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Performance of Pond Based Integrated Farming Systems in Different Agro-Ecosystems: An On-farm Survey

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The paper presents insight into pond based integrated farming system (IFS) in humid tropics of Eastern India in terms of ecosystem area allocated and income generated from different enterprises. It is based on on-farm survey conducted in 51 farmer fields using stratified random sampling technique in 3 agro-ecosystems (coastal waterlogged, rainfed plateau, and canal irrigated) during the year 2012-13. The results revealed that highest average net economic return of ₹ 115485 ha^{-1} under IFS was accrued in irrigated ecosystem. It was closely followed by coastal waterlogged ecosystem (₹ 111740 ha^{-1}) while lowest amount of ₹ 61,964 ha^{-1} was noted under rainfed ecosystem. This return for coastal waterlogged ecosystem was very high as it increased by 6.7 times as compared to the common practice of rice-fallow sequence with a net return of ₹ 16801 ha^{-1} only. Such increases were 3.0 and 2.2 times under rainfed plateau and irrigated ecosystems, respectively. Net return from IFS were further divided into 3 broad components *viz*., pond, embankment and adjoining upland, and field crop component. In case of the pond component, average net return was quite lucrative under coastal waterlogged ecosystem (₹ 181085 ha^{-1}), however, for embankment and adjoining upland component, it was under irrigated (₹ 209843 ha^{-1}) ecosystem.

***(Key words:** Canal irrigated, Coastal waterlogged, Net economic return Rainfed plateau, Integrated farming)*

Food and agriculture sector depends heavily on water and energy resources, globally using 70% of water withdrawals and 30% of end-energy (FAO, 2014). Problems of water and energy shortage (FAO, 2014) and declining soil productivity (Rautaray *et al*., 2009) are evident under intensive agriculture practices. In India, in spite of large scale expansion of irrigation system, about 55% of the gross cropped area is under rainfed system and likely to increase under the climate change scenarios and increased demand from competing sectors (DWM, 2013). Construction of new irrigation projects is capital intensive and frequently encounters opposition from ecologists and environmentalists. Even in the existing canal irrigated areas, tail end farmers commonly experience water scarcity. Groundwater irrigated areas have inherent problems of energy intensiveness and adverse environmental effects like declining water table. So, water security at individual farm level using rain water harvesting ponds and multiple use of harvested water under integrated farming is the option for assured food production in rainfed areas (Rautaray *et al*., 2016). This is more important in the context of climate change with adverse effects on rainfall availability and distribution (Rautaray *et al*., 2013).

Globally, the land area needed to feed one person has decreased from 0.50 to 0.22 ha (FAO, 2014). It is further aggravated by the declining productivity resulting from non-judicious use of available natural resources. In India, the number of marginal holdings (below 1 ha) is 92.82 million accounting for 67.1% of total holdings. The increase in number of marginal holdings is very fast over the years and quite distinct from the remaining type of land holdings (Anonymous, 2014). Also, the area operated by farmers of such land holding category is steadily increasing over years and it was 35.9 M ha as per the Agricultural Census 2010-11. The per capita land availability in India may decrease to 0.09 ha by 2020 AD. Under the situations of reduced per capita land availability and increased rural unemployment, adoption of IFS is a viable option for enhancing farm income and generating

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employment (Behera and France, 2016; Mohanty *et al*., 2016; Rautaray, 2011; Ravishankar *et al*., 2007) especially for marginal and small farms. Careful planning and recycling of by-products (Manjunath and Itnal, 2003) in farming system lowers the cost of production and hence results in higher farm income. There exists complex interrelationship among the components in a farming system (Behera and Mahapatra, 2011). A farming system comprises of a complex and highly diverse agricultural production system in developing countries like India, whose outputs include crop, tree, livestock and fish and a vast multitude of ecological goods and services (Behera *et al*., 2012). Farming system being labour intensive, it can address the problem of burgeoning unemployment and provide the farm family with fresh and nutritious farm products (Gill *et al.,* 2009). Water harvesting pond based IFS is the foreseeable management option to generate more income, food, and employment per unit area with the ability to moderate the adverse effects of climate change. Economic benefits from IFS is reported mostly from on-station trials and few on-farm trials. However, information is meagre regarding farm income from pond based IFS for the marginal, small, semi-medium, medium and large farmers under rainfed plateau, irrigated and waterlogged ecosystems as compared to the dominant cropping system of rice-fallow under rainfed situation in eastern India.

