J. Indian Soc. Coastal Agric. Res. 34(2): 15-21 (2016)

Integrated Farming System: A Holistic Approach for Farm Income Optimization and Risk Minimization in Coastal Region of India

SUKANTA K. SARANGI*, B. MAJI, K. K. MAHANTA, D. BURMAN, S. MANDAL
U. K. MANDAL, S. RAUT, T. D. LAMA and D. K. SHARMA
ICAR-Central Soil Salinity Research Institute, Regional Research Station
Canning Town - 743 329, West Bengal

Received: 19.08.2016 Accepted: 03.12.2016

Majority of households in the coastal region are small and marginal with average land holding size below 0.5 hectare. The tininess will be more prominent in the coming days with fragmentation of the land and its competitive use for other purposes. With provision of adequate water resources, there is scope for optimization of farm income in the coastal region through an integrated approach involving sustainable cropping system planning and adoption of integrated farming system approach. Rice based cropping system with water productive crops, tolerant varieties/hybrids, best management practices, adoption of efficient irrigation practices result in higher productivity. Combining complementary enterprises like pisciculture, duckery, mushroom cultivation with rice cultivation result in better use of natural resources through recycling of byproduct of one enterprise as input for other enterprise and reduction of the cost of cultivation. Pond silt can be directly used as base manure for field and fodder crops. Integrating fish and cow farming reduces the necessity to purchase fertilizers and fish feeds, and increases the income generated by the fish farm. Fresh animal manure can be applied directly to the fish ponds, which avoid energy losses due to processing and transportation. Livestock feeds that are not fully digested can be directly utilized by the fish. Ducks can be integrated directly with the pisciculture in the pond with resting place made inside the pond by use of locally available materials like bamboo, which saves land area. Droppings of the duck will act as a feed for fishes. The effect of aeration due to the movement of ducks in the pond water will enhance the growth of fishes. Fish ponds provide ducks with an excellent, essentially disease-free environment. Ducks consume juvenile frogs, tadpoles, and dragonfly larvae, thus eradicating many predators of fry and fingerlings. Furthermore, the protein content of these natural food organisms for duck is high. Therefore, duck raising in fish ponds reduces the demand for protein in feeds. Paddy straw abundantly available in coastal areas can be utilized effectively for mushroom cultivation. The utilized straw can be further used as compost for field crops and vegetables. Improved protected cultivation technology may be adopted for cultivation of off season vegetables, flowers etc. Thus, an integrated farming system approach as discussed in this paper will pave a way for ever green revolution, and provide benefits for effective adaptation and mitigation to climate change in the vulnerable coastal region.

(***Key words:*** *Farming system, Holding size, Integration, Income, Risk, Small and marginal farmers*)

The coastal lands are predominantly mono cropped with very low farm productivity and income. In all most all the coastal states of India the income is far behind the household consumption per month for small and marginal farmers (Fig.1), except for Kerala for small farmers. Due to this deficit, farmer's investment capacity in agriculture and risk bearing ability is very low. They have to depend on money lenders or financial institutions for availing credit. However, due to prevalence of monocropping and natural calamities, there is high chances of crop failure. In such circumstances, they resort to extreme steps by loosing mental balance. Therefore, there is urgent need for finding out solutions for social problems. For sustainable enhancement of the farm productivity and income, the appropriate option is integrating farming components requiring lesser space and time and ensuring round the year income to the farmer. This system helps in ecofriendly utilization of waste of one component as input of another, leaving behind nutrient and organic matter rich soil for higher end products for sustaining the soil productivity. Integrated farming system seems to be the possible solution to meet the continuous increase in demand for food, stability of income and diverse requirements of food grains, vegetables, milk, egg, meat etc., thereby improving the nutrition of the small-scale farmers with limited resources. Integration of different agriculturally related enterprises with crops provides ways to recycle the products and by-products of one component as input to another linked component and reduce the cost of production and thus raise the total income of the farm (Ravisankar *et al*., 2007).

