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Enhancement in productivity and income sustainability through Integrated farming system approaches for small and marginal farmers of Eastern India

SANJEEV KUMAR*, SHIVANI, SK SAMAL, SK DWIVEDI AND MANIBHUSHAN
ICAR Research Complex for Eastern Region, Patna- 800 014 (Bihar) India

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ABSTRACT

Integration of different components viz. livestock, fishery, horticulture, mushroom etc. along with field crops not only enhanced productivity but by-products (waste) of one component act as input for another component through resource recycling within the system. Six integrated farming systems models with suitable combinations of Crop, vegetables, fruit trees, fish, livestock, mushroom etc. were made and evaluated at the experimental farm of ICAR Research Complex for Eastern Region, Patna during 2012-16 for harness maximum income, nutrient recycling and employment. Among six combinations, crop + fish + duck + goat resulted as most profitable combination in terms of productivity (RGEY- 22.2t), net income (Rs. 2,15,900/ha), additional employment (170 days/year) with income sustainability index (ISI) by 90.2. Upon nutrient recycling prepared from different wastes from the system Crop + fish + duck + goat combination added N (56.5 kg), P (39.6 kg) and K (42.7 kg) into the soil and reduced the cost of cultivation by 24 percent and was followed by crop + fish + goat combination. Crops grown under IFS mode with different types of manures produced 31 percent higher yield over conventional rice- wheat system. The contribution of crops towards the system productivity ranged from 36.4 to 56.2 %, while fish ranged from 22.0-33.5 %; for goat 25.4-32.9 %; for poultry 38.7 %; for duck 22.0-29.0 %; for cattle 32.2% and for mushroom 10.3 %.

Keywords: Integrated farming systems, cropping systems, productivity, sustainability, nutrient recycling and economics

INTRODUCTION

Indian economy is mainly agriculture oriented where small and marginal farmers are the core of the Indian rural economy constituting 85% of the total farming community but possessing only 44% of the total operational land (GOI, 2014). The average size of operational land holdings has reduced by half from 2.28 ha in 1970-71 to 1.16 ha in 2010-11. The operational farm holding in India is still declining. In Bihar and Kerala, the average size of holding fell by more than three times during the last four decades, whereas in Andhra Pradesh, Karnataka, Madhya Pradesh and Maharashtra, it has reduced by more than two times. This is reflective of the immense population pressure on the limited land resource available for cultivation (NABARD, 2014). The declining trend of per capita land availability poses a serious challenge to the sustainability and profitability of farming (Siddeswaran *et al.*, 2012). In the eastern states situation is even more critical as more than 80 percent farmers lies under small and marginal farmer category and per capita land availability is around one acre (4000m^2) or less than one acre. Due to ever increasing population and shrinking land resources in the country, practically there is hardly any scope for horizontal expansion of land for food production. Only vertical expansion is possible by integrating appropriate farming components that require lesser space and time to ensure reasonable periodic income to farm families. From green revolution, onwards farmers are mostly concentrating on single enterprise based agricultural systems that lead to deterioration of soil health, increased risk of crop failure and downward trends of productivity (Rahman and Sarkar, 2012). Rapid population growth, urbanization and income growth in developing countries like India, the demand for food of animal origin is increasing, while also aggravating the competition between crops and livestock (increasing cropping areas and reducing rangelands).

Farming with system approach is the need of the hour for fulfilling the demand of ever increasing population without disturbing the ecological balance. Integrated farming system seems to be the possible solution to the continuous increase of demand for food production, stability of income and nutritional security particularly for the small and marginal farmers with limited resources. It is not only a reliable way of obtaining a fairly high productivity with substantial fertilizer economy but also a concept of ecological soundness, leading to sustainable agriculture. Further, modest increments in land productivity are no longer sufficient for the resource-poor farmers. Hence, intelligent management of available resources, including optimum allocation of resources, is important to alleviate the risk related to land sustainability. Planning and implementation of different enterprises in Integrated farming system in our country lacks scientific and systemic approach. Moreover, proper understanding of

*Corresponding Author Email: shiv_sanjeev@yahoo.co.in

interactions and linkages between the components would improve food security, employment generation as well as nutritional security. This approach can be transformed into farming system that integrates crops with enterprises such as – agro forestry; horticulture; cow, sheep and goat rearing; fishery; poultry and pigeon rearing; mushroom production; sericulture; and biogas production to increase the income and improve the standard of living of small and marginal farmers. Therefore, the present investigation was undertaken to identify suitable combination of components for higher net returns and employment generation in a farming system mode.

