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Sewage Fed Farming Systems and Sustainable Livelihood in Peri-urban Kolkata

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Abstract

The study is an inquiry of prevailing farming systems in peri-urban mega city Kolkata. Due to lack of fresh water farmers are dependent on the domestic sewage water for cultivation of crops and running a pisciculture unit. The study revealed the pre-dominance of small farmers with abundant supply of workforce both male and female. Around 61.67 % (74 no.) of farmers have a fishery unit (small or large) under their execution. Due to the availability of ample wastewater throughout the year, 61.67 % (74 no.) of sampled farmers practices pisciculture and 59.17 % (71no.) of sampled farmers have intensive vegetable production unit. In this context the study focuses on optimizing production with sustainability. The normative plan suggests that incorporation of a piggery or a poultry unit sufficiently increase the net income by 47 to 58 % over existing earnings. Intensive vegetable cultivation along with a fishery unit also increase the net income significantly (47.29%).

Keywords: Farming system, urban farming, managing wastewater, wastewater productivity.

Continuing population growth and urbanization, rapid industrialization, expanding and intensifying food production are all putting pressure on water resources and increasing the unregulated or illegal discharge of contaminated water within and beyond national borders. This presents a global threat to human health and wellbeing, with both immediate and long term consequences for efforts to reduce poverty whilst sustaining the integrity of some of our most productive ecosystems. It is equally clear that future demands for water cannot be met unless wastewater management is revolutionized.

Wastewater can mean different things to different people with a large number of definitions in use. However this report has taken a broad perspective, and defined wastewater as “a combination of one or more of: domestic effluent consisting of blackwater (excreta, urine and fecal sludge) and greywater (kitchen and bathing wastewater); water from commercial establishments and institutions, including hospitals; industrial effluent, stormwater and other urban run-off; agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter” (Corcoran *et al*., 2010).

A paradigm shift is required towards new multi-sectoral approaches incorporating principles of ecosystem-based management that include wise investments and technological innovation in wastewater management. This will generate significant returns, as addressing wastewater is a key step in reducing poverty, increasing labour productivity, conserving fresh water resources, improving soil integrity, preventing discharge to surface and groundwater resources, improving economic efficiency and sustaining ecosystem services.

The Ramsar Bureau selected 17 case study sites from all over the world to demonstrate and understand wetland wise use as adaptive capacities in vulnerable wetlands are related to coping mechanism at the grassroots level for sustainable livelihood and climatological considerations. In that list the East Kolkata wetlands covering an area of about 12,500 hectares is the only entry from India and also the only one that is by the side of a city and is largely acclaimed as an urban facility for using the 1000 million litres of city sewage by allowing at least 30 days detention time in traditional practices of fisheries and agriculture, that saves cost of ₹ 400 crores for setting up a conventional sewage treatment and about ₹ 100 crores of yearly maintenance cost. Appreciating this wetland function that core Kolkata has not been provided with any fund for constructing sewage treatment plants, the wetland ecosystem of the east Kolkata is thus one of the rare examples of environmental protection and development management where a complex ecological process has been adopted by the local farmers by mastering the resource recovery activities. The goods and services provided by this wetland include, in addition to fisheries, a very cheap, efficient and eco-friendly system of solid waste and sewage treatment system for the city of Kolkata, habitat for waterfowl and housing for a large flora and fauna.

This multifunctional wetland is divided into eleven zones and includes four major sub-regions: freshwater fishponds, brackish fishponds, garbage farms, and paddy lands that includes a mosaic of vegetable fields, a series of more than 300 or so fishponds covering a total area of 3,500 hectares, wholesale markets, a few roads, and 43 villages with 60,000 people in all (Ghosh, 1990). The ownership pattern of this wetland rests upon; landlords, many of them absentee, let the majority of ponds to commercial managers, some others are managed by the government and some have been given to fishermen's groups and cooperatives.

The fishponds produce around 13,000 tons of fish annually, whose yield at 2-4 times higher than average fish ponds, is among the best of any freshwater pisciculture in the country. Not only do the nutrients in the wastewater increase crop yields, but this practice is particularly lucrative during the dry season when wholesale market prices rise between two and six fold. Some 150 tons of vegetables per day are harvested from small-scale plots irrigated with wastewater (Ghosh, 1998). Apart from those people actually raising fish (about 8,000) or growing vegetables, there are porters, auctioneers, traders, retailers and people raising fish seed, making nets, maintaining drainage canals and reinforcing the banks depend on the wetlands for their livelihoods.