**Corresponding Author :* E-mail: sksarangicanning@gmail.com

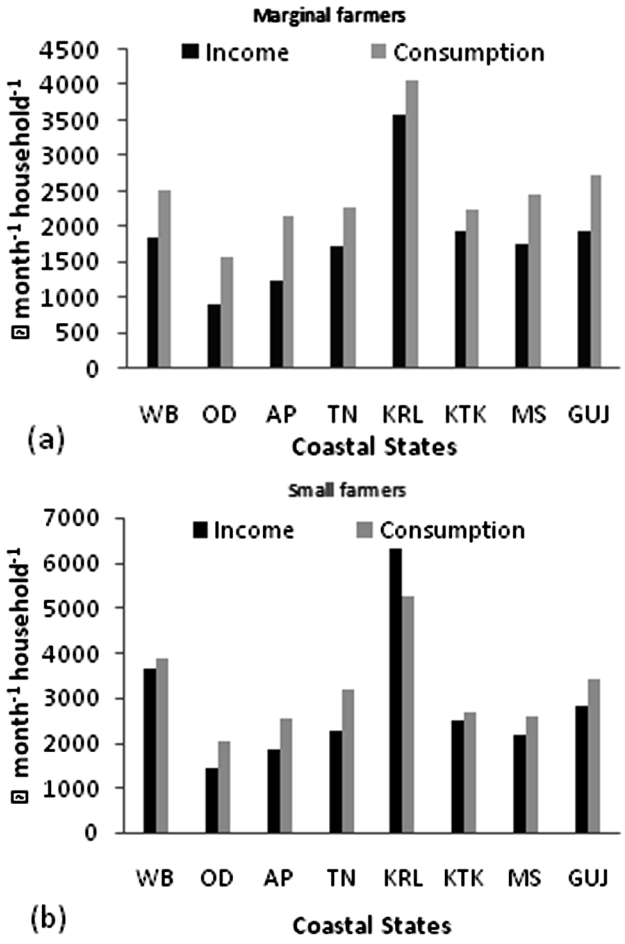

Fig. 1. *Income and consumption of (a) marginal and (b) small farmers in coastal states of India, WB: West Bengal, OD: Odisha, AP: Andhra Pradesh, TN: Tamil Nadu, KRL: Kerala, KTK: Karnataka, MS: Maharashtra, GUJ: Gujarat (Source: Dev, 2012)*

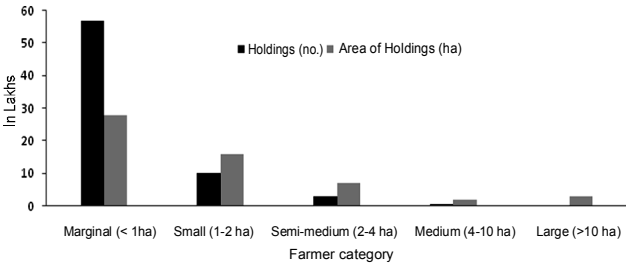

Fig. 2. *Farmer category and land holding size in West Bengal*

Average land holding of the majority farmers in the coastal states of India is marginal and their economic condition is poor (Fig. 2). Hence to raise the income of the farming community, it looks imperative to diversify the mono cropping of rice with other farming options, viz. poultry, duckery, fishery, dairy, apiary, mushroom cultivation, etc. Integrated farming system (IFS) provides an opportunity to increase the economic yield per unit area per unit time by virtue of intensification and diversification of crops and integration of allied enterprises (Singh *et al*., 2007). 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 (Behera *et al*., 2008). The diversity in the farm is to be recognised and utilized *e.g.* in the rice fields of coastal India, 30-40 kinds of edible herbs are found in large quantities; kalmi (*Iopmoea*), thankuni (*Centella asiatica*), brahmi, sushni, kanchire, kulekhara etc. are even sold in some town and city markets of West Bengal (Chatterjee, 2009). The various components of the system have to be mutually synergic, complementary and efficient through recycling of the by-products like organic wastes/residues, thereby rendering the system more remunerative and environmentally safe (Yadav, 2006).

The *Sundarbans* delta has about 102 numbers of Islands, out of this 54 are habited and 48 are reserved forests. The climate is sub-tropical with high humidity and high annual rainfall (about 1800 mm). The soils are saline due to presence of brackish ground water table at shallow depth and occasional saline water flooding. The soils are low lying with flat topography and suffer from heavy drainage congestion. The entire area is almost mono-cropped with long duration poor yielding tall *indica* rice varieties during *Kharif*. Hardly any irrigation facility is available in this region.