MATERIALS AND METHODS

Field studies on integration of different components with crop in Integrated Farming Systems (IFS) mode and recycling of resources within the system were carried out at main farm of ICAR Research Complex for Eastern Region, Patna during 2012-15 which involved crops, poultry, cattle, goat, mushroom farming, fishery and duckery in different combinations, to recycle the residues and by-products of one component over the others. Soil of the experimental block was clay loam in texture, having pH 6.8, Electrical conductivity 0.42 dsm-^{1}, organic carbon 0.58 (kg/m^{3}), available N 180.2 kg/ha, P 12.1 and exchangeable K 168.6 kg/ha. Seven farming systems were taken for evaluation and each treatment was allocated an area of 0.8 ha (2 acre). These systems were (i) crop alone (ii) crop + fish + poultry (iii) crop + fish + duck (iv) crop + fish + goat (v) crop + fish + duck + goat (vi) crop + fish + cattle (vii) crop + fish + mushroom. In 2 acre (0.8 ha) farm, an area of 0.1 ha for growing fodder crops to feed cattle (2 cows + 2 calves) and goat (20 female goat + 1 buck), 0.02 ha allocated for goat shed, 0.02 ha for cattle shed, 0.02 ha for mushroom shed, 0.02 ha for FYM and vermipits and remaining 0.12 ha allotted to fish pond. The cropping area of each system varied depending upon the area occupied by different components/enterprises of that farming system (Table 1).

Table 1: Productivity [rice grain equivalent yield (RGEY) in t/ha] of different cropping sequences under integrated farming system as affected by different manures /by-products (2012-15)

Source of nutrients	Rice- wheat-moong (R-W-M)				Rice-maize-dhaincha (R-M-D)				Average of R-W-M and R-M-D cropping systems			
	2012-13	2013-14	2014-15	Pooled data	2012-13	2013-14	2014-15	Pooled data	2012-13	2013-14	2014-15	Pooled data
Recycled pond silt (poultry) + poultry manure	11.36	11.59	11.10	11.35	13.24	13.38	13.14	13.25	12.30	12.49	12.12	12.30
Recycled pond silt (duck)	11.15	11.27	10.96	11.13	12.85	12.96	12.77	12.86	12.01	12.12	11.87	12.00
Goat manure	11.33	11.42	11.12	11.29	13.10	13.16	13.06	13.11	12.21	12.29	12.09	12.20
Cattle manure	11.36	11.21	11.14	11.24	12.93	13.15	12.75	12.94	12.15	12.18	11.95	12.09
Vermicompost	11.42	11.78	11.21	11.47	13.05	13.37	12.80	13.07	12.23	12.57	12.00	12.27
Mean	11.38	11.51	11.17	11.36	13.03	13.20	12.90	13.05	12.21	12.36	12.04	12.20
S.D.	0.21	0.35	0.20	0.25	0.15	0.18	0.18	0.15	0.14	0.25	0.12	0.17

