Transactions Matter, but Hardly Cost:

Irrigation Management in Kathmandu Valley

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Abstract

This paper estimates the transaction cost in maintaining Farmers Managed Irrigation System (FMIS) in Nepal. It analyzes the factors influencing the transaction cost and compares it with the production cost in agriculture. This study is based on a case of Kathmandu valley covering 60 irrigation systems.

The findings of the study show that the main element of transaction time is watching, waiting and negotiating which constitutes more than 92 percent of the total transaction time. The study also shows that the transaction time is relatively low for FMIS amounting to 5 % to that of total time required for the production of crops. The transaction time is higher for the households cultivating the land at downstream of the canal compared to the households cultivating the land at upstream of the canal. In terms of crops transaction time for the cultivation of winter crops is three times higher than that of the summer crop. The total value of output per hectare is significantly affected by transaction cost, reliability of the irrigation facility and infrastructure quality. However, there is an advantage of being a free rider and hence there seems to be a problem in collective action. If the institutions could somehow control for free-riding or deviant behavior, then presumably it would improve institutional efficiency and reduce expost transaction cost.

Key Words: ***Transaction cost, Irrigation Systems, Nepal, Agricultural Productivity, Institutions,*** **Kathmandu Valley**

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1. INTRODUCTION

Agriculture is the main source of subsistence for a majority in developing countries. In Nepal, where this study is based, it contributes about 32 % of the GDP and provides employment for more than two third of the population of the country (NPC, 2007). Improvements in rural incomes is crucially dependent on productivity-enhancing infrastructure, irrigation being one of them. Nepal is famous for its farmer's managed irrigation systems (FMIS). There are about 16,000 FMIS and irrigate approximately 7,14,000 ha. of cultivated area or 67 % of the total irrigable area of the country (Pradhan, 2002). Historically the government of Nepal perceived irrigation development as being the domain of local concerns because of which farmers in disparate locations of the country organized themselves to construct, govern, operate and maintain a large number of irrigation systems (Lam, 1998, Shivakoti *et. al*, 2002).

Irrigation systems have two semi-public good features – non-excludable but rivalrous. It is costly to exclude potential beneficiaries from using it (non-excludable) and the use of water by one individual reduces the availability of water to others (rivalrous). Thus the irrigation systems are characterized as common pool resources and water allocation and provisions are two major sources of collective-action problems (Ostom, 1990). Operation and maintenance of an irrigation system requires coordination among many farmers and is riddled with free-rider problems . Collective action problems arise easily when each farmers has the incentive to use more water and invest less in the system. These problems often result in poor maintenance as well as conflicts in water allocation (Tang, 1992).

In the absence of individual access to irrigation water, the institutional development of collective management assumes importance. The nature of institutional development, however, has a symbiotic relationship with transaction costs. The efficiency of a system is influenced by the transaction cost and institutional malleability in turn determines the degree of transactions costs. There are no empirical studies available that have studied transaction costs in FMIS in Nepal. It is important to understand how transactions costs influence agricultural productivity on farms. This study aims to fill this gap in the literature. This paper is organized as follows: Section 2 discusses the history of development of FMIS and locates the study in the relevant literature on Transaction costs. Section 3 details the study area and data collection strategy. In Section 4, we analyze our data and conclude with policy implications in Section 5.

2 FMIS AND TRANSACTION COSTS

In the 1960s and 1970s huge investments were made for the construction of irrigation canals with the support of external agency and were managed by the government. Despite sophisticated engineering infrastructure and presence of highly educated staffs, the performance of these government managed irrigation system was poor (APROSC, 1978). The result was severe deprivation of tail-enders and low productivity in these systems (WECS, 1982). Until 1980's, there was no formal recognition of the contribution of Farmer's Managed Irrigation System (Pradhan, 2002). However, with the basic needs fulfillment program of the government during 1980s, there was felt need for high rate of agricultural development which was not possible without the development of irrigation. The government found it difficult to develop large infrastructure to achieve the desired rate of agricultural growth. Thus during 1980s government with different donor driven programs (e.g. Irrigation Line of Credit-ILC, Irrigation Sector Program-ISP), started to provide assistance to FMIS in different parts of the country and which increased the irrigated area (Pradhan, 2002). Thus for a short period of time many of the FMIS came under the domain of Irrigation Department.

However, after 1990, the devolution of responsibility for irrigation water resource management to local users' organization gained importance in Nepal. The government enacted Water Resource Act, 1992, Water Resource Regulation, 1993 and Irrigation Regulation 1999 which required registering the canal even if it was being managed traditionally by farmers. The right over the source and the canal could be protected only after the registration as the act established the ownership of water to state. GoN has also adopted the policy of not only transferring irrigation systems to farmers but also creating a strong institution of farmers for the management of irrigation water (NPC, 2007).

Despite all these regulatory provisions the institutional development of irrigation systems does not seem to developing well. Even in Kathmandu Valley less than 50 % irrigation institutions are registered following the legal provisions (Dulal, 2002). Question arises why the institutional growth is slow. One of the factors that influences institutional growth is transaction costs. Against this backdrop, this paper attempts to estimate the transaction costs in FMIS in Nepal. The specific objectives of the study are to:

a) assess the major components of transaction costs in FMIS and factors influencing the transaction costs incurred by households,
b) assess relative share of the transaction costs as compared to production cost
c) role of transaction costs in influencing institutional development as well as its impact on production

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This brings us to a short discussion on the theory of transaction costs. The literature states that costs that arise when an individual or a group of individual exchange ownership rights to economic assets and enforce their exclusive rights is called Transaction costs. It includes costs of : (a) information search, (b) bargaining & negotiation, (c) ensuring fulfillment of contract, (d) compensation valuation, (e) legal expenses for gathering evidence, presenting a case, challenging opponents, awarding and collecting damages etc. (Field *et. al.,* 1995).