The farming communities constitute about 95% of the population which is dominated by SC, ST and backward classes of people and about 83% of the farmers are resource poor or very low (Fig. 3). Majority of them are having marginal and small holding size with extremely poor livelihood and food security. About 25% of the people are landless agricultural labourers having no employment for about 5 to 6 months in a year and

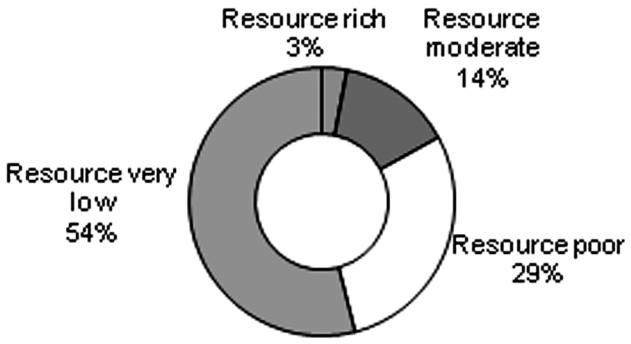

Fig. 3. *Economic status of farming community in Sundarbans, West Bengal*

about 10-12% land less families depends on fishing. About 38% of the population falls below poverty line and majority of them migrate to nearby cities in search of livelihood for 5-6 months a year.

Research efforts to develop appropriate integrated farming system models in the country are continuing. Integration of improved cropping with components like fish, poultry/pigeon/goat at Tamil Nadu resulted in higher productivity, profitability, employment generation and scope for nutrient recycling as against cropping alone. This system generated highest employment of 576 mandays (Jayanthi, 2002). For small and marginal farmers who are short of cash, integration of crop (0.80 ha) with pigeon (10 pairs on 0.01 ha), goat (5 female + 1 male on 0.05 ha), agroforestry (0.10 ha) and farm pond (0.04 ha) was found to be a good alternative farming with recycling of composted goat manure to the crop (Shekinah and Sankaran, 2007). Behera and Mahapatra (1999) at Bhubaneswar observed that IFS involving crops, pisciculture, poultry, duckery, mushroom cultivation, apiary in a land area of 1.25 hectares resulted a net return of Rs. 58,360 from an investment of Rs. 49,286 and the system generated an emplyment equivalent to 573 man days. The marginal and small farmers usually have more than sufficient family labour to engage in farm activites. They prefer enterprises which require less land and capital, and also provide periodic income to meet day-to-day family expenses (Behera *et al.*, 2014). In the coastal region there is potentiality for diversifying the farming taking into the landform, soil, climate and biodiversity. However, studies on combination of such enterprises in the coastal saline agroecosystem for marginal farmers are megre, hence to address the needs of these farmers, farming system model on a representative farm sizes of 0.5, 1.0 and 1.5 acres has been conceptualized and proposed to identify and optimize the enterprise combination to sustain the productivity, income and employment generation and to be studied for the benefit of the poor farmers of coastal region.

Monocropping of rice during *Kharif* season in coastal region is still in practice despite potentiality for diversifying the farming taking into the landform, soil, climate and biodiversity. However, studies on combination of enterprises in the coastal saline agroecosystem for marginal farmers are meagre, hence to address the needs of these farmers, farming system model on a representative farm sizes should be identified and optimized. The enterprise combinations should sustain the productivity, income and enable in employment generation for the farmers of coastal region.

Need for integrated farming system in coastal areas of India

Coastal areas are most vulnerable to climate change and natural calamities. There is plenty of rainfall, which forms the basis for integrated farming system. Farmers are mostly marginal and small, therefore need income from other enterprises. Enterprises which needs less area like mushroom cultivation, dairy, apiary, duckery etc. will increase income and provide livelihood security. The term integrated farming has been used for integration of resources and management, which may not only mean inclusion of livestock or fish components. However, integration of livestock over or adjacent to fish ponds helps in easy utilization of wastes of these components. As per the convenience of farmer, livestock and fishery may be taken up in separate locations and still can be integrated to cropping systems.

Integrated farming system (IFS) provides an opportunity to increase the economic yield per unit area per unit time by virtue of intensification and diversification of crops and integration of allied enterprises (Singh *et al*., 2007). For small and marginal farmers who are short of cash, integration of crop (0.80 ha) with pigeon (10 pairs on 0.01 ha), goat (5 female + 1 male on 0.05 ha), agroforestry (0.10 ha) and farm pond (0.04 ha) was found to be a good alternative farming with recycling of composted goat manure to the crop (Shekinah and Sankaran, 2007).