MATERIALS AND METHODS

A field survey was conducted to document information on pond based IFS with the help of questionnaire in coastal waterlogged, irrigated and rainfed plateau agro-ecosystems in the year 2012-2013. Stratified random sampling method was used to select farmers considering three agro-ecosystems as different strata. Within each strata, farmers of different land holding size (marginal (< 1 ha), small (1-2 ha), semi-medium (2-4 ha), and medium (4-10 ha) were selected. Out of 51 farmers, 18 farmers were from coastal waterlogged areas of Puri, Bhadrak, Kendrapada and Cuttack districts, 17 from irrigated areas in Balasore, Bhadrakh, Sambalpur, Khorda, Puri, and Kendrapada districts and 16 from rainfed plateau areas of Dhenkanal and Cuttack districts.

The economic analysis was done by considering the variable production cost only (Parihar *et al*., 2017). The cost of family labour was not imputed in cost calculations as farmers traditionally follow farming systems from time immemorial and they become part of natural farming (Ponnusamy and Devi, 2017). Also, the farmers usually do not keep the record of family labour involved in farming, as they do not pay for it. Net economic return was computed by deducting from the gross returns, the cost incurred on different inputs. Such inputs were seed/planting materials, fertilizer, pesticides, animal feed, fish feed, medicines for animal/fish, hired human labour, farm machinery and implements. The local cost of inputs and price of outputs were considered for calculating the gross expenditure and gross return, respectively.

Area under IFS was divided into three broad components (Mohanty *et al*., 2016). The components were (a) pond, (b) embankment with the adjoining upland, and (c) field. Pisciculture was the sole enterprise in pond. Suitable horticultural crops (papaya, banana, drumstick, coconut, arecanut and vegetables) with or without animal rearing (poultry and dairy) were farmed on the embankment and adjoining upland area. In the field component, paddy crop was grown invariably in the wet season while seasonal pulses or vegetables were grown in the dry season. Area, input used and yield from each component were recorded in the survey schedule as per the information provided by the farmers. The data was finally converted to net return per unit area (1 hectare) for facilitating comparison among the different size holdings as well as farm enterprises. In addition, we also studied the most profitable on-farm farming system units for each ecosystem to know the potential achievable return from an ideal pond based farming system under humid and sub-humid situations of eastern India. We also examined the social factors (age, educational qualification, holding size, non-farm income, distance of the farming system unit from the residential area, involvement of other members in the farm family) behind some of the successful farming system units.

RESULTS AND DISCUSSIONS

Area and net economic return from pond

Pond size in coastal waterlogged ecosystem varied from 120 m^2 to 24000 m^2 (data not presented). This varied from 320 m^2 to 7500 m^2 for irrigated ecosystem and 150 m^2 to 8000 m^2 under rainfed plateau ecosystem. Average pond size (Table 1) was the lowest under rainfed plateau ecosystem (1079 m^2). Relatively less availability of water in this ecosystem restricts the farmers to opt for higher pond size. Average pond size under coastal waterlogged ecosystem (3187 m^2) and irrigated ecosystem (2345 m^2), respectively, was higher by 3.0 and 2.2 times of that under rainfed plateau ecosystem.Within coastal waterlogged ecosystem, the average pond size of marginal farmers was 810 m^2 (lowest). It increased to 1619 m^2 for small farmers and further increased to 7140 m^2 for semi-medium farmers and declined to 5500 m^2 under medium category. Similar trend of increased pond size (up to 7500 m^2) for semi-medium land holding size was also noted for irrigated ecosystem. Increased land availability from marginal to semi-medium holding might have favoured an increase in pond size within these groups. However, farming system is a labour intensive activity with major contribution from family labour. Medium farmers with land holding between 4 to 10 ha might have faced operational difficulty in getting enough family labour for farming system leading to a decrease in pond size. For rainfed plateau ecosystem, there was increase in pond size with increase in land holding size even up to medium land holding. This was due to distribution of small ponds in this ecosystem, highest average pond area being 2750 m^2 only.

