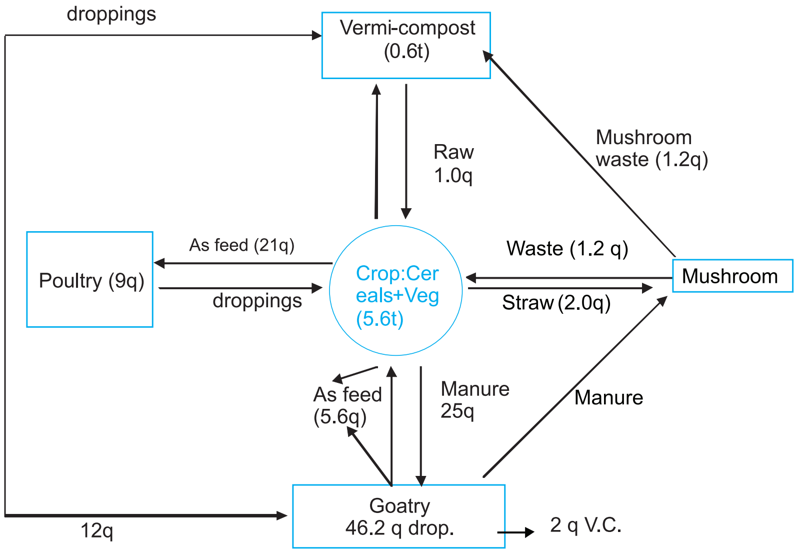

Fig 4. Interdependence of components in 1 acre IFS model

Table 6. Employment generation under one acre IFS module

Farming System	Cereals Only	Vegeta-bles	Poultry	Duckery	Fishery	Goatry	Dairy	Total man days
Cereals Only	416	-	-	-	-	-	-	416
Crop+Veg	220	310	-	-	-	-	-	530
Crop+Fish+ Poultry	376	94	60	-	40	-	-	570
Crop+Fish+Duck	376	94	-	50	40	-	-	560
Crop+Fish+Goat	376	94	-	-	40	110	-	620
Crop+Fish+Cattle	376	94	-	-	40	-	170	680
Crop+Fish+Poultry+Duckery	376	94	60	30	40	-	-	600
Crop+Mushroom+Goat	376	94	-	-	40	110	70	650

Note: 1man- day = 8 hrs.

Therefore, it can be emphasized that Integrated farming system is very much suitable for Bihar and eastern states. Economy of Bihar is predominantly rural and agriculture oriented where the marginal and small farmers constitute 76.2% of farming community. Due to failure of monsoon, the farmers are forced to judicious mix up of agricultural enterprises like dairy, poultry, pigeon, fishery, sericulture, apiculture etc., suited to their agro-climatic and socio-economic condition and largely dependent on the farm size. (Kumar *et at.,* 2012).

For such prevailing situations, There is need to integrate agriculture, horticulture, fisheries and other allied enterprises like apiculture, sericulture, mushroom cultivation etc.

Table 7. Establishment and expenditure statement of one acre IFS

Components	Establishment cost	Gross Income (₹)	Net Income (₹)
Crop (0.2 ha)	-	5495	8398
Horticulture Crops (0.09 ha)	1080	9225	21015
Fodder Crop (0.06 ha)	-	4206	Used within the system
Goatry (20+1) (0.018 ha)	45000	10820	39180
Mushroom Production (0.018 ha)	10000	5200	16800
Poultry (200) (0.0015 ha)	12000	20000	32500
Vermicompost & Goatry FYM pits	8000	2660	Used within the system
Beekeeping	8000	5700	10800
Total ₹	84080	63306	128693

with livestock which holds promise for this region in a scientific way for improvement in the livelihood of marginal, small and medium household farm families. The resource use efficiency at present level is poor du e to lack of adoption of appropriate farming system models. Good quality of fertile land, rich water endowments, biodiversity and manpower can be used in an integrated manner in a farming system mode by recycling of wastes to secure high resource use efficiency and improved livelihood.

2. State: Chhattisgarh

Alternative model of farming system for Chhattisgarh has been presented in Table 8.