Under integrated farming system by-products of one component act as input for another linked component thereby showing input-output relationship. Number of units or allocation of area under different enterprises follows this relationship. It gives an idea about the output of one component, which can fulfill the input requirement of other related component so that an effective integration can be made among different enterprises. One unit of goat (20+1) or one unit of cattle (2 cows) has been selected for integration in 2acre model. Two cows provide sufficient amount of FYM to fertilize the soil in combination with inorganic fertilizer. Vegetable and fruit crops are grown to fulfill the family requirement and for getting regular income. The animal waste from cow @14kg/day/animal, goat@ 300g/day/animal, poultry litter along with the unutilized feed and crop residues/ byproducts were collected and used for preparing vermicompost, which was recycled to the field of the respective IFS model. Depending upon the requirement of a family having seven members this model has been developed. The area required for animal as well as crop was allocated in 0.8 ha area (Table 1). Hundred numbers of poultry birds, 40 ducks sheltered over the fish ponds and cattle unit maintained in cattle shed were linked to supplement the feed requirement of polycultured fingerlings (1000 numbers) reared in each pond to assess the feasibility of rearing fishes by using different manure as feed. Vermi-pits and FYM pits were also linked with cattle and crops. Under goatry component, 20 female goats + 1 buck (Black Bengal breed) were reared for meat purpose and goat droppings were used as goat manure to the crops. In one year, 45 kids were reared and sold @ Rs. 200/kg live weight (kids were sold at the age of 8-9 months). Under poultry component, one-day-old broiler chicks of Ross breed were reared in batches. 100 broiler chicks/batch (total 7 batches/year) were maintained for meat purpose. Each batch was maintained for 40 days. The broilers attained an average weight of 1.5 kg during the period (35-40 days), which were sold @ Rs. 90/kg live weight. 50 percent poultry droppings/ litters were used in pond as feed for fishes and rest 50 percent of droppings were used in the crops as manure. Under fishery component, composite fish farming was practiced. Fresh water fish, rohu (*Labeo rohita*) as column feeder (30 percent), catla (*Catla catla*) as surface feeder (30 percent) and mrigal (*Cirrhinus mrigala*) as bottom feeder (40 percent) were raised in both the ponds. At the end of first year, the grown-up fishes were harvested thrice at 20 days interval. Water in the ponds were drained and dried and settled silts (5 tonnes) were removed and applied as organic source to the first crop in the sequence. Under duckery (Khakhi Campbell), 30 female and 5 male ducks were integrated with the pond. Three months old 35 ducklings were purchased and reared which after five months started laying eggs. Droppings of ducks were fed to fishes and no extra feed was provided to the fishes. Number of eggs laid /annum were recorded. Year-round mushroom production was also included in the system in an area of 0.02 ha by making a small hut with available local materials. From April- September, 100 bags of Milky mushroom (Calocybe indica) whereas, from October to March, 100 bags of Oyster mushroom (Pleurotus spp.) were raised by making bamboo racks in the shed through out the year. Proper humidity (75- 80 per cent) was maintained in the hut during the crop season by sprinkling water over the walls of hut and over the bags. Proper agronomic management to all crops, healthy and hygienic conditions was maintained to animals and birds as per recommendations.

In another 2 acre (0.8 ha) area, conventional cropping system as practiced by farmers was taken up for comparison. In conventional cropping systems i) Rice (*Oryza sativa* L.) – wheat (T. *aestivum*) and ii) Rice (Oryza sativa L.) - maize (*Zea mays* L.), each in 0.4 ha as practiced by farmers were followed while under IFS, i) Rice (*Oryza sativa* L.) – wheat (*T. aestivum*) - moong (*Vigna radiata*) and ii) Rice (*Oryza sativa* L.) - maize (*Zea mays* L.)- dhainha (*Susbania spp*.) were taken as crop. In treatment 'crop alone' two cropping systems viz. rice-wheat-moong and rice-maize-dhaincha were grown with recommended dose of fertilizer i.e. 120:60:40kg NPK/ha each for rice, wheat & maize and 20:40 kg N&P/ha for moong/dhaincha crop (in inorganic form) where as in other farming systems inorganic as well as organic manure (obtained through that particular system) were applied to the crops. The yield of rice- wheat- moong and rice- maize-moong obtained from different organic and inorganic fertilizers as discussed were taken as yield of treatment 'crop alone' as well as crop component under different farming systems. To sustain the productivity of soil, inorganic fertilizers combined with organic wastes obtained from various components of IFS recycled pond silt, poultry manure, duck manure, goat manure and cow dung as FYM, composted residues (cereal residues) and vermicompost each @ 10t/ha were applied to the crops grown under different IFS module. The FYM, vermicompost, poultry manure, duck manure, goat manure as well as poultry and duckery recycled silt were used once in a year for raising crops. The rest of the nutrients were applied in form of inorganic fertilizer to each crop as per recommendation. Water was applied as per requirement of different enterprises. All crops were irrigated on the basis of optimum IW:CPE ratio and 5 cm water was applied for each irrigation. Summer maize (*Zea mays* L.)- napier grass (*Pennisetum purpureum* Schum.)- berseem (*Trifolium alexandrinum)*/oat (*Avena spp.*) fodder system were followed in 0.1 ha of land.

The birds and animals were fed upon straws, green fodder and oil cakes/maize grains obtained from the system. Only concentrate mixtures for animals and poultry were purchased from market and expenditures on these items were included in the cost of production. Observations were made on productivity in terms of rice–grain equivalent yield, economics and employment for different farming systems as well as conventional cropping system. Economics were calculated on prevailing market price of different commodities viz. Rice grain @ Rs. 14/kg; poultry @ Rs. 90/kg; duck egg@ Rs. 4/egg (or say Rs. 40/kg); goat meat @ Rs. 200/kg; milk @ Rs. 30/lit. and fish @ Rs. 120/kg.

