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Transaction Costs and Household Participation in Community-based Village Tank Aquaculture in Dry Zone

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ABSTRACT. *Village tanks help the rural food security in various ways of which supply of animal proteins from freshwater fish plays an important role. Community-based aquaculture has been introduced in village tanks to enhance this potential. Despite favourable technical and financial performances indicated in the pilot programmes in village tank aquaculture, the rate of adoption as well as the level of participation by communities has been rather low. Both community cooperation and household participation involve some trade-offs in terms of transaction costs and household shadow prices, which are affected by various factors. This paper attempts to understand such factors that affect the community cooperation and household participation.*

The necessary data were collected from 340 households in 41 village tank communities in Anuradhapura district. Two regression models were estimated to analyze the factors affecting transaction cost and household participation respectively. Results highlight that transaction cost for protecting fish from poaching overwhelmingly dominates others. Factors that represent the physical nature of the resource and technical aspects of culture operations such as tank size and culture period seem to affect this most. In addition, group size also has a positive relationship with transaction costs. At the household level, the source of household income affects participation significantly. Findings of the study highlight that viability of community-based aquaculture depends largely on ability to minimize transaction cost for effective cooperation and share of household opportunity cost for participation.

INTRODUCTION

Recently, a high level of enthusiasm has been witnessed over small village tanks as an important source of food security for rural poor in rain-fed areas of dry zone of Sri Lanka (Panabokke *et al.,* 2001). These village tanks help the rural food security in various ways, of which, animal protein from inland freshwater fish has an important role to play in the nutrition of local communities.

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Having recognized the potential of increasing freshwater fish production by promoting community-based aquaculture in village tanks in dry zone, former Inland Fisheries Division (IFD) of the Ministry of Fisheries and its successor, and National Aquaculture Development Authority (NAQDA) implemented a number of programmes to promote fish production. Scientific investigations conducted by these agencies have strongly established the technical feasibility and commercial viability of the system (Thayaparan, 1982; Chakrabarty and Samaranayke, 1983; Chandrasoma, 1986;). The practice involved here is stocking of village tanks with fingerlings of exotic food fish species such as Tilapia and Indian and Chinese Carp species when tanks get filled by monsoon rains. Stock of fish is allowed to grow extensively for 4-8 months before the harvest, which is obtained when tanks run dry. The government facilitates the programme providing technical know-how and fish fingerlings for few initial cycles of production.

Village tanks are Common Property Resources (CPR). Therefore, in addition to technical and financial viability, a suitable institutional arrangement for organization of community-based activities is an essential prerequisite for sustainable implementation of aquaculture programmes. Recognizing this fact, from the mid nineties onwards, village tank aquaculture was promoted as a community-based venture organized by Farmer Organizations (FO). FO is a recognized legal body vested with rights and powers for supervision and administration of village tanks by the Agrarian Development Act, 2000.

Despite the high technical and financial performances in the pilot programmes, mixed results have been observed so far in actual implementation. In overall, it seems that the rate of adoption of community-based aquaculture by village tank communities and the level of interest shown by community members to participate in the programmes have been rather low. Naturally this has led to a question about the FO's capacity to mobilize sufficient level of cooperation among community members for collective action.

As in any common property resource management system, community-based aquaculture also demands two fundamental conditions for achieving a sustainable outcome. These include attracting a sufficient level of participation from members involved, and ensuring effective cooperation of community members for collective action. Both these conditions involve some form of trade-offs and transaction costs. Therefore, estimation of the transaction costs and its influencing factors are of paramount importance for understanding the sustainability of the production. Also, it is vital to identify the factors affecting household participation for community-based aquaculture. This information is needed in overcoming institutional barriers faced by the community-based aquaculture in village tanks.

Against this background, the objectives of this paper are to (a) assess the transaction cost (TC) of community cooperation and identify the factors that affect the TC for community-based aquaculture and (b) identify factors that affect the household participation in community-based aquaculture. The overall aim of this exercise is to recognize suitable policy options that can be recommended for enhancing the viability[3] of village tank aquaculture.

[3]Viability of the village tank aquaculture is defined here in terms of continuation of the activity as a community venture without considering other factors that can lead to collapse of the system due to risks such as sole dependency on single species, outbreaks of diseases, adverse impacts on local species etc.