There are now numerous studies available on the effectiveness of institutional arrangements at the local level for managing common pool resources in developing countries (Wade, 1988; Bromley, 1989; Ostrom 1990,1992 Agrawal, 2001). Some researchers have estimated the transaction costs related to co-management of fisheries, tank aquaculture, wildlife and community forestry (Kuperan *et al*., 1998; Sumalde and Pedroso *et al*., 2001, Senaratne, 2006, Mburu *et. al*., 2003; Adhikari and Lovett, 2006, Meshack et al., 2006). However studies of transaction costs of FMIS are not available and this study is a first attempt in this direction.

3. STUDY AREA AND METHODOLOGY

The present study was conducted in three districts of Kathmandu Valley (Kathmandu, Lalitpur and Bhaktapur) which is famous for its agricultural production. Total population of Kathmandu valley is about 1.7 million of which, 60% reside within the urban centers and remaining 40 % reside in the countryside of these districts (CBS, 2001). The irrigation canals exist only in villages of these districts. Total cultivable area in Kathmandu, Lalitpur and Bhaktapur is about 12,800 ha., 11069ha. and 7,097 ha respectively. The major cereal crops of the valley are paddy, wheat, maize and millet. Potato, oilseeds and vegetables are the major cash crops. Among these crops paddy, wheat and potato need irrigation water. The importance of irrigation water is mostly for early (paddy plantation before monsoon i.e. on May) paddy, wheat and winter potato[1].

3.1 Data Collection & Analysis Strategy

Nepal is divided into 75 districts which are further divided into Village Development Committees (VDCs) and Municipalities as local units. There are 3,914 VDCs and 58 Municipalities including one metropolitan and four sub-metropolitan cities. VDCs and Municipalities are sub-divided into smaller units called the ward. There are 9 wards in each VDC and number of wards in a municipality ranges from 10 to 35. The survey for this study was conducted during winter of 2007 and 2008. As a first step, all the irrigation systems within all districts of Kathmandu Valley (Kathmandu, Lalitpur and

[1] After plantation, normal rainfall provides sufficient water to paddy plants. The summer potato which is cultivated just after the harvesting of paddy does not need much water since the land is wet during this period and only winter potato needs irrigation. In some part of Kathmandu farmers plant paddy in May, so that they can cultivate potato twice after the paddy.

Bhaktapur) were listed and categorized according to the number Village Development Committees (VDCs) they cover: large (3 VDC and above), medium (2 VDCs) and small (1 VDC). Altogether there are 415 systems in Kathmandu valley and among them 51 are large, 122 are medium and 242 are small. Primary data collection involved both system level data as well as household level data using questionnaires[2]

We selected twenty systems from each category randomly (see Table 1 for household selection strategy) to compare the transaction costs in large, medium and small systems. Though the total number of system is different under each category we selected same number so that if would be easy to compare. In the large system, farmers were divided into three groups — head, middle and tail. Farmers in medium systems were divided into two – head and tail. All farmers in the small system were considered as head-end users. Three households from each subsystem (total of 360 households) were randomly selected for household level data collection. As the variability within each sub-system is low information from three household would be sufficient to understand the sub-system characteristics. The survey collected socio-economic and institutional data but mainly focused on transaction cost information.

While analyzing the transaction cost and its impact on productivity, infrastructure was categorized as good, medium and poor depending upon the physical condition and leakage situation. However, for the purpose of regression analysis these 3 categories were reduced to two (Yes_Infr) – for existence of infrastructure. It then becomes a dummy variable with value zero for poor quality and value one for good and medium infrastructure. We created a new variable free-ride which takes value zero when households incur less than Nrs 150 ex-post transaction cost and value one for amounts greater than this.

3.2 Elements of Transaction cost and its Measurement

Transaction costs are incurred both at the organisation and the household level. **System level** transaction costs occur both at the ex-post and ex-ante stage (for organization formation). Meeting, registration and negotiation (formation) costs, are ex-ante in nature as they arise prior to the formation of an organization. Ex-post cost, on the other hand, is the time cost for watching, waiting and negotiating, meetings, conflict resolution and communications (Bhattarai, 2007). Transaction costs are also calculated at the household level where we include the cost for watching, waiting and negotiating cost post organisation formation but incurred during irrigation management, (Bhattarai, 2007)(see Table 2~~Table 2~~).

Transction cost estimation involved a direct monetary measure as well as an imputed one – a) direct measure includes payment to hired labour for waiting (b) Imputed costs

[2] The three questionnaires were used to collect data at (i) system level, b) sub-system (Head, Middle and Tail) level questionnaire and c) household level).

had to be calculated for the time contribution by members for various activities. To measure the imputed cost of time spent by individuals in organizational work we valued the opportunity cost valued at the average wage rate[3]. These households in Kathmandu valley, have the option of gaining work outside their farm throughout the year. Thus the labour wage rate in Kathmandu can be used as a proxy for calculating the opportunity cost of time (Mburu, 2003).

