Property Rights and Natural Resource Management: Equitable Water Distribution Using Indigenous Technology in a Farmers Managed Irrigation System in Nepal

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Abstract

Agency interventions for technological fixes and performance improvement as the most effective policy tool for irrigation management continue to produce counterintuitive and counterproductive results. Technological innovations designed and installed by local farmers using locally available materials can be a powerful tool for equitable water distribution and improve performance of resource base. Using a case study method, the paper demonstrates that Farmers Managed Irrigation System (FMIS) using local resources can consolidate indigenous knowledge bases and help strengthen institutional robustness for irrigation management. Results from the study indicate that while farmers have achieved equality across the landholding sizes, spatial inequality continues to be a challenge. The paper argues that property right structure created by local initiatives help reduce asymmetries of interests and endowments amongst irrigators which in turn help foster incentives to contribute to infrastructure maintenance.

Key words: *Property Rights, CPR, FMIS, Equity, Indigenous Technology, Nepal*

1. Introduction

In Nepal, alongside other developing countries, rural households depend extensively on local natural resources such as irrigation water for their livelihoods sustenance. Households' higher dependency on natural resources has meant that, common pool resources (CPRs) such as irrigation, rangelands, and forests are very difficult to manage at household the individual level (Meinzen-Dick et.al. 2001). Costly exclusions and rivalry are two inherent characteristics of many CPRs, including irrigation systems which have rendered them vulnerable to unsustainable use with real possibilities of possibilities of depletion leading to tragedy of the commons (Hardin, 1968; Ostrom and Gardner, 1993).

The finite flow of water in canal and its non-stationary nature which is shared by multiple users simultaneously adds complexity for sustainable management. The above mentioned characteristics of irrigation systems and the failure of centralized governance in maintaining resource sustainability and redistributive justice has meant that community based natural resource management (CBNRM) are increasingly preferred in

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irrigation management and are often credited for their sustainable use and developing local economies (Ostrom, 1990; Pradhan, 2000; Marshal, 2008).

Historical evidence vis-à-vis present trends show Nepal's rich portrayals of communal engagement in natural resource management particularly pasture land, forests and irrigation canals. In particular irrigation systems initiated, designed, constructed and maintained through community initiatives commonly referred as Farmers Managed Irrigation Systems (FMIS) have continued drawing attention from both academic and policy circles (Ostrom, 1990; Lam, 1998; Pant and Howarth, 1987; Martin and Yoder, 1985 & 1996; U. Pradhan, 1990, Pradhan , 1989; Pradhan & Pradhan, 2000).

The FMIS continue to occupy prominent position in agricultural development in Nepal as they are the highest contributors towards the gross irrigated agricultural practices. Currently the FMIS contribute up to 70 per cent of total irrigated lands in Nepal (Pradhan, 2000). The role of FMIS is critical in the hilly areas than terai[4] since as much as 90 percent of irrigated areas derive water from them compared to about 70 percent in the terai (Pradhan, 2005).

Furthermore, despite investments, the performance of agency managed irrigation systems (AMIS) has been rather disappointing. In fact, many FMISs have consistently outperformed AMIS in most of the performance indicators (Lam, 1998; Loitos et.al., 1986; Pradhan, 1983; Hilton, 1992; Yoder, 1986). In response to these failures, it is argued that organized civil societies can and do play an important role in correcting externalities, provide incentive structures, provision of local common goods and credits which neither the market nor the state can reliably solve (Molians, 1998).

In recognition of the unique contributions made by the CBNRM initiatives, participatory resource management has often been posited as a viable solution to avoid the 'tragedy of the commons' (Hardin, 1968). It is thought that, granting property rights to communities would provide sense of ownership and responsibilities and help bring long term communal welfare as oppose to short term private gains through equity resource distribution and maintaining resource sustainability.

In CPR literature, it is generally reported that the poorer households make greater use of and are more reliant on natural resource bases, which contribute substantially to their livelihoods sustenance. Particularly, poorer households derive a greater proportion of their income from the local commons, compared to their richer counterparts (Cavendish 2000; Beck and Nesmith 2001; Fisher 2004; Shackleton and Shackleton 2006). However, in absolute terms, richer households, particularly with market accessibility, benefit more than their poorer counterparts (Cavendish 2000; Dasgupta, 1993) by selling the products from the CPRs. There is a common assumption that greater reliance upon CPRs equates to greater benefit derivation by the poorer households making them the primary beneficiary from CPRs (Campbell et.al., 2001). Contrary to this assumption, however, a growing number studies report that, neither the degree of resource dependency equates to the level of benefit appropriation nor the asset poor

[4] Terai is the plain land in the Southern part of Nepal which represents 17 per cent of Nepal's territory

households become the primary beneficiary of the local commons (Adhikari, et.al, 2004; Kumar, 2002).

The paper is divided in seven sections. The first section reviews some theoretical work on community based natural management and makes a case for the FMIS. Section two sets the scene including data collection and discusses the methodological issues employed in this research. In section three discusses governance structure of Phalebs irrigation system. Section four presents institutional analyses of the FMIS under consideration, while section five illustrates traditional technology and mechanisms for water distribution. Section six presents the findings of the study with regards to reducing asymmetries amongst the farmers while managing irrigation canal system. Some conclusions and policy recommendations are made in section seven.