3. North Eastern Hill Region (by Bujarbarua, Satapathy and Bhatt, 2004)

Agricultural based land use

The system can be adopted on hill slope up to 50% where soil depth is more than 1 m. Bench terraces, and contour bunding are the major soil conservation measures; selection of the crop should be based on farmer's choice as well as market potentialities. Hilltops should be kept under forest (fuel-cum-fodder trees bamboo and timber trees etc.). Based on the farming systems, agro climatic and soil conditions, the cropping systems visualized are: Rice based cropping system Rice-mustard/ potato/radish); Maize based cropping systems (Maize-groundnut/ soybean/mustard/radish/ potato/tomato); oil seed based cropping systems etc. Cultivation of crops in topose-quence is useful on hill slopes. Normally rice is taken in the bottom and cassava, buckwheat etc. grown at the upper terraces. Maize is grown next to rice. Dairy cow can be effectively integrated with crop production on terraced hill slopes for sustainable agriculture under the system. By product of crops and fodder raised on bunds and terrace raisers occupying about 30% of land provide scope for subsidiary source of income through animal husbandry. Among perennial grasses and legumes- *Setnria spliacilata,* thin napier, *Guinea* and *Stylosanthes* were found good for terrace risers. Management of forage crops on the terrace risers is

Table 8. Alternative model of farming system for Chhattisgarh

Farming system model	State government intervention
Crops + community based fish cum duck culture	Village tanks are used for fish cum duck culture in scientific manner with appropriate fish breed and feed. Village farmers are involved on lease basis in village pond for one to two years in the supervision of village Panchayat for fish cultivation. Seeds availability and market are being developed.
Crops + mushroom cultivation	Large-scale training of mushroom cultivation including span preparation is being given to village farmers particularly women under Indira Sakti Yojana. However, market needs to be developed in a big way near city area.
Crops + diary + poultry	1. Special emphasis are given to develop dairy and poultry sector by state department of veterinary 2. The milk collection centre is established in village under cooperative scheme in nearly capital area. However, major districts need to be included under the scheme. 3. Easy bank loans are available for poultry and dairy development. 4. Breed improvement for increasing milk production is being done.
Crops + Horticulture/ Forestry, Medicinal plants	Chhattisgarh is declared as horticulture and herbal state. Development of cultivation of plantation crops, forestry and medicinal plants are priority sector of state government. Action plan is prepared but availability of planting material is major constraint for fast growth.
Other enterprises	Training is imparted for 1) Silk cultivation 2) Honey bee rearing 3) Lac cultivation

Source: J. S. Urkukar and R. K. Mishra (2004)

important. They should not be allowed to grow more than 50 to 60 cm tall to avoid any shade to food crops on the terrace. On the wide terraces, fodder trees can be planted. The deficit green fodder during winter can be met by feeding leaves of broom grass and crop maintaining 1.18 livestock unit (one unit equal 10 buffalo, 1.25 cattle, 5.0 pigs and 100 goat). *In situ* generation of farmyard manure from livestock refuse, weeds and non edible crop residues can be effectively utilized under integrated nutrient management to reduce the chemical fertilizer requirements. Analysis of sustainability and livelihood potential showed that the system incorporates the classical organic recycling and non competitive land use elements, pushing the system towards sustainability by reduced dependence on external inputs, arresting nutrients in rainwater flow by growing forage crops on the terrace risers, negligible soil erosion and converting in a chain all biomass produced in the watershed into economic outputs (Singh *et al.,* 1987).

Horti-silviculture

These are land management systems for the concurrent production of fruits and forest crops; the latter provides packaging, fuel, fodder and small timber requirement of the farmers. Here various tree species can be grown as wind breaks, shelterbelts or fillers in the orchard to protect" it from the high velocity wind/storms. *Salix, Popidus* and *Alnus nepalensis* have been proved successful around -the fruit farms without any adverse effect on the fruit production. Agricultural crops can also be grown between the rows of fruit trees to form a multitier agri-horti-silviculture system, lemon and pineapple were found to grow very well with fodder cowpea, the latter provides 90 to 100% ground coverage by the end of June which prevents soil loss during monsoons. This type of land use system can be adopted successfully in the areas having less than 50% slopes with moderately fertile and deep soils (Gupta, 1998).