Developed IFS models were evaluated based on sustainability index (S.I.) as described by Kumar *et al.* (2012b). The S.I. for any IFS model can be computed as:

S.I.= (NR- SD) / (MNR)

Where, NR stands for net returns obtained under any model, SD stands for standard deviation of net returns of all models and MNR stands for maximum net returns attained under any model. A suitable and viable IFS model could be identified for their existence based on net return, sustainability index, employment generation and improvement in soil fertility attained over a period of time.

RESULTS AND DISCUSSION

System productivity

Maximization of yield of each component can be done under Integrated farming system per unit area and per unit time by virtue of intensification of crop and allied enterprises. The productivity of different components (viz. crop/fish/duck/ poultry/ goat/cattle/mushroom) integrated in each system was expressed in terms of rice grain equivalent yield. The contribution of crops towards the system productivity ranged from 36.4 to 56.2 %, while fish ranged from 22.0-33.5 %; for goat 25.4-32.9 %; for poultry 38.7 %; for duck 22.0-29.0 %; for cattle 32.2% and for mushroom 10.3 % (Table 4). Results on different combinations for three years revealed that integration of crop+fish+duck+goat resulted in highest system productivity in terms of rice grain equivalent yield. Crop +fish +duck + goat and crop +fish +goat model recorded 167 and 164 % more productivity over cropping alone. Similarly crop +fish + poultry model gave 162.2 % higher productivity than growing crops alone. Besides inorganic fertilizer application of recycled pond silt, poultry manure, duck manure, goat manure and cow dung as FYM, composted residues (cereal residues) and vermicompost under different IFS module provide congenial situation to increase the yield. Productivity of conventional cropping system was lesser than the productivity of cropping systems practiced in integrated farming system models (Table 2 and 3). Korikanthimath and Manjunath (2009) working in Goa also opined that integrated farming systems are much better over existing cropping system.

Table 2: Rice grain equivalent yield and economics of conventional cropping system (2012-15)

Cropping Systems	RGEY (t/ha)				Gross returns (Rs./ha) (x 10^3/ha)	Production cost (Rs./ha) (x 10^3/ha)	Net return (Rs./ha) (x 103/ha) (x 10^3/ha)	B:C ratio
	2012-13	2013-14	2014-15	Av.				
Rice-wheat	8.02	8.1	8.2	8.11	94.2	52.0	40.2	1.8
Rice-maize	9.2	9.0	9.3	9.2	8402	50.2	40.0	1.7
Mean	8.6	8.55	8.7	8.6	89.2	51.1	39.7	1.7
S.D.	0.55	0.69	0.56	0.60	6010	798	6808	0.15

Among different cropping sequences, under IFS compared, rice- rice- moong recorded higher mean yields than rice-maize- dhaincha cropping sequence viz. 13.25, 12.86, 13.11, 12.94 and 13.07 kg when applied with recycled fish pond silt + poultry manure, duck manure, goat manure, cattle manure and vermicompost, respectively than rice- wheat- dhaincha cropping sequence (Table 1 and 2). However, rice- maize-moong registered higher average productivity of 13.25t with recycled pond silt + poultry manure (50 + 50 per cent). 32.3 tonnes of grasses and legume mixture (maize-napier- berseem) was also obtained from 0.1 ha, and was utilized as feed for animals. Crop + fish +duck + goat and crop + fish + goat integration recorded nearly equal rice- grain-equivalent yield 22.2 and 20.3 t/ha (Table 4) but in terms of economics crop + fish +duck + goat supersedes (Rs. 2,15,900/yr).

The highest yield from different cropping sequences was obtained with poultry recycled droppings with pond silt and was followed by vermicompost in combination with 50 per cent inorganic fertilizers. Crops applied with enriched pond silts having higher nutrients and integration of high value components like fish/poultry/duck/goat/cattle might have contributed for better crop productivity. Similar results of high productivity were also reported by Gill et al (2009) by integrating crop + fish + goat in lowland farming.