Experience and principles on integration of field and fodder crops with fish, livestock, duck etc. in other countries like China, Germany, Switzerland, US and Australia proved to be beneficial to the given site and situation. To raise the energy utilization efficiency, to decrease costs, and to increase production and income, several models could be interwoven to an integration web through longitudinal and transverse nutrient cycling and energy flow in line with the local conditions.

Brief description of important components of IFS

Crop

Rice is the predominant crop during wet season. Improved rice varieties being developed recently for coastal environments have better tolerance of the abiotic stresses prevailing in these coastal agro-ecosystems and could provide higher and stable yields**.** For low-lying fields during wet season tall, long duration varieties which are submergence tolerant should be grown

following improved management practices (Sarangi *et al*., 2015a, b). During *rab*i season low-water requiring and soil health building crops should be grown utilizing the conserved water in the channels. The biomass of crop as well as weed produced from cropping system may be utilized as organic manure. Fruit plants may be planted on the dikes/bunds of the system to augment the income of the farmer. Edible herbs like *Ipomoea aquatica* may be allowed to grow on the bunds/free space of rice field for green vegetable purpose. Fodder crops that are feasible under coastal agro-ecosystem may be suitably integrated (Table 1). The cropping systems not only provide income, food security but also nutrient security to the small holder farming communities (Table 2).

The channels in the low land should be designed in such a way that it will have controlled connection to the paddy field. Fresh water fish species **(**Composite fish consisting of rohu, mrigal**,** catla etc.) may be reared utilizing the channel as well as the paddy field during the *kharif* season. The fish concentrate in the channels at the end of the *kharif* season, which help easy catching.

Dairy (Cow for milk purpose)

Dairy component of the system should be functionally interlinked to the crop cultivation by utilizing the crop residues and weed biomass as feed/fodder for the dairy cattle and the by-product of the dairy through vermicomposting should be utilized as manure for crop cultivation. Farm yard manure as a component of integrated nutrient management, enhance the soil health and improve the productivity of the crops in rice based cropping system (Sarangi *et al*., 2014).

Vermi-compost (Cow dung + crop residues + weed biomass decomposed by earthworm)

The residues and by-products produced from crop cultivation and dairy husbandry should be quantified and efficiently utilized after decomposing through suitable earthworm species suitable for saline ecosystem. Earthworm species which are efficient under saline environment should be identified and used for composting.

Fishery

Pisciculture with stocking density of 7500 numbers per hectare in the ratio of 4:3:3 (Catla, Rohu and Mrigal) may be followed. Fish pond should be integrated to other enterprises like duckery, dairy etc. as per the model (Fig. 4). Pond silt can be directly used as a base manure for fodder crops. Integrating fish and cow farming reduces the necessity to purchase fertilizers and fish feeds, and increases the income generated by the fish farm. Fresh animal manure can be applied directly to the

Table 1. *Fodder crops for integrated farming system in coastal areas*

Fodder crop	Sowing type	Use
Rye grass	Spreading drilling and transplanting	Stalk as fodder
Sudan grass	Drilling, spreading dibbling and transplanting	Stalk as fodder
Para grass	Drilling, spreading	Leaves and stalk as fodder
Hybrid Napier	Transplanting	Leaves and stalk as fodder

Table 2. *Cropping system for different land types under integrated farming system in Coastal Areas*

Season	Land type	Crop/Enterprise	Remark
Kharif	*Low land*	Paddy (Flood/submergence tolerant) + fish	Dry direct seeded rice (DSR)
	Up land	*Vegetables:* Arum/taro, lady's finger, brinjal, gourds, beans etc. *Fruit crops:* papaya, banana, sapota, guava	On the boundary fruit crops can be grown to provide additional income
	Medium land	Medium duration paddy (Dudheswar, Sumati, Utpala, Bhutnath) with Kalmisag (*Ipomoea aquatica*)	
*Rabi/ Summer**	*Low land*	Salt tolerant paddy	Salt tolerant fruits: Papaya, banana, sapota, guava, etc. on the boundary
	Up land	*Salt tolerant vegetables:* Tomato, gourds, leafy vegetables, raddish, brinjal, beet, carrot, cauliflower, cabbage, knol-khol etc. *Medicinal/Aromatic plants:* Aloe vera/Tulsi/ Lemon grass, etc.	
	Medium land	Hybrid maize, sunflower	

*Source of irrigation: rain water harvested in trenches/ channels/ farm ponds in conjunction with ground water

fish ponds. Fresh manure thus enters the ponds directly, and energy losses as a result of processing and transportation are avoided. Livestock feeds that are not fully digested can be directly utilized by the fish. The number of animals should be compatible with the pond area.