2. Methods: Study Site and Data Collection

2.1 Setting the Scene

This study was undertaken in Phalebas area in Parbat district, western Nepal where irrigated agriculture has been practiced since at least a century or so. The Phalebas Irrigation System (PIS) is an example of FMIS which provides irrigation facilities to more than 134 hectare of fertile land along the Kali Gandaki river belt. The canal command area of the PIS is characterized by a westerly sloping undulating landscape consisting of *tar*[5] land which is bounded by the Kali Gandaki river flowing on the western side along a deep gorge of more than 130 meters while to the south by the Lamaya stream, which is also the source of water feeding the irrigation system. While the majority of the PIS canal command is plain, some parts are mixed of hills and plains called the hillocks. The deep ravine created by both the Kali Gandaki river and the Lamaya stream has meant that the landscape of the canal command areas is located higher than the rivers necessitating the construction of the canal intake at a location considerably higher upstream to divert water in the system.

<u>Figure 1: Study Site: Map of Parbat district, Nepal</u>

In Phalebas area, the cropping calendar for the local farmers is typically determined by rainfall and temperature indicating a clear deficit of irrigation facilities.

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[5] Elevated flat and dry land and usually boarded by rivers on both sides

Figure 2: The monthly variation in rainfall and temperature in the Phalebas area is presented in Figure 2a & b below.

Fig 2a: Monthly Rainfall

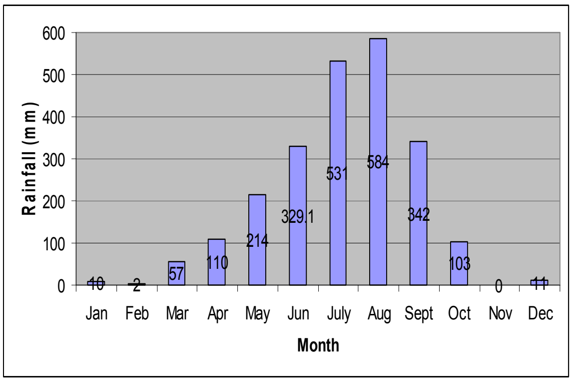


Fig 2b: Monthly Temperature

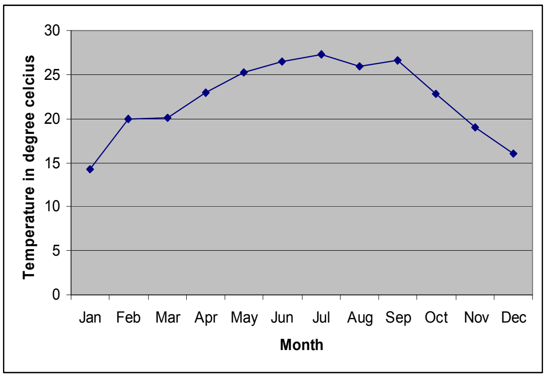


Table 1: Crop importance as reported by farmers Phalebas area (N=67)

Name of Crop	**Crop1 (in %)**	**Crop2 (in %)**	**Crop3 (in %)**	**Crop4 (in %)**
Monsoon Paddy	100	0	0	0
Maize	0	64.2	31.8	0
Wheat	0	34.3	59.1	1.7
Vegetables	0	1.5	4.4	82.4
Dry Paddy	0	0	3	0
Millet	0	0	1.5	0
Legumes	0	0	0	1.7
Mustard	0	0	0	13.8

The water supply in the system is abundant during the monsoon season, while in winter and spring the system suffers from acute water shortage which is caused principally by seasonal nature of the water source feeding the system. The nature of water availability in the canal is presented in Table 2. The severe water shortage particularly during winter and spring has meant that optimal use and effective management of water is critical for agricultural practices.

Table 2: Seasonal Characteristics of Water Availability in Phalebas (N=67)

Seasons	Characteristics of Water Availability (in Percent) [N=67]			
	Abundance	Limited	Scarce	Non-existence
Monsoon	97	3	0	0
Winter	1.5	91	6	1.5
Spring	0	43.3	50.7	6

The total length of the canal system is 14 kilometers including 4 kilometers of tertiary canal (distributory network) making a longitudinal arch across Plalebas areas. In the Phaleas area, the soil type is characterized by dominant of sandy loam to sticky red soils with a high water requirement which requires a regular water supply for crop production. The canal itself is run-of-the-river type with temporary diversion intake which is made of a combination of mud (*lapcha*), sandbags, stones boulders, wooden logs, and tree branches. Also, the majority of canal linings are not cemented.

Photo 1: Headwork (Intake)

Photo 2: Canal Cross section

2.2 Data

The data employed for this study were obtained through a case study method and primary data were collected using various tools and techniques including household survey, focused group discussions and unstructured expert interviews and field observations in Phalebas area of Parbat district in western Nepal.

The data collection took place between Nov-Dec 2007. For the purpose of survey, households were the operational sampling units. The households were classified into three categories of landholdings: small, medium and large landholdings. The criteria used for household classification are presented in table 3 below. A number of scholars have applied similar wealth ranking exercise to sample populations into different income groups (see Fox, 1983; Richards et.al., 1999). The administration of a pre-tested structured questionnaire was carried out amongst randomly selected households. A total of 67 households were surveyed of which 51 were males headed and the remaining 17 were headed by females.

However, classification of households by an individual researcher was assumed to be highly susceptible to arbitration and biases causing severe methodological flaws (Adhikari, 2003). While the conventional definitions of 'household headship' have been criticized (Rosenhouse, 1989) and policy recommendations have been debated (Buvinic and Gupta, 1997; Bruce and Lloyd, 1997), they have become a common sampling unit in research. Often is the case that definitions of both household and household-headship are context specific and have been used in different ways in different countries. It is therefore the extent to which the household heads' views represent that of the other members of the household is open to debate. Also, the term 'head of household' is neither neutral nor universally accepted and is often loaded with additional meanings reflecting traditional conceptualizations. It is argued that using the household as a sampling unit represents undifferentiated units in a patriarchal mode of governance with no reflection of internal conflicts in the distribution of resources (Folbre, 1990). Evidence aplenty have suggested that an excessive focus on the household heads can ignore important experiences of other members of the households (Deshingkar et.al., 2003).

