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Rice-Based Farming Systems and Its Diversification:An Economic Analysis in Coastal Ecologies of Eastern India

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ABSTRACT

For understanding the role of different types of farming systems on the livelihoods of small and marginal farmers, a study was made under eastern Indian situations during 2015-16 comprising around 100 farming systems. The study revealed that rice - fallow and rice-rice system in the region can be made profitable and sustainable through introduction of legume crop. Integrated farming systems (IFS) are important for the efficient management of available resources at the farm level to generate adequate income and employment for the rural poor, for the promotion of sustainable agriculture, and for the protection of the environment. The synergistic interactions of the components of integrated farming systems need to be explored to enhance resource use efficiency and recycling of farm by-products. IFS has proved to be the boon to the small and marginal farmers by providing regular income of about Rs. 500/day/ha, thus playing a vital role in improving and stabilizing the farmers economy. Such farm proved to be climate resilient in nature and a better strategy for climate change adaptation and mitigation. Promotion of integrated farming systems can be a vital strategy for developing climate resilient technology and improving the livelihood of small and marginal farmers in the region.

1. Introduction

Rice is the mainstay of large mass of population in eastern India occupying an area of 27.5 million ha. Farming is the backbone of farmers' economy in the region. The region is facing poor economic growth. One of the important reasons for this is low returns to farmers from agriculture. Rice – rice and rice-fallow are the dominant systems contributing farmers income. Income of the farmers can be further enhanced by addressing rice-fallow. The fallow area after rice can be used for growing green gram, mustard, and groundnut under rainfed situation by utilising the residual moisture or under limited irrigation (1-2 irrigations) availability situations. This provides a scope for enhancing the system productivity and farm returns (Behera *et al.*, 2015).

Rice-rice cropping system has been in practice in the region since 1970's or late 1960s after dwarf rice came in force. This system was remunerative for some years and helped in earning profit to the farmers. However, in recent years, this system has been quite unprofitable and unsustainable. The reasons for un-sustainability of rice cultivation or rice-rice system are: (i) hike in input costs including the labour charges, (ii) unavailability of labours for farming due to various Govt. programmes attracting the labour force for alternative employment opportunities, (iii) low price of rice and depressed sale of rice in the region. The rice grain is sold @ Rs. 900/q at the local market. Farmers are not able to sale the produce to Govt. agencies at the procurement price, (iv) rice requiring huge quantities of water (4000 litre/kg of rice production) jeopardising the system and creating a threat for its long-term sustainability, (v) profit from rice cultivation has reduced drastically and has become almost zero or negative and (vi) availability of 3 kg rice/capita and 2 kg wheat/capita

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to the BPL (Below Poverty Line) card holder in the regions has further reduced the demand of rice and creating problems for its market in the locality.

2. Materials and Methods

A study was conducted in the different villages of Baliapal, Balasore, Remuna, Soro, Khaira and Simulia blocks of Balasore district of Odisha state during 2015-16. An analysis of role of IFS on livelihood, farm income and employment and sustainability of small farms was made by collecting information with the help of a well structured questionnaire. During the process of study and interview with the farmers, the line department officers facilitated the process for recording relevant information. In the process of recording/collecting the information emphasis was made to analyse various constraints for enhancing agricultural production, ecological and socio-economic constraints of the farmers.

3. Results

The rice cultivation in eastern India has become very unprofitable due to various reasons and the farmers are now exploring the opportunities to replace rice with alternative crops. However, agro-climatic situations and land types of majority of areas do not allow to take other crops in most of the cases during rainy season. Diversification of rice-based farming systems particularly rice-rice system and rice-fallow system has been a potential option to enhance income and provide better livelihood option to the farmers of the region. The other agro-ecological problems emerged due to rice cultivation in the region are as follows:

3.1 Issues and challenges for sustainable rice production

(i)Loss of valuable genetic diversity

Due to continuous replacement of improved high yielding rice varieties over the years in the region, the local rice cultivars are getting out of cultivation. Though the gain due to HYV rice is tremendous, but the loss of the valuable local varieties is a great threat to genetic diversity and sustainability to rice cultivation.

(ii)Natural Resource base-degradation

In 1960s and 1970s the water tables were at about 1-2 m depth in many places. Even 30 ft digging for a tube well was sufficient. In the past few decades, the water table is going quite below, as a result, the tube well digging and water lifting cost has increased and water scarcity has been a major problem. This could be due to intensive rice cultivation, where mining of water is more than the recharge. The pressure on groundwater can be minimized through diversification of rice-rice system to alternative low water requiring crops in *rabi/summer* season (Behera *et al.,* 2007).

(iii) Food chain contamination due to more pesticides use in rice

With the greed to earn more and harvest more, farmers have been using pesticides in an un-judicious manner. For rice cultivation, the pesticides application on an average is 10 times in a season in many districts in eastern India. The farmer himself do not use the rice produced from farm for his own consumption but sell it for earning profit. This has resulted in pesticides load in food grain and straw, contaminating the whole food chain system, which is more dangerous and putting a threat to the future of our future generations. Under this situation, crop diversification with pulse and oilseed helped in reducing the pesticides application.