Similarly the formation cost are one time fixed cost and calculated on the basis of time and resources devoted by farmers at the time of organization formation. Hence to estimate the annualized expense the lowest bank interest rate (9%) is used to the annualised transaction cost of formation.

Total annual transaction time was estimated by adding the expenses incurred by households at the system level as well as the household level. In order to make these compatible, system level total annual transaction time was divided by the total number of households within the system and added to the household level transaction time. In order to avoid the problem of double counting, the general meeting time at system level is not added to the total transaction time since this is already accounted for in the households transaction cost estimate. The time devoted to repair and maintenance is converted to day-measure by converting every 7 hours into one working day.

We will now discuss the estimates of transaction cost in the next section.

4. DESCRIPTIVE ANALYSIS OF FINDINGS

We start with descriptive analysis of the physical condition of the canal, institution and government assistance and general characteristics of the household. In the second sub-section we discuss the relative importance of transaction days and repair/ maintenance days in comparison to that the total human labour requirement in crop production.

4.1 Physical Condition of the Canal & External Support

Most of the systems in this area were constructed by the ancestors of the present users and few were constructed by direct bilateral assistance. The source of most of the canals is rivers and streams.

Average irrigated area is highest in large system (151 ha.) and lowest in small system (15 ha.). Similarly average length of the canal is, 4.2 km. for large, and 2.2 km. for small canals. The sampling strategy was to include twenty canals from each category of irrigation systems (i.e. large, medium and small) and the households surveyed are 180, 120 and 60 for large, medium and small system respectively.

[3] For the estimation of the opportunity cost, average wage rate of the peak and slack season is used.

Considering various parameters like use of concrete in the canal, quality of lining of the canal, leakage in the canal etc., we classified canals into three categories:. good, fair and poor. Most of the canals are in poor conditions i.e. there is leakage in canals due to the lack of proper lining; canals are not able to consolidate water from the source due to lack of proper dam structure at the intake point of the canal. Similarly canals which pass through the rocky parts have lot of leakages and farmers have not repaired the canal. The findings shows that about 63 % of the households were using the canal with poor infrastructure, whereas only 5 % of the surveyed households were using the canal with good infrastructure and remaining households had canal with medium (fair) quality infrastructure.

Among surveyed systems, 50% were rehabilitated during last 30 years. Among these rehabilitees about two thirds received partial support from the government, whereas only 10% were repaired by the user farmers and remaining systems were repaired by users with partial support by the government, NGO or INGOs. During our survey we found both types of irrigation systems – those with formal registration and those that had no formal registration. Most of the formal institutions were formed after 1990 and the motivating factor to organize and register the institution seemed in most cases was to receive external assistance for repair of canal. As evident, percentage of households with registered organizations is highest among the large systems (see Figure 4~~Figure 4~~).

The ones that have been registered with the government agencies are the ones that have the possibility of receiving financial support for maintenance (correlation between Support and Registered Organisation is 0.7, significant at .01%). But households with many systems have not managed to come together to register their organisation (61%, i.e. 220 of the 360 observations) and many of them did not receive support (222 households out of 360). Out of these 222 households, who did not receive any support, 196 households did not have a registered organization. (Figure 5~~Figure 5~~).

The formation and continuance of such organisations involves time and money on the part of the farmers which we have termed as transaction costs as discussed earlier. The post-formation expenses are incurred so that irrigation facilities are properly supervised and water flows to their fields. This is borne out by the significant difference in Exante transaction cost per hectare that farmers spent in forming the organization (see Table 3).

Those who were able to get external support, also had good or medium infrastructure. Those who had a high exante transaction cost also had a high expost transaction cost, but not surprisingly, they also had a higher agricultural output. However, being downstream does not seem to be correlated to support but expectedly correlated to having infrastructure and expost transaction cost. The possible explanation for this could be that those who are downstream are likely to spend more time and effort at ensuring that irrigation water reaches their fields. It will, only if the infrastructure exists and they spend time supervising. Interestingly, systems that had registered organizations, and good infrastructure also had more reliable irrigation. But if the expost transaction cost was low (i.e. farmers who spent less effort on ensuring water flow) or farmers were downstream they had less reliable irrigation (see Table 4).

Did receiving support make any difference ? There is a significant difference in Expost Transaction Cost between those who did receive support and those who did not (irrespective of type of system). However, while the farmers of small systems seemed to have a lower ex-post transaction cost when they received support, the medium and large systems had larger expost transaction costs when they received support (see Table 5).

Interestingly, the large systems had a significantly higher average output (total value per hectare) and the small significantly lower than the middle sized systems (see Table 6). When the farms were disaggregated by location, we find that in large systems only the tail-end showed a significantly lower output than the group average. For the rest of the farmers the location did not seem to make significant difference to average output.

Among all the farmers, those in the middle location of large systems reported the highest output per hectare followed by the head-enders. The next highest output was reported by the tail-enders in the middle sized systems and closely followed by the head-enders in mid- sized systems. The tail end farms, even though worse off in their own systems, reported a higher output than the average in small sized systems. So farmers are better off (on average) being partof a large system than a middle or small segment (see Table 6).

About one third (31%) of the total surveyed households were members of at least one organization (including drinking water, community forestry, farmers cooperatives and irrigation) within their village but only about 14 % households of the total surveyed were members of water users association (WUA)**.** Even in the registered organizations only 24 % of the households are member of WUA. Among the tail-end farmers, only 14% of the farmers were members of the WAU and of all members of WAU, only 34% were tail-end users. Interestingly, 68% of the registered organization members reported good or medium infrastructure quality of canals.