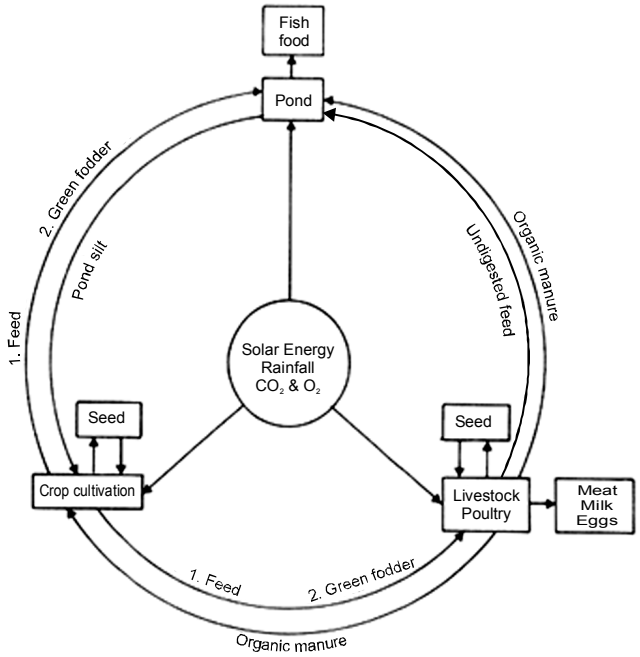

Fig. 4. *Recycling of material in a well managed integrated fish farm*

Duckery unit

Ducks are integrated with the pisciculture in the pond. A duckshed/platform is to be made on the bond or inside the pond for resting during night and other occasions. During day time the ducks utilize the pond. Droppings of the duck act as a feed for fishes. The effect of aeration due to the movement of ducks in the pond water enhance the growth of fishes. Fish ponds provide ducks with an excellent, essentially disease-free environment. Ducks consume juvenile frogs, tadpoles, and dragonfly larvae, thus eradicating many predators of fry and fingerlings. Furthermore, the protein content of these natural food organisms of duck is high. Therefore, duck raising in fish ponds reduces the demand for protein in duck feeds. Khaki Campbell or any other proven breed should be adopted. Duckery unit generate additional income to the farming family.

Mushroom cultivation

Paddy straw is abundantly available in coastal areas, which should be utilized for mushroom cultivation. Low cost house to be constructed for growing paddy straw mushroom, which provide additional income to the farm family. The utilized straw can be used as compost for field crops and vegetables.

Protected cultivation

Improved technology is available to be adopted for cultivation of off season vegetables and flowers (Table 3). In conventional agronomical practices, the crops are being grown / cultivated in the open field under natural conditions where the crops are more susceptible to sudden changes in climate i.e. temperature, humidity, light intensity, photo period and other conditions due to which the quality, yield of a particular crop can get affected and may be decreased. In protected cultivation, the weather parameters are controlled therefore, the effect on crop yield is positive. The yield and quality are improved, inputs are utilized efficiently and there is assured income for farmers (Table 4).

By adopting an integrated model, there is efficient use of farm resources as by-products as there is recycling through use as inputs (Fig.5). This system is self-reliant and reduces the dependence on external inputs, thereby reduce the cost of cultivation, provide employment opportunity and balance nutrition to the farming family.

Integration of enterprises however has positive and negative consequences on capital assets (Table 5). Integration of fish farming in crop and livestock system has positive effect on natural resources as ther is reduced pressure on biodiversity, at the same time there is negative effect due to increased pressure on water, extra requirement of nutrients etc. The effect on social and human resources mostly positive due to increased income, resultant effect to diversify livelihood strategies. Negative effects may be social conflict for use of water as seen in case of brackish water farming in coastal areas. Some farmers are interested for brackish water fishery, whereas some are interested for arable framing.