(iv)Pulse cultivation in rice – fallow

- ***Returns/ System Productivity***

The small and marginal farmers are very much happy to go for green gram cultivation in the region. They are easily harvesting seed yield of 1.0 t/ha and a gross and net returns of Rs. 60-65000/ha and Rs.35-40000/ha, respectively. The production cost for pulse crop (green gram & black gram) production comes around Rs. 20-25,000/ha. As a result, a net profit of Rs. 35-40,000/ha is achieved. While, in rice production, the farmers profit is almost nil at rice yield level of 5.0 t/ha. However, a profit of Rs. 8000 to Rs. 10,000 is obtained when yield level of 6.0 t/ha is achieved, otherwise the profit from rice farming in *rabi* is almost nil. Another interesting aspect is that selling of rice is very difficult. Even after a lot of efforts, the farmers are able to sell at Rs. 9000/tonne, while green gram is sold at the door step. The middle men or agencies purchase the produce at the door step at the rate of Rs. 60,000 to 65,000/tonne. There is assured market for pulses.

- ***Better family nourishment***

Pulse production has helped in enhancing the family nutrition by consuming a part of pulse produced at the farm by the family members. This has helped in dietary intake of protein and better nutrition to the resource poor farmers of the region.

- ***Pulse crop is climate resilient***

Under changing climate scenario, pulse crops *viz*. pigeon pea, green gram, black gram, lentil etc. are promising as an important component of farming system for mitigation and adaptation to climate change. The carbon footprint in pulse in the system is better. Pulses also bring N economy in cereal – fallow/ cereal – cereal systems (Behera *et al*., 2014).

(v)Rice-based farming systems and intervention with pulse crops

The green gram variety PDM 139 and SML-668 were provided to the farmers, the technical back up was provided and wherever, required input supports were also provided. The cultivation of pulses took place in large areas in the region. An impact analysis during April-May, 2016 revealed the following benefits due to pulse cultivation in the region.

- ***Pulses for soil health***

Pulse cultivation enhanced the resource-base by improving the system productivity and soil fertility, due to legume crop residue incorporation in the system and biological nitrogen fixation. Monoculture of rice or rice-rice systems has deteriorated the land by depleting the nutrient and creating nutrient imbalance in the soil.

- ***Irrigation water saving and enhancing water productivity***

Rice-rice replaced by rice-green gram/black gram required only 2 irrigations (one at pre-sowing and one at flowering) for green gram/black gram, whereas rice cultivation needed around 14-16 irrigations. This helped to cover around 7- 8 times more area under pulse production utilizing the same available irrigation water for rice. Thus, the water productivity in the region was enhanced. We have around 6.0 million ha under rice –pulse/ oilseed for enhancing water productivity.

3.2 Performance of Integrated Farming Systems

An analysis of role of IFS on livelihood, farm income and employment and sustainability of small farm was made in the Baliapal, Balasore, Remuna, Soro, Khaira and Simulia Block of Balasore district in Odisha during 2015–2016.

3.2.1 Performance of Integrated Farming Systems in Basta Block

Farmers having IFS were surveyed and the data of various components of IFS during 2015-2016 was recorded from a progressive and representative farming system (Table 1). The farm family is highly dependent on agriculture. Farm family is having 11 members out of which 9 adult (>18 years) and 2 member of children (<18 years). Four adult brothers are engaged in farming since, they do not have alternative employment opportunities. One brother is engaged in car garage, earn wage on contractual employment, and support the family. The family is having labour availability of about 1000 man-days/year for farming. The family needs a net income of Rs 500/day on daily basis to the family requirement of various items.

(i)Food requirement of the farm family

- ***Cereal***

The family requirement of cereal food (rice) is 200 g (milled rice)/meal. Per head consumption of rice is 500 g per adult per day while per head consumption of children (<18 years) was 250 g/day. The 9 number of adult per day consumption is 4.5 kg rice, while 2 number of children per day consumption is 0.5 kg rice. Total consumption of rice/day is = 5.0 kg and round the year consumption = 365×5 = 1825 kg which comes around rough rice requirement: 3.2 tonne/ year. This food requirement is met from farming of cereal (rice-rice). The additional cereal is sold at the farm gate @ Rs 9000/tonne. For producing 3.2 tonne rough rice, farmer need around 0.6 to 0.75 ha area either during *kharif* or in *rabi.*

- ***Pulse grain requirement***

The family requires minimum of 500 g pulse/day/whole family, Which comes around 15.0 kg/month. However due to economic scarcity, the family purchase only 5.0 kg pulse (mung/lentil/arhar dal)/month from the market. The family requires around 180 kg pulse for yearly requirement of the farm family. This much pulse production can be achieved by cultivating an area of 0.2 to 0.25 ha under green gram after rice cultivation.

- ***Vegetable requirement***

Though part of the vegetables (raw papaya and raw banana) is met from the farm. But the majority of vegetables (bitter gourd, potato, brinjal and okra) are purchased from the market.

- ***Protein requirement***

The family is not having dairy unit in the farm. Though milk need is very much felt by the farm family, no milk is available for the farm family for both adult and children. It has been a general feature in the village that no milk is available to the majority of the farm family. The concerned family purchase around 10 kg chicken meat every month and around 120 kg chicken meat per year is purchased from the market. The family consume about 120 kg of fish in year which is harvested from the fish pond.