Recognizing above mentioned criticism, and in order to minimize arbitrations, the researcher made use of participatory rural appraisal (PRA) techniques, where snowball samples reported that, generally the ‘household heads’ not only hold land disposal rights but also control household’s income/expenditure and make important decisions on the behalf of the family members. It was observed that the household head also takes part in meetings and village level discussions of public interests. It is therefore assumed that, they are more likely to be aware of and have knowledge about irrigation issues.

Table 3: The framework used to sample households

Households Category (based on size of landholding	Size of Landholdings in (Ha/Ropani)
Small/Marginal	0-0.45Ha (0-9 *Ropani*)
Medium	0.45-0.96 Ha (9-19 *Ropani*)
Large	>0.96 Ha (>19 *Ropani*)

Based on the above mentioned criteria, majority of the farmers were small landholders which shows land fragmentations in the areas.

Table 4: Total number of households included in the Study

Landholding Categories	Total Number of Households (% of total)
Small	42 (62.7)
Medium	11 (16.4)
Large	14 (20.9)

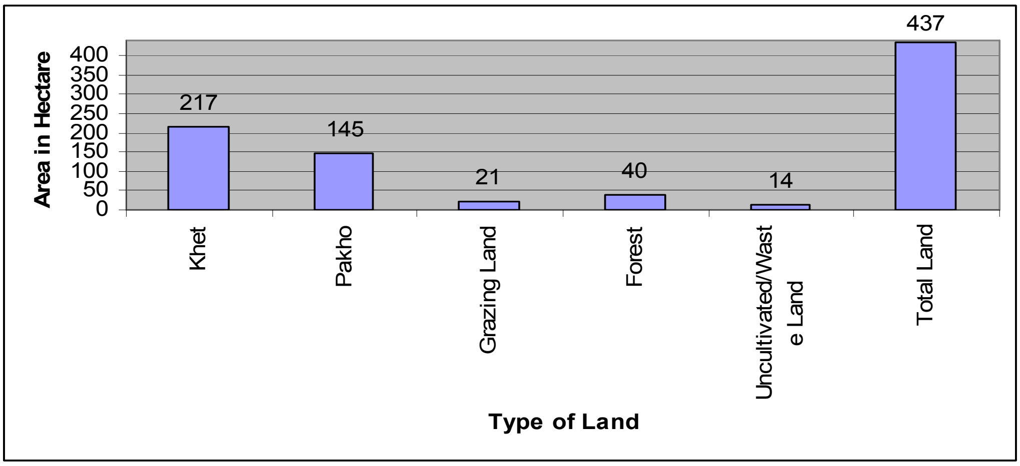
Also, in order to capture spatial variations, the households were selected from all parts of the canal command area. The spatial characteristics of households are presented in the Table 5 below.

Table 5: Households and their landholdings location in the Sample

Spatial Location	Total Number of Households (% of total)
Head end	10 (14.9)
Middle end	40 (59.7)
Tail end	17 (25.4)

The total area of Phalebas Devisthan is 437 hectares of which 362 hectare is arable. Of the total arable land of 362 hectare, 217 hectares of land has irrigation facilities of which 134 hectare are served by the Phalebas irrigation system, while remaining 145 hectares are non-irrigated. The Devisthan VDC has 102.8 hectares of land under forest cover of which 42.71 hectare is under community management. The type of land in Devisthan, V.D.C. is presented in Figure 3 below.

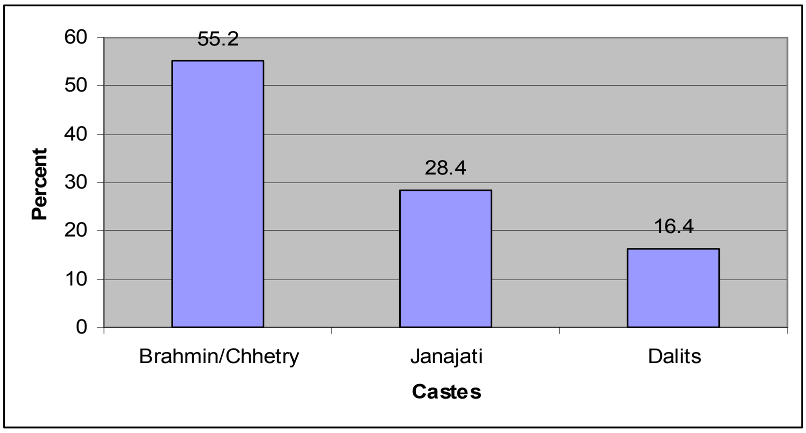
Figure 3: Type of Land in Phalebas area



Source: PDDC (2001)

Demographically, the population of Phalebas is very heterogeneous with majority of Newar and Brahmin-Chhetry castes. Other castes groups in the area include Gurung, Magar, Gharti and dalits (Damai/dholi, Kami, Sarki). The total population in the Phalebas is 3308 of which 1563 are male and1745 are female. The average household size of Phalebas Devisthan is 6 persons per household while the population density remains 8.72 persons per hectare (CBS, 2001)

Figure 4: Caste/Ethnic distribution in the Sample (N=67)



3. Irrigation Governance in Phalebas

Governance is a complex combination of mechanisms, processes, relationship and institutions through which individuals, and groups articulate their interests, exercise their rights and obligations and mediate their differences (UNDP, 2002). In the context of irrigation governance, it can be defined as a set of principles, and rules designed and implemented to exercise power and practiced in all spheres from private to public and in the management of irrigation resources and the 'relationship between the state, its citizens, civil society and private sectors (Brown et.al., 2002).