4.2. Transaction Cost, and production

Transaction cost can be classified into two broad categories: Exante cost and Expost cost which can be segregated into five broad activities — (i) watching, waiting and negotiating, (ii) meeting, (iii) conflict resolution, (iv) communication and (v) formation cost. Among the above transaction costs watching, waiting and negotiating cost, conflict resolution costs are ex-post cost. Similarly communication cost and formation cost are ex-ante transaction cost. Meeting costs depending on the nature of the meeting could be either ex-ante or ex-post. Ex-ante transaction cost on average is very low (Rs. 6 per year per household) in comparison to ex-post (Rs 326 per year per household) transaction cost. Among them watching, waiting and negotiating constitutes about 92 % of the total transaction cost. The time spent in meetings constitute about 7 % of the total transaction cost and remaining time was used for conflict resolution, formation and communication cost (Figure 1).

We did not collect the detailed production cost from our sample but for the purpose of comparison we use the total human labour requirement for the cultivation of paddy, wheat and potato from secondary sources. The amount of human labour requirement (except transaction time) for the production of paddy, wheat and potato per hectare of cultivated land was estimated to be about 183, 141 and 235 man days respectively (GoN/MoAC/DoA, 2006/2007).

The share of transaction time is relatively low compared to the total human labour required for the production of crops –in an average it is about 4 % for upstream and it is about 6 % for downstream households. The transaction time for winter crops is three times higher than the transaction time for summer crops. It is mainly because the summer crop gets the benefit of monsoon rain and canal water is less critical. On the other hand, for the winter crop farmers rely on canal water to irrigate the crops and therefore devote more time for watching, waiting and negotiating. If we compare the transaction cost with the total value of output it is only about one percent of the total value of output (Figure 2 and 3).

There are no other studies on TC in FMIS so it is hard to say whether these results are high or low. The findings of the present study are consistent with those of Mburu et al. (2003) who compared the transaction cost with other costs to the landowners in collaborative wildlife management in Kenya and found it relatively low. The findings of the study also reveal that the transaction cost in FMIS are relatively low compared to the community forestry in Nepal. Adhikari et al (2006) found that annual transaction cost for the household in community forestry ranges between 9-14% of total cost which is much higher than the findings of this study where it was 4-6% of total labour cost and just 1% of total production cost.

We now proceed to set up our econometric model to test for the significance of factors influencing total value of output (per hectare) and the role played by transaction cost among other factors.

4.3 Econometric model and its results

The critical factor that determines productivity on farms in the non-monsoon period is the availability of irrigation water at the farm level, which is determined by existence of canals and the state of maintenance and operation. Transaction costs influence both the maintenance and operation of irrigation canals (while the actual cost of maintenance is not part of transaction cost). There is high uncertainty in the water flow of irrigation canals and pose a challenge for efficient management and hence result in transaction costs. It also depends upon the physical characteristics of the canal system as well as the location of the cultivated farm to the source of the canal.

4.4.1 The Model

A simple regression model is used to understand the effect of farm locations as well as other variables on productivity. Since this study focuses on the impact of transaction cost we did not attempt to model a regular production function. However, the attempt here is to study other factors – farm location, infrastructure quality, reliability of irrigation, free riding, transaction cost, external support and their impact on productivity. The general function that we fitted using OLS technique is:

$$\textbf{Total value of output (per Hectare)} = \textbf{f (Dispute, Dominant Caste, Location of field, Re}$$

The expected sign of the different variables is presented below in Table8 and the regression results are presented in Table~~Table 10~~. It is anticipated that if there is a dispute in the system then productivity would be adversely affected. However, if the farmer belonged to the dominant caste then he might have be better placed. Presence of better infrastructure should improve productivity but this effect is expected to be captured by reliability of irrigation water. The reliability of irrigation would directly impact on productivity – the more reliable water supply is the better will be the outcomes. In terms of location, those in the tail end should have a higher transaction cost but the impact on productivity is not certain. If there are free riders they would have a higher net productivity as they take advantage of the semi-public good nature of irrigation systems. However, those who contribute also find a positive impact on their productivity. If the farmer put in effort to form an organization then they are likely to have gained support for maintenance of infrastructure. And if they continued to put in effort to ensure supply, then output would increase. Transaction cost also contribute positively for the increase in output by increasing the reliability of irrigation water in the field.

For the purpose of analyzing variables affecting total value of output per hectare, the econometric model is estimated with the following dependent and independent variables. Econometric software stata 10 version is used to estimate the regression and other statistical results.

$$totval_{Ha} = \beta_0 + \beta_1 dispute + \beta_2 dom_{caste} + \beta_3 dumlh + \beta_4 dumlm + \beta_5 dumlt + \beta_6 dummedh + \beta$$

The detailed description of these variables and their expected signs are presented in Table~~Table 8~~

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4.4.2 Regression results

Table~~Table 10~~ shows the impact of explanatory variables on the total value of output per-hectare. The regression results show that reliability of irrigation system have positive impact on the total value of output per hectare. It shows that more reliable the irrigation more will be the output. This satisfies our hypothesis. Similarly better infrastructure of irrigation system also have significant positive impact on the total value of output. Improvement in the quality of infrastructure may result increase in productivity and output. The regression result satisfies our hypothesis that free rider have more productivity. If a farmer get the water without any transaction cost or bearing a minimum transaction cost can be better off. More chances having freeriding better will be the value of output perhectatre.