Agri-horti-silvipastoral land use

Land up to 100% slope with soil depth greater than 1 metre can be used for this mixed land-use system. The system comprises agricultural land use towards the foot- hills, horticultural in the mid portion of the hill and silvipastoral crops in the top portion of hill slopes. Contour bunds, bench terraces, half moon terraces, grassed ways are the major conservation measures. Land development may cost about 190 man days/ha. Such land uses are expected to retain over 90% of the annual rainfall with negligible soil erosion. This is the ideal system suited to steep hill slope. Variety of agricultural, horticultural and silvipastoral crops mentioned in three systems can be grown in this system. Choice of crops will vary according to altitudes. The fodder from terrace risers, horticultural portion and silvipastoral unit can sustain an unit of 10 goats with reproduction efficiency of 170% and the pigs can met part of their nutrient requirement through succulent grasses, grains and radish produced in the watershed. The diverse agro-activities would help in producing most of the produce that remote area farmers would like to grow for their self-sufficiency in a highly remote region of the hills (Singh *et al,* 1987). Thus it is an integrated system of farming and capable of providing full time" and effective employment to a tribal family.

Livestock based farming system

Land up to 100% slope with minimum of 0.5m soil depth may be utilised for livestock farming. Contour trenches and grassed waterways are the minimum requirement of land treatment. Selection of leguminous and non-leguminous annuals and perennials, shrubs and trees will depend on the type of enterprises (such as milk, beef, mutton, wool, pork and poultry production). The fodder production system has to ensure stability in fertility status of soil, availing the moisture supply towards maximum fodder production for longer period during the year and conservation of fodder for lean season. Annual legumes develop 100% canopy within 45 days of the onset of rains. Combination of cultivated varieties of perennial legumes, grasses, shrubs and trees can extend availability of green fodder up to February at low altitude thereby shortening the requirement of conserved fodder for lean season. Carrying capacity of such high land, use has been estimated to be 4 to 5 livestock/ unit/ha with setaria and stylo (1:1) mixture of fodder production. Livestock-based farming system has potential for substantial income from the farmyard manure and self-sufficiency in the matter of fuel through biogas plants.

Multi purpose tree species and silvi-pastoral systems

Non-arable hilly areas with high slopes and shallow soil can be best managed under suitable multi purpose tree species (MPTS). Native and exotic species play complementary roles in forest planning. The introduction of fast growing exotic would reduce pressure on indigenous species. A number of species have been identified for use in afforestation and silvipasture programmes. Tailoring a number of forage plant species in the hill land use systems will provide continuous vegetatives cover on the hill slopes to protect land resources from intense rains and conserve the abundant native forage plant species (bio diversity) in the high rainfall zone. Fodder tree plantations along the village roads and on the community lands; shade tolerant grass plantation in the forest, intensive forage production on commercial livestock farms under semi-organic farming, horti-pastoral systems, utilization of terrace risers bunds and bamboo shaded area for fodder production these are few of the options of forage resource development in the hill agro-ecosystems.

Issues in Farming Systems Research and Development

In order to implement integrated farming system activities using modern methods, the issues which need greater emphasis for agriculture development on sustainable basis in rural areas are:

- Implementation in relation to the time required for obtaining results, organizational flexibility, staffing requirements, FSR costs and Governmental support. At times, researchers conduct trials to screen locally available technologies for their applicability to a specific farmer condition.
- At an early activity of FSR programme there is need to develop broad based manpower training to meet the requirements of IFS in rural areas.
- Characterization of existing farming systems and identification of main and complementary location-specific, need based enterprises for proper linkage between on farm and on station research and extension activities.
- Formation of a dedicated multi disciplinary core team under the dynamic broad based scientific leadership, by providing suitable rewards and encouragements to start IFS activities in some selected fragile and problematic environments in rural areas.
- The impact and changes related to expanding market infrastructure and activity in rural areas, as well as broader implications of reduction in barriers to trade within and in between countries and future pattern of demand for agricultural outputs.
- Development of dynamic farming systems required a conductive enabling policy and environment. Structural adjustments have to be reduced, leaving in urban bias in policies. The role and impact of the state and related institutions and functioning of farming systems, expressed principally - through policies/programmes, institution, services, and public investment in rural space.
- The recent evaluation of farming systems based upon increasing specialization requires extra knowledge on the part of farm operators. Farmers have to understand the nature of demand that they are responding to in terms of its implications for varieties, timing, packing and permitted chemicals,, etc. and increasingly to modify their products and

activities as market demand changes. The relevance of non-material capital to the farming systems, in terms of knowledge information, and ability to assess and utilize such knowledge is required.