Average net return from pond on unit area of 1 ha was lowest (₹ 84566) under rainfed plateau ecosystem. This increased to 120712 (43%) under irrigated, and ₹181085 (114%) under coastal waterlogged ecosystem. Highest return from pond component under waterlogged ecosystem was associated with availability of enough water depth for a prolonged period up to April month in pond favouring pisciculture enterprise. High groundwater table, and low seepage percolation rate due to high clay content in water logged lowlands favoured prolonged period of standing water in pond. Higher profitability from pisciculture as compared to on-dyke horticulture or field crops on unit area basis is reported under rainfed lowland ecosystem (Rautaray, 2011). Among the land holding sizes, average net return from pond was highest for marginal farmers (average of ₹ 145865 across 3 ecosystems). This varied from ₹ 120721 to ₹ 134310 for the remaining category of farmers.

Area and net economic return from embankment and adjoining upland area

Mean area of embankment and adjoining upland (Table 2) was highest under rainfed plateau ecosystem (2650 m^2) followed by waterlogged (988 m^2) and the

Table 1. *Area and net economic return under pond as influenced by agro-ecosystems and land holding size*

Land Holding Size	Pond area (m^2) in different ecosystems			Net return from pond (₹ ha^{-1}) in different ecosystems		
	Waterlogged	Irrigated	Rainfed plateau	Waterlogged	Irrigated	Rainfed Plateau
Marginal	810	1588	250	215833	139680	82083
Small	1619	2455	412	166297	110350	85516
Semi-Medium	7140	7500	1067	179242	94667	89583
Medium	5500	1600	2750	223958	96875	82098
Average	3187	2345	1079	181085	120712	84566

Table 2. *Area and net economic return under embankment and adjoining upland as influenced by agro-ecosystems and land holding size*

Land holding size	Embankment and upland area (m^2) in different ecosystems			Net return from embankment and upland (₹ ha^{-1}) in different ecosystems		
	Waterlogged	Irrigated	Rainfed plateau	Waterlogged	Irrigated	Rainfed plateau
Marginal	312	559	1263	193217	213259	67827
Small	497	928	2030	118268	202926	210923
Semi-Medium	2341	2500	4567	123963	133600	23646
Medium	1417	400	3375	102946	317500	94337
Average	988	838	2650	128451	209843	110888

lowest under irrigated ecosystem (838 m^2). Increase in embankment and upland area with increase in land holding size was noted up to semi-medium land holding category. A decrease in area under this component for medium land holding was due to operational difficulty for diversified farming requiring enough family labour.

Average net return from 1 ha embankment and upland area was lowest (₹ 110888) for rainfed plateau ecosystem. This return was increased by 1.2 and 1.9 times forcoastal waterlogged (₹ 128451) and irrigated (₹ 209843) ecosystem, respectively. Lowest net return for embankment and upland area under rainfed plateau ecosystem was associated with less availability of water due to smallest pond size and high seepage percolation rate. In case of pond, average net return was quite lucrative under coastal waterlogged ecosystem, however, for embankment and upland component, it was under irrigated (₹ 209843 ha^{-1}) ecosystem. Poverty and irrigation availability is reported to be negatively correlated (Ghosh *et al*., 2012) in the eastern region of India. Net return from embankment and upland area and size of land holding exhibited variable trend. Diversified horticulture and animal rearing practised on this component under IFS is most labour intensive. The success of this component depends mainly on the interest of the farm family for such work and nearness of the system to the residential area of the farmer. This was the reason for variable response of net return to size of land holding.