The same type of result found in the urban fringes of twin city Hubli-Dharwad, that a comparison of vegetable yields from wastewater and borehole- irrigated fields revealed a 20–25 % yield advantage from wastewater irrigation. Although their economic conditions prior to growing vegetables were not determined, farmers owning small plots of land tend to be poor, so intensive vegetable production employing the women and family labour may be one route out of poverty (Bradford *et al*., 2003).

Anecdotal evidence suggested that growing cauliflowers shows the greatest potential in terms of profit, although associated risks were not assessed. Innovations, particularly concerning the introduction of new varieties appear largely to result from farmer led initiatives, no respondents reported receiving advice or assistance from local government departments or NGOs. Although not scientifically trained, farmers in the region have acquired significant knowledge through practical experience. However, the absence of ongoing support and training in the region means new entrants may not be able to readily adopt horticulture on vacant or accessible land, whilst existing producers may be poorly equipped to cope with rapid change associated with urbanisation or unforeseen perturbations (Bunting *et al.*, 2002).

This paper considers the Judicious and sustainable use of such a perennial water resource in peri-urban environment, and its effects upon livelihood practices of farmers. The meaning of livelihood, in the sustainable approach, refers to more than income, encompassing: 'the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide Sustainable Livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the long and short term' (Chambers and Conway, 1992). It has been observed that though ample planning was made to develop fisheries but at the same time the resource base potential of intensive vegetable production of this area is not exhausted fully. Thus this study attempts to unveil the resource productivity potential of this area in a holistic manner. The farming system approach is mostly uttered in now a days because through a small change in allocation of farm resource readily available with the farmer can augment the profitability in more than proportionately.

Materials and Methods

This study has a special focus on wastewater based farming systems and sustainability. A sample of 120 farmers is selected from six villages namely, Bantala, Golabari, Pakdaha, Bankanda, Gobindapur and Kheyadaha which comes under the jurisdiction of Kolkata district of West Bengal through simple random sampling without replacement technique for the agricultural year 2010-2011. The enterprise that generated at least 10 % of the total farm income is considered to evaluate the farming systems. A well structured and pre-tested schedule has been used to collect primary information related to production and marketing of farm produce. For the computation of cost of cultivation on per farm basis simple arithmetic calculations are used. Optimization techniques and a composite sustainable index are computed in order to draw meaningful inferences on farming systems profitability and sustainability.

To capture the ability of the farmer to achieve the maximum profitability with the adopted farming systems the following model is used:

Objective function:

$$\text{Maximize } Z = \sum_{j=1}^{n} C_j X_j$$

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Subject to the constraints,

1. $\sum_{j=1}^{n} a_{ij} X_j \geq b_i$..(j = 1 to k)

2. $\sum_{j=1}^{n} a_{ij} X_j \leq b_i$..(j = k + 1......m)

3. $\sum_{j=1}^{n} a_{ij} X_j = b_i$..(j = m + 1......n)

4. $X_j \geq 0$.....................................(j = 1 to n)

Where,

Z = Net returns from all crop and allied activities included in the model

C_j = Net returns from j^{th} activity measured in rupees per hectare of land

X_j = Level of j^{th} activity in hectare (for crop/horticulture activity) and in unit (for allied activities).

a_{ij} = Quantity of i^{th} input required per unit of j^{th} activity.

b_i = Quantity available of the i^{th} resource.

A composite sustainability index is calculated for deriving the sustainability of the farming system through combining six components, which are gross income per acre, ratio of output value to input cost, fertilizer productivity, pesticide productivity, Percentage cost of eco-friendly inputs in total cost of cultivation and ratio of cost of owned inputs to the total cost of cultivation. The six components have been measured and expressed in different units. Hence the values were converted into unit values (U_{ij}) by using simple range and variability as given below:

$$U_{ij} = \frac{Y_{ij} - \text{Min}\,Y_j}{\text{Max}\,Y_j - \text{Min}\,Y_j}$$

Where,

Y_{ij} is the value assigned by i th respondent on j th component

Min Y_j is minimum score on j th component

Max Y_j is maximum score on j th component

U_{ij} is unit value of i th respondent on j th component

These unit values are unit less and ranged from 0 to1. When Y_{ij} is the maximum, unit value will be 1 and when Y_{ij} is the minimum, unit value will be 0.