- ***Economics of IFS***

The farm having an operational area of 4.4 ha followed an integrated farming systems with crops (rice – rice) – fishery (composite pisciculture) – horticulture (mostly on pond dykes). Overall income from the IFS is not enough from 4.4 ha under farming practice. Farmer was able to earn a gross and net returns of Rs. 2,06,200 and Rs. 47,700 respectively. With an investment of Rs. 162,700 out of which about 60% of the investment was towards family wage engagement in farming. The family labour availability was adequate (1000-man days) which were underutilized. The family needs a net income of 182,500 @ Rs 500 day for smooth running of the family expenses. His major efforts are mainly concentrated in rice cultivation, which keeps the member busy round the year. The family is making expenses of about Rs. 162,700 per annum for various agricultural activities. However, an expenses of Rs. 200,000 can be made by the farmer to achieve the targeted income for the farm family.

- ***Farmer's Reaction***

Farmer is afraid of rice cultivation. Farmer expressed that if they will take all expenditure in to account, there is no profit at all. They are idle and have no alternative employment opportunity they are able to get employment in this farm, even though it is not profitable. On the contrary, rice farming is a tension for the farm family because during 2013 and 2011, due to flood situations, the entire rice was damaged, there was total loss of rice, not a single grain was harvested. Thus, rice cultivation in *kharif* is a risky business. Though the rice requirement of the family can be met by cultivating only 2.0 acres (0.8 ha) of area. They can divert the land for alternative remunerative crops during *rabi* season.

3.2.2 Performance of Integrated Farming System in Khaira block

A typical rice-based farm having IFS was evaluated for its ability to generate income and employment and how it can be resilient to climate change. The size of the farm was 10 acres (2.5 ha). The farm was having the enterprises Fishery – Horticulture (fruits and vegetables) – Dairy (2 number of cross bred cows) – Field crops (Rice - Rice). The enterprise – Horticulture crops was well developed with inclusion of mango plants of 200 numbers, coconut 50 numbers, papaya – 50 number, Palm tree 100 number and drumstick is planted in 50 numbers. Besides, during *rabi* season around 0.5 acre is diverted for cole crops (cabbage, cauliflower) and other vegetables like cow pea and okra. The boundaries of the farm are planted with Acacia plant *(Acacia mangium*, Australian Saguan). These plants will provide returns after few years.

Table 1. Economics of integrated farming systems of a progressive farmer in Basta Block (Balasore) in Odisha during 2015-2016.

Enterprise	Area allocation (Acres)	Gross yield (kg/Acre)	Gross Returns (Rs)	Production cost (Rs)	Net Returns	B:C ratio	Employment generation (man days)
Kharif rice (MTU 1001, Swarna (MTU 7029), Pooja, Kalachampa)	6.0	1500	90,000	81,000	9,000	1.11	288
Rabi Rice	3.5	1800	56,700	51,700	5,000	1.10	154
Fishery	1.0	500	50,000	20,000	30,000	2.50	25
Horticulture (Fruit crops)	0.5	200 kg (from 0.5 acre)	13,700	10,000	3,700	1.37	40
Total	11.0		2,06,200	1,62,700	47,700	1.27	507

Kharif rice production cost Rs. 13,500/acre while gross return Rs. 15,500/acre. Value of fish @ Rs. 100 / kg live weight, value of rice Rs. 9/kg.

The 2.5 ha farm is well distributed with different enterprises. Such farm provides regular income to the farm family. Besides, provides cereal, vegetables, fruits, timber, milk. Green fodder requirement for dairy animal is met from the farm but cutting grasses from the bund of field and dykes of pond. Besides, fuel wood in the forms of twigs of the plants and trees are diverted for cooking of food. Overall, the farm is considerably self sufficient in its family requirement and it is considerably sustainable and risk level is minimum due to multi-enterprise in structure. A 2.5 ha farm generated gross income of Rs. 8,45,000 with investment of Rs. 3,55,000 with a B:C ratio of 2.38. The fishery enterprise found to be more remunerative contributing about 48% of the farm income. This enterprise also provided a B: C ratio of 6.0. Next to this enterprise, horticulture enterprises played a vital role with net return of 85,000 from an expenditure of Rs. 75,000 and with a B: C ratio of 2.13. This enterprise generated maximum employment of 300 man days. Dairy enterprise was very useful to bring sustainability to crop production due to the fact that around 50 kg of cow dung was generated/ day which was diverted for the crop field and horticultural unit benefiting in building the soil fertility. Besides, the part of decomposed manure was diverted for manuring the fish pond. This enterprise was supported by recycling the residual or excess food of the farm family and the grasses from the pond dykes and bunds of the field. Field crops comprising of rice–rice in an area of 65% of the total area was considered to be less remunerative. Rice-rice cultivation requires more number of man days, but this could help in meeting the family requirement of food (cereal) for 6 member family. The rice-rice system occupies in major areas (6.5 acre) and also consumes around 300 lakh litres of water for its cultivation. Due to depleting ground water, during the summer months the shallow tube wells dries up. On the other hand, the farm family needs family consumption of pulse about 200 kg/year. This *rabi* rice can be diverted for pulse (green gram and black gram) production in at least 2.5-4.0 acres and oil seed (mustard and sesame) for about 2.5 acres. With this diversification, the same productivity can be achieved with 25% of the water required for the rice crop. Besides, this will help in reducing the load of pesticides for growing mono-culture of rice-rice system. The farmers have 3 ponds, in the farm for fish production. Feed is the major component of cost of fish production. The pond may be integrated with duck farming as a result part of the feed requirement of fish can be reduced, making fishery enterprise more profitable.