Way Forward

Experience over the last three decades reveals two major evolutionary strands. One is a pervasive farming perspective which is relevant for all agricultural research. Instilling this perspective system wide is essential for improving the relevance and productivity of the NARS (Byerlee and Tripp 1988). This requires intensive and structural linkages between specialists, between them and farmers in different targets domains. The commodity research units, coordinated projects and main stations of SAU need to build this component in their research programmes and budgets. Presently, the task is assigned to extension with reluctant participation of a few junior scientists. Fostering and supporting these linkages in the research farm should be a priority for the ICAR.

* The other dimension is the classical FSR model involving diagnostic surveys and field experimentation in a target domain with intensive involvement of farmers, extension services and other agencies. This, despite conceptual elegance, has suffered from several infirmities such as ambiguities in concept (Merrill-Sands, 1986), isolation from mainstream research, inexperienced personnel, inadequate incentives, etc. These needs to be addressed and the ZRS should emerge not only as main centres for technology refinement and testing but also as determinants of research agenda at higher levels. Unfortunately, state funds are in such disarray that this revival cannot stem from there. Once again the responsibility would fall on ICAR. A significant portion of future incremental funds should be so directed. This will also translate the rhetoric of decentralization into reality.

* Specialists with FSR perspective will have to be trained. For this farming systems ideology and principles should be integrated in degree programmes in universities and leading research centres. This will sensitize specialists. Those who are involved in on-farm research will need to be trained in social science skills.

* In addition, there is need for a systematic and genetic initiative on farming systems. ICAR should create a Systems Research and Training Institute (SRTI). The agenda of the Institute should be (a) to undertake delimitation of farming systems prevalent in the country and validate NARP zones, (b) to initiate studies in collaboration with local institutions to understand different systems, sub-systems and their constraints, (c) to refine and develop methodologies for FSR, (d) to undertake modeling and system simulations at various levels for assessment, evaluation of prospective technological or other interventions and (e) undertake training in FSR methodologies, systems analysis and its application in agriculture.

Some of the Farming System Options for Irrigated Ecosystem in Eastern Region

1. Irrigated Ecosystem (Low and medium lands)

System	Crop/Crop sequence	Livestock	Fish	Fruits/flowers	Vegetables	Allied enterprise
A) For small and marginal Farers						
1. Rice-fish	*Kharif :* Rice *Rabi :* Wheat, winter maize, lentil, gram, mustard					Mushroom/ apiculture
2. Sole crop/ Fish+ Duckery + apiculture	Kharif : Rice *Rabi :* Wheat, winter maize, lentil, gram, mustard	Goat, Duck, Honey bee	Carp culture	Banana, papaya	*Kharif :* Elephant foot yam, okra, sweet potato, leafy vegetables, cucurbits *Rabi :* Beans, tomato, potato, Cole crop, cucurbits	
B) For medium and Large farmers						
1. Rice / fish + Dairy	*Kharif :* Rice *Rabi :* Wheat, winter maize, lentil, gram, mustard, fodder	Buffalo/cattle or both	Carp culture	Banana, papaya, mangoes	*Kharif :* Elephant foot yam, Colocasia, okra, sweet potato, leafy vegetables, cucurbits Rabi : Beans, tomato, potato, Cole crop, root crops, cucurbits, onion, chilli	
2. Crop + Dairy + Fish + Poultry + Duckery + Vegetables + Fruits + Flowers	*Kharif :* Rice, *Rabi :* Wheat, winter maize, lentil, gram, mustard/rye, fodder	Buffalo/cattle or both, Duck, Poultry	Composite fish culture	Mango, jackfruits, guava, banana, lemon, litchi, marigold, gladiolus/ cut flowers	*Kharif :* Elephant foot yam, Colocasia, okra, sweet potato, leafy vegetables, cucurbits *Rabi :* Beans, tomato, potato, cole crop, root crops, cucurbits, onion, chilli	