Area and net economic return from field crops

Kharif season

Rice was the dominant field crop during *kharif* season and integral part of each farming system unit. In fact, rice is the predominant crop in Eastern India by default due to the prevailing agro-ecosystem and historical association with life and culture of the people. Prolonged period of water stagnation under waterlogged ecosystem compels farmers for growing of rice using suitable variety and management practices. In irrigated system, rice is the dominant crop to get an assured high yield (Mollinga and Veldwisch, 2016). Many irrigation systems are designed for protective irrigation to rice crop (Srivastava and Brewer, 1994). Farmers grow rice under rainfed plateau ecosystem also as it provides staple food, food security, and social status. Scope for crop diversification by substituting low yielding upland rice with horticultural crops exists in this ecosystem. However, growing of vegetable crops suffer from marketing problem, if the production site is remote from urban conglomeration. Fruit crops face the problem of long gestation period, so farmer has to wait for 4 to 5 years to get return on investment. Many of the farmers are poor in this handicapped ecosystem and cannot wait for such long period to get returns for livelihood. Average area of rice crop under pond based IFS (Table 3) was highest under rainfed plateau (3219 m^2) followed by coastal waterlogged ecosystem (2989 m^2) and the lowest under irrigated ecosystem (2517 m^2). Mohanty *et al*. (2016) also reported that in

Table 3. *Area and net economic return from field in kharif season (rice) as influenced by agro-ecosystems and land holding size*

Land holding size	Rice area (m^2) in different ecosystems			Net return from embankment and upland (₹ ha^{-1}) in different ecosystems		
	Waterlogged	Irrigated	Rainfed plateau	Waterlogged	Irrigated	Rainfed plateau
Marginal	1700	1754	1050	19458	21198	21271
Small	2740	2813	2700	16997	27698	21522
Semi-Medium	3375	3000	4667	15763	19000	17950
Medium	4750	5000	4950	15244	36000	20060
Average	2989	2517	3219	16801	24918	20424
	(0.21)	(0.24)	(0.17)	(1.17)	(1.15)	(1.15)

Figures in parentheses indicate fraction of the rice area and net return under IFS of the total rice area and net return for a farmer.

rainfed plateau ecosystem, the area under paddy crop was high for most of the farming system units. Higher crop productivity and population density in irrigated ecology may be associated with lower area (2517 m^2) for paddy crop. There was progressive increase in area under rice crop with increase in land holding size.

Average net return from 1 ha rice area was highest under irrigated ecosystem (₹ 24918) followed by rainfed plateau (₹ 20424) and the lowest amount of ₹ 16801 undercoastal waterlogged ecosystem. Lowest net return under coastal waterloggedecosystem was mainly due to excess water stress leading to crop submergence for different duration at various growth stages. Also, stress due to water deficit sometimes occurs during the period from germination to early establishment stages. In rainfed upland rice, the major constraints were weed infestation and moisture stress during dry spell. These stresses are partly overcome by adopting practices for weed management and water conservation using farm pond. Mohanty *et al*. (2016) reported a similar low net return of ₹ 15900 to ₹ 24500 ha^{-1} from paddy crop in rainfed plateau ecosystem. Highest net return of paddy crop from irrigated ecosystem was due to favorable situation for water management. Net return under different landholding sizes exhibited variable trend. A limited area of rice crop was under pond based IFS which were located nearby. Thus, the major area of this important crop was not within the purview of farming system. The average fraction of rice area under IFS as compared to the total area under rice varied from 0.17 under water waterlogged ecosystem to 0.24 under irrigated ecosystem indicating about 20% rice area only under IFS. The average fraction of net return per unit rice area under IFS was higher as compared to the total rice area ranging narrowly from 1.15 to 1.17 indicating about 16% higher net return for rice crop under IFS. Higher yield of rice under IFS was associated with controlled water management using farm pond and easy crop monitoring due to nearness to the system unit.