In the context of the PIS, elsewhere in other FMIS in Nepal, the irrigation governance represents *"the decentralised natural resource management by the local community […] that has developed its own organisation system, norms and values governing the management of water resource, resource mobilisation based on obligations and right to use the natural resource"* (Pradhan 2000). It should be noted that, devolution is a form of decentralisation and have been often used interchangeably in the literature (Parajuli; 2008; Fisher 2000; Litvack et al. 1998; Cohen and Peterson 1997).

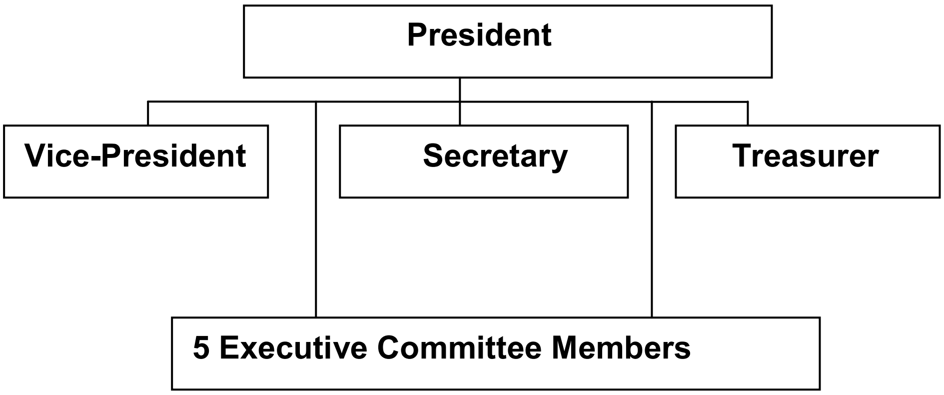
In the case of PIS, the decision making authority has been transferred to the lower level farmers or group of farmers in a socio-physical hierarchy of irrigation system whereby the groups of farmers at the lower level elect their own committees, raise their own resources and have independent authority to manage system operation. The management committee also have all three sets of power: legislative, executive and judicial (Agrawal and Ribot; 2000).

From management point of view, the PIS consists of two entities namely, the main committee also called Phalebas Irrigation Management Committee (PIMC) and the branch committees. The main committee members consists of the president, vice president, secretary, treasurer and executive committee members.

As such the irrigators have created two tier organisational structures. Firstly, a five members branch committee are constituted from each of four branches in the PIS within the Devisthan V.D.C. The branch committees are second tier administrative units with primary remit of managing branch canals. The branch committees are entrusted with the tasks of operation and maintenance (O & M activities) within the branch canal and occasionally in the main canal. In Phalebas, elsewhere in Nepal, each branch consists of a number of hamlets. The hamlets are ethnically diverse, mixed and homogenous depending on settlement patterns. In general, the hamlets in Phalebas area are mixed.
The branch committees meet on ad-hoc basis to discuss issues pertinent to irrigation. The branch committee is presided by a president and other executive members. The formation of branch committees takes place by mutual understandings rather than by a direct voting. For the purpose of committee formation, the farmers select their representative by mutual understandings to represent their interests at branch level. However, it is crucial that representatives are chosen from all the parts of the command area and all castes groups served by the branch canal. While different caste groups bargain to have their representative in the branch committee, not all castes can be accommodated in the branch committee. Nonetheless, the committee consists of members of different caste groups.

The decisions on designations and roles of the members of the branch committees are decided by the first meeting of the committee through mutual understanding again. Usually the president of the branch committee is a well respected local farmer with substantial experience of social work within the locality and demonstrates an amicable impartiality. Since the presidents of the branch committee are ex-officio member of the main committees, they are expected to be an articulate and able to defend their interests. It is generally believed that, at a branch level committee created through mutual understanding is more effective, responsible and transparent in its conduct than those elected through direct voting.

Figure 5a Structures of Branch Committee in Phalebas Irrigation System

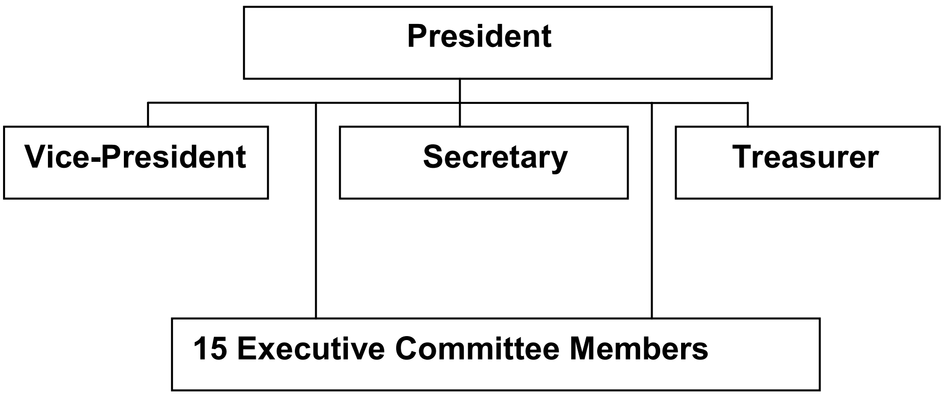


Usually but not always, a female member of branch committee is nominated for the post of treasurer partly to avoid misuse of the fund as females generally keep them safely, while men tended to misuse fund (based on personal conversation with farmers).

