Integrated Farming Systems for Improving the Productivity of Small Holder Farmers in SAT Region

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1. Introduction

In India, out of 115 million operational holdings 80% are small and marginal with an average land holding of less than one hectare. The basic needs of house hold like food (cereal, pulses, oilseeds, milk, fruit, honey, meat, etc.), feed, fodder, fibre, etc are to be obtained from this small piece of land. This warrants an attention of Integrated Farming System (IFS) approach in agriculture. Farming systems refers deliberate raising of crops, forest and fruit trees, animals including fisheries, piggery and duck farming, sericulture, mushroom, on a given unit of land to increase the productivity and profitability, to upgrade natural resource base and to achieve overall improvement in the environment (Singh, 2005). IFS was perceived as a mixed animal crop system where the animal component is often raised on agricultural waste products while the animal is used to cultivate the soil and provide manure to be used as fertilizer and fuel (Jayanthi et al., 2000). Edwards (1997) and Jitsanguan (2001) defined the IFS as an aquaculture system that is integrated with livestock and in which fresh animal waste is used to feed fish and also reported that there are synergies and complementarity between enterprises that comprise a crop and animal component that form the basis of the concept of IFS.

Radhammani et al. (2003) emphasized that integrated farming system takes into account the concepts of minimizing risk, increasing production and profits whilst improving the utilization of organic wastes and crop residues. The integration should be made in such a way that product of one component should be the input for other enterprises with high degree of complimentary effects on each other (Panke et al., 2010) and is different from mixed farming as the enterprises in the integrated farming system are mutually supportive and depend on each other (Csavas, 1992). For instance, the fodder fed to the cattle produces milk. The dung, urine and litter produce farmyard manure and energy used for crops and fish pond. The siltation of fish pond is utilized as manure to crops. The farmyard manure can substitute about 25% of recommended N P and K for crops, besides improving the physical and biological properties of soil (Sridevi and Ramana, 2016). The fish pond water can be used by gravity method while there is breakdown in electricity supply. Oil-seeds provide nectar for honeybee, edible oils for human and oilseed-cake for animal feed. Integrated nutrient management can enhance the productivity of cereals by 0.5 to 1.0 t ha^{-1}. Processing of different products enhances the value addition to the extent of 25 to 50% besides generating 50-75-man days $family^{-1}$ $year^{-1}$ of employment. The fish pond embankment comprising 20–30% can be used for growing cucurbits and fruit trees which provide effective soil cover to checks the soil erosion and also make the system economically viable (Gill et al., 2009). Another advantage of integrated farming systems is the selection of crops into creative crop rotations that can effectively minimize insect and disease problems minimize risks from climatic and economic fluctuations maximize vegetative cover to control soil erosion and protect the environment. Longer rotations allow better control of weeds, insects and diseases. The inclusion of legumes in the rotation enhances biological

nitrogen fixation and reduces the need for chemical nitrogen fertilizers and, thus, lowers the overall energy consumption (Viaux, 2001). Hence, IFS can be described as an integrated set of elements / components and activities that farmers perform in their farms under their resources and circumstances to maximize the productivity and net farm income on a sustainable basis (Singh and Ratan., 2009). Researchers in India and abroad evaluated various farming systems under different ecological situations and the benefits of integration are well documented.

2. IFS for irrigated Situations

Integrated farming system (IFS) comprising the components like cropping, vegetables, fishery, poultry and goat rearing was found to be suitable for small and medium farmers of Tungabhadra project area of Karnataka (Channabasavanna, 2009). IFS approach recorded 26.3 and 32.3 per cent higher productivity and profitability, respectively over conventional rice-rice system. Among the components, the highest net returns was obtained from crop (63.8 %), followed by goat (30.9 %), fish (4.0 %) and poultry (1.3 %), respectively. Employment generation and water requirement was 275 Man days ha^{-1} $year^{-1}$ and 1247 mm, respectively under the integrated farming system. Specific energy was low in IFS (3.09 MJ kg^{-1}). The benefit cost ratio was also higher (1.97) in IFS than conventional system (1.64). Among the various components, goat recorded the highest benefit cost ratio (2.75) followed by fish (2.23) due to low cost of cultivation. This was followed by vegetables (2.00). Poultry showed the lowest benefit cost ratio (1.13) as a result of high cost of maintenance.

