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RURAL LIVELIHOOD SECURITY THROUGH INTEGRATED FARMING SYSTEM FOR SUSTAINABLE AGRICULTURE - A REVIEW

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Abstract

Integrated farming system is a multidisciplinary intact farm approach and incredibly efficient in solving the tribulations of marginal and small farmers. The approach aims at escalating income and employment from small-holding by integrating diverse farm enterprises, recycling of crop residues and byproducts inside the farm itself. The farmers necessitate to be secured of customary income for living at least above poverty line. The advancement in production or stable growth in output is obligatory to face the challenges posed by current technological, economic and political environment. In this circumstance, integrated farming system approach is one of the significant solutions to countenance this unusual condition as in this approach the different enterprises can be suspiciously undertaken and the location specific systems are developed based on obtainable resources which will consequences into sustainable development.

Keywords- Integrated farming system, sustainable agriculture, diversification, natural resources.

Introduction

Agriculture is the mainstay of the Indian economy, as it constitutes the backbone of the rural livelihood security system. It is the core of planned economic development in India, as the trickle-down effect of agriculture is significant in reducing poverty and regional inequality in the country. Indian agriculture at present faces a multitude of various challenges and constraints due to the ever increasing population, escalating food and fodder demands, degradation of natural resources, higher cost of agro-inputs and climate change. A phenomenal boost in foodgrains production from 51 million tonnes in 1950-51 to a record production of 297.50 million tonnes (https://eands.dacnet.nic.in/) in the year 2019-20 could be achieved using improved technologies including integrated farming systems (IFS).

The country's population is expected to reach 1660 million by the year 2050 and for which 349 million tonnes of foodgrains will be required. It is predictable that land area available in 2050 would be 137 million ha. To meet out this prerequisite there is vital need to double the productivity of agricultural crops from the existing level. Since there is no further scope for horizontal expansion of land for cultivation of farm enterprises, the emphasis should be on vertical expansion by increasing the productivity using the available resources properly and choosing the best enterprises. The income from cropping alone is barely enough to sustain the

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farmer's family in case of small and marginal farmers; those comprise of 80.3 % agricultural population with only 36 % of area operated. With decline in farm size due to detonation of population, it would be increasingly difficult to produce enough food for the family by the end of 21st century. The farmers have to be assured of customary income for living at least above poverty line. The progress in production or steady growth in output is necessary to face the challenges posed by present technological, environmental, economic and political. A majority of these farmers is suffering from poverty and unemployment, which results a failure to achieve necessary households makes a living over time (Dashora and Singh, 2014).

Status of rural livelihood

At present, India alone accounts for 1/4th of all world hunger. Inadequate or lack of purchasing power among the poor is the main cause of food insecurity in rural India. The per capita consumption of most food items in rural India is far below the recommended dietary allowances. Though the per capita intake of cereals is closer to or above the standard requirements, the consumption of all other food items throughout the country is woefully lower than their respective dietary requirements as per Indian Council of Medical Research (ICMR) norms. In eastern- central India the per capita cereal, pulse, oilseed and vegetables consumption are 483.8, 20.5, 9.6 and 57.8 g/day, respectively which are very lower as compared to the ICMR Norms except cereals. The Norms are 420.0, 40.0, 22.0 and 125 g/day, respectively for daily requirement of cereal, pulse, oilseed and vegetables. A general low intake of pulses, vegetables, fruits, fats and oils, eggs, meat and fish is responsible for widespread occurrence of protein energy malnutrition (PEM) and chronic energy deficiency (CED). It was reported that 23 to 70 % of the rural population in different parts of India is suffering from PEM, while the CED affected 17 to 54 % of people. Child malnutrition rates in India are still very high. According to the UNDP, 53 % of children under five in India were under-weight during the period 1990-97, the highest rate from any of the 174 developing countries listed (Gautam *et.al*, 2007).

In this context, farming system approach is one of the important solutions to face this distinctive situation as in farming system approach the different enterprises can be carefully undertaken and the location specific systems are developed based on available resources which will result into sustainable development. It is also a fact that highly productive lands have been diverted from agriculture to infrastructural development, urbanization and other related activities. Under these circumstances the only option is to increase the productivity vertically. Increasing productivity of crops ensure the livelihood security of the farmers because it depends upon the productivity of their fields. It accelerated progress in enhancing the productivity, profitability, stability and sustainability of the major farming systems is the best safety net against hunger and poverty. In view of these situations, Integrated Farming System is the only way through which the target could be achieved.