- ***Diversity***

This farm is an example of a climate resilient farming system in which more than 20 different crops and trees were raised. The risk minimization is achieved in such farm due to diversity in production system. There is scope to increase, the number of cows, this can help in providing manure for requiring the same to the crop area and fish pond. There is need to diversify part of area for grass production (cowpea/berseem) to provide green fodder to the dairy unit. The perennial grass (Hybrid napier – CO2, CO3) may be taken in upland areas to meet the fodder requirement of dairy.

3.2.3 Performance of Integrated Farming System in Soro block

The farmer is managing an IFS [Crop-fish-Horticulture (fruits and vegetables)-poultry] in an area of 3.5 acres. A net return of Rs. 4,50,000 was generated by the farmer with an investment of Rs. 2,85,000 (Table 3). The family members could get an employment round the year. The fruits *i.e.* papaya, banana, mango, guava etc., were very well raised with the help of poultry manure. The farm was less dependent on external sources of nutrients. The poultry unit was developed in collaboration with the local company, who could purchase the broiler and also provide the part of the feed required for poultry birds.

Table 2. Economics of integrated farming system of a progressive farmer in Khaira Block (Balasore) in Odisha during 2015-2016.

Enterprise	Area allocation	Gross Returns (Rs.)	Cost of production (Rs.)	Net Returns (Rs)	B:C ratio	Employment generation (man days)
Fishery	2.0 acres	3,00,000	50,000	2,50,000	6.00	60
Horticulture	1.5 acres	1,60,000	75,000	85,000	2.13	300
Dairy	2 cross bred cow (100 m^2)	1,75,000	1,00,000	75,000	1.75	120
Field crops (Rice-Rice)	6.5 acres	2,30,000	1,30,000	1,00,000	1.77	400
Total	10.0 acres	8,45,000	3,55,000	5,15,000	2.38	980

2 cross bred cows – per day milk production is 10×2 = 20 litres.

Among the all farms, this farm was able to utilize the available resources of the farm more efficiently by recycling the by-product and farm wastes for which the profit from such farm was maximum in comparison to other farms. The returns from rice were the minimum, even though it occupied in an area of 1.0 acre. But, rice is an important component of the FS as it is important to meet the food requirement of the farm family. Besides, the area utilized for rice cultivation cannot be profitably utilized for other purpose due to water logging situation during rainy season.

3.2.4 Performance of integrated farming systems in Baliapal block

Baliapal block is located nearer to Bay of Bengal adjacent to seashore. The area is frequently affected by flood. Every year, rice crop remains under submergence of varying duration (02-20 days) during rainy season depending upon the flood situations. Due to the nature of land types, rice is the only option under rainfed lowland. A typical rice-based farming system was selected for the study.

Economic analysis of integrated farming system revealed that a gross returns and net returns of Rs. 3,61,000 and 175,000, respectively was obtained from 3.5 ha area farm with production cost of Rs. 1,86,000. The farmer could earn the maximum profit by growing vegetables. Besides, coconut was also an important source of income. Around 200 coconut plants are in the farm. Coconuts from these plants were sold after meeting the family requirement for consumption. Besides, the IFS helped in the way of better nourishment to the farm family by producing variety of products, *viz*. fish, meat, milk, vegetables, fruits and oilseeds at the farm itself. Otherwise, they would not be able to purchase these items from the market. Besides, the family is able to earn a regular income from the farm for which he was able to meet the regular daily expenses of the family. The enterprises like, poultry, goat and dairy could not contribute substantially to the income of the farm family, but the farms were not spending much for these enterprises. The waste (kitchen wastes) and by-products (rice straw) available at the farm level were used for the feed of the livestock.

Table 3. Economics of integrated farming system (Fishery- poultry – Crops (horticulture and field crops) of a progressive farmer in (village: Gopinathpur) in Soro block.

Enterprise	Area (acres)	Gross Return (Rs.)	Cost of production (Rs.)	Net Returns (Rs)	B:C ratio	Labour generation (man days)
Fishery	1.0	3,00,000	1,00,000	2,00,000	3.00	40
Poultry (broiler) 4000 broiler	0.2	2,00,000	1,00,000	1,00,000	2.00	180
Horticulture (Vegetable)	1.0	1,50,000	50,000	1,00,000	3.00	100
Horticulture (fruits)	0.5	50,000	15,000	35,000	3.33	40
Rice	1.0	35,000	20,000	15,000	1.75	80
Total	3.5	7,35,000	2,85,000	4,50,000	2.58	450

Fish value @ Rs 150/kg live weight

Table 4. Economics of an integrated farming system of a progressive farmer in Baliapal block (Jamkunda GP) in Balasore district in Odisha