The regression result show that transaction cost have also positive impact on production. This indicates that as farmers contribute more for negotiating for the reliability of irrigation they can generate more output from the irrigated land. (see TableTable10). However, square of expost transaction cost have negative impact on the value of output. This indicates that increasing amounts of expost transaction cost bring in only decreasing levels of output gains. The variables, dummy for tail end of medium irrigation schemes and Dispute and Dominant caste, even though not individually significant, are jointly significant. The variables location dummies are not significant. Robust Standard errors were also calculated but have similar values (not presented here). These results are in conformity with our expectations. As far as the locational dummies are concerned, it seems that once we control for other factors, the difference in productivity is insignificant. The overall goodness of fit (adjusted-R square) is 0.3033 which is in an acceptable range and the joint test of hypothesis (F-test) is also significant. All the signs of the variables confirm to expectations.

5. CONCLUSIONS AND POLICY IMPLICATIONS

It is worthy of note that the transaction cost, as a share of the total human labor required for the production of crops, is very low in the Kathmandu valley. Our results confirm the existing findings in the literature that downstream farmers have higher transaction costs compared to upstream farmers. However, the location did not seem to significantly affect productivity when controlled for other institutional factors. Since the transaction cost is small in comparison with the total cost of production, it makes economic sense for farmers to put in more effort to oversee the water supply. The results also confirm that the quality of infrastructure of the canal has a significant positive impact on increase in the total value of output per hectare.

Since our survey only covered farmers who were part of irrigation systems, it was not possible to examine the difference between irrigated and non-`irrigated farms. But unreliable irrigation is included as close proxy of unirrigated area for the purpose of examining difference between irrigated and unirrigated. According to the regression analysis, those who had reliable irrigation had higher productivity per hectare on average by NRs 66,528 after controlling for various institutional and locational factors. In comparison with this, the cost incurred by the farmers in transaction is minimal. This justifies farmer behavior in undertaking transaction costs to ensure an adequate water supply for irrigation.

The question then is why every farmer does not make the effort to ensure a good water supply. This is probably another instance of failure in collective action where there is an evident advantage to being a free-rider (see the positive coefficient in TableTable 10). But if the proportion of free-riders is large (i.e., at least some people undertake collective works to ensure canal maintenance), the reliability of irrigation can fall drastically. Forming an organization does not solve the problem necessarily since not even the formal or registered organizations have the authority to prohibit non-members from using canal water. And all the water users associations in our study reported the problem of free-riding. Therefore, it is imperative to devise strategies to control free-riding or deviant behavior. It would in turn improve institutional efficiency and reduce ex-post transaction costs to those who co-operate in the collective action. As the results from our study show, transaction activities do not cost much but they do matter for the collective action as well as for the increase in productivity.

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Table 1: Selection of system

Systems	Systems covering village	Total systems within Kathmandu Valley	No of systems selected randomly	Households selected randomly
Small	1	242	20	60 (3 from each system)
Medium	2	122	20	120 (3 from head and 3 from tail of each system)
Large	3 and above	51	20	180 (3 from head, 3 from Middle and 3 from tail end users)
Total		**415**	**60**	**360**

Table 2: Methods of Estimating Annual Transaction Costs

Transaction	**Nature of Transactions/ elements of transaction**	**Nature of Cost**	**Approach**	**Cost estimation**
Formation of Organization	Meetings/ dealing with stake holders/	Time for meetings	Value of time Wage rate*time	Interest rate as annual cost
Formation of Organization	Dealing with government offices	Travel cost, registration cost, statute preparation cost	Monetary expenditure	Interest rate as annual cost
Ensuring the implementation of decisions	Meetings/ dealing with agents/ communication/conflict resolution	Time for meetings	Wage rate*time	Opportunity cost
Protecting and negotiating	Watching, Waiting and Negotiating	Time	Wage rate*time	Opportunity cost

Table 3: Difference in Ex-ante transaction cost (per hectare) with and without support (T-test with unequal variances)

Variables	Observations	Mean	**t-value [Mean (without support) – Mean (With support)]**	**Satterthwaite's Degrees of freedom**	**H0:**	**Ha:**
Without support (no)	212	30.70	**-2.86**	**138.526**	Diff =0	**Diff< 0 ; Pr (T>t) = 0.0024** **Diff = 0; Pr (T>t) = 0.0048** **Diff >0; Pr (T>t)= 0.9976**
With support (Yes)	137	157.37				
Combined	349	80.43				
Difference		-126.67				

Table4: Correlation Matrix (Pairwaise)

```
             |  support totva~Ha type_org exante~Ha expost~Ha yes_infr downst~m prel_i~f
-------------+------------------------------------------------------------------------
     support |   1.0000
   totval_Ha |  -0.0069   1.0000
 type_of_org |   0.7004*  0.0284   1.0000
 exantetc_Ha |   0.1868*  0.2872*  0.1637*  1.0000
 exposttc_Ha |   0.1041*  0.3995*  0.0190   0.6778*  1.0000
    yes_infr |   0.4391*  0.1215*  0.4890*  0.0347  -0.0072   1.0000
  downstream |   0.0694   0.0459   0.0457   0.0400   0.1380*  0.1582*  1.0000
  prel_irrif |   0.0328   0.0821   0.1238* -0.0760  -0.1736*  0.1088* -0.2223*  1.0000
-------------+------------------------------------------------------------------------
(Significant at 10%, N=349)
```