Rabi season

Average area under field crops during *rabi* season was highest under irrigated ecosystem (2337 m^2) followed by waterlogged ecosystem (1520 m^2) (Table 4). It was conspicuously low (56 m^2) under rainfed ecosystem. This was due to small size ponds and low availability of water for field crops. The farmers opted for growing vegetable crops in the *kharif* season on bunds and adjoining uplands. Similarly, net return from field crop during *rabi* season under rainfed plateau was conspicuously low. Net return from *rabi* crops was about ₹ 1 lakh ha^{-1} under coastal waterlogged as well as irrigated ecosystem which was about 5 times the *kharif* rice. This was due to higher return from vegetables as compared to rice.

Area and net economic return from pond based IFS vis-à-vis rice fallow

Average area under pond based IFS was highest under waterlogged ecosystem (0.72 ha) followed by rainfed plateau (0.69 ha) and lowest under irrigated ecosystem (0.57 ha). This indicates area under farming system was well within the marginal land holding size of <1 ha. High labourrequirement, especially interms family labour compelled the farmers for a limited area under farming system considering operational convenience.

Net economic return from kharif rice - fallow sequence was ₹ 17750 ha^{-1} (average of 51 farmers). This income was increased to ₹ 63063 ha^{-1} by land modification for pond based IFS. Net economic

Table 4. *Area and net economic return from field in rabi season as influenced by agro-ecosystems and land holding size*

Land holding size	Area (m^2) under rabi crops in different ecosystems			Net return from rabi crops (₹ ha^{-1}) in different ecosystems		
	Waterlogged	Irrigated	Rainfed plateau	Waterlogged	Irrigated	Rainfed plateau
Marginal	710	2318	0	28169	114996	0
Small	280	2438	113	77417	82829	600
Semi-Medium	1000	3600	0	8750	130556	0
Medium	4250	400	0	130000	95000	0
Average	1520	2337	56	102319	99598	300

return was highest under irrigated ecosystem (115485 ha^{-1}) followed by waterlogged ecosystem (111740 ha^{-1}) while lowest amount of 61964 ha^{-1} was noted under rainfed ecosystem (Table 5). In a coastal waterlogged ecosystem by integrating field and horticultural crops, fishery, dairy and agro-forestry (Behera *et al*., 2010) reported that net returns of ₹ 47,825 was obtained in a year with an investment of ₹ 18,515 (excluding family labour) from 0.4 ha area. Mohanty *et al*. (2016) while analyzing the net returns from 10 water harvesting pond based farming system units in rainfed plateau ecosystem reported that highest amount of ₹ 251000 ha^{-1} was obtained from the farming system unit having pisciculture in pond, intensive horticulture on bund and poultry in the adjacent area. The authors reported that the lowest net return of ₹ 16800 ha^{-1} farming system area. The huge variation in net income was associated with the enterprising nature of the farmer and sincerity in approach with the extension agencies. Among the 4 categories of land holdings, there was variable response to net return from IFS. The success and net return was dependent upon the interest of farmer and distance of farm from residence affecting operational convenience.

The average fraction of area under pond based IFS to the total cultivated area for a farmer was 0.28 under rainfed plateau ecosystem, 0.38 under waterlogged ecosystemand 0.43 under irrigated ecosystem. This indicates that about 36% of the total cultivated area was under IFS. The average fraction of net return per unit area under IFS to the total cultivated area was higher ranging narrowly from 1.83 under to 2.00 indicating about 89% higher net return from area under IFS. The interesting feature is that even in case of the disadvantageous ecosystems the net return per unit area from pond based IFS was about two-fold as compared to the total cultivated area.