Each components are ranked in the descending order according to their relative importance and Garrett's ranking technique is involved to reveal their importance. The ranks assigned were transformed into % using the formula:

$$\text{Percentage position} = \frac{100(R_{ij} - 0.50)}{N_j}$$

where,

R_{ij} = Rank given for the i^{th} item by the j^{th} individual and

N_j = Number of items ranked by the j^{th} individual.

The percentage positions are transformed into scores on a scale of 100 points by using Garrett's table. From the scores so obtained, the average score was derived. This is termed as scale value (S_j) of each component. The unit values (U_{ij}) for each combinations and category of farmers were multiplied by respective component scale value, summed up and divided by total scale value to get Sustainability Index (SI_i) of each of the combinations in different categories of farmers. The value of SI_i is in percentage. Higher the SI_i higher will be the sustainability of the farming systems.

$$SI_i = \frac{\sum_{i=1}^{n} U_{ij} * S_j}{\sum_{i=1}^{n} S_j}$$

Results and Discussion

Classification of farmers into different categories based on operational holding and age

The sample respondents were post-stratified into small, medium and large farmers based on the size of operational holdings. The number of respondents under different categories is presented in the Table 1. Due to the availability of perennial supply of wastewater year round production is possible in this area and naturally the gross cropped area is more and it is mostly 3 to 4 times of net cropped area. Due to excess water in kharif season the predominant farming system covering cent percent is paddy and paddy cum fish farming system. Though farmers grow some vegetables in their kitchen premises but it is very less in quantity and do not comes under the farming systems. In Rabi and summer seasons several vegetables are grown. Most of the farmers have owned or leased in ponds where intensive fish cultivation is practiced throughout the year both for home consumption and commercial purpose. In this respect for categorization of the sampled farmers slight modification is made and they are classified according to the gross cropped area. It is found that 67.50 % of sample farmers belonged to small farmers (≤ 5 acres), 19.17 % are medium farmers (5-10 acres) and 13.33 % of the sample farmers were large farmers (>10 acres).

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Table 1: Classification of the sample farmers according to operational holding

Type of farmers	Size of land holdings	Number of farmers
Small farmers	Less than or equal to 5 acres	81 (67.50)
Medium farmers	5 to 10 acres	23 (19.17)
Large farmers	More than 10 acres	16 (13.33)
Total	120 (100.00)	

Note: Figures in the parentheses indicate percentage to the total

Age of the farmer is one of the important factors that influence risk bearing capacity and type of farming system practiced by the farmers. The sample respondents were classified into young (20-35years), middle age (36-50 years) and old age (> 50years) based on their age (Table 2). Majority of the sample farmers belonged to the young and middle age group (83.33%) who are innovators and early adopters. Hence, introduction of new enterprise, dissemination of age breaking technology, organizing farm schools and training programme is quite easy with them. Whereas, the percentage of old farmers is 16.67 who mostly are risk averters and generally late majority or laggards.

Table 2: Age-wise classification of different categories of sample farmers
(in numbers)

Age group	Small farmers	Medium farmers	Large farmers	Total
Young (20-35 years)	43	7	2	52 (43.33)
Middle (36-50 years)	25	12	11	48 (40.00)
Old (>50 years)	13	4	3	20 (16.67)
Total	81	23	16	120 (100.00)