THEORETICAL scaffold

Factors affecting community cooperation

The cooperation among community members for a collective venture needs appropriate institutional arrangements. Implementation of such institutional arrangements involves a wide spectrum of contracts that give rise to diverse types of transactions, assigning their costs to different parties. Therefore, any given institutional arrangement is always associated with a corresponding structure of transaction costs (Eggertson, 1990). A number of researchers have attempted to investigate the transaction cost and its implication on community based management of natural resources systems such as forestry, fisheries, irrigation and rural farming systems in developing countries in Asia and Africa (Abdullah *et al.,* 1998, Kuperan *et al.,* 1998; Falconer, 2000; Mburu *et al.,* 2003; Adhikari and Lovett, 2005). Table 1 summarizes the major types of transactions associated with organizing collective action for community-based aquaculture. An in-depth analysis of transaction cost involved in community-based aquaculture has been made by Senaratne and Karunanayake (2008).

Table 1. Transactions in community-based aquaculture in village irrigation tanks

Type	Transactions
Searching and information	Accessing scientific methods and species for culture of fish
Collective decision making	Organizing meetings, reaching agreements, coordinating with authorities
Enforcement and monitoring compliance	Collective organization of tank preparation actions, stocking etc.
Prevention of free riders activity	Protection from poaching
Distribution of benefits	Organizing collective harvesting Monitoring the distribution of benefits

Recent developments in new institutional economics (NIE) provide useful conceptual tools to examine the impact of various factors on collective action through analyzing the key attributes of transaction costs. Accordingly, there are three major attributes of transactions identified under NIE framework, namely asset specificity, frequency and uncertainty (Williamson, 1998; Birner and Wittmer, 2000).

Asset specificity

This attribute refers to how specific is a given transaction to a given asset (resource). If a transaction is very specific to a given asset, delivery of that transaction may need special arrangements, thereby increasing the cost of transaction. For instance, village tank situated in a location which is not easily monitored by residents may need special arrangements for protection of fish from poachers and free-riders.

Frequency

This refers to how frequently a given transaction needs to be carried out to attain the desired purpose. Naturally, if the frequency of a transaction is high, it tends to be more costly than less frequent transactions. FO with a large number of members may require more frequent meetings/gatherings (transactions) to reach collective agreements.

Uncertainty

Outcomes of various transactions are not equally certain always. Transactions with more uncertainty usually carry extra burden of cost with them. For example, a closely related group of community members may reduce the uncertainty in collective decisions, thereby avoiding additional cost for ensuring compliance.

Cost of transactions necessary to achieve the cooperation among community members for village tank aquaculture (Table 1) may vary subjected to a number of factors depending on the way the above attributes are influenced by such factors. In the present study, an analytical device called 'transaction cost matrix' was developed that helps to predict the impact of selected factors over the cost of specific transactions involved in community-based aquaculture (Table 2).

Table 2. Matrix for Transaction Cost (TC) analysis

Factor	Transaction(s) involved	Major attribute(s) of transaction affected	Impact on TC	Hypotheses
Government Extension activities	Searching information	Frequency and Uncertainty	Negative	Extension decreases TC
Large groups	Group organization	Frequency	Positive	Large groups increases TC
Tank size	Protection from poaching	asset specificity and frequency	Positive	Large tank size increases TC
Culture period	Protection from poaching	Frequency and uncertainty	Positive	Longer culture period increases TC
Distance of tank from the village	Protection from poaching	Frequency and uncertainty	Positive	Distance of location increases TC
Existence of already formed groups	Group organization	Frequency and uncertainty	Negative	Already formed groups decreases TC
Distribution of ownership to more stakeholders	Protection from poaching	Asset specificity and frequency	Negative	Wider distribution of ownership decreases TC

The matrix provides a logical criterion to predict the impact of various factors on the specific attributes of transactions, thus indicating the effect of those factors on transaction cost. For instance, assistance of extension workers may help to reduce the frequency of transactions undertaken to search for information and thereby lowering the transaction cost for information. Correspondingly, large group size increases the transaction cost due to high frequency of transactions necessary for achieving consensus and agreement.

It should be acknowledged here that other than the transaction cost approach to collective action, which is examined in this study; there are other analytical perspectives of collective action and common property resources such as social capital and strategic behavior (Putnam, 1995; Dasgupta, 2008). These approaches explain different aspects of the complex phenomena of collective action and common property resources. Transaction cost approach, therefore, is not an alternative for them but examines the problem from different perspective, which is complementary rather than competitive.