Rainfed plateau and coastal waterlogged areas are generally considered as low yielding handicapped ecosystem with rice-fallow sequence. By adopting pond based IFS, the net return was increased by 6.7 times as compared to rice-fallow sequence (₹ 16801 ha^{-1}) in waterlogged ecosystem. Such increase was 3.0 times under rainfed plateau ecosystem (₹ 20424 ha^{-1}). Canal systems in Eastern India are designed for irrigating to rice crop and often rice-rice sequence is practiced. Net return under IFS in irrigated ecosystem was increased by 2.2 times as compared to rice-rice sequence (₹ 51418 ha^{-1}). Higher yield of rice associated with IFS was due to controlled water management using farm pond (Thakur *et al*., 2015) and easy crop monitoring due to nearness to the system.

Most profitable pond based IFS in different ecosystems

The farmer earning highest net return under coastal waterlogged ecology was a semi-medium farmer (3.6 ha) with all his land under pond based IFS. Highly educated farmers also tend to adopt technology with greater intensity (Saha, *et al*., 1994). About 67% of land was put under pond, 22% under embankment and adjoining upland and remaining 11% under field crop component (Table 6). The most profitable component under IFS was pond with highest net return of ₹ 250000 ha^{-1} from raising of fish fingerling and grow out aquaculture with Indian Major Carps. This was followed by embankment and upland component comprising coconut, arecanut, mango and banana with net return of ₹ 158750 ha^{-1}. Lowest net

Table 5. *Area and net economic return under pond based IFS as influenced by agro-ecosystems and land holding size*

Land holding size	Area (ha) under IFS			Net Return (INR ha^{-1}) from IFS		
	Waterlogged	Irrigated	Rainfed plateau	Waterlogged	Irrigated	Rainfed plateau
Marginal	0.30 (2)	0.39(7)	0.26 (4)	175991	122601	48235
Small	0.56 (10)	0.62(8)	0.51(5)	84408	14096	107844
Semi-Medium	1.29 (4)	1.30(1)	1.03(3)	109302	120846	27701
Medium	1.17 (2)	0.70 (1)	1.11 (4)	189021	71429	44041
Std.Dev. ±	0.90	0.26	0.42	44609	26154	62597
Average	0.72	0.57	0.69	111740	115485	61964
	(0.38)	(0.43)	(0.28)	(2.00)	(1.83)	(1.84)

Figures in parentheses indicate number of farms under different land holding groups considering total farmland for a farmer except for the row 'average' in which case it indicates the fraction of the area and net return under IFS of the total farm area and net return, respectively, for a farmer.

Table 6. *Area and net economic return under most profitable pond based IFS vis-a-vis average in different agro- ecosystems*

Ecosystem	Area (ha)					*Net Return (ha^{-1}) from IFS					
	Pond	Bund and upland	*Kharif*	*Rabi*	IFS	Pond	Bund and upland	*Kharif*	*Rabi*	IFS	Average of an ecosystem
Coastal waterlogged	2.4	0.8	0.4	0.4	3.6	250000	158750	18750	35000	302000	111740
Irrigated	0.4	0.215	0.2	0.2	0.815	62525	290818	34000	137500	149479	115485
Rainfed platue	0.08	0.304	0.45	0	0.834	87500	584868	23111	0	234053	61964

**Net return from different components of the IFS are presented on 1 ha area basis for easy comparison.*

return was incurred from field component, at the rate of ₹ 18750 from rice during *kharif* season and ₹ 35000 ha^{-1} from mung bean cultivation during *rabi* season. The net return from IFS was ₹ 302000 ha^{-1}.

For irrigated ecosystem, the highest net return was earned by a farmer who owns 1.15 ha land and the source of income was from the farm only. Out of total land holding, 71% area was under pond based IFS.The distribution of area under IFS include, 49% under pond, 26% under embankment and adjoining upland and remaining 25% under field crop component. The most profitable component under IFS was embankment and upland component with highest net return of ₹ 290814 ha^{-1}. This high income was associated with high return from dairy and poultry followed by papaya and banana. High net return from vegetables grown during *rabi* season in field resulted in net return of ₹ 137500 ha^{-1}. Net return from pond was also promising (₹ 62525 ha^{-1}). The net return from IFS was ₹ 149479 ha^{-1}. In addition to household works, the women members wereinvolved in sun drying, cleaning and processing of paddy grain based products.