Note: Figures in the parentheses indicate the percentage to total

Family size and work force availability for farming operations

The family size is an important decisive factor that indicates the availability of family labour and the capacity to save and re-invest in farming. This issue attracts much more concentration of the policy makers because of the fact that most of the family members are forced to employ in agriculture due to unavailability of alternate employment opportunity. From the data presented in Table 3, it can be easily seen that the available workforce for different type of farmers is almost same if the calculation is done on per farm basis. It is found that the average family sizes of the sample farmers are 6, 7 and 10 persons in small, medium and large categories of farmers respectively. It is noteworthy that 81.93%, 67.22 % and 61.67 % are actual workforce (male and female) and remaining 18.07 %, 32.78 % and 38.33 % are dependents consisting of old, feeble, child and handicapped in the three categories of farmers, respectively. The total available male labour days is 423 days per annum for small farmers' category while 546 and 869 male labour days per annum in the medium and large categories, respectively. Similarly the female labour force is 267, 282 and 314 days per annum in the small, medium and large categories of farmers respectively. The general statistics shows that the average family size is positively related with the operational holdings of the households i.e., the family size increased with the size of operational holdings. But, the fact is that per capita availability of cultivable land is very small and the people having joint family generally have more work force and greater farm size. If an able bodied, mature, married person having offsprings or not is considered as a family and the per family availability of land is worked out then almost 95% of the household will come under small farmer category. All the male, female and children are more or less involved in farming operations as per their capability. Except some specialized work like ploughing, transporting, marketing etc. women usually work shoulder to shoulder with men. The data suggests that with the increase in farm size the participation of women workforce in agriculture diminishes indicating their engagement in non agricultural work increases with the increase in farm size. Another thing to be noted is that a significant quantity of labour is exchange labour. For the ease of calculation this quantity of labour is incorporated with the family labour. This abundant availability of male and female work force throughout the year reduces the requirement of hired labour on the one hand and on the other hand, it reduces the share of external inputs and in turn reduces the risk by means of sufficient supply of labour force in time.

Table 3: Average family size and work force available under different categories of farmers

(in numbers)

Particulars	Small farmers	Medium farmers	Large farmers
Male	2	2	4
Female	2	2	3
Children	2	3	3
Average family size	6	7	10
Per cent of work force to family size and dependents			
Male	48.56	38.67	47.74
Female	33.37	28.55	13.93
Dependents	18.07	32.78	38.33
Availability of family labour per annum in man days			
Male	423	546	869
Female	267	282	314

Existing farming systems and cropping pattern

The details of the types of farming systems followed by the sampled farmers are furnished in the Table 4. The major farming systems identified in the area are Paddy farming (P), Paddy +Fishery (Pa+F), Paddy +Dairy (Pa+D), Paddy +Vegetables (Pa+V), Paddy +Vegetables+Fishery (Pa+V+F), Paddy +Vegetables +Fishery +Dairy (Pa+V+F+D), Paddy + Vegetables +Fishery +Poultry (Pa+V+F+Po), Paddy +Vegetables +Fishery +Piggery (Pa+V+F+Pi), Paddy +Vegetables + Poultry (Pa+V+Po) etc. Among these farming systems, three predominant farming systems are Paddy+ fishery, Paddy+ Vegetables and Paddy+ Vegetables + Fishery which all together is practiced by 56.67 % (68 farmers) of the farmers. In this context, it is important to note that almost 90 % of the farm operation is executed by family labour only and dependence on hired labour for any type of farmers is very less which implies that resource poorness coupled with lack of alternate employment opportunity compelled the family members to strict in farming. Due to the natural, climatological and hydrological reason, the area under study is dominated by Paddy, vegetables and fishery enterprises. All the farmers having a paddy

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cultivation unit as the staple food for this region is rice and the general consumption pattern of the people of this area is three meals of rice a day. Around 61.67 % (74 no.) of farmers have a fishery unit (small or large) under their execution. Due to the availability of ample wastewater during rabi and summer season, intensive vegetable cultivation is possible in this zone. Out of the total 120 farmers, 59.17 % (71no.) farmers are cultivating several type of vegetables like, cauliflower, cabbage, brinjal, bitter gourd, ridge gourd, pointed gourd, pumpkin, spinach, beat, coriander leaf, lal data and several other types of leafy vegetables.