Factors affecting household participation

In any collective action context, decisions on participating in community-based activities are taken at the household level. Even when the community factors that affect cooperation among villagers are favorable, there are host of other household factors that influence the participation decisions by individual households. In the case of community-based aquaculture, household contributions come mainly as a share of labour-time. Rural households usually operate in complex household economic strategies (HES). HES can be defined as the aggregation of various economic activities (both market as well as subsistence) carried out by members of the household, which claim shares of overall resource and time constraints faced by the household. Within the HES, household choices are not always determined by market based prices. Instead, such decisions are backed by 'shadow prices', which reflect the opportunity cost of household choices (Becker, 1965). Details of a household economic model developed to analyze the household opportunity cost are given in the Appendix 2 Table A2.

Accordingly, opportunity cost (shadow price) of household participation in community-based aquaculture is jointly determined by the amount of time allocated on respective actions and earning potential of the household per unit time (wage rate). Households may decide on whether to participate or not depending on the profile of factors specific to a given household that affect those two parameters.

$$P_i = P(t_f, W / \phi_1 \ldots\ldots\ldots \phi_n) \qquad (1)$$

where

P_i = Level of participation by i^{th} household

$\phi_1 \ldots\ldots\ldots \phi_n$ = Household factors affecting the opportunity cost of collective action

t_f = Time spent on collective action for community-based aquaculture

W = Wage rate

Two types of factors, (a) factors that directly change either the amount of time allocated for participation in collective action or wage rate and, (b) factors that indirectly influence either one or both yielding changes in relative opportunity cost of activities pertaining to collective action, can affect the household participation in community-based aquaculture. Usually, household opportunity cost is influenced by host of household specific factors such as household income, education level, asset ownership etc. Such factors vary even among households that depend on the same village tank, thereby leading to variations in household participation in community-based aquaculture. Accordingly, set of hypotheses on the impact of respective household factors on the participation in community-based aquaculture are described below.

Regular household income

Higher the income from regular sources, higher the opportunity cost of time. As a result, level of participation in community-based aquaculture by households with higher regular income tends to be low *(Negative)*.

Seasonal household income

Households which derive more income from seasonal sources, have less opportunity cost unless the aquaculture activities heavily overlap with peak seasonal demand for labor. Hence, households with higher proportion of seasonal income tend to participate more in community-based aquaculture (*Positive)*.

Land ownership

Usually, lands are the main productive asset of rural households. Given the fact that the major source of income is agriculture, higher ownership of land increases the opportunity cost of engaging in community-based aquaculture. Hence, households which own more, lands under cultivation, tend to participate less in community-based aquaculture *(Negative)***.**

Education

High level of formal education prepares household members for market-based employment, increasing the opportunity cost of time as they have a greater chance of getting off-farm employment. Hence, tendency to participate in community-based aquaculture is less among households with high level of education *(Negative*).

Access to market sources

Market is an alternative source of income and consumption for households. Poor market access caused by longer distance to the market, and poor infrastructure often leads to increasing the opportunity cost in relation to market-based economic activities, thereby increasing the dependency on village sources. Therefore, participation in community-based aquaculture becomes a more attractive option for households with poor market access *(Positive).*

Distance to the tank

Distance to the tank tends to increase time involvement necessary and therefore more cost to households located far away from tanks for participation in community-based aquaculture *(Negative)*.

Income support from the government

Usually, households, which receive income support from the government, have limited sources for their livelihood and therefore opportunity cost of time is low. Hence their tendency to participate in community-based aquaculture is high *(Positive).*

DATA AND METHODS

Study area

The study was conducted in Anuradhapura district, which has a high density of village irrigation tanks. A survey undertaken by the Agrarian Development Department has recorded 2334 inland water bodies in the district covering a total inland water area of 51,500 ha. It has also been recorded as having the highest consumption of freshwater fish with the per capita consumption of 2,482 g/month per household (Department of Census and Statistics, 2002). Besides, it is the district where community-based aquaculture has been practiced in the highest number of village tanks.