While, considering the individual animal component, average productivity of 5.8t was obtained with 20 + 1 goat unit. The goat unit also produced 2,300 kg of goat manure, which was used in crops within the system. While, assessing the feasibility of rearing fish by using poultry and duck droppings as feed, the fishes fed with poultry droppings resulted in higher average fish yield of 171 kg/0.06 ha over duck fed droppings (147kg/0.06 ha) during the experimental period (Table 5). Singh (2012) also reported a higher level of fish productivity through recycling of poultry manure by owing to better plankton development as well as direct feed to fishes. An average productivity of 4370 litres of milk was obtained through two unit of cattle. Poultry was reared for meat purpose where as ducks were reared for egg purpose. Ducks under IFS produced 6240 eggs/year on an average.

Table 3: Productivity in terms of rice grain equivalent yield (t/ha) of different models of integrated farming systems models (mean value of 3 years, 2012-15)

Farming Systems	Component Productivity (RGEY)							System RGEY (t/ha)
	Crop	Poultry	Fish	Duck	Goat	Cattle	Mushroom	
Cropping alone	7.25 (100)	---	---	---	---	---	---	7.25
Crop + Fish + poultry	7.0 (36.4)	7.3 (38.2)	4.9 25.4)	---	---	---	---	19.2
Crop + Fish + Duck	6.6 (40.2)	---	4.9 (20.0)	4.9 (29.9)	---	---	---	16.4
Crop + Fish + Goat	8.7 (43.0)	---	4.9 (24.1)	---	6.7 (32.9)	---	---	20.3
Crop + Fish + Duck + Goat	6.8 (30.6)	---	4.9 (22.0)	4.9 (22.0)	6.7 (25.4)	---	---	22.2
Crop + Fish + Cattle	8.0 (42.1)	----	4.9 (25.7)	---	---	6.1 (32.2)	---	19.0
Crop + Fish + Mushroom	8.2 (56.2)	----	4.9 (33.5)	---	---		1.9 (10.3)	14.6

Note: Figures in parenthesis indicates percent contribution of individual component to total system productivity

Table 4: Productivity (t) and economics (Rs.) of individual components under developed farming systems (2012-16)

Components	RGEY (t)				Av. RGEY (t) (2012-16)	Production cost	Net return	B:C ratio
	2012-13	2013-14	2014-15	2015-16				
Cropping alone	7.28	7.51	7.36	7.32	7.38	48,000	40,560	1.8
Crop + poultry manure	9.84	9.99	9.70	9.80	9.84	52,120	65,480	2.3
Crop + Duck manure	9.60	9.70	9.50	9.42	9.60	52,004	63,196	2.2
Crop + goat manure	9.77	9.83	9.67	9.81	9.76	51,886	65,234	2.3
Crop + FYM	9.72	9.74	9.56	9.61	9.67	51,580	64,460	2.2
Crop + vermicompost	9.78	10.06	9.59	9.46	9.81	52,100	67,180	2.3
Poultry (200 no./batch)	4.50 (1400 broilers)	4.50 (1400 broilers)	4.50 (1400 broilers)	4.5 (1400 broilers)	4.50 (1400 broilers)	24,600	29,400	2.2
Duckery (30 + 5)	1.56 (6240 eggs)	1.56 (6238 eggs)	1.55 (6232 eggs)	1.57 (6251eggs)	1.56 (6240 eggs)	10,990	7,730	1.7
Goat (20 +1)	5.56 (445)	5.60 (448)	5.73 (459)	5.8 (463)	5.63 (450)	24,814	42,746	2.7
Cattle (3+3)	7.33 (4398 lit)	7.25 (4350lit)	7.27 (4362 lit)	7.10 (4310)	7.28 (4370 lit)	66,820	20,540	1.3
Mushroom	1.1	1.2	1.00	1.1	1.10 (160 kg)	5,620	7,580	2.3
Fish fed - poultry drop. (0. 06 ha)	1.02 (176 kg)	0.98 (168 kg)	0.98 (168)	1.0 (172)	0.99 (170kg)	4,810	7,070	2.5
Fish fed - duck drop. (0. 06 ha)	0.82 (140 kg)	0.83 (142 kg)	0.82 (140 kg)	0.81 (140)	0.82 (140 kg)	4,810	5,030	2.0

Note: Figures in parenthesis denotes actual yield, RGEY: Rice grain equivalent yield

Economics of the system

Individual component wise net income, production cost and benefit: cost ratio during the three years' study period is presented in Table 5. However, the pooled economic analysis of the system for one hectare revealed that crop integrated with fish, goat and duck was highly economical with the highest net return as well as net return per day. Crop integrated with fish and goat was next best in terms of net returns. In other words, the highest average net return of Rs. 2,15,900/yr. was obtained from an area of 1.0 ha with an average annual expenditure of Rs. 94,915/yr by integrating crop + fish + duck + goat combination in the system followed by crop + fish + goat (Rs. 1,99,078/yr.) and crop + fish + poultry (Rs. 1,84,900/yr.) combinations.