India's land resource and food production

India has 2 % of world's land, 4 % of freshwater, 16 % of human population, and 10 % of its cattle population at global level .The geographical area is 329 million ha of which 47 % (142 million ha.) is cultivated, 23 % is under forest, 7 % under non-agriculture use and 23 % under waste lands. The per capita availability of land 50 years ago was 0.9 ha, which would be only 0.14 ha during 2050. Out of the cultivated area, 37 % is under irrigated area, which produces 55 % food; whereas 63 % is under rainfed condition producing 45 % of the total 210 million tonnes

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of food produced. In next 50 years, the proportion could be 50:50 producing 75:25 of 500 million tonnes of required food.

Causes for Yield Gap

There is wide gap between farmer yield and achievable yield of different farm commodities. The farmer yield, achievable yield and gap in the yield of some farm commodities are given in Table 1.

Table 1. Gaps between farmer yield and achievable yield of the component enterprises.

Farm commodities	Farmer yield	Achievable yield (Av.) q/ha	Gap (%) (Av.) q/ha
Sugarcane (Plant)	540	1,100	103
Sugarcane (Ratoon)	740	1,300	75.7
Wheat	46	65	41.3
Rice	42	65	54.8
Milk (Improved cow)	7.36 kg/animal/day	20 kg/animal/day	171.7
Buffaloes	5.22 kg/animal/day	12 g/animal/day	129.9

Source: Singh, J.P. and Gill, M.S. (2010).

Similarly the production of other enterprises such as horticultural crops, bee-keeping and fisheries etc. is also much less than potential yield of different commodities. The major factors responsible for poor yield identified are given here.

Production constraints

Crop production

- Delayed sowing / planting of crops, especially of wheat and sugarcane.
- Use of higher seed rate.
- Improper sowing methods, broadcasting in most of the cases.
- Use of undecomposed farm yard manure.
- Imbalanced use of fertilizers and method of application.
- Lack of knowledge about diseases and pests management.

Animal husbandry

- Rearing of poor yielder, uneconomical animal breeds.
- Feeding poor quality feed & fodder and that too in imbalanced form.
- Non availability of green fodders throughout the year.
- Little use of minerals, salts and vitamins.
- No price support – poor milk price at farmer doorstep.
- Widespread fertility problem, anoestrus, repetitions in heat, improper time of service, service by local and non-destructive bull.

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Horticultural crops

Mango: The main problems of mango include:

- Alternate bearing
- Malformation
- Diseases like bacterial blight and powdery mildew
- Pests like hopper and mealy bug
- Talking orchard by non-traditional farmers
- Grow unsuitable crops in orchards
- Lack of processing units.

Vegetables: In vegetables main problems are:

- Non-availability of good quality seed
- Sowing of seed without proper treatment
- Lack of suitable variety
- Suitable techniques
- Pest and diseases problems.

Floriculture: In floriculture problems are:

- No suitable variety of marigold particularly for rainy season crop.
- Disease and pest.

Bee-keeping

- Lack of technical know-how
- Adoption at small scale
- Non-availability of desired flower plants round the year for honey bees feeding
- Lack of improved honeybees colonies
- Incidence of pests and diseases

Poultry

- Lack of technical know-how
- Poor housing facility
- Non-availability of electricity
- High risk of diseases

Fishery

- Social and religious factor
- Small size ponds
- Theft
- Poisoning
- Lack of technical know-how
- Unawareness

Farming Systems Strategy

In view of serious limitations on horizontal expansion of land and agriculture, only alternative left is for vertical expansion through various farm enterprises required less space and time but giving high productivity and ensuring periodic income specially for the small and marginal farmers located in rainfed areas, dry lands, arid zone, hilly areas, tribal belts and problem soils. The following farm enterprises could be combined:

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- Agriculture alone with different crop combinations
- Agriculture + Livestock
- Agriculture + Livestock + poultry
- Agriculture +Horticulture + Sericulture
- Agro-forestry + Silvi-pasture
- Agriculture (Rice) + Fish culture
- Agriculture (Rice) + Fish + Mushroom cultivation
- Floriculture + Apiary (beekeeping)
- Fishery + Duckery + poultry

For meaningful execution of integrated farm-enterprises, the following activities should be undertaken by a multi-disciplinary team of extension professionals with farmer's participation and involvement at all stages.