Data collection

The study was carried out using primary data collected separately at community (tank) and household levels. Information on selected village tank communities was gathered using a tank checklist of 41 tanks. Data for checklist of each tank was gathered from a number of sources, which included official records, village officers (*Grama Niladharis*), officers of the Departments of Agriculture, Agrarian Services and Irrigation, members of Farmer Organizations and experienced villagers. The information collected were, (a) physical information on the village tank, (b) details on agricultural activities and irrigation and (c) details on fish production in tanks (data on past culture cycles, cost/return details on the last culture cycle, group characteristics, funding of aquaculture programs, organizational activities/meetings, time allocation, extension services, marketing etc.)

The household survey was conducted using a sample of 340 households, which were selected randomly from the same 41 villages covered by the tank checklist. Sample included 208 households that participated in community-based aquaculture at least once and 132 households that did not participate in aquaculture programmes. The household survey covered the information on the following aspects. (a) general household information, (b) living conditions/facilities, ownership of assets, (c) location and infrastructure facilities in the village, (d) income and earning activities, (d) household expenditure and credit, (e) details on agriculture activities, (f) nature of involvement in fish culture activities (contribution, labor use, organizational involvements, sharing of benefits etc.)

Analysis

Estimation of transaction costs

The mmajor transaction costs involved in community-based aquaculture are incurred as opportunity cost of labour time and only a limited amount of direct cash payments. In the estimation of transaction costs, general wage rates available in the area for agricultural labour was used as a proxy for opportunity cost of unit time. However, watching for protection from poachers was an activity usually undertaken during night time. Therefore, application of general wage rates in this case was not appropriate. This activity was carried out by hired watchers in 7 tanks and average wage rate paid for these watchers was used to estimate the cost of watching in other tanks too. Table 3 summarizes the major types of transaction cost involved and methods adopted to measure them.

Testing of hypotheses

Hypotheses on community as well as household level factors were tested with the help of regression models. Dependent variable of the model on community level factors was aggregate transaction cost per cycle of production. Factors that have been hypothesized to affect the transaction cost were either measured quantitatively or ranked on an ordinal scale. All hypotheses were tested simultaneously by estimating a single equation multiple linear regression model as follows.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + Ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (2)$$

Where, Y=total aggregate transaction cost (in Rs); X_1 = group size; X_2 = tank area; X_3 = culture period; X_4 = contact with extension workers; X_5 = ownership distribution; X_6=group formation; X_7 =distance to the tank. U_i is the random error. The details of the explanatory variables are given in the Appendix 2, Table A1.

Table 3. Methods of estimating transaction costs

Transaction	Nature of Transactions	Nature of Cost	Approach
Organization of collective action	Meetings/ dealing with agents	Time for meetings/ action	Value of time (WR × time)
Ensuring the implementation of decisions	Meetings/dealing with agents	Time for meetings/ action	Value of time (WR × time)
Avoiding free rider activities	Watching/dealing with officers	Cash payments/ time cost for watching	Wage cost / Value of time (WR × time)
Organizing the sharing of benefits	Meetings	Time for meetings	Value of time (WR × time)

WR = average wage

Hypotheses on factors affecting the household participation also were tested using a regression model. The dependent variable of this model is a discrete dichotomous variable as participants and non-participants of aquaculture programmes represent two distinctive groups of households. The model attempts to capture the variation between these two groups rather than the variation of level of participation among the group of participants. Independent variables included a set of household characteristics that were hypothesized to affect the household participation in community-based aquaculture. They were measured quantitatively, ranked on an ordinal scale or treated as dummies. A Probit model was specified here as:

$$P\,(Y = 1/0) = F\,(\beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8) \;\ldots\ldots\ldots\; (3)$$

where, X_1 = level of Education; X_2 = cultivated land area; X_3 = age of head pf the household; X_4 = access to market; X_5 = distance to the tank; X_6 = income support; X_7 = regular income and X_8 = seasonal income. Ui is the random error. Table A2 in Appendix 2 provides the details of the explanatory variables.

RESULTS AND DISCUSSION

A summary of the transaction cost estimates is given in Table 4. It shows that transaction cost for community-based aquaculture, though variable, is substantially high in certain village tanks. Three major categories of transaction cost can be identified, namely, (1) information cost, (2) collective decision making cost and, (3) enforcement and monitoring cost. Among them, cost of information is the lowest. It should be noted however, this does not include the expenses made by the government for awareness programmes. Groups have incurred transaction cost for making collective decisions also. Many communities have held meetings to decide on organizational matters of community-based aquaculture (2.5 times on average in the range of 0-4). Compared with information and collective decision making costs, enforcement and monitoring costs were substantial. This basically implies cost of watching for prevention of poaching. Poaching used to be the most important problem faced by community-based aquaculture in many village tanks. It could either be an act of theft (carried out by outsiders) or free-riding (when members of the same community are involved). In few occasions, litigation action has also been pursued calling on the Police for redress. Profile of transaction costs discussed above helps to understand the impact of different factors on transaction cost.