Table 3. *Crops and varieties recommended for protected cultivation*

Crop	Varieties
Tomato	GS 600
Tomato (Big Fruit)	Himosona
Capsicum	Indra, Natasa, Swarna, Orobelly, Bombay
Cherry Tomato	Pusa Cherry Tomato
Sweet Pepper	Nun 3019, Nun 3020, Indira
Cucumber	Hilton, Mini Angel, Satis and Gian
Rose	First Red, Golden gate, Mercedes
Gerbera	Cabana, North star

Table 4. *Economic benefits from protected cultivation of high value crops*

Crop	Estimated Yield (t ha^{-1})		Increase in Yield (%)	Estimated Net Returns (Rs ha^{-1} crop^{-1})		Increase in Net Returns (%)
	Open Cultivation	Protected Cultivation		Under Open Cultivation	Under Protected Cultivation	
Tomato	2.0 – 2.5	15.0 – 20.0	678	5000 - 6000	30000 – 40000	536
Capsicum	1.0 – 1.5	5.0 – 6.0	340	4000 – 5000	40000 – 50000	900
Cucumber	1.5 – 2.0	10.0 – 12.0	678	3000 – 4000	50000 - 60000	1471

Table 5. *Integration of pisciculture in crop/livestock systems*

Capital assets	Possible impacts	
	Positive	Negative
Natural	Reduced pressure on biodiversity	Increased pressure on water, nutrients
Social	Increased fish and other aquatic products available for enhancing social relationships	Theft, increased conflicts over water use
Human	Skills and knowledge developed that can be used to further diversify livelihood strategies Improved nutrition enhances physical and mental health	Competition with more vital activities for time and attention Extra labour burden
Physical	Improved potential for diversification of farming systems and livelihoods, reduce risk to both flood and drought	Reduced area available for staple crops
Financial	Improved overall income and regularity of income, credit worthiness, and savings	High investment cost

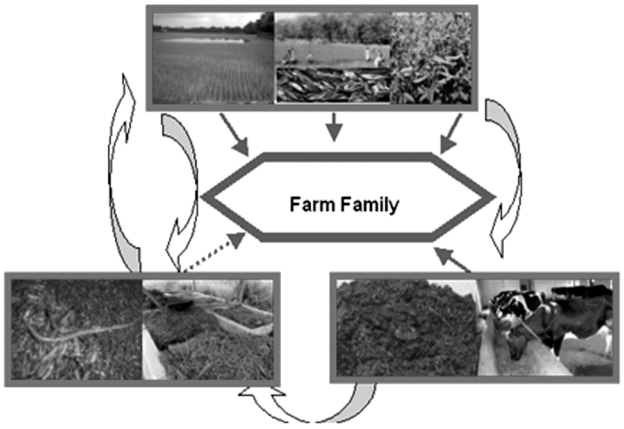

Fig. 5. *Functional relationships in different components of the farming system for sustaining the productivity of small and marginal farms in coastal agro-ecosystem*

However, even with all there effects, there is overall improvement of financial status of most of farmers, therefore, this IFS should be further supported by financial institutions for scaling up in coastal areas. The economic feasibility of such models in rice based systems with integration of duckery, fishery and mushroom (Table 6) for marginal farmers has been proved to be sufficiently higher than conventional farming.

Advantages of FSR in Coastal Region

The coastal areas of India are complex, diverse and risk prone. Even though there are similarities in agroecosystem, the farming situations varies from states to state and even within a state it varies from district to district, block to block, village to village and farmers to farmers depending upon the availability of resources, holding size, location of the farm, accessibility to market, financial and developmental institutions, soil and water type etc. Therefore, FSR will target location specific transfer of technologies related to improved variety, irrigation methods, and management practices. FSR will result in better utilization of natural resources through multiple use of water, complementary use of land, recycling of by-products, reduction in use of chemicals and effective management of stresses like salinity and submergence. Increase in employment opportunities in farm result in reduction in migration.