Research Findings

Research carried out in low land, irrigated upland and rainfed lands of different parts of country have demonstrated the technical feasibility and economic viability of the integrated farming systems.

i) Low Land Farming System

Paddy-poultry- fish-mushroom integration on-station studies were conducted between 1987-1992 talking the marginal farmers' situations *i.e.* problems and opportunities into considerations. Economic analysis of the study of the system under low land ecosystem of Tamil Nadu in India revealed that a net profit of Rs. 11,755/year was obtained from paddy-poultry-fish-mushroom IFS in 0.4 ha area while, in conventional cropping system with paddy-paddy-green manure/pulses gave a net income of Rs. 6,334/year (Table 2) from the same area.

Table 2. Economics of paddy based farming systems for a marginal farmer (0.4 ha) under low land ecosystem in Tamil Nadu (mean of 5 years)**.**

Component	Expenditure (Rs)	Gross Return (Rs)	Net Return (Rs)
Integrated Farming System			
Crop	11,398	19,076	7,678
Poultry	1,944	2,861	917
Fishery	1,486	3,568	2,082
Mushroom	5,078	6,156	1,078
Total	19,906	31,661	11,755
Conventional cropping system (CCS)	7,202	13,536	6,334
Additional income in IFS over CCS			5,421

Source: Rangaswamy *et al.* (1996).

A study was carried out during 2008-09 to 2010-11 at farmers' field utilizing aqua-terrestrial ecosystem situated under new alluvial zone of West Bengal. Experiment comprised of 11 enterprises, of which 5 sole systems of crops and fishes and 6 treatment of integration of deep-water paddy, underutilized aquatic food crops, water chestnut or *singhara* and foxnut or *makhana* and fish variables (mixture of carp and air-breathing live-fishes) under aquatic, ducks (*Khaki campbell*) in semi-aquatic and vegetables/other perennial tree plantations under arable land was carried out on 1.0 ha area. All the enterprize combinations were productive and profitable than that of sole system either aquatic crop or fishes individually. In these enterprizing combinations it not only led to higher productivity but also generated more income employment opportunity sustainable for livelihood security including improvement of fertility status of pond-bottom soil. Maximum benefits were obtained from IFS, where foxnut or *makhana* combined with live fisheries in aquatic including other variables practiced under adjacent arable lands, while lower values exhibited with deep-water paddy integrated with carp-fishes. Besides integration of fishes, duckery was found to be good alternative farming system, especially for development of women empowerment in the areas (Puste *et. al*., 2013).

ii) Irrigated Upland Farming System

Three farming system models were evaluated during 2008-09 and 2009-10 at Rahuri, Maharastra. On-station IFS Model-I, involving field crops, horticulture, dairy, poultry and fishery was developed at the research farm. Similarly, on-farm IFS model-II, involving crop dairy, poultry was developed and on-station cropping sequence model –III, involving soybean-wheat was taken for comparison. These models were developed in 2.0 ha area under irrigated condition. On-station and on-farm IFS models were found more remunerative than the on-station cropping sequence model, showing maximum net return of Rs. 1,99,848/- water productivity (Rs 991/ha-cm), employment generation (1,275 man-days/ha/year) and energy balance (4,11,949 MJ/ha), while the on-farm IFS model resulted Rs 48,477, Rs 406/ha-cm, 657 man-days/ha/year and 3,25,528 MJ/ha values of these parameters, respectively. These values for the model-III were the minimum with Rs 32,613, Rs 375/ha-cm, 227 man-days/ha/year and 1,53,379 MJ/ha, respectively (Surve *et.al.*, 2014). Thus, IFS proved promising and remunerative to soybean-wheat cropping system with higher net returns, water productivity, employment generation and energy output.

Table 3. Physico-chemical properties of soil of different farming system models at initiation and after completion of research work

Soil Properties	**On-station IFS model-I**		**On-farm IFS model-I**		**On-station cropping model-III**	
	Initial	Final	Initial	Final	Initial	Final
Physical properties						
Texture class	Clay loam		Sandy clay loam		Clay loam	
Field Capacity (%) by weight basis	32.2	34.7	30.1	29.6	34.1	34.9
Permanent wilting point (%) by weight basis	19.2	18.2	17.2	17.9	20.1	20.3
Available Soil moisture (%)	13.0	16.5	12.9	11.7	14.0	14.6
Bulk density (mg/m^3)	1.3	1.2	1.4	1.4	1.3	1.2
Chemical properties						
Soil pH (1:2.5)	8.0	7.7	8.8	8.9	7.9	7.6
EC (ds/m)	0.4	0.3	0.5	0.5	0.4	0.3

Organic Carbon (%)	0.6	0.7	0.4	0.4	0.4	0.4
Available nitrogen (kg/ha)	150.5	175.2	130.5	120.0	160.5	178.2
Available phosphorus (kg/ha)	14.1	16.9	16.2	15.9	16.8	15.1
Available potash (kg/ha)	616	672	480.0	455.0	490.0	478

Source: Surve *et.al.* (2014).