Table 4. Transaction costs for community-based aquaculture

Type of transaction cost	Average (Rs.)	Range (Rs.)
Information cost	1,744	0 - 9,450
Collective decision making cost	1,998	0 - 9,075
Enforcement and monitoring cost	30,319	0 – 168,720
Aggregate transaction cost	**34,012**	**0 – 168,720**

Table 5 presents the estimates of the regression model that provides the details of the factors affecting the transaction costs of community-based aquaculture. Accordingly, five variables have signs predicted in hypotheses, namely, group size, tank area, culture period, level of ownership distribution and whether a new or already formed group is involved. Of these, group size, culture period and tank area had statistically significant relationships with the transaction cost.

Tank area and culture period are connected to transaction cost through their impact over the effort on protecting fish harvest from poachers and free-riders, which has given rise to the largest share of transaction cost in all locations. Large tanks make it difficult to protect the harvest, as more frequency of watching is needed. Similarly, longer the period fish to be kept in the tank before it being harvested, more transaction cost have to be borne to protect it.

Table 5. Factors affecting the transaction costs of community-based aquaculture

Variable	Co-efficient	t- value	*Probability*
Constant	-26245.591	-1.068	0.294
Group size	531.445	2.521	0.017 **
Tank area	372.855	5.781	0.000 **
Culture period	1763.468	2.168	0.038 **
Contacts with Ext.O	9574.303	2.080	0.046 **
Ownership distribution	5789.375	0.886	0.383
Group formation	-9567.942	-1.404	0.171
Distance to the tank	-26872.504	-2.054	0.049 **

** Significant at P = 0.05   * Significant at P = 0.10 $R^2 = 0.66$ Adj. $R^2 = 0.58$

On the other hand, group size is also having a significant positive relationship with transaction costs. This is an institutional variable that has an impact over all types of organizational activities from searching information to distribution of benefits. Two other institutional variables, whether the community-based aquaculture is organized by an already formed group and level of distribution of ownership, though complying with theoretical expectations, are not statistically significant.

Two variables, level of contact with extension workers and average distance to tanks have indicated opposite, yet statistically significant relationships against the theoretical expectations. Contacts with extension officers, is the only variable that represent a supra-community level factor. It seems that other reasons are influencing these variables more than theoretical expectations and therefore alternative explanations are necessary. Theoretical expectation was Extension Officers provide the information and a higher number of visits imply lower cost of information for community. However, discussions with some Extensions Officers revealed that they have to pay more number of visits to village tanks, which are having problems among community members. Naturally, transaction cost tends to rise in such tanks that helps to explain the positive relationship with level of contacts with extension officers. The negative relationship between distance to the tank from village and transaction cost seems to be less explainable. However, data indicates that variation observed in this variable lies within a very narrow range.

As far as household participation in community-based aquaculture is concerned, the outcome of the Probit analysis (Table 6) shows that only two factors significantly affect the household decisions to participate in community-based aquaculture. They are income from regular sources and cultivated land area. As theoretically predicted, households with regular income earning activities have a high opportunity cost in respect to community-based aquaculture, thereby causing lesser participation from such households.

Statistically significant negative relationship indicated by cultivated land area requires explanation. The outcome can be explained once it is taken into consideration with activities undertaken in respective land resources. As far as household land ownership is concerned, paddy lands take the dominant place. Further, participant households have a significant income from seasonal sources and the major part of seasonal income comes from paddy. Hence, even though land ownership lends them to depend less on CPR based activities, the fact that lands are more involved with seasonal crops rather than permanent crops allow them to participate in collective action for community-based aquaculture.