Pond based integrated farming system (field and horticultural crops, fishery, dairy, and agroforestry) for marginal farmers of 0.4 ha land in flood-prone coastal ecosystem generates employment of 248 man-days and net returns of Rs. 47,825 in a year with an investment of Rs. 18,515 (excluding family labour). The production of

Table 6. *Economics of rice based farming systems for a marginal farmer (0.4 ha)*

Component	Expenditure (000' Rs)	Gross return (000' Rs)	Net return (000' Rs)
Crop	33	60	27
Duckery	6	9	3
Fishery	4.5	10.5	6
Mushroom	15	18	3
Total	58.5	98.5	40
Conventional cropping	21	39	18

fish, milk, food grains, vegetables, fruits etc. within the farm helped in improving the standard of living and provided better nourishment to the family members. The recycling of cow dung manure, paddy straw, green weed biomass and kitchen wastes etc. was achieved in gainful and sustainable way (Behera, 2014).

CONCLUSIONS

Integrated Farming System (IFS) is a necessity for coastal region for augmenting income generation of small and marginal farmers through complementary enterprises. Impacts of integration should be addressed for long term sustainability, while improving productivity, profitability and employment round the year. The improved model of IFS will enhance food security, reduce poverty, and improve livelihood of the farmers in the coastal region.

REFERENCES

Behera, U. K. (2014). A Text Book of Farming Systems. Agrotech Publishing Academy, Udaipur, India. pp 172.

Behera, U. K. and Mahapatra, I. C. (1999). Income and employment generation for small and marginal farmers through integrated farming systems. *Indian Journal of Agronomy* **44**(3): 431-439.

Behera, U. K., Yates, C. M., Kebreab, E. and France, J. (2008). Farming systems methodology for efficient resource management at the farm level: a review from an Indian perspective. *Journal of Agricultural Science* **146**: 493-505.

Behera, U. K., Kaechele, H. and France, J. (2014). Integrated animal and cropping systems in single and multi-objective frameworks for enhancing the livelihood security of farmers and agricultural sustainability in Northern India. *Animal Production Science*, http://dx.doi.org/10.1071/AN14526.

Chatterjee, A. S. (2009). Diversified farming systems – learning from past to move into future. *LEISA INDIA* **11**(1): 8-10.

Dev, S. M. (2012). Small farmers in India: Challenges and opportunities, Indira Gandhi Institute of Development Research, Mumbai. http://www.igidr.ac.in/pdf/publication/wp-2012-014.pdf

Jayanthi, C. (2002). Project report submitted to ICAR on sustainable farming system models for low land farms of Tamil Nadu, India.

Ravisankar, N., Pramanik, S. C., Rai, R. B., Nawaz, Shakila, Biswas, Tapan, Kr. and Bibi, Nabisat. (2007). Study on integrated farming system in hilly upland areas of Bay Islands. *Indian Journal of Agronomy* **52**(1):7-10.

Sarangi, S. K., Maji, B., Singh, S., Sharma, D. K., Burman, D., Mandal, S., Ismail, A. M. and Haefele, S. M. (2014). Crop establishment and nutrient management for dry season (boro) rice in coastal areas. *Agronomy Journal* **106**(6): 2013-2023. doi: 10.2134/agronj14.0182.

Sarangi, S. K., Maji, B., Singh, S., Burman, D., Mandal, S., Sharma, D. K., Singh, U. S., Ismail, A. M. and Haefele, S. M. (2015 a). Improved nursery management further enhances the productivity of stress-tolerant rice varieties in coastal rainfed lowlands. *Field Crops Research* 174 (2015): 61-70 http://dx.doi.org/10.1016/j.fcr.2015.01.011.

Sarangi, S. K., Maji, B., Singh, S., Sharma, D. K., Burman, D., Mandal, S., Singh, U. S., Ismail, A. M. and Haefele, S. M. (2015 b). Using improved variety and management enhances rice productivity in stagnant flood-affected coastal zones. *Field Crops Research,* http://dx.doi.org/10.1016/j.fcr.2015.10.024.

Shekinah, D. E. and Sankaran, N. (2007). Productivity, profitability and employment generation in integrated farming systems for rainfed vertisols of western zone of Tamil Nadu. *Indian Journal of Agronomy* **52**(4): 275-278.

Singh, Kalyan, Bohra, J. S., Singh, T. K., Singh, J. P., Singh, Yogeshwar and Singh, C. S. (2007). Productivity and economics of integrated farming system in irrigated agro-ecosystem of eastern Uttar Pradesh. *Indian Journal of Agronomy* **52**(1):11-15.

Yadav, J. S .P. (2006). Improved farming and ecological security in coastal region. *Journal of Indian Society of Coastal Agricultural Research* **24**(2): 229-240.