The branch committees usually meet every month (more frequently during emergencies) to discuss issues pertinent to irrigation issues including conducting operation and maintenance activities (O& M), collecting irrigation levy and liaison with the main committee. The branch committee also has jurisdiction to disputes settlement if any arises within the branch areas.

Secondly, the PIS consist of the nineteen members main executive committee called Phalebas Irrigation Management Committee (PIMC). The nineteen member executive committee are formed through a direct voting by the general assembly (*Mahasamiti*). As mentioned earlier, the presidents of the branch committees are ex-officio members of the PIMC. The Water Users' Association (WUA) memberships are granted to every beneficiary farmer within the canal command area and a meeting of the general assembly is called upon to decide the executive committee. Nominations are sought for the WUA elections from farmers within the PIS canal command area. The farmers fill nominations for various designations and contest election to be in the executive committee.

Figure 5b Structures of Phalebas Irrigation Committee



The main executive committee is elected for a period of three years, with a remit of managing irrigation system effectively. The constitutions of the PIMC provide a comprehensive framework for the roles and responsibilities of both branch and main executive committees. The responsibilities of the main committees include collecting water levy, carrying out O & M activities, conflict resolutions, liasioning with the Department of Irrigation (DoI) amongst others.

4. Institutional Framework Governing Phalebas Irrigation System

The long terms viability of irrigation systems grossly depends on the rules that can accommodate actions emanating from bounded rationality and safeguard against opportunistic behaviors (Tang, 1989) and institutions help to ensure above mentioned conditions. North (1990) argues that, institutions are humanly devised constraints that shape human interactions. Institutions delineate action situations where human interactions take and individual and collective decisions are made (Ostrom, 1990; Commons; 1968; Bromley, 2003). Hall and Taylor (1996) argue that, ‘institutions provide moral and cognitive templates for interpretations and actions’. Institutional configurations are important for providing cognitive framework for transformation of information into economically and socially useful knowledge through interpretation of data, habits, and routines at individual and collective level to coordinate individual and social interactions (Hodgson, 1998).

Coase (1960) argues that, in the world of imperfect knowledge and information, institutions are important entities to help individuals make rational decisions in relation to themselves and their surroundings (North, 1990). Simon (1957) posits that institutions help enlarge human capacities and offset their limitations imposed by limited knowledge, foresights and skills in connection with the ways individual relate to their surroundings.

Institutions not only constraint choices, but also provide opportunities for human interactions (Acheson, 1994) by setting parameters for system management, choice set for actors shaping actors’ vision and defining their identities (Granovetter, 1985; March & Olsen, 1989). The institutional configurations dictate rules of the game, as Common (1968) posits institutions as ‘working rules of growing concern’ with regards to what individuals must or must not do (*compulsion or duty*); may or may not do (*permission or liberty*); can do (*capacity or right*); cannot do (*incapacity or exposure*) individually and collectively.

In the context of irrigation management, institutions are sets of rules that constraints the interactions of farmers, irrigators, irrigation officials and others associated with irrigation directly and indirectly in different capacities. The institutional arrangements for irrigation governance provide farmers *vis-a-vis* irrigation officials with ‘a set of order relationship’ which defines their rights, exposure to the rights of others, privileges and responsibilities (Schmid, 1972) determining economic conditions and action situations (Ostrom, 1990; Bromley; 1989).

Over the course of time, the PIS have been able to establish robust institutional arrangements to govern their irrigation system. The institutional setups of the PIS can be conceptualized at two levels namely operational rules and collective choice rules.

The characteristics and operational mechanisms of the rules in the PIS are discussed in the following section.

I. Operation Level Rules

The operational rules delineate the conditions that farmers are required to meet in order to make legitimate use of the irrigation facilities.

a. Boundary Rules:

The boundary rules dictate the membership of the irrigation systems, and the holders of the memberships are recognized as the legitimate users of the irrigation infrastructures including the water. The framework mentioned in the constitution of the PIS demarcates that memberships of the PIS are grantable to the farmers with landholdings and crop-sharers within the canal command area. The right holders can independently transfer their share of water to other farmers in accordance with mutual understanding without explicit permission from the PIMC. Also, the membership is distributed only after the payment of membership fees. It is absolutely essential that individual households hold membership for their concern to be heard and interventions made by the PIS with any issues concerned with irrigation including conflict resolutions. The boundary rights are essentially access rights whereby all defined users have a right to enter into the system as per specified rules and withdraw water that they are entitled to.

b. Allocation Rules

While the boundary rules provide conditions that individuals are required to meet in order to enter into the resource system, the allocation rules stipulate actual mechanism for members to claim their rights and withdraw water from the appropriate resource i.e. water distributions. In Nepal, although a wide range of mechanisms are practiced for water allocation including fixed proportion, fixed time slots and fixed orders. The allocation procedures depend on various factors including, size of landholdings, spatial location, crop-water requirement, individual's water share and government discretion amongst others. However, in the PIS, fixed time slots proportional to the size of the landholdings are practiced. Depending on the season, and water availability in the system, two types of fixed timed slots of water allocations are practiced in the PIS which are described in section 5.2 below.
It is believed that, fixed time slots mechanism of water allocation is economically efficient through optimization of water use. In this system, all irrigators are aware of their turn for irrigation and they usually promptly turn up to divert water into their own their plots immediately after farmers preceding their turns. The advantage of fixed time slots method of water allocation is that, the water supply is reliable and predictable. Also, allocation of water rights proportional to the size of holding is considered to be more equitable way of water distribution.

c. Input Rules

Input rules stipulate the obligatory aspects expected of the irrigators in return for withdrawing water from the canal system. Tang (1989) articulated four major types of inputs that irrigators are expected to contribute which include regular water fees, labour contribution for regular operation and maintenance, emergency repairs and contribution towards capital investment. The input rules designed and practiced in the PIS are consistent with Tan's findings. In historical times, the beneficiary farmers made the capital investment for the construction of the canal. The contributions were made both in cash and kind. Earlier, the allocation of water share was based on the contribution made during the constructions; however a recent amendment to the PIS constitution has changed the rule for water allocation and currently water distribution takes place in proportional to the household landholdings.