Table 4: Existing farming systems under different categories of sample farmers

(in numbers)

Farming systems	Small farmers	Medium farmers	Large Farmers	Total
Pa	12	0	0	12 (10.00)
Pa+F	23	2	3	28 (23.33)
Pa+D	7	2	0	9 (7.50)
Pa+V	14	4	0	18 (15.00)
Pa+V+F	11	6	5	22 (18.33)
Pa+V+Po	3	2	2	7 (5.83)
Pa+V+F+D	6	3	3	12 (10.00)
Pa+V+F+Po	3	2	2	7 (5.83)
Pa+V+F+Pi	2	2	1	5 (4.17)
Total	81	23	16	120 (100.00)

Note: 1. Pa=Paddy, D=Dairy, V=Vegetables, F=Fishery, Po=Poultry, Pi=Piggery

2. Figures in the parentheses indicate the percentage to total

Net farm income

Farming system is aimed at the efficient use of resources to maximize the income. The details of net farm income derived from the existing farming system are furnished in the Table 5. It is found that the small farmers' having crop/dairy/fishery enterprise earned more money per acre than other than other two groups of farmers. This is mainly due to their more engagement of family members and negligible quantity of hired labour in farming operations. It should be noted that the farmers having commercial enterprises like poultry rearing or piggery unit earn a lumpsome amount than other farmers because of the fact that returns from these two enterprise is multiple time higher than other crops. But all the farmers could not able to adopt to raise poultry and pigs because of their economic and socio-cultural situations. The medium and large farmers realized more profits than small farmers having the same farming system because of their comparative resource richness and size of the farm.

Table 5: Annual net farm income per acre from the existing farming systems among different categories of farmers (in rupees)

Farming systems	Small farmers	Medium farmers	Large Farmers
Pa	18535	0	0
Pa+F	23580	21675	20328
Pa+D	21388	19924	0
Pa+V	28367	26253	0
Pa+V+F	31769	29846	29303
Pa+V+Po	87569	98567	122644
Pa+V+F+D	34123	32756	31943
Pa+V+F+Po	93443	103489	131351
Pa+V+F+Pi	58345	79495	133608
Total	81	23	16

Note: Pa=Paddy, D=Dairy, V=Vegetables, F=Fishery, Po=Poultry, Pi=Piggery

Table 6: Models developed for maximization of net income under different categories of sample farmers

Farming systems	Small farmers	Medium farmers	Large Farmers
Pa	S1	-	-
Pa+F	S2	M1	L1
Pa+D	S3	M2	-
Pa+V	S4	M3	-
Pa+V+F	S5	M4	L2
Pa+V+Po	S6	M5	L3
Pa+V+F+D	S7	M6	L4
Pa+V+F+Po	S8	M7	L5
Pa+V+F+Pi	S9	M8	L6

Note: Pa=Paddy, D=Dairy, V=Vegetables, F=Fishery, Po=Poultry, Pi=Piggery

Normative farm plans for maximization of net income of small farmers

Keeping in view the objective viz., maximization of net income, the models are developed for small farmers. The normative plans developed by simply altering the combination of existing cropping pattern shows an increase in the net farm income for each case of S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8 and S_9, respectively (Table 7). Among the models developed, S_9, S_8 and S_5 generated maximum income followed by S_2, S_3 S_4 and S_6.

The normative plan suggests that incorporation of a piggery unit (8 pigs), or poultry unit (3340 Birds) sufficiently increase the net income by 47 to 58 % over existing earnings. Intensive vegetable cultivation along with a fishery unit also increase the net income significantly (47.29%).

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Table 7: Normative farm plans for maximization of net income of small farmers

(area in acre)

Farming system Activity	Pa	Pa+F	Pa+D	Pa+V	Pa+V+F	Pa+V+Po	Pa+V +F+D	Pa+V+ F+Po	Pa+V +F+Pi
Kharif Crops	S1	S2	S3	S4	S5	S6	S7	S8	S9
Paddy	1.81	1.81	1.67	1.67	1.81	1.67	1.53	1.53	1.53
Fallow Land	0	0	0	0	0	0	0	0	0
Rabi Crops									
Paddy	1.33	1.33	1.33	0.33	0.33	0.33	0.33	0	0
Cauliflower	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25
Cabbage	0	0	0	0.25	0.25	0.25	0.25	0.17	0.17
Tomato	0	0	0	0	0.17	0.25	0	0	0
Brinjal	0	0	0	0	0.17	0.33	0.33	0.25	0.17
Leafy vegetables	0	0	0	0.33	0.33	0.26	0	0.28	0.17
Bitter gourd	0	0	0	0.17	0	0	0	0.25	0
Ridge gourd	0	0	0	0.17	0	0	0	0	0.25
Fallow Land	0.48	0.15	0.34	0.17	0.06	0	0.12	0	0.27
Dairy (No.)	0	0	2	0	0	0	2	0	0
Fishery	0	0.33	0	0	0.25	0	0.25	0.33	0.25
Poultry (No.)	0	0	0	0	0	3340	0	3340	0
Piggery (No.)	0	0	0	0	0	0	0	0	8
Net income (₹)	20843	32842	29435	39645	46792	119030	44111	138155	92235
Percentage increase	12.45	39.28	37.62	39.76	47.29	35.93	29.27	47.85	58.09