The farmer earning highest net return under rainfed plateau ecosystem was a small literate farmer fully associated in farming. Their holding size was 1.65 ha and the source of income was from the farm only. Out of the total land holding, 51% of land was under pond based IFS. Hard working nature of the farm family, medium land holding and involvement of the young and educated son might have helped in operating successful farming system. Of the total area under IFS, about 10% of land was put under pond, 36% under bund and adjoining upland and remaining 54% under field crop component. The most profitable component under IFS was bund and upland component with highest net return of ₹ 177800 from 3040 m^2 which works out as ₹ 584868 ha^{-1}. The farmer practiced dairy farming 50 m^2 area using surplus family labour. The gross and net returns from dairy component were ₹ 171000 and ₹ 36000, respectively. The next profitable enterprise was poultry farming (broilers). The gross and net returns from broiler cultivation were ₹ 75000 and ₹ 22500, respectively, from an area of 50 m^2. Mushroom cultivation in 50 m^2 area resulted in gross and net returns were ₹ 25200 and ₹ 14000, respectively. The gross and net returns from pond were ₹ 16000 and ₹ 7000, respectively.Thus, net return works out as ₹ 87500 ha^{-1} water area of pond. In the field, rice was grown during *kharif* season with a low net return of ₹ 23111 ha^{-1} only. In the *rabi* season, the field remain fallow mainly due to engagement of farm family for dairy, poultry, mushroom and vegetable cultivation on embankment and upland areas. Also, there was not enough water for growing *rabi* season field crops after meeting the embankment and upland needs. The net return from IFS was ₹ 234053 ha^{-1}. The female members were involved in feeding of cows, milking, cleaning of cowshed and disposal of raw cowdung for use as fish feed. Similarly, mushroom cultivation, feeding of poultry birds, sun drying and cleaning of paddy grain was attended by them. In addition to household works, the women members were involved in sowing vegetable crops and plucking, transporting farm wastes to compost pit and other miscellaneous activities like store keeping of farm implements and accessories.

For coastal waterlogged ecosystem, the net return from the most profitable farming system unit was 2.7 times the average net return for the ecosystem. This ratio was highest (3.8 times) for rainfed plateau ecosystem. It was due to low average net return for the ecosystem, while the most profitable farming system unit was promising. This also reflected in highest standard deviation for net return (₹ 62597). Low average net return for this ecosystem was due to small size ponds and less available water in pond due to high seepage percolation loss. High profit for the promising farming system unit in this ecosystem was due to hard work and keen interest of the farm family, adoption of profit making enterprises like poultry, dairy, mushroom cultivation and vegetables on embankment and adjoining upland. Also, the pond was moderate in size (800 m^2) and it was located on the drainage line which helped in retaining water for a longer period. For irrigated ecosystem, the net return from the most profitable farming system unit was only 1.3 times of the average net return for the ecosystem. This was due to the favourable situation of water availability and net returns generated from most farms were similar to the average value.It is reflected in the lowest standard deviation for net return (₹ 26154).

Pond based IFS was predominant with small and marginal farmholders with surplus family labour. Successful farming systems were located vicinity to the residential area of the farmer. Selection of pond site was very important, particularly under rainfed plateau ecosystem. In this ecosystem, water level in the pond remained for longer period up to March, if the ponds were located on drainage line. Pond based farming system generated higher income over the conventional rice fallow sequence in rainfed areas, more importantly in coastal waterlogged ecosystem. Pond based farming system should be promoted for farm income generation, especially in coastal waterlogged and rainfed plateau ecosystems. Financial support for excavation of farm ponds, technological support from extension agencies, timely supply of farm inputs, land consolidation, marketing mechanism and farm mechanization will help in promoting such farming system units.

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