In the PIS area, two types of water charges are levied. Firstly, general membership fee (*sadasya shulka*) at a flat rate of NRs 5 is levied from each member irrespective of landholdings and their locations. Secondly, water fee (*sewa shulka*) at a rate of NRs 3 per ropani of cultivated land is levied from the farmers, of which 20 percent is required to be deposited at the revenue office while the remaining 80 percent is deposited in PIMC's own account in the bank. The amount is used for organizing operation and maintenance activities. Along with paying water fee, the users also make contribution towards system operation and maintenance on a regular basis.

The temporary nature of headwork and canal transcending along the landslide prone area has meant that regular O & M activities are required. The average person-day labour contribution made by the farmers in O & M activities, WUA meetings and costs associated with those activities are presented in Table 6. Usually the PIMC carries out a walkthrough along the canal to identify any urgent O & M activities and all farmers are called upon to carryout the needed O & M activities.

Similar to water allocation, a variety of bases for input are practiced in Nepal. The most commonly practiced input rules includes, equal contribution irrespective of water share, inputs proportion to land cultivated or to amount of water required for cultivation.

Table 6: Farmers' Participation in O & M Activities and WUA Meetings (N=67)

Activities	average man-day Contribution in a year (N= 67	Average Costs for O & M +WUA meetings (NRs)
O & M activities	5.13	453.88
WUA meetings	2.80	
Total	7.93	453.88

In the Phalebas area, a combination of the above criteria is used which is tabulated below in Table 7. However, during the time of emergencies such as landslides and flooding, equal contribution is made by all the beneficiary farmers irrespective of their water share to maintain a constant flow of water in the system.

Table 7: Labour Contribution Rule for O & M Activities in Phalebas

Number of Days contributed O & M activities	Landholdings
<5 days	All farmers irrespective of amount of landholding
between 5 & 10 days	farmers with cultivated land of > 5 ropani
>10 days	Farmers with cultivated land of >10 ropani

d. Penalty Rules:

In the absence of penalty rules, the individual have little or no incentive to follow allocation or input rules increasing incidence of free ridings. The penalty rules restrict irrigators from defrauding which helps to ensure rule compliance. Similar to allocations and input rules, the penalty rules might take several different forms including fines in cash, incarceration, restricted use and temporary loss of appropriation rights altogether. However, incarceration is least likely to be practiced in many FMIS including the PIS partly due to the fact that it requires the involvement of lawsuits and can often be very costly. A single penalty rule is highly unlikely to ensure compliance and a combination of rules is commonly practiced in Nepal. The penalty rules commonly used in the PIS reported by the farmers are presented in Table 8. The penalty rules helps to ensure rule compliance and maintain cooperation to achieve collective outcomes while managing irrigation system.

Table 8: Nature of Penalty for Rule Infringement as Reported by Farmers in Phalebas (N=67)

Nature of Penalty (N=65)	Number of respondents (% of the total)
Fined in cash	36 (53.7 %)
Restricted use	1 (1.5%)
Cash, restricted use leading suspension of membership	25 (37.3%)
Do not know	1(1.5%)
No sanctions	2 (3.0%)

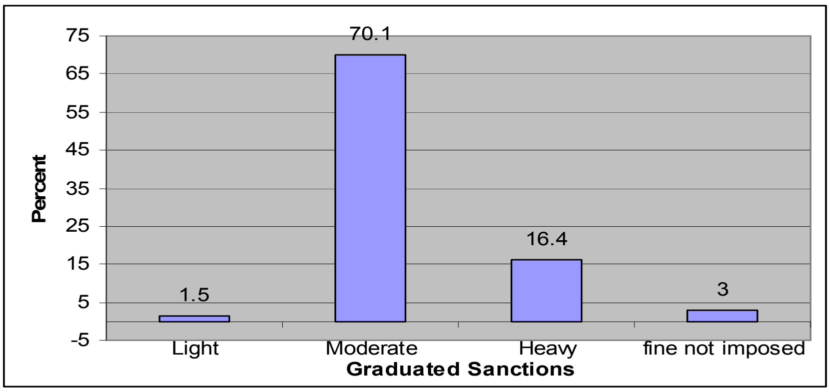
Figure 6 shows the nature of graduated sanctions imposed in Phalebas area depending on the nature of refractions and damage caused by them. For the first infractions, if proven guilty, the defrauders are fined NRs. 100,[6] while for second and time defrauders they are fined NRs. 250 and NRs. 500 respectively. In the cases of severe and repeated defrauding the PIMC can temporary suspend the water rights of the defrauders. Evidence from field observation indicate that, in the PIS area, a maximum of NRs. 5000 was fined to a head-end defrauder causing severe damage to the irrigation infrastructure as an attempt was made to transport wooden logs through the canal water. Often is the case that if a farmer is found involved in water theft, his/her next time slots will be suspended temporarily.

It should be noted that, the operational level rules are neither self –generating nor self enforcing (Ostrom, 1990) and their effective implementation depends on the existence of rule enforcers, number of users and degree of co-ordinations between them.

While it may be relatively easy to enforce operational level rules in systems with less members, it is quite difficult to enforce them with large members due to higher transaction costs for monitoring and sanctioning (Tang, 1989).