Note: Pa=Paddy, D=Dairy, V=Vegetables, F=Fishery, Po=Poultry, Pi=Piggery

Normative farm plans for maximization of net income of medium farmers

With respect to the maximization of net income, the farmers could realize a significant increase in their net income through adopting any one of the models, viz. M_3, M4, M_5 or M_8. The normative plan (Table 8) suggests that three dairy cows, a fishery unit, a piggery unit (14 pigs) or three thousand nine hundred birds (six batches of six hundred and fifty birds/batch) can be recommended to achieve the respective objective of maximization of net income.

Table 8: Normative farm plans for maximization of net income of medium farmers

(area in acre)

Farming system Activity	Pa+F	Pa+D	Pa+V	Pa+V+F	Pa+V+Po	Pa+V+F+D	Pa+V+F+Po	Pa+V+F+Pi
Kharif Crops	M1	M2	M3	M4	M5	M6	M7	M8
Paddy	3.86	3.86	3.86	3.54	3.72	3.72	3.54	3.72
Fallow Land	0	0	0	0	0	0	0	0
Rabi crops								
Paddy	2.85	3.17	1.42	1.42	1.89	1.89	1.42	1.89
Cauliflower	0	0	0.33	0.25	0.25	0.25	0.25	0.25
Cabbage	0	0	0.33	0.25	0.25	0.25	0.25	0.25
Tomato	0	0	0.25	0.17	0.17	0	0	0
Brinjal	0	0	0.17	0.17	0.17	0	0	0.00
Leafy vegetables	0	0	0.67	0.33	0.67	0.33	0.33	0.33
Bitter gourd	0	0	0.25	0	0	0	0.27	0
Ridge gourd	0	0	0.25	0.17	0	0	0.00	0.17
Fallow Land	0.34	0.69	0.19	0.11	0.32	0.33	0.35	0.16
Dairy (No.)	0	3	0	0	0	3	0	0
Fishery	0.67	0	0	0.67	0	0.67	0.67	0.67
Poultry (No.)	0	0	0	0	3936	0	3936	0
Piggery (No.)	0	0	0	0	0	0	0	14
Net income (₹)	24369	22994	33577	39191	134573	41081	119353	101467
% increase	12.43	15.41	27.90	31.31	36.53	25.42	15.33	27.64

Normative farm plans for maximization of net income of large farmers

The normative farm plan for large farmers presented in Table 9 depicts that the models L_3, L_5 and L_6 increased the present net profit from 34 to 45 %. Incorporation of a dairy unit (4 cattle) along with crop enterprises increases the present income by 26.79 %. Similar to the small farmers, here also intensive wastewater irrigated vegetable production increase the farm income by 22.65 %. In order to accomplish the respective objectives, farmers can adopt any combination according to their resource-base.

Table 9: Normative farm plans for maximization of net income of large farmers

(Area in acre)

Farming system Activity	Pa+F	Pa+V+F	Pa+V+Po	Pa+V+F+D	Pa+V+F+Po	Pa+V+F+Pi
Kharif Crops	L1	L2	L3	L4	L5	L6
Paddy	6.33	5.67	6.33	6.33	5.67	6.33
Fallow Land	0	0	0	0	0	0
Rabi Crops						
Paddy	4.67	2.67	3.67	3.67	2.67	3.67
Cauliflower	0	0.33	0.33	0.33	0.25	0.25

Contd.