Enterprise	Area (acres)	Gross Return (Rs)	Production cost (Rs)	Net Returns (Rs)	B:C ratio	Employment generation (man days)
Fishery (Yield 1.5 q)	0.2	15,000	5,000	20,000	3.0	5
Horticulture (fruits) (coconut, banana, guava)	0.5	20,000	5,000	15,000	4.0	10
Vegetables	2.0	2,00,000	1,00,000	1,00,000	2.0	300
Field crops (Rice)	2.5	50,000	50,000	0.0	1.0	125
Field crop (groundnut) (yield : 8 q)	1.0	35,000	16,000	19,000	2.18	40
Live stock (8 Goat + 6 backyard poultry)	0.025	15,000	5,000	10,000	3.0	25
Dairy (3 local cows) 3.5 litre milk/ cow	0.025	16,000	5,000	11,000	3.2	100
Total	6.25	3,61,000	1,86,000	1,75,000	2.91	605

3.2.5 Performance of rice-based integrated farming system at Pratappur (Baliapal block)

The farmer is a very progressive farmer and once has been the Chairman of Agricultural Technology Management Agency (ATMA) and shown path to other farmers to go for improved cultivation of various crops and other enterprise like fishery. With the support of seed production company the farmers has been able to take hybrid rice seed production from company working in the region, the farmers has been able to take hybrid rice seed production programme in his farm in an area of 8.0 acres. Besides, the farmer has been able to motivate many other farmers to take up hybrid seed production in an area of more than 100 acres, thus, benefiting the farmers to earn more income. During *rainy* season the farmers were growing improved rice (MTU 1001, Swarna and Pooja) in an area of 8 acres and in *rabi* the same area was utilized for hybrid seed production. During rainy season the farmer was able to harvest rice yield of 6.0 t/ha with an investment of Rs. 45,000. He was able to sell the rice @ Rs. 1000/q. Thus, could earn a profit of Rs. 15000/ha. Besides, he was able to manage his fish enterprise in an efficient manner so that he was able to harvest a high level of fish yield (4.0 t/ha). In fact, he was harvesting, fish twice in a year at 6-month interval. The farmer has initiated the hybrid rice seed production programme, which is a labour consuming activity. The skilled labourers are needed to go for artificial pollination of the crop, since, farmer himself and his children are skilled enough to take up the activities, the farmer could be able to produce hybrid seed and also guided the nearby farmers in the village to go for hybrid seed production. Betel vine production (*Panbaraj*) is an important activity of the region. Many farmers consider it as an important enterprise/economic activity and take it as cash crop.It provides regular income to the farmer. However, such practice is an important aspect of many farmers and help in improving the economy of small farmers and enhancing their livelihood security. However, sometimes, betel vine production is very much affected, if heavy cyclone occurs, disease occurrence and if there will be problem of management. Overall, the farmer has done an exemplary achievement by managing the various enterprises in a very efficient manner. About 3-4 members of the farm family get effective employment from the farm, which prevents them to migrate to nearby cities (Balasore and Kolkata) for search of contractual employment. From an area of about 2.0 ha, the farmer could earn gross income of Rs. 11,88,000 with an investment of Rs. 6,85,000 and earned a net profit of Rs. 5,37,000/annum. Besides, providing round the year employment to the 3 important family members, it could also provide employment to other members of the village. Thus, such IFS of the farm could play a vital role for providing additional income and employment to the farm family and improving the livelihood. From 1 acre *kharif* rice yield is 24.0 q, production cost is Rs. 18,000, Value of rice Rs. 1000/q for *kharif*. During *rabi* yield of Female parental line/acre is 10.0 q, male parental line is 8.0 q. The value of female parental line is Rs. 6000/q and value of male parental line is Rs. 1000/q. Production cost of *rabi* rice is Rs. 33,000/acre including the cost involved around Rs. 8000/- for artificial pollination/acre. Production cost for fishery Rs. 60,000/acre, fish yield is 8.0 q/acre which value is 80,000/acre. Net profit as 10,000/acre in 6 months and yearly return is Rs. 40,000/acre. Milk yield is 4-5 litres/day from crossbred and 1-1.5 litres/cow from local for about 8 months.

Table 5: Economics of rice-based integrated Farming System atPratappur of Baliapal Block of Balasore in Odisha.

Enterprise	**Area (acres)**	**Gross Returns (Rs)**	**Production cost (Rs)**	**Net Returns (Rs)**	**B:C ratio**	**Employment generation (man days)**
Rice (*Kharif*)	8.0	1,92,000	1,44,000	48,000	1.33	400
Rice (*Rabi*)	8.0	4,80,000	2,64,000	2,50,000	1.82	600
Fishery (5 ponds) (Harvesting 2 times in year)	2.5	3,00,000	1,62,000	1,38,000	1.85	30
Dairy (2 cows: 1 cross breed + 1 local)	0.025	24,000	20,000	4,000	1.20	50
Horticulture (Betelvine)	0.25 ($1000m^2$)	1,60,000	80,000	80,000	2.00	200
Horticulture (Fruits, Mango, Banana, Coconut)	0.25 ($1000m^2$)	22,000	12,000	10,000	1.83	30
Horticulture (Vegetables) (Bitter gourd, Poi greens)	0.25 ($1000m^2$)	10,000	3,000	7,000	3.33	30
Total	11.0	11,88,000	6,85,000	5,37,000	1.73	1340