Table 6. Factors affecting the participation of households

Variable	Co-efficient	t- value	Prob
Constant	-0.0216	0.02	0.984
Education	0.0197	0.10	0.918
Land area	0.5625	1.75	0.079 *
Age	-0.0148	-0.98	0.324
Access to market	-0.0089	-0.15	0.884
Distance to the tank	-0.0183	-0.06	0.948
Income support	0.00008	0.77	0.438
Regular income	-0.000007	-2.01	0.043 **
Seasonal income	0.000004	0.66	0.510

** Significant at P = 0.05 * Significant at P = 0.10 Log Likelihood = -37.27

Five other variables, namely, distance to the tank from the household, access to markets, income support from the government and total seasonal income, though agreeing with the theoretical predictions, are statistically non-significant. Level of education contradicts the theoretical expectation. However, education level has a very low prominence and therefore, can be considered as a variable having little impact over decisions to participate in community-based aquaculture.

It is acknowledged that other than the variables discussed in the above two models, there could be other important community as well as household variables which affect TC and household participation, significantly. For instance, tank parameters such as location and access may significantly determine the TC but they were not considered due to difficulties in measuring them. Similarly, cultural/religious factors could significantly affect household participation but given the homogeneity of the sample in terms this factor, it was not included in the model.

CONCLUSIONS AND POLICY IMPLICATIONS

Overall, results help to highlight few important points. Although there are three major types of transaction costs involved in community-based aquaculture, monitoring costs overwhelmingly dominates others. However, transaction cost for protecting fish from poaching, which was found to be substantial in many tanks, has a larger impact over the viability of the activity, in terms of both maintaining the overall profitability of venture and ensuring the cooperation of households.

The factors that represent the physical nature of the resource and technical aspects of culture operations seem to determine the outcome rather than institutional factors. These factors are connected to transaction cost through their impact over protection of fish from poachers and free-riders, which have given rise to the largest share of transaction cost in all locations. In addition, group size is also having a positive relationship with transaction costs. It seems that institutional factors such as forming of special groups, their size, ownership or supra-community interventions such as extension support has little role to play in this regard.

At the household level, the most important issue is participation. Mainly, the source of household income matters here and households, which earn more income from regular sources tend to get involved less in community-based aquaculture. Conversely, households that are having more involvement with seasonal crops participate in collective action.

A major policy implication which is emanating from overall findings of the study is viability of collective enterprise which depends largely on ability to minimize transaction costs and enlarging the share of benefits for active group of participants who bear these costs. Even if the programmes are effective in terms of cash flow to FOs, viability of operations may not be ensured if active participation and cooperation could dissipate gradually due to high burden of transaction costs. It has been indicated that these transaction costs are highly variable among tanks and adjustment of institutional arrangements are also taking place in tanks, which have entered subsequent cycles of operation.

Overall, it seems that two factors merit special attention. First, how the unaccounted, individually borne costs would be taken care of and what impact they have on decisions to participate in community-based aquaculture by individual members. Second, how successful is the ongoing experimenting with institutional arrangements to minimize associated transaction costs and increasing the productivity of tanks, simultaneously. These points are particularly important in the point of view of long-term viability of community-based aquaculture in village irrigation tanks.

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APPENDIX 1

Household Opportunity Cost and Shadow Prices

Rural householders usually operate in complex household economic strategies (HES).HES is an aggregation of various economic activities that claim shares of overall resource and time constraints faced by the household. Broadly, three types of economic activities can be identified in the economic strategy of a given household: (a) home-based production**,** (b) working for market determined wage and, (c) leisure.

Adopting the terminology used by Becker (1965), output of home-based production can be defined as 'commodities'. Inputs from diverse sources (e.g., market purchased goods, products from home garden, products from CPR) are combined with time and other factors such as skills to produce commodities. Surplus of certain home-based output may be sold in the market for cash income ('tradables') for which exogenously determined prices exist and households respond to variations in prices, rationally. In case of tradables, surplus (Q_i) over the domestic consumption (C_i) is sold in the market helping to supplement household cash income. Thus the total output of a given tradable commodity Z_i, can be written as,

$$Z_i = C_i + Q_i \quad (4)$$

Assuming single member households, individuals attempt to maximise utility,

Max

$$U = U(C_i) = U(Z_i - Q_i) \quad (5)$$

Commodities (Z_i) are produced subject to the technical relationships given by a set of household production functions defined as follows.

$$Z_i = Z(X_m, X_h, t_i / S_i) \quad (6)$$

Where,

X_m = material inputs from market sources;
X_h = material inputs from non-market sources;
T_i = time used for home production of Z_i;
S_i = umbrella term for any structural household variables (e.g. asset profile, education, skills, experience, household technologies etc.)