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Farming system Activity	Pa+F	Pa+V+F	Pa+V+Po	Pa+V+F+D	Pa+V+F+Po	Pa+V+F+Pi
Kharif Crops	L1	L2	L3	L4	L5	L6
Cabbage	0	0.33	0.25	0.33	0.17	0.25
Tomato	0	0.25	0.33	0.25	0	0
Brinjal	0	0.25	0.25	0	0.25	0.25
Leafy vegetables	0	0.33	0.67	0.67	0.45	0.33
Bitter gourd	0	0.25	0.25	0	0.25	0
Ridge gourd	0	0	0.25	0	0.17	0.17
Fallow Land	0.66	0.26	0.33	0.08	0.46	0.41
Dairy (No.)	0	0	0	4	0	0
Fishery	1.00	1.00	0.00	1.00	1.00	1.00
Poultry (No.)	0	0	4970	0	4970	0
Piggery (No.)	0	0	0	0	0	23
Net income (₹)	22481	35940	165054	40501	198408	194627
% increase	10.59	22.65	34.58	26.79	42.38	45.67

Note: Pa=Paddy, D=Dairy, V=Vegetables, F=Fishery, Po=Poultry, Pi=Piggery

Comparison of cost effectiveness under various categories of sample farmers

As indicated in the methodology, farmers were categorized into cost-effective groups, potential groups and less cost effective groups based on the costs and returns of respective farmers. The final results are presented in the Table 10. It can be observed from the table that the percentage of farmers classified under cost effective groups is accounted to 28.40%, 21.74% and 18.75% in small, medium and large farmers respectively. Further, the % of less cost effective group is found to be high in case of large farmers with 56.25%, than in medium farmers with 43.48% and small farmers with 35.80%. The potential groups are found to be 35.80%, 34.78% and 25% for the three categories of farmers, respectively. Hence from this result we can say that the small and medium farmers were comparatively more sustainable than the large farmers who are comparably less sustainable due to their less cost-effectiveness.

Small farmers

Less cost effective zone	High Cost (₹16,160) Low Return (₹ 12, 152)	Medium Cost (₹ 8, 177-₹16, 160) Low Return (₹12,152)	Low Cost (₹ 8,177) Low Return (₹ 12,152)	
	High cost (₹ 16, 160) Medium Return (₹ 12, 152- ₹ 22,672)	Medium Cost (₹ 8, 177 ₹ 16,160) Medium Return (₹12, 152- ₹ 22, 672)	Low Cost (₹ 8, 177) Medium Return (₹12, 152- ₹ 22, 672)	
	High Cost (₹ 16, 160) High Return (₹22, 672)	Medium Ccost (₹ 8, 177- ₹ 16,160) High Return (₹ 22, 672)	Low Cost (₹ 8, 177) High Return (₹ 22, 672)	**Cost effective zone**

Potential zone (all diagonal groups)

Medium farmers

Less cost effective zone	High Cost (₹ 44, 282) Low Return (₹ 43, 160)	Medium Cost (₹ 29, 426-44, 282) Low Return (₹ 43, 160)	Low Cost (₹ 29, 426) Low Return (₹ 43, 160)	
	High Cost (₹ 44, 282) Medium Return (₹ 43,160-₹ 57,831)	Medium Cost (₹ 29, 426-44, 282) Medium Return (₹ 43, 160-₹ 57,831)	Low Cost (₹ 29, 426) Medium Return (₹ 43, 160-₹ 57, 831)	**Cost effective zone**
	High Cost (₹ 44, 282) High Return (₹ 57, 831)	Medium Cost (₹ 29, 426-44, 282) High Return (₹ 57, 831)	Low Cost (₹ 29, 426) High Return (₹ 57, 831)	

Potential zone (all diagonal groups)

Large farmers

Less cost effective zone	High Cost (₹ 85, 297) Low Return (₹ 51, 093)	Medium Cost (₹ 51, 093-₹ 85, 297) Low Return (₹ 61, 339)	Low Cost (₹ 51, 093) Low Return (₹ 61, 339)	
	High Rost (₹ 85, 297) Medium Return (₹ 61, 339-₹ 1, 12, 140)	Medium Cost (₹ 51, 093-₹ 85, 297) Medium Return (₹ 61, 339-₹ 1, 12, 140)	Low Cost (₹ 51, 093) Medium Return (₹ 61, 339- ₹ 3,36,530)	
	High Cost (₹ 85, 297) High Return (₹ 1, 12, 140)	Medium Cost (₹ 51, 093-₹ 85, 297) High Return (₹ 1, 12, 140)	Low Cost (₹ 51, 093) High Return (₹ 1, 12, 140)	**Cost effective zone**