While considering the individual animal component, higher average net return of Rs. 42, 746/year was obtained with one goat unit (20+1).

Poultry (broilers) rearing is economical only when proper care had been taken, otherwise, it is a risky enterprise due to frequent occurrence and breakout of severe pest and diseases

Table 5: Productivity (RGEY) t/ha and economics of different farming systems (2012-15)

Farming Systems	**RGEY (t/ha)**	**Production cost (Rs/ha)**	**Net return ($Rs10^3$/ha)**	**Net return/ day (Rs.)**	**Income Sustainability Index**
Cropping alone	7.25	48,000	53.5	146	15.4
Crop + fish + poultry	19.2	83,945	184.9	506	78.4
Crop + fish + Duck	16.4	70,219	159.4	436	65.2
Crop + Fish + goat	20.3	83,925	199.3	546	84.2
Crop + fish + duck + goat	22.2	94,915	215.9	591	90.2
Crop + fish + cattle	19.0	125,625	140.4	284	58.4
Crop + fish + mushroom	14.6	70,799	133.6	366	55.6
Mean	17.0	82490	155.3	425	64.0
SD	4.18	24138.5	35.4	90	
CV (%)	24.0	29.3	3.3	0.38	

leading to 50-100 per cent mortality of the birds, which will result in high degree of economic losses. So, proper hygienic conditions should be maintained and birds should be properly vaccinated (Solaiappan *et al,* 2007). A higher B:C ratio was obtained with application of different droppings/ recycled manures used in the crops in combination with inorganic fertilizers in integrated farming system over crop raised alone on chemical fertilizers in conventional cropping system (Table 3) as well as in case where only crops were taken. The crop + fish + duck + goat and crop + fish + goat model produced higher and nearly equal rice- grain-equivalent yield (22.2 and 20.3 t/ha, respectively) over all other models but while considering the economics of different models, crop + fish + duck + goat model was on the top position where as crop + fish + cattle model acquired fourth position in respect of net returns and sustainability index. The reason behind it is that average incurred expenditures in crop+ fish + cattle model was more in case of cattle rearing (Rs. 66,820/yr) i.e. nearly 47% of the total system expenditure per year (Rs. 1,25,600). Gill *et al* (2009) and Singh *et al.* (2012) also reported increase in net income through integrated farming system due to use of recycled products within the system. Crop + fish + duck + goat model emerged as highest profitable enterprise for irrigated lowlands with an average net return of Rs.437/day during the period of experimentation. This was due to the fact that system as a whole provided opportunity to make use of byproduct or waste materials, of one component as input of another.

Income Sustainability Index (ISI)

The different models were evaluated on the basis of income sustainability index. The income sustainability index of integration of different components has been worked out for sustainability of different models of farming systems (Table 5). Results revealed that the highest average income sustainability index for net returns (90.2 %) was obtained from crop + fish + duck + goat model which was followed by crop + fish + goat (84.2 %). Other combinations say IFS models, tested here showed Income sustainability index in the range of 55.6 – 78.4 percent. However, income sustainability index of integration of different components were much higher in comparison with cropping alone (15.4). Income Sustainability Index itself clarifies the benefits from different combinations/unit area. Higher the Income Sustainability Index, higher will be the net return (Kumar *et al,* 2011) and more profitable will be the model. A suitable IFS model could be identified for adoption based on net returns, income sustainability index, employment generation and improvement in soil fertility attained over a period of time (Mali *et al,* 2014).