Table 5: Difference of Means in Expost TC_Ha (t test with unequal variances)

Type of the System	Support	No Support	Combined	t-value Diff = mean(no) - mean(yes) Ho: diff = 0	Satterthwaite's degrees of freedom	P-Value	Alternate Hypothesis
Large	4479	3142	3743 (N=178)	-1.3429	106.017	.0911	Ha: diff < 0
Medium	4067	2937	3357 (N=113)	-1.5549	90.9057	.0617	Ha: diff < 0
Small	1038	2101	1826 (N=58)	1.4471	48.162	.0772	Ha: diff > 0

Table 6: Difference of Means in TotVal_Ha (t-test) for different System types with unequal variances

	TypeSys 1	TypeSys 2	TypeSys 3	All Systems
TotVal_Ha	2,30,123	1,89,409	1,60,885	2,05,434
N	178	113	58	349
Difference of Means	Ha: Diff =< 0	Ha: Diff == 0	Ha: Diff > 0	
Head	2,37,165	1,82,929	1,60,885	
Middle	2,73,507	--	--	
Tail	1,79,934*	1,96,007	--	

Table7: Differences in Ex-post transaction cost per hectare (with unequal variances)

Variables	Observations	Mean	**t-value [Mean (without support) – Mean (With support)]**	**Satterth waite's Degrees of freedom**	**H0:**	**Ha:**
upstream	173	2572.6	**-2.61**	279.009	Diff =0	**Diff < 0; Pr(T<t) =0.0048** **Diff=0 ; Pr(T>t) = 0.0096** **Diff >0; Pr (T>t) = 0.9952**
downstream	176	4014.6				
Combined	349	3299.8				
Difference		-1442.0				

Table8: Variables definitions and expected signs

Factor context	**Variable name**	**Definition of variable** **(Type:** Continuous=C Dummy = D)	**Expected Impact on Productivity**	**Reason**
Dependent Variable	Totval_Ha	Total Output per hectare in (NRs)		
Explanatory Variables	Dispute	Existence of dispute within the system (D)	-ve	More dispute within the system the reliability of water flow will be low and hence low productivity in the land
	Dom_caste Caste	Dominant caste (Bramhin and Kshetry) (D)	+ ve	Existance of dominant caste may manage the resource and facility in their favour and hence positive impact on production.
	Dumlh	Dummy for large head households	+ve	Positive impact on output as more irrigation facility will be available.
	dumlm	Dummy for large middle households	+ve	Positive impact on output as sufficient irrigation facility will be available
	dumlt	Dummy for large tail households	-ve	Negative impact on output as less irrigation water will be available in the tail end.
	dummedh	Dummy for medium head households	+ve	Positive impact on output as more irrigation facility will be available.
	dummt	Dummy for medium tail households	-ve	Negative impact on output as less irrigation water will be available in the tail end.

	prel_irrif	Reliability of irrigation facility (D)	+ve	More reliable the irrigation facility more production on the land.
	free_ride	Free riders (households having less than Nrs 150 expost transaction cost)(D)	+ve	Free riders have positive impact on output as they have more net benefit.
	exposttc_Ha	Per hectare transaction cost incurred after the formation of organization (C)	+ve	More time and efforts for the collection of water and improvement in the reliability of water availability for irrigation in the field more will be the production.
	exantetc_Ha	Per hectare transaction cost during the process of formation of organization (C)	+ve	More time and efforts for the institutional development for the smooth and regular flow of water more will be the output in the field.
	sqexpost_Ha	Square of the expost transaction cost per hectare (c)	-ve	However, use of increasing amount of transaction cost results decreasing rate of output gains.

Table9: Summary Table

Variable	N	Mean	SD	Min	Max
totval_Ha	349	2.05e+05	2.53e+05	27600.00	2.81e+06
dispute	349	0.30	0.46	0.00	1.00
dom_caste	349	0.71	0.46	0.00	1.00
dumlh	349	0.17	0.37	0.00	1.00
dumlm	349	0.17	0.38	0.00	1.00
dumlt	349	0.17	0.38	0.00	1.00
dummedh	349	0.16	0.37	0.00	1.00
dummt	349	0.16	0.37	0.00	1.00
prel_irrif	348	0.78	0.42	0.00	1.00
free_ride	349	0.30	0.46	0.00	1.00
exposttc_Ha	349	3299.82	5230.99	0.00	67500.00
exantetc_Ha	349	80.42	331.63	0.00	5864.05
sqexpost_Ha	349	3.82e+07	2.55e+08	0.00	4.56e+09

Table10 Regression Results

Dependent Variable: Totval_Ha

Explanatory Variables	Coefficient	t

dispute	-43021.9	-1.57
dom_caste	30993.39	1.23
dumlh	6041.323	0.15
dumlm	30460.02	0.74
dumlt	-18247.74	-0.44
dummedh	-60721.12	-1.51
dummt	-18273.09	-0.45
prel_irrif	63939.38**	2.20
support	-89161.5***	-3.30
yes_infr	59280.18 **	2.17
free_ride	155474.4***	5.64
exposttc_Ha	45.41855 ***	9.81
exantetc_Ha	421.8475***	4.55
sqexpost_Ha	-.0009478***	-5.82
_cons	-25387.06	-0.62