2. Irrigated uplands:

System	Crop/Crop sequence	Livestock	Fish	Fruits/flowers	Vegetables	Allied enterprise
A) For small and marginal Farers						
1. Crop + fish + duck + vegetables/ fruits	*Kharif:* Rice, Sugarcane, Maize *Rabi :* Wheat, winter maize, lentil, green gram, mustard	Duck, pig/ goat	Composite fish culture	Mango, jackfruits, guava, banana, lemon, litchi ,phalsa and filler crop, papaya	Seasonal vegetables and fruits	Mushroom
2. Crop+ Vegetables + piggery/ Goatery/ Poultry + apiculture	*Kharif :* Rice, groundnut *Rabi :* Wheat, winter maize, lentil, green gram, mustard, fodder	Pig/goat, poultry, Honey bee	Carp culture	Mango, jackfruits, guava, banana, lemon, litchi, phalsa and filler crop, papaya	Bottle gourd, ridge gourd, cucurbits, spinach, beans, brinjal, okra	Mushroom and apiculture
B) For medium and Large farmers						
1. Crop + fish + Dairy + Vegetables + Fruits/ Flowers	*Kharif :* Rice *Rabi :* Wheat, winter maize, lentil, gram, mustard, fodder (Jowar, oat, bur seem, cowpea)	Buffalo/cattle or both	Composite fish culture	Mango, jackfruits, guava, banana, lemon, litchi, phalsa and filler crop, papaya	*Kharif :* Seasonal vegetables, gourds, colocasia, okra, sweet potato, leafy vegetables, cucurbits, melons *Rabi:* Beans, tomato, potato, cole crop, root crops, cucurbits, onion, chilli	
2. Crop + Dairy + Fish + Poultry/ Goatery + Duckery + Vegetables + Fruits + Flowers	*Kharif :* Rice, maize *Rabi :* Wheat, winter maize, lentil, gram, mustard, fodder (Jowar, oat, bur seem, cowpea)	Buffalo/cattle or both, Duck, Poultry	Composite fish culture	Mango, jackfruits, guava, banana, lemon, litchi, marigold, gladiolus/ cut flowers	*Kharif :* Elephant foot yam, Colocasia, okra, sweet potato, leafy vegetables, cucurbits *Rabi :* Beans, tomato, potato, cole crop, root crops, cucurbits, onion, chilli etc.	

Summary

Keeping in view the case studies conducted previously and recently is emphatically entail the need to promote farming system approach as a National programme. Undoubtedly, this approach is a location specific, technically skill based, play multi dimensional role in fulfilling the domestic requirement, employment avenues, rational use of resources, rejuvenation of resources, sustaining productivity, investability and economic ability of the systems. In the present scenario of agriculture sector, this only approach enable the Indian farmers self sufficient and competitive in the global market by producing quality edible products which is the main base in farming system on account of their inheritance of recycling- the by-products of different enterprises and even a pinch of material always considered of economic value.

On the basis of the above studies again it is imperative to say that there is great scope for integrated farming system research in India as well as in Eastern region and that too in Bihar in all types of ecosystem. Unfortunately, Eastern India is lagging far behind than other regions in respect of Integrated Farming System Research in spite of endowment of good soil of alluvial tract, a markable percentage of land under cultivation, abundant sunshine, ample water resources, a large number of livestock and vast human resources. In other words we can say that it is high potential, low productivity area. There is ample scope to boost the productivity in terms of resources and endowments. Challenge to us to convert adversity to boon. We have to find the path to convert Indo-Gangetic Basin as a feeding bowl of the country giving main emphasis to lower part of the IGB i.e. Eastern UP, Bihar and West Bengal and integrated farming system may serve the purpose along with other modern technologies. So, a proper attention is needed to strengthen the Integrated Farming System Research Programme in India as well as in the eastern part of the country.

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