Among the 3 farming system models, there was better improvement in fertility status of soil in research farm integrated farming system model as compared with on-farm integrated farming system model and research farm sequence cropping model (Table 3).

iii) Rainfed Farming System

Rainfed agriculture occupies about 68% of country's cultivated area and accounts for nearly 44% of the total food production. Rainfed agriculture is complex, highly diverse and risk prone. It is characterized by low levels of productivity and input usage coupled with vagaries of monsoon emanating from climate change; resulting in wide variation and instability in crop yields. In view of the growing demand for food grains in the country, there is a need to develop and enhance the productivity of rainfed areas. If managed properly, these areas have tremendous potential to contribute a larger share in food production and faster agricultural growth compared to the irrigated areas which have reached a plateau.

Field experiment was conducted at 5 clusters located in 3 districts of Odisha, under rainfed medium land situations across 2010-13. The experiment aimed at comparing performance of pond based IFS model comprising paddy-Onion cropping system, pissiculture + on dyke plantation, poultry and mushroom with conventional cropping system with paddy-green gram for system productivity and impact of soil health. The IFS model gave total system productivity of 31.92 tonnes paddy equivalent yield (PEY) as compared to 3.78 tonnes and net returns of Rs 1,61,148/- as compared to Rs. 11,631/- under paddy-green gram cropping system. There was decrease in bulk density, increase in soil pH, Organic Carbon, soil N, P and K status and increase in the population of soil micro-organisms (bacteria, actinomycetes, Azotobacter) compared to initial values (Sahoo *et. al*, 2015)

A study was conducted in Maitha and Akbarpur block of district Kanpur Dehat, Uttar Pradesh, India to find out a sustainable and economically viable farming system model being integrated with the components like crop, livestock, poultry and goatary on 1 acre land. Among the various model being followed, integration of 2 bullocks +1 cow +1 buffalo +5 goats +10 poultry birds along with crop cultivation was found most profitable with a net income of Rs 35687/ year as compared to crop cultivation alone Rs 9276/ year. This occupied the highest B: C ratio 1:2.33 and 295 days of employment generation. Significant amount of animal feed was available from the system itself. The farmyard manure from the animal component used for manuring saved 30-35 % chemical fertilizer in mixed farming system. From the study, it is concluded that integrated farming system with 2 bullocks + 1 cow + 1 buffalo + 10 goats along with other subsidiary enterprise like poultry was proved more beneficial for augmenting the income and livelihood of the marginal farmers (Khan *et al.*, 2015).

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Importance of mixed crop-livestock systems

Mixed crop-livestock systems produce 50% of global cereals, 34% of beef and 30% of milk. Almost one billion people rely on these systems as their primary source of livelihood. An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained 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 express a winning combination that reduces erosion, Increases crop yields, soil biological activity and nutrient recycling, Intensifies land use, improving profits and can therefore help reduce poverty and malnutrition and strengthen environmental sustainability but small farmers need to have sufficient access to knowledge, assets and inputs to manage this system in a way that is economically and environmentally sustainable over the long term (Indira, 2017).