Individuals have to maximise their total utility subject to certain time and resource constraints Other than technical constraints imposed by equation (3).
The time constraint can be given as

$$T = T_w + T_i + T_1 \quad (7)$$

where,

T_w = Total time working for wage
T_i = Total time allocated for home based production activities
T_l = Total time available for leisure

$$T = T_w + \sum T_i + T_1$$

t_i is time allocated for individual home based production activities.
Money income has three sources, namely, (i) income earned by working for a wage, (ii) revenue from tradable commodities and (iii) revenue from other sources such as property rents, transfer payments etc. The money income constraint can be given as follows.

$$\sum P_i X_{mi} = I = T_w W + \sum R_i Q_i + V \quad (8)$$

where,

P_i = Price of market purchased goods i
I = Total money income
W = Wage rate
R_i = Price of Q_i at market
V = Other income

According to (4), total working time (T_w) can be defined as,

$$T_w = T - \sum t_i - T_1$$

Substitution in (5) yields the single resource constraint,

$$\sum P_i X_{mi} = W(T - \sum t_i - T_1) + \sum R_i Q_i + V \quad (9)$$

Based on (3), which represents the technical constraints on home-based production, we can write X_{mi} and t_i explicitly as a_iZ_i and b_iZ_i where, a_i is the amount of market purchased goods needed for a unit of Z_i and b_i is the amount of time needed for unit of Z_i. By substituting these co-efficients the single resource constraints is derived in (6),

$$\sum P_i a_i Z_i = WT - W\sum b_i Z_i - WT_1 + \sum R_i Q_i + V$$

Rearranging,

$$\sum P_i a_i Z_i + \sum W b_i Z_i + WT_1 = WT + \sum R_i + V$$

The total set of constraints faced by households in terms of time, cash income and technical productivity can be written as

$$\sum Z_i (P_i a_i + W b_i) + WT_1 = WT + \sum R_i Q_i + V \quad (10)$$

Equation (7) represents the overall constraint faced by a given household in terms of resources, time and technical production of commodities. The left hand side of the equation comprises the 'total expenditure' spent on all commodities consumed by a household in terms of cash and time. The right hand side gives the 'full income' available to meet this expenditure. The term $(P_ia_i + Wb_i) = \pi_i$ is the 'shadow price' of each Z_i. Shadow price (π_i)

consists of two components; (a) time component spent on production of Z_i and (b) cash component paid for market purchased inputs.

APPENDIX 2
Specification of Regression Models

Table A1. Specification of model to test factors affecting the transaction cost

Variable	Description	Type	Unit	Hypotheses	Remarks
Dependent variable					
TotATC	Total Aggregate Transaction Cost	Ratio	Monetary (Rs.)	-	
Independent variables					
Group size	No. Involved in fishery activities	Ratio	Number count	(+) relationship	
Tank area	Tank area	Ratio	Area (ac)	(+) relationship	Multiple linear regression model estimated using OLS
Culture period	Culture period	Ratio	No. months	(+) relationship	
Contacts with Ext.O	Level of contact with extension workers	Ordinal	(1-3 scale)	(-) relationship	
Ownership distribution	Whether assigned to a small group	Ordinal	(1-3 scale)	(+) relationship	
Group formation	New or already formed group	Nominal (Dummy)	1/0 dummy	(+) relationship	
Distance to the tank	Average distance to the tank	Ratio	Distance (km)	(+) relationship	

Table A2. Specification of model to test factors affecting the household participation

Variable	Description	Type	Unit	Hypotheses	Remarks
Dependent variable					
Participation	Whether the household participate or not	Nominal	1/0 dummy	-	
Independent variables					
Education	Level of Education	Ordinal	(1-6 scale)	(-) relationship	Probit model estimated using the maximum likelihood method
Land	Cultivated land area	Ratio	Area (ac)	(-) relationship	
Age	Age of Head HH	Ratio	No. years	Non predicted	
Access to market	Distance to road access	Ratio	Distance (km)	(-) relationship	
Distance to the tank	Distance to the tank	Ratio	Distance (km)	(-) relationship	
Income support	Whether receiving state income support	Nominal	1/0 dummy	(+) relationship	
Regular income	Total regular income	Ratio	Monetary (Rs.)	(-) relationship	
Seasonal income	Total seasonal income	Ratio	Monetary (Rs.)	(-) relationship	

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