Potential zone (all diagonal groups)

Table 10: Comparison of cost effectiveness under various categories of sample farmers

(in numbers)

Cost effectiveness	Small farmers	Medium farmers	Large farmers
Cost effective group	23 (28.40)	5 (21.74)	3 (18.75)
Potential group	29 (35.80)	8 (34.78)	4 (25.00)
Less cost effective group	29 (35.80)	10 (43.48)	9 (56.25)
Total	81 (100.00)	23 (100.00)	16 (100.00)

Note: Figures in parentheses indicate the percentage to total.

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Share of internal inputs, eco-friendly inputs and external inputs

To assess the sustainability among the different categories of farmers, indicators like value of internal inputs, eco-friendly inputs and external inputs to total cost of cultivation for respective categories are presented in Table 11.

The share of external or internal inputs used in production process indicates the dependency of the resources from the external source. If the share of the inputs from the internal source i.e., if the inputs required for production process are generated by farming activities within the farm, the farmers are said to be less dependent on the external inputs. If the share of the internal inputs is less, it can be concluded that the farmers are dependent on external inputs. High dependency on the internal inputs makes them relatively sustainable and vice versa.

The share of internal inputs, eco-friendly inputs and external inputs in the total value of inputs for different categories of farmers revealed that the small farmers have highest share of internal inputs (59%) to the total value of the inputs. This is mainly due to the engagement of very few or none, hired labour for farming operations. Whereas, medium and large farmers used only 42 % and 37 % of internal inputs, respectively, to the total value of inputs, indicating their more dependency on external source. Hence, we can conclude that small category farmers were relatively more sustainable as compared to the medium and large farmers.

The share of eco-friendly inputs in the total value of inputs was relatively high (21%) in the case of medium farmers followed by small (17%) and large farmers (9%). From this it can be concluded that the medium farmers are relatively more environment friendly as compared to the other types of farmers. The share of external inputs of medium and large farmers is relatively high, indicating their extent of dependence on external sources for inputs and less sustainable approach towards farming systems.

Table 11: Share of different inputs to the total cost of cultivation under different category of farmers

(in ₹)

Category of farmers	Small farmers	Medium farmers	Large farmers
Value of internal inputs	7, 180 (59.00)	15, 479 (42.00)	25, 232 (37.00)
Value of external inputs	4, 990 (41.00)	21, 375 (58.00)	42, 963 (63.00)
Total value of inputs	12,170 (100.00)	36,854 (100.00)	68,195 (100.00)
Value of eco-friendly inputs	2, 070 (17.00)	7, 740 (21.00)	6, 140 (9.00)

Note:

1. Internal inputs includes family labour, ground water, own bullock/ tractor power, own seeds, own FYM, green manure and green leaf manure.
2. Eco-friendly inputs include FYM, bio fertilizer, green manure and green leaf manure.
3. External inputs include chemical fertilizer, plant protection chemicals and hired labour.
4. Figures in parentheses indicate the percentage to total.

Conclusion

The study has shown that the gross cropped area is 3 to 4 times of net cropped area due to perennial supply of waste water and the paddy-fish farming system is prevalent farming system which is practiced by 67.5 % of small farmers. A comparison of cost effectiveness and share of internal, eco-friendly and external input is done among the various types of the farmer. It has revealed that large farmers are less cost effective than the other two categories of farmers. The findings of the study revealed that due to lack of capital and other sources of income the small farmers are largely dependent on internal input mainly family labour and gets higher value in sustainability Indices. In terms of use of eco-friendly inputs, medium farmers ranked first but medium and large farmers use higher amount of external inputs which shows their less sustainable approach towards farming systems. To provide sustained income the small farmers tries to maximize the utilization of available family labour by following intensive cultivation practices and literally they never left the land fallow. It is also observed that the small farmers are mainly sharecroppers and tries to replace capital by labour. Thus strengthening the policy measures through providing stimulus like easy accessibility of credit, land shaping technology, channelling the timely flow of sewage water, etc. can augment the profitability by two or three times.

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