Integrated Fish Farming is one of the best farming systems (IFS). Integrated fish farming refers to the simultaneous culture of fish or shell fish along with other culture systems. This type of farming practices in different forms mostly in the East and South East Asian countries is one of the important ecological balanced sustainable technologies. The technology involves a combination of fish polyculture integrated with crop or live stock production. On farm waste recycling, an important component of integrated fish farming is highly advantageous to the farmers as it improves the economy of production and decrease the adverse environmental impact of farming. For lowlands of Bihar, Kumar et. al. (2012) identified crop + fish + duck + goat as the best integrated farming system in terms of productivity, sustainability index (0.80%), net return (1,59,485 $year^{-1}$) and employment generation (752 man-days $year^{-1}$) apart from addition of appreciable quantity of N, P_2O_5 and K_2O into the system in form of recycled animal and plant wastes. Crop + fish +duck + goat and crop + fish + cattle integration also recorded nearly equal amount of rice- grain-equivalent yield (21.20 and 21.18 tonnes ha^{-1}, respectively) but in terms of economics crop + fish +duck + goat supersedes. The waste material/by products of crops and animals were recycled and used as inputs for other components of integrated farming system. Crop + fish + cattle model added higher quantity of N P and K overall other models. Sonjoysha et. al., (1998) indicated that for irrigated situation rice-fish-vegetables-fruit crops farming system was profitable. The integrated farming system consisted of pisciculture, field and horticultural crop (agroforestry), poultry, mushroom, apiculture and biogas enterprises was tested at in low lands/pond based situations of Odisha (Behera and Mahapatra,1999). Apiculture produced the highest returns (Rs 7.94 per rupee invested), followed by pisciculture (Rs. 5.46 per rupee invested). Among the crop enterprises, best returns were obtained with multistorey cropping involving pumpkin, ridge gourd, and poi as ground storey; pineapple, colocasia, ginger and turmeric as first storey; and coconut as second storey. Poultry and mushroom enterprises fetched low returns. The highest level of employment (180 man days per year) was achieved in mushroom cultivation. The integrated farming system generated a net income of Rs 58 360 and an employment of 573 man days on a small piece of land (1.25 ha), ensuring a high standard of living for small and marginal farmers.

2.1. IFS under Irrigated dry situations

In the small and fragmented land holdings of Telangana state, under irrigated situations Integrated

Farming of Crop (0.7 ha with diverse cropping systems) + Horticulture (0.2 ha Guava with under storey seasonal vegetables) + Livestock (0.1 ha with 2 buffaloes, 6 goats and back yard poultry) was evaluated. IFS unit on an average (2011-12 to 2015-16) recorded a productivity of 29.39 t REY ha^{-1}. The system recorded an average net income of Rs. 1,51, 000 ha^{-1} as against the average farmers income of Rs.54,000 ha^{-1}in the region. On an average annually 2591 kg of cereals, 160 kg pulses, 405 kg oil seeds, 2436 litres of milk, 1140 kg of vegetables were produced in the system as against annual demand (Indian Council of Medical Research standards) of 730 kg of cereals, 125 kg pulses, 120 kg oil seeds, 400 litres of milk and 300 kg of vegetables for five member farm family. Feed and fodder requirement of livestock unit with 2 buffaloes and 3 calves could also be met through average production of 21,400 kg green fodder and 4262 kg dry fodder as against the demand of 17,500 kg green fodder and 3000 kg dry fodder per year. Continuous use of crop residues and manures through residue recycling over five years helped improving the soil fertility of the unit with perceptible improvement in organic carbon from an initial status of 0.36% in ID block to 0.49%. Similar advantage in increased available phosphorus and potassium was observed from an initial status of 14.8 and 170 kg ha^{-1} to 19.3 and 200 kg ha^{-1}. From the system through residue recycling and manure production, on an average, 8625 kg of FYM and 1269 kg of vermicompost could be produced which was equivalent to 135-77-103 kg of N, P and K and saving a fertilizer worth of Rs 9000 $year^{-1}$. The system also provided an average employment generation of 806 man days and an opportunity to save around Rs. 94,320/- worth of labour wages per year through engaging farm family labour (524 man days). Mean maximum employment generation was recorded in Livestock unit with 513 man days (63.72%) followed by 117 man days (14.50%) for Cropping unit. Employment was available throughout the year including the lean period (Ramana et al., 2016). In North Telangana zone, farming system with agriculture and dairy generated more than 200% additional employment over agriculture alone. The net returns were higher in agriculture and dairy followed by agriculture and poultry and agriculture and sheep (Reddy, 2005).