3.2.6 Performance of IFS in Hasimpur of Baliapal block

An economic analysis of rice-based farming system of a small farmer having 1.7 ha land area revealed an interesting picture (Table 6). The farmer earned net returns of only Rs. 6000 from 1.2 ha area with an investment of Rs. 60,000. While from the same area during *rabi* season, the farmers could earn net returns of Rs. 75,000/- from groundnut cultivation. Fishery enterprise proved to be more profitable, though farmer could earn a profit of about Rs. 80,000 from 1 ha pond area. The dykes of the pond were well utilized by planting fruit trees like coconut, banana, papaya and lemon. These fruits plant not only provided the fruit requirement of the farm family, but also provided considerable quantities of fuel wood for the family fuel requirement. The mainstay of the economy of the farm family was dairy unit. This unit could provide a daily basis income to the farm family. Though rice and rice – rice system was dominant in the region, but a stability and sustainability of the system could be observed through inclusion of multiple enterprises *viz.* crops, horticulture crops, fishery and dairy. This multi-enterprise farming system helped in better utilization of the farm resources. For example, the entire manure of 6 milch cows were diverted to the crop fields and poultry to fishery pond for which a high level of crop and fish yield were obtained. Besides, the family kitchen wastes and by-products were better utilized for the dairy animals. From 1.7 ha area of the rice-based farming systems, the farmer could generate gross and net returns of Rs. 8,48,000 and Rs. 2,33,000, respectively with an investment of Rs. 6,15,000. In terms of economic efficiency groundnut cultivation, fishery and horticulture (fruits) resulted B: C ratio of 2.0, 1.53 and 2.0, respectively. Rice cultivation was highly unprofitable with B: C ratio of 1.10 only. Dairy unit resulted B:C ratio of 1.25, this was due to the major expenditure of the diary unit on feed, Overall, the farmer could generate a daily income of Rs. 638 from his farm, which could provide a stability to the livelihood of the farm family. Fish yield is 9.2 q in a year, Dairy unit consists of 6 milch cross bred cow (Jersey) each cow gives milk yield of 6.5 litres/day. Groundnut cultivated in *rabi*, reduces the pressure on water use. Fruit cultivation is undertaken mainly on dykes- coconut, papaya, banana and lemon. Resulted in daily net return of Rs. 638/ from 1.7 ha area of land.

3.3 Constraints for rice production in the regions

(i) Organic manure availability

Organic manure has become a great scarcity in the region due to mechanization and decline in animal population. Without manure, the crop cannot be grown successfully. It was not predicted earlier. More intensification of rice and rice-rice system increased the fertilizer consumption over the years and farmers forget and ignore to prepare manure and recycle the same to the crop field. Besides, keeping of crossbred cow becomes a fashion as a result the rearing of local cow by the famers was quitted. Mechanization helped the farmers not to keep bullock. As a result, the manure availability has decreased. On an average, out of 10 farmers, one farmer may have local or crossbred cow, which is insufficient to his crop field requirement.

(ii) Unprofitable rice farming

Few medium to small farmers, who are fully dependent on farming express their views – "we cannot live in decent way by doing farming due to increased cost of inputs on the other hand without farming we cannot live". Because, farming is their prime profession for last so many years. This is the feeling of an experienced and educated farmer. He expressed his concern that in this region by doing rice farming even labour cost is not returned.

Table 6. Economics of integrated farming system of a progressive farmer in village: Hasimpur of Baliapal Block (in Balasore Odisha) during 2015-16

Enterprise	Area (acres)	Gross Returns (Rs.)	Cost of production (Rs.)	Net Returns (Rs)	B:C ratio	Employment generation (man days)
Rice (*Kharif*)	3.0	66,000	60,000	6,000	1.10	150
Groundnut (*Rabi*)	3.0	1,50,000	75,000	75,000	2.0	180
Horticulture	0.25	40,000	20,000	20,000	2.0	50
Fishery	1.0	92,000	60,000	32,000	1.53	30
Dairy (6 milch cow)	0.025	5,00,000	4,00,000	1,00,000	1.25	368
Total	4.25	8,48,000	6,15,000	2,33,000	1.38	775

(iii) Erosion of farming system through disciplinary approach

After the introduction of high yielding rice varieties both in *kharif* and *rabi*, the farmers become more dependent on rice cultivation. Even other enterprises, like keeping dairy animal, goat, planting trees etc. were fully neglected. Earlier practice of maintaining a compost pit for manure preparation and recycling the manure to field in summer month were left by the farmers due to application of heavy dose of inorganic fertilizers. This, in the long-run resulted in imbalance of nutrient status of the soil and decline in the native fertility of the land/field to support the crop to harvest in its full potential. Even, the trees like tamarind, karanj (*Pongamia*), neem (*Azadirachtaindica*), *etc.* which were usually found in the farm were fell for various purposes and never went for replanting. This resulted in a state of degradation of ecology of the farming systems in the region.