Nutrient recycling within the system

Integration of different components and recycling of by-products and farm wastes have been practiced in this study. Samples of raw manures/dung of animal and bird, recycled products like FYM, goat manure, vermicompost and silted silt in the ponds were collected and analyzed for their N, P, K contents. An ample quantity if wastes in form of poultry (2.3 t/year), duck (1.6t/year), goatry (2.9t/ha), cattle (14.0t/year) and plant wastes (11.3t/year) in form of vermicompost (0.8t/year) had been obtained from the system which were recycled to the different components in the form of FYM, vermicomposting or feed. The nutrient content of manure increased manifolds after recycling into compost and vermicompost. Residue recycling revealed that integration of crop with fish and duck resulted in higher fish productivity over poultry dropping fed fishes; resulting higher net return of Rs. 7200/yr from 0.06 ha of pond. Poultry unit produced 2.9 t of raw droppings, out of which 25 per cent was fed to fishes and 75 percent was used for preparation of poultry manure and finally applied to the crops. From duck unit, 1.6t of raw droppings were produced per year and total droppings were fed to fishes. Recycling of droppings (25% poultry droppings and 100% duck droppings) through fish ponds, enhanced the nutrient content by 2-3 folds. Due to recycling of different droppings viz. poultry, duck, goat, cattle and plant waste (vermicompost) an additional quantity of 56.5 kg N, 39.6 kg P and 42.7 kg K were added to the soil which added Rs. 4,826/year additional income. Acharya and Mondal (2010) also reported similar benefits due to recycling of different animals' droppings and plant wastes from their findings. By analyzing all waste materials obtained from animals and plants, it can be interpreted that cattle recycled droppings generated highest P and K while poultry generated highest N into the system. Integration of different components with crop depending upon suitability in the system and preferences provided encouraging results and to enhance the productivity, economic returns, generating employment and maintaining soil health of farm and farm families, crop + fish + duck + goat combinations could be adopted in eastern part of India instead of cultivating crop alone on same piece of land under irrigated condition (Singh *et al,* 2012). A flow chart based upon the interaction among different components has been presented as Fig.1.

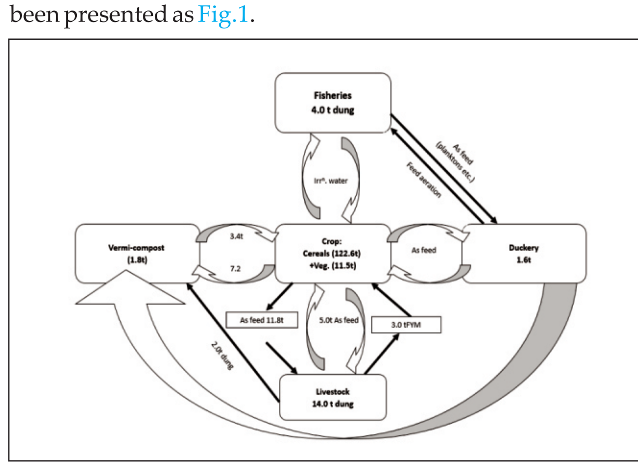

Fig. 1: Nutrient recycling under developed IFS model

System Employment

It can be well understood that due to integration of different component average employment generation increased to 456 man- days/ha/yr. by integrating crop + fish + cattle over all other farming systems and was followed by crop + fish + duck + goat (426 man- days/ha/yr). An extra average employment of 46 and 12 man-days per year was generated from crop components due to inclusion of one more crop (moong or dhaincha), respectively into the system over the traditional cropping system (rice-wheat). Keeping in view, the other enterprises like fish, duck and goatry an additional employment of 40, 60 and 80 man-days, respectively. Combining of crops with other enterprises increased labour requirement and thus provided scope to employ more family labours round the year without giving much relaxation during lean season as in traditional agriculture. Similar increase in employment was also confirmed by Kumar *et al.* (2012a) and Ravishnkar *et al.*(2007) with integration of crop + horticulture + goat + poultry into the system.

CONCLUSION

On the basis of above figures and facts, now it can be well emphasized that small and marginal farmers can't survive with conventional rice- wheat cropping system and they have to switched to integrated farming system mode. It is demand of time to adopt integrated farming system on larger scale in our country as well as in the whole eastern region. As IFS not only ensures high economic returns but also provides more employment to farm families and others. Due to nutrient recycling, organic matter is added to the soil which makes the land more productive on a longer run. Therefore, development of ecologically stable and environmentally sound IFS model is very much advocated to maximize the productivity and getting higher returns to improve the livelihood of small and marginal farmers. Here, Crop + fish + duck + goat integration provided the best integration and provided maximum productivity, net return and employment followed by crop + fish + goat combination and may be adopted on large scale in the eastern part of India.

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