3. Ifs Under Rainfed Farming

Traditionally rainfed farmers of SAT region are small subsistent land holders and integrating livestock (small ruminants) with crop production is a viable option. Agri-sheep farming with 10 lambs and growing crops and use of farm by products in one ha of marginal lands gave an additional net returns of Rs. 8700 ha^{-1} as compared to growing cotton alone at Warangal in Andhra Pradesh (Rs. 27500 ha^{-1}) under cotton based production system (TAR-IVLP, 2003). In Oilseed based production system, Groundnut cake is the most important by product used as protein source and cattle feed at Anantapur. Groundnut haulms are used for feeding cattle and sheep. Integration of sheep rearing (10rams) in groundnut farming system offers gainful employment (65 mandays) in rainfed areas in addition to increased pod yield (17%) and haulm yield (53%) due to sheep penning (ARS, Ananthapur, 2012). In this scarce rainfall zone of Andhra Pradesh, the highest net returns were recorded with farming with the poultry of broilers (Rs. 43360) followed by farming by dairy with three buffaloes having 2 ha (Rs. 40606) while sole crop of groundnut (2.6 ha) recorded the net returns of Rs. 14872 ha^{-1}. Radhamani (2001) reported the additional 234 employment gains (314 man-days $year^{-1}$) through integrated farming system with crop+goat under rainfed vertisols. The Agri-silviculture system is recommended for land capability class IV with annual rainfall of 750 mm. Short duration dryland crops such as pearlmillet, blackgram and greengram, combined with widely spaced tree rows of Faiderbia albida and Hardwickia binata, have been found compatible in semi-arid tropical areas (Korwar,1992).

In rainfed regions having undulating terrain where the traditional irrigation systems, viz. canal irrigation and tube well irrigation are not feasible due to topographical, geological and hydrological constraints, rainwater harvesting has been found to have potential of being an irrigation water resource which can provide full irrigation in conjunction with rainfall to transplanted rice based two

crop rotation. Utilization of stored water in both monsoon and post-monsoon season crops increases the efficiency of the system which is evident from higher water yield-storage capacity ratio of 1.75. The evaluation of a rain water harvesting system has shown that integrated farming approach of utilizing the system enhances the economics of the system. While the B–C ratio with only crop was 1.89, it increased to 2.27 if horticultural crops are taken on the embankment of the tank. It further increased to 2.80 when fish culture is taken up in the stored water. There is possibility of its increasing to more than 3.0 if duckery is also taken up (Srivastava et. al., 2004).

Under rice–fish integration system in rainfed medium land ecosystem of Odisha, Mohanthy et. al., (2004) reported that irrespective of stocking density, faster growth rate was recorded for Catla catla followed by Cyprinus carpio, Cirrhinus mrigala, Labeo rohita and Macrobrachium rosenbergii, C. carpio and C. Mrigala performed better growth rate against that of L. rohita probably due to the fact that being bottom dwellers, C. carpio and C. mrigala are more tolerant to fluctuation of oxygen concentration. Productivity of fish and prawn was, however, higher ($p < 0.05$) in refuges with 10-cm weir height plots, irrespective of stocking density, while overall yield performance was good at stocking density of 25, 000 ha^{-1}. It was observed that, even with supplemental feeding, with increase in stocking density, biomass yield increased up to an optimum and then decreased. An average minimum and maximum yield of 906.6–1282.3 kg ha^{-1} of fish and prawn has been achieved, which was much higher than the earlier recorded productivity in a season under rice-fish integration system. Highest grain yield was recorded at 15-cm weir height plot (3629 kg ha^{-1}), probably contributed by higher number of panicles per square meter (235.5) and number of filled grains per panicle (121.7). Percentage increase in rice yield under rice–fish integration system was 7.9–8.6% against control, where paddy was cultivated without integration of fish and prawn probably due to better aeration of water, greater tillering effect and additional supply of fertilizer in form of leftover feed and fish excreta. Irrespective of stocking density, the overall rice equivalent yield (REY) of the system was high (4.22–4.55 tons ha^{-1}) at 12.5-cm weir height plots-cum-refuge, without using any pesticide, herbicide, etc.

4. Conclusion

IFS proves it's tremendous potential for developing farms to their optimum levels by integrating different enterprises in a farming system mode to make agriculture a profitable venture for farmers under different agro-climatic and ecological situations.

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