[6] 1 US$. = NRs. 63.05

Figure 6: Graduated Sanctions in Phalebas area (N=67)



II. Collective Choice Rules:

The ‘non-self-generating’ and ‘non- self-enforcing’ nature of the operational rules has meant that in the absence of external coercive agents, users are more likely to refrain in order to maximize their own utilities causing *free rider* problems (Ostrom, 1990).

In order to overcome this particular problem, the PIMC has successfully designed collective choice rules aiming to formulate, modify and enforce operational rules and provide users incentives to maintain collective endeavors and to exercise mutual self-restrain while using the resources. The collective choice rules are institutions encompassing of collectively chosen rules, procedures and principles that enable users to respond to change in operation rules; resolve conflicts and sustain productive relationship amongst users through monitoring and sanctions against rule violations. This helps to overcome three basic problems of supply, credible commitment and mutual monitoring which are often nested hierarchically.

In order to deal with the *problem of supply*: The PIMC has designed workable sets of rules, procedures and sanctions with regards to irrigation management, water harvesting and controlling fraudulent activities. The constitutional provisions empowers the PMIC and the WUA members provide them with the necessary mandate to amend operational rules, to fix water charges (both water tax and membership fees) and to utilize surplus fund for irrigation related or other community development work within the canal command area. In fact, a branch committee of PIS intends to build a temple at close vicinity of the head end to avoid unnecessary intrusions as temples are considered sacred in Nepal.

In order to overcome the *problem of credible commitment*, rules are put in place to raise awareness amongst the users that long term net benefits of collective engagement are substantially higher than the net benefits by short term dominant individual strategies (Ostrom, 1990) and users are urged to demonstrate long term commitment to following rules, and maintain self restrain Similarly in the PIS, the arduous tasks of *mutual monitoring* is achieved through the employment of watchman called the *dhalepas*. Altogether two *dhalepas* are employed by the PIMC on a salaried basis with the first one assigned responsibilities of looking after the upper half of the canal (head end) and second one with responsibilities of observing the lower second half of the canal. Along with observation, the watchmen also contribute towards system operation and maintenance. While the dhalepas are instrumental in monitoring users activities, the users themselves are very watchful and have the rights to file petitions against any suspected fraudulent activities to the PIMC.

The successful design and implementation of the above mentioned collective choice rules has helped to achieve positive collective outcomes through mutually imposed, self-financed and binding contracts limiting users' resource consumptive activities.

5. Use of Indigenous Technology for Water Distribution

Irrigation itself is a technological innovation which helps to divert water from the source to the field in order to support plant growth (Vincent, 1977). In doing so, irrigation employs many irrigation infrastructures which include diversion dam, canal, siphons, gates, weirs, pipes to deliver water to the plants. The application of these structures in combinations helps actualize water delivery in irrigation systems. While Nepalese farmers mostly those within the FMIS use three types of water division structures are used namely open-closed type, ad-hoc adjustment and fixed proportion types, the latest warrants more elaboration.

The salient features of the Phalebas Irrigation System are presented in Table 9 below.

<u>Table 9: Attributes of Collective Choice Rules in Phalebas Irrigation System</u>

Principles		**Salient Features**
Autonomy:		*PIMC is mandated by the WUA making them autonomous to cont water flow in the system. Increased autonomy helps readjust wa flow depending on the availability of water in the canal*
Contiguity		*Water appropriation with same frequency with a fixed continuous or help ensure reliability of water supply*
Proportionality	Rights	*Users receive water with same frequency although with different ti slots proportional to the amount of land cultivated*
	Duties	*All users are expected to contribute their fair share of labour for O & activities; pay water fee and membership fees.*
Uniformity	Rights	*Users receive water with same frequency; however, in case convincingly higher water requirement, some allowances entertained with assurance that everyone will be provided with sim opportunities.*
	Technique	*The technological adaptations are uniform i.e. 'gahak' in all outlets deliver users' fair share of water proportional to the amount of cultiv lands.*
Transparency		*Allocation and usage rules are known to all users and adequ monitoring mechanism put in place to maintain compliance. Financ transparency is maintained through proper accounting and ann auditing*
Regularity		*For last 14 years, PIMC has practiced same routine for wa distribution (although, routine varies within the branch) and use 'tinpalo' and 'pachpalo' to ensure regularity and uniformity in wa distribution*
Graduated Sanctions		*Sanctions are imposed upon the defrauders, but severity var according to the gravity of the offence*

Framework adopted from Trawick, 2002).

5.1 Water division structure

The core process of irrigation practices include control, allocation and distribution of water and water make available to farmers to apply for crop growing. In doing, so water control structures provoke a particular type of water allocation and distribution practices (T.Pradhan, 1996). Parajuli (1999) argues that, the irrigation technologies employed shape operational characteristics which in turn strongly influence equity, operational flexibility and organizational development. As mentioned earlier, in Nepal, the most commonly used water division structures include ad-hoc adjustment, open close and fixed proportion. The water division structures used in Phalebas irrigation includes a combination of ad-hoc adjustment and fixed proportional types. The fixed proportional type is used at the secondary canal level while the ad-hoc adjustment is used at the tertiary canal level. For the purpose of this paper, the fixed proportional type of water division structure draws our immediate attention.

In phalebas irrigation system, farmers have designed and installed traditional proportional weirs using locally available resources. The proportional weirs, called 'gahak' are hydraulic structures made of timber with notches of uniform depth cut into it.