Economic Importance of IFS

Jayanthi *et al*. (2003) and Ravishankar *et al*. (2007) observed that the findings of net returns obtained from all the components was Rs. 22,887 with an increase of 32.3 % higher returns than conventional rice-rice system. Ramrao *et al*. (2005) developed a crop livestock mixed farming model of 1.5 acre small scale holders with the employment generation of 571 man days, net income of Rs. 58,456 per year against crop farming alone with employment generation of 385 man days and net returns of Rs. 18,300 per year only. Ramrao *et al*. (2006) reported that the mixed farming of 2 bullocks + 1 cow + 1buffalo + 10 goats + 10 poultry and 10 ducks gave a net return of Rs 33,076 compared to Rs 7843 from arable farming. Veerabhadraiah (2007) noticed that the crop livestock integrated farmers were getting higher returns i.e. a farmer with 2.5 acres of irrigated land, HF and Buffaloes were earning Rs. 1, 04,321 and a farmer with 3.5 acres of irrigated land with 2 cows and 4 sheep earning Rs. 78,867 and a farmer with one acre of irrigated land with 4 HF cows were getting Rs. 1, 32,000. Ramasamy *et al*. (2008) reported that the income from integrated crop + livestock + goat + poultry was Rs. 98,270 than Rs. 28,600 in traditional farming system. Similarly income of Rs. 99,209 in IFS with the crop + livestock + goat + poultry than conventional farming system. Nageswaran *et al*. (2009) identified that the annual net revenue per acre is higher for IFS as compared to CFS: the average net annual revenues per acre of IFS and CFS are Rs. 11,662. 57 and Rs. 4, 553.31 respectively. Annual employment per acre is turned out to be 185.78 person days in IFS and that of CFS 89.3 persons respectively. Ray (2009) reported that the IFS with cropping, fisheries, poultry, mushroom provided a net additional income of Rs. 12,500 /ha /year and created an additional employment of 550 man days / year as compared to conventional cropping system. Channabasavanna *et al*. (2009) calculated the benefit cost ratio of 1.97 in IFS compared to conventional system which is of 1.64. Amongst the different components of Palladam district of goat recorded the highest benefit cost ratio (2.75) followed by fish (2.23), vegetables (2.00) whereas poultry showed the lowest benefit cost ratio (1.13) as a result of high cost of maintenance. Tripathi *et al*. (2010) revealed that the integration of 7 different enterprises namely, crop + fish + goat + Vermicompost + fruit production + spice production + agro forestry obtained the net return to the tune of Rs. 2,30,329 annually with the benefit cost ratio (BCR) of 1.07:1 and also reported the maximum per cent contribution of the enterprise is the fish production (68.53 %) followed by vermicomposting

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(9.90 %), spices (8.46 %) and animal production (7.40 %). The BCR was found to be highest for the spice production (1.83:1) after fishery (2.25:1) followed by the vermicomposting (1.45:1).

Opportunities

- Intensification of agriculture which is currently occurring in most farming systems favours crop–livestock integration.
- Optimal crop and livestock combination consistent with the farm resources instantly provides an opportunity to increase profitability and regular flow of income by virtue of intensification of crops and allied enterprises.
- Poor soil fertility, unavailability or increases in prices of fertilizers, and labour shortages, have forced farmers to rely on alternatives such as manure and traction.
- In Integrated farming System, organic supplementation through effective utilization of on/off farm residues / waste of linked components as manures. In addition vermi-composting constitutes an essential component of Integrated Farming System. Thereby IFS helps to maintain sustainable status of soil fertility in terms of physical, chemical and micro biological properties.
- Immigration of rural poor and agricultural labors could be solved by integrating allied appropriate components in different eco-zones as situated to varied resource situations. The rural and farm women falling under small and marginal categories as well as Agricultural landless laborers will be benefited through the regular employment by integrated farming system.
- The integration of small ruminants and buffaloes, agro-forestry and silvi-pastoral system along with cropping provide good scope for livelihood even under erratic rainfall situations.
- Farmers can grow crop in the wet season and engage in livestock enterprises in the dry season.
- Livestock enterprises are more lucrative than crop farming so it is advantageous to integrate livestock into farm activities.
- Many indigenous, emerging, and developed technologies are available to support sustainable crop– livestock integration. These include improved cereal and grain legume varieties, cropping systems, weed and nutrient management strategies, the eradication of most livestock diseases, and the development of modeling and all-year-round feed packages for animals.

Conclusion

Per capita availability of land in India has declined from 0.9 ha in the year 1950-51 which would be only 0.14 ha during 2050. Therefore, no single farm enterprise is able to meet the growing demands of food and other necessities of the small and marginal farmers. Agriculture is in the hands of 125 million farm families of which 75% are the marginal farmers (<1 ha holding). “Farming Systems” represent the integration of farm enterprises such as cropping systems, horticulture, animal husbandry, fishery, agro-forestry, apiary etc. for optimal utilization of farm resources bringing prosperity to the farmers. A thoughtful combination of cropping systems with allied enterprises like horticultural crops, sericulture, poultry, dairy, piggery, duckery, goatary, fishery, mushroom etc. suited to the given agro-climatic conditions and socio-

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economic status of the farmers shall be able to generate additional employment and income for the small and marginal farmers both under rainfed and irrigated conditions.

Farming system approach to agricultural research and development efforts would accelerate agricultural growth of the country and thereby providing influence for transforming poverty prone rural India to a prosperous India by strengthening rural economy. Certainly this will play significant role in agricultural revolution in the 21st century, which is very much imperative to sustainable economic growth for farming communities in country.

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