** Significant at 5 % level of significance

*** Significant at 1 % level of significance

Figure 1: Different Category of Transaction cost (in hours)

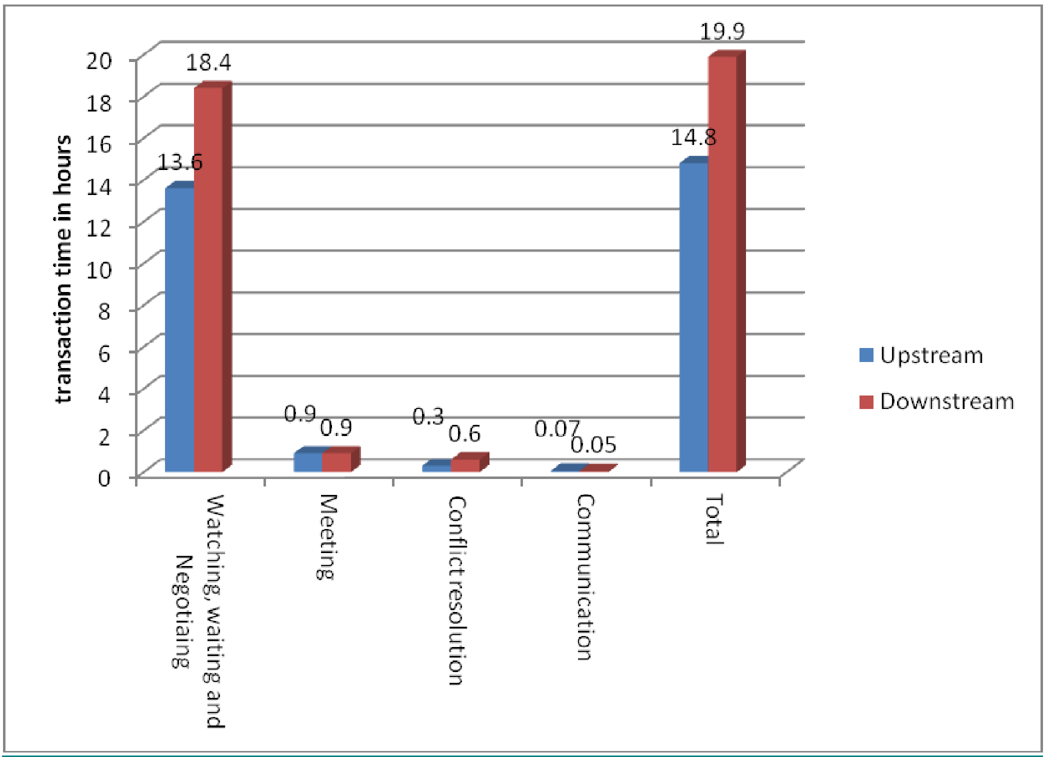


Figure 2: Transaction time, Repair and Maintenance time and Total time for the Production of Crops per Household (in man days)