(iv) Depressed sale of rice

Rice-rice farming system has become highly unremunerative and a major reason for poor economic growth in the region in recent years. During 1970s and 1980s the farmers were able to earn lot of profit from the system, but now-a-days due to low value of rice in the market, rice cultivation has become quite unprofitable. Though, the procurement price is fixed at Rs.1440/q, but at farm level, the farmer is facing problem to sale the rice at Rs 900/q. This is the reason many farmers are quitting farming, who sometimes take loan for rice cultivation with the hope that he will earn profit and get wage of his own, but finally get disappointment from rice cultivation. If the natural calamities like cyclone and flood occur, he is not able to harvest any grain. This leads to shake his economic backbone, and force to take deadly attempt. Hence, under this situation agriculture, department should take attempt for diversification of the rice based farming system with minimum area under rice just to meet the family requirement of food.

4. Discussion

Agriculture in India is at the crossroad. In one side, small and marginal farmers are dominated having > 86% of the total farming community (ASG, 2015). Their number is increasing gradually. On the other hand, farming is becoming unprofitable due to continuous hike in price of inputs required for farming and decline in factor productivity (Behera and France, 2016). The natural resources are degrading at a faster rate, putting pressure on land resources and threat on sustainability of agriculture.

Under the situation, it is needed to increase the income of the farmer 2 – 3 times, to make farming economically viable and enhance the livelihood of the majority of the farming population. The farm ecology needs to be improved through maintaining biodiversity at the farm level and making farming system more climate resilient. The diversity at the farm level is eroding over the years. The tree component, which was serving as buffering agent against farm vulnerability to climate change, is missing from the farm. Similarly the strong link of crop with livestock, which can be considered as 'backbone of agriculture' has become weak, at the same time the farmers are moving towards specialized farming through imported inputs. The local breed of dairy animal is vanishing gradually, whereas the crossbreed cow is not able to fit into the farming systems, particularly in climate change situation. Under the situation, the present study revealed the real picture of farming system at the rural/ ground level in eastern India. From the study, it became clear that rice farming which is the backbone of the farmers' economy in eastern India has been the main reason for their poverty in recent years. Farmers have lost their interest to go for rice farming. The main reason for this is the rice farming which involves a lot of drudgery and risk has becomes unprofitable. One important aspect is that this rice farming is only pride for many, those who have no alternative employment opportunity. Now making rice farming profitable to a reasonable level is the major challenge for the researchers, planners, extensionists and development agencies. However, there are examples from other country, that efficiency of the resources in rice farming has been improved making it profitable to certain degrees with the adoption of real time N management, use of resource conserving technologies and conservation agriculture practices (Jat*et al*., 2013; Bhan and Behera, 2014).

Besides, diversification of rice- fallow/rice-rice system with pulses and oilseed provides ample scope for making the

system profitable by providing an income of Rs. 40,000/ha. Through this farming practice, an additional area (about 6-8 times) which was lying fallow can be brought under cultivation. The study over a 100 farming systems in the region revealed that the income of a farm can be enhanced by adopting integrated farming systems instead of monoculture of rice-rice or rice-fallow. Besides, such IFS helped in supporting the livelihood of the farmers by producing variety of products *viz*. food, fodder, fuel wood, milk, fish, vegetables, fruits, spices etc. Such farming was important to minimise the risk. Rice farming in the region has becoming uneconomical year after year, sometimes it results in total failure of the crop. Under the situation, multi – enterprise farming is an insurance against the risk. Such farming has been providing stability to the farmer's income, minimise the risks, and provides a regular income.

Besides, it not only checks the migration of the farmers to cities for contractual employment, but it provides the employment at the farm level for the farm family and nearly local people including the rural youth. This helps in a better settled life at the farm for a decent living. Among the various enterprises, fishery enterprise was more or less stable in its performance and a higher level of income and benefit: cost ratio was obtained across the farming system level from fish farming. A study conducted by Behera *et al.* (2008) under eastern Indian situations - based on risk analysis for different levels of income and enterprise combinations under varying sizes of farming systems revealed that the fishery enterprise was less risk-prone whereas the crop enterprise involved greater risk. Our study also revealed similar findings. Further, dairy farming is very important for improving the productivity of the crop field in the farm and in fish pond due to the fact that manures from the dairy unit are recycled for these enterprises. However, the enterprise is facing challenge from its proper design point of view. In most of the cases the dykes of the fish pond are eroding from all sides. Settling of the dykes is an important challenge. Besides, duck and fish enterprise has shown a synergetic effect (Behera and Mahapatra, 1999). This integration was invariably lacking in farming systems of the region. By linking duck farming with fishery can further increase the income of the farmers and bring more stability to the system. However, in one farm in Simulia block of Balasore, duck-fish farming was found, but in this system the duck house was very improperly constructed, which created a very unhealthy situation for the duck birds.

Some farmers in the regions are rearing local cows. Their level of satisfaction for local cow vis-a-vis crossbreed cow was evaluated. It was observed that local cows are more adapted to the farmer situations. With the by-products of farm and kitchen wastes and grasses from the farm, they are able to maintain the local cow in a comfortable way. Crossbreed cows (CBC) are less adaptable to the situation due to rise in temperature and heat stress. A common farmer is not able to provide concentrates to the cows and green fodder and cannot take a very high level of care. On the other hand, the farmer's are happy with 2-3 litres of milk production from local cow against CBC having 10-12 litres of milk.

Energy has been the major driver of present day farming systems (Behera *et al*., 2015). Energy consumption is increasing in way of tillage, cooking, lightening of house, lifting of water etc. Energy has been the major culprit for climate change contributing more than 60% for climate change (Aggarwal 2008).

There is need to depend more on renewable energy *viz*. Biogas production, solar energy and wind energy (Behera *et al*., 2015). Besides, energy plantation is also a viable option for the region. No farmer in the study area is aware of the renewable energy. The cow dung generated in the farms is used in a wasteful manner, which could have been used in an effective way. For this policy inventions are needed. For example, the department of new and renewable energy are promoting bio-gas production through establishing biogas plant without having much consideration of the manure availability with the farmers. Similarly, in the IFS programme of ATMA, energy component is missing. This gives a mismatch of biogas production with manure availability; as a result the programme becomes unsustainable. Decline in biodiversity has been a common feature in the farming system in the region. Diversity is a measure of sustainability. Besides, to bring a better adaptation and mitigation to climate change, bio-diversity can play a vital role. In the IFS studied farms, the farmers are able to maintain 10-20 species of plants in their farm, which provides a stability to the farmer and helps in sequestrating a large quantity of CO_2 and creating a healthy micro-climate for the farm. Farmers of their own expenses grow variety of crops having medicinal values, for example, drumstick (*Moringaoleifera*) for meeting iron requirement and sahada plants (*Strebulusasper*) for use as toothbrush to check dental decay. There is need to maintain such biodiversity at the farming system level through integrated farming systems.

5.Strategies for agricultural development in the region : Issues needs to be addressed

(i) Injudicious use of agro–chemicals

Monoculture of rice-rice system has led to the injudicious

pesticides consumption in the region. In rice cultivation, the farmers were consuming more pesticides by applying around 8-10 times spray in a season. However, the use of pesticides in pulse production is less (around 2–4 sprays). Even, if more than 2 sprays is not required, the farmers are of the opinion that more they spray, it provides more yield. There are famers who claims to harvest 8–10 q/acre or 20–25 q/ha of seed yield of green gram or black gram by applying about 8–10 spray to the pulse crop along with growth regulators. This is a major concern, and they may be discouraged to apply more pesticide, which is not required.

(ii)Sale of produce and shifting of produce to other states

The prices of pulse grain in local market are Rs. 170/kg for arhar, Rs. 150 for green gram and Rs. 120/kg for lentil. State Govt. is making efforts to bring self-sufficiency in pulse production in the Odisha state. However, the bulk of produce of pulse in the region are collected by the agents from west Bengal. The produce is shifted to other states, while it could have been consumed in the Odisha state where it is produced. Such practices can be checked by policy intervention. There is need of providing post harvest technology like dal processing unit in local level. This may further help to enhance the income by farmers through value addition.

(iii) Climate change

The greatest threat to the rice-based farming system in the region is the effect of climate change. Each and every farmer have the opinion that their yields from crop production are quite uncertain in recent years due to more frequent occurrence of drought, cyclone and flood. Similarly, the livestock are also affected under the changing climate scenario. Farmers claim that the crossbred cows are less tolerant to the heat stress of the region.

(iv) Conservation agriculture (CA) has enough success in north India. However, it has potential application in eastern Indian situation. There is need to evaluate and modify the technology considering the soil type and agro-climatic and cropping situation in eastern India. Such technology may help further promoting the pulse production in the region (Behera*et al*., 2014).

(v) *Rabi* groundnut proved to be more profitable than *rabi* rice. This system requires 40% of the water required for *rabi* rice. Promotion of *rabi* groundnut is more suitable for the region. This can help in bring water economy in the region compared to rice-rice system.

Conclusion

- The rice farming in the region is facing many challenges and has been quite unprofitable and unsustainable. Rice - fallow and rice- rice systems in the region can be made profitable and sustainable through introduction of pulse/oilseed crops.
- IFSs are important for the efficient management of available resources at the farm level to generate adequate income and employment for the rural poor, for the promotion of sustainable agriculture, and for the protection of the environment. The synergistic interactions of the components of IFSs need to be explored to enhance resource use efficiency and recycling of farm by-products. The IFSs approach should be adopted as an important strategy to accelerate agricultural growth in fragile hill and mountain and coastal ecologies and thereby provide leverage for transforming poverty-prone rural of the region into a more prosperous one.
- IFS has proved to be the boon to the small and marginal farmers by providing regular income of about Rs. 500/day, thus playing a vital role in improving and stabilizing the farmers economy. Such farm proved to be climate resilient in nature and a better strategy for climate change adaptation and mitigation.
- Energy production needs to be linked to IFS to bridge the gap between energy demand and energy requirement at the farming system level. There is need to promote IFS by considering the farmers resource-base, knowledge, skill, market opportunity and constraints at the farm level. Such an approach may be a powerful tool to revolutionise small farm in the region and to bring 2nd green revolution.

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