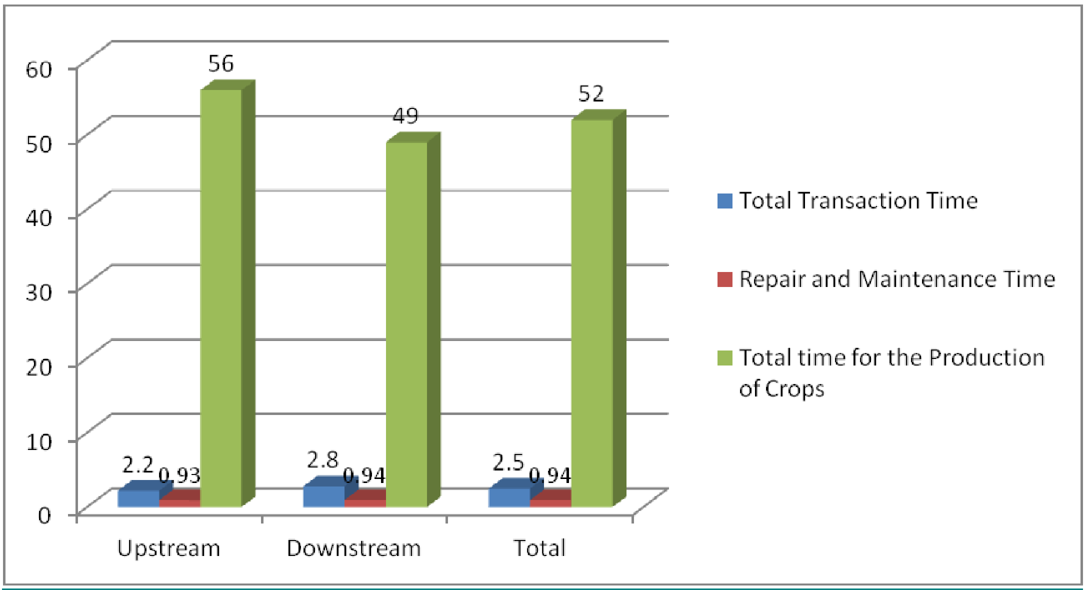


Figure 3: Transaction Cost (in NRS) by Season

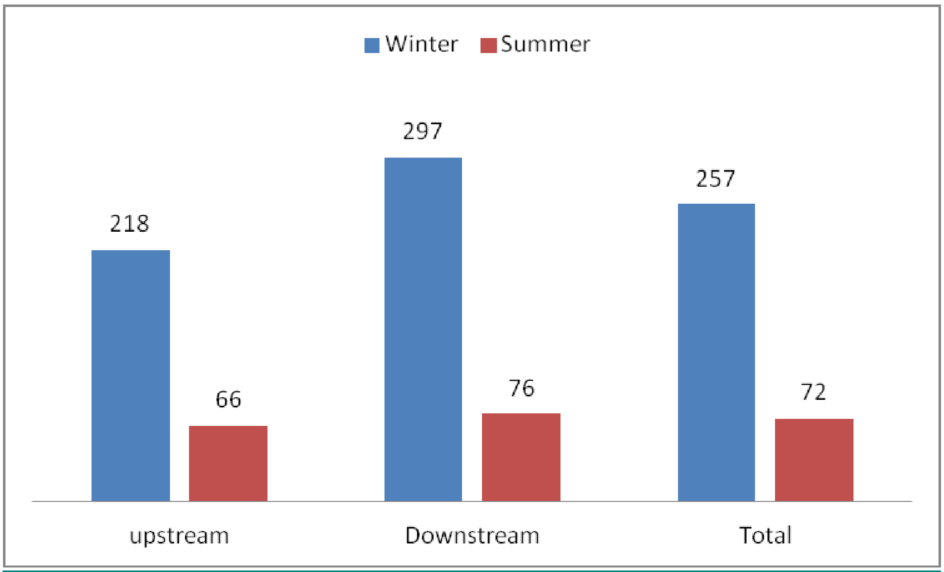


Figure 4: Proportion of Households with Registered organizations (by Type of System)

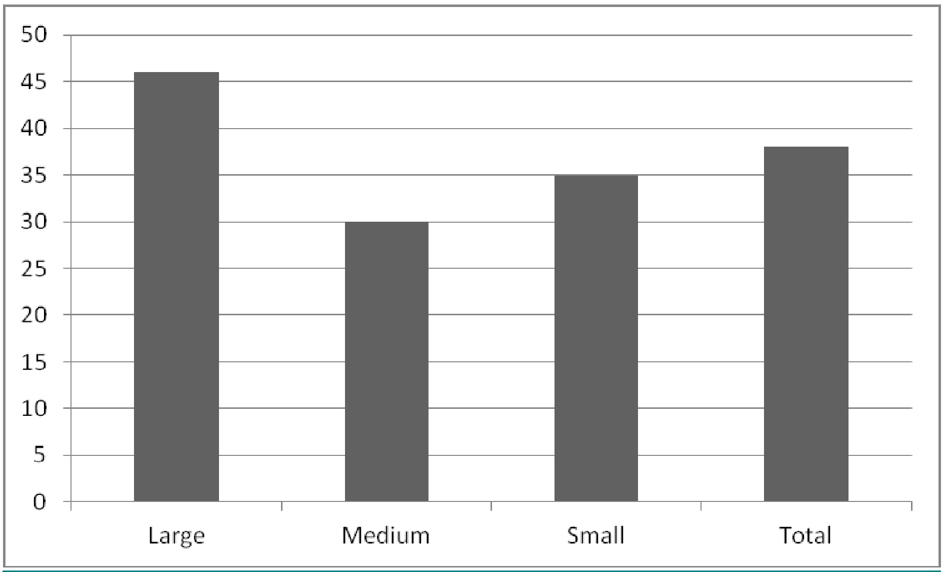
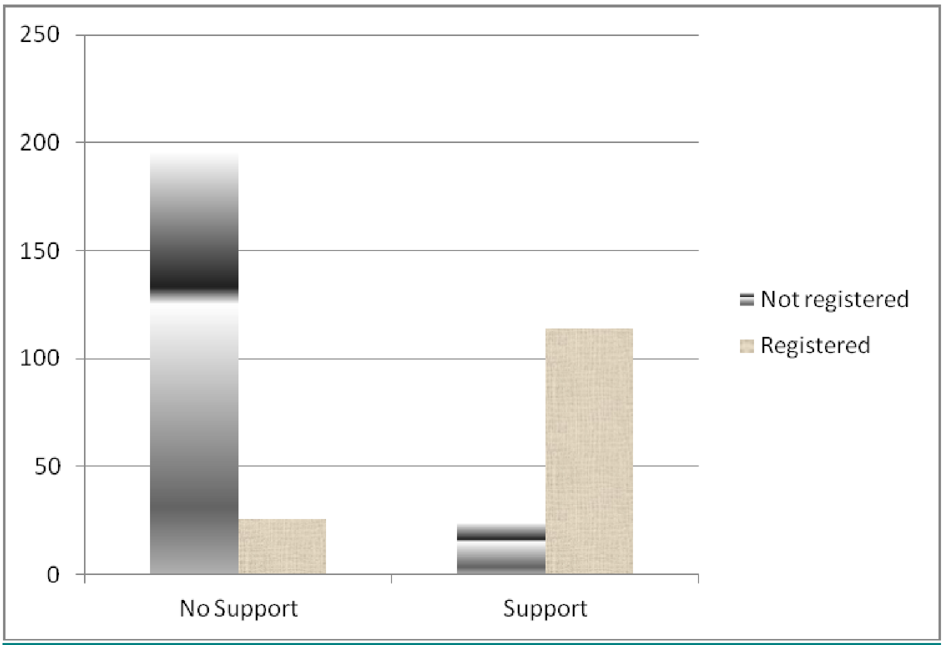


Figure 5: Households with Registered Organisaitons and External Support



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