<u>Table 10: Characteristics of Water Division Structures used in Nepal</u>

Type	***Characteristics***
Open-Close	*-simple bifurcated hydraulic structures fitted with open-clo device* *-divide water into two or more parts* *-frequent open/close requirement* *-used at tertiary canal and farm level* *-share only benefits but not risks associated with excessive wate*
Ad-hoc Adjustment	*-simple open cut (turnout)* *-Adjustment through either altering turnout size/shape or hydrau head* *-divide water into two or more parts* *-great human artisanship requirement for adjustment* *-used at main and branch canal level* *-share only benefit but not risks associated with excessive water*
Fixed Proportional	*-simple orifice or weirs* *-divide water into two or more parts proportional to water share* *-usually made of wooden timer* *-consists of multiple notches with uniform depth* *-used at main and branch canal* *-share both benefits and risks associated with excessive water*

The flow splinters (gahak) help to place across the direction of flow of water in the canal and divide water volumes into different secondary and tertiary canals which are proportionate to the land area which the secondary/tertiary canals are irrigating.

The gahak are made of *simal* tree (<u>*Bombax ceiba*</u>) which are water resistant with high durability. The widths of the notches in the gahak represent farmers' water entitlements (water share) in a particular branch. To ensure that equity in water distribution is maintained, farmers in Phalebas area have used pressure normalization technique, which is a very traditional technique. For the purpose of pressure normalization, simple wooden or obstruction by a block consists of a combination of rod-cement are constructed across the flow of water to break its speed and hence normalize water pressure and maintain level crest on the canal bed. It is important to point out that, due to hydraulic characteristics, the water pressure decreases as it travels further down the canal and in absence of speed breakers, the net total flow of water through outlets at the head end are always more than their counterparts at the tail ends despite their equal sizes. However, the use of pressure normalization technique forbids hydraulic flexibility to exceed by unity.[7] The control of hydraulic flexibility at less than unity level helps to maintain uniform flow fluctuations rates in both parent and branch canal when water supply at parents canal increases.

Furthermore, use of proportional weir (*gahak*) coupled with pressure normalization technique has some additional advantages. Firstly, it helps to distribute the final products of irrigation efforts i.e. water equitably according to farmer's water share. Secondly, it helps to internalize the externalities created by oversupply of water particularly during the monsoon. The *gahak* system helps to dissipate externalities equally amongst the farmers and avoid flooding of terrace bund used for cultivation as any fluctuation in water supply at the parent canal has equal impacts on branch canals. Thirdly, the fixed structures of the *gahak* have meant that a frequent adjustment of outlets by operational staff and farmers are not required and help maintain equity at a lower transaction costs. Also, by using the *gahak*, illegal water appropriations through tempering the water division structures are minimized as they are fixed and inflexible.

It is therefore, farmers who are required to manage their water share at the secondary canal level. However, at the tertiary canal level, the use of ad-hoc adjustment of water distribution has meant that, farmers exercise more flexibility in terms of actual water use and can and do exchange irrigation turns particularly during water scarce periods.

<u>Table 11: Branch, Command Area and Size of Gahak in Phalebas</u>

Branch Name		Command Area in hectare	Size of Gahak in Inches
sJogichaur		32	32
Dee-area		14	14
Kumal Gaun		26	26
Saatkuriya	Thulachaur	6	6
	Wallosaat	18	18
	Pallosaat	12	12
Chaubiskuriya	Wallochaubis	18	18
	Pallochaubis	16	16

[7] It is defined as the rate of change of flow in the parent and branching canals.

5.2 Water Distribution Mechanism

Water distribution is probably the most contentious issue in irrigation management as it involves the allocation of water to the farmers according to certain principles and rules (Parajuli, 1999; Mamatov, 2007) In Nepalese FMIS, a wide range of water entitlements are commonly practiced, some of them being customary (Poudel, 2000). In some irrigation systems the allocations are based on prior appropriations, while in others water rights are based on the level of contributions made during canal construction (Martin & Yoder, 1983). In general, however, farmers' water rights are based on the amount of land and especially the amount of land under cultivation.

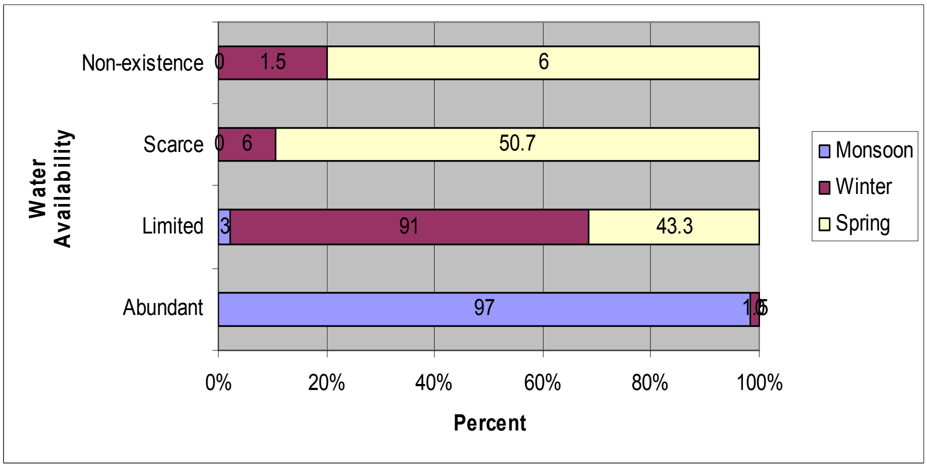
The water distribution practices implemented in Phalebas area represent a unique distribution method in many different ways. In historical times, while water used to be distributed on a share system based on the initial contributions made during canal constructions, a constitutional change has meant that in recent years, the principles of water distribution are based on amount of land under crop cultivation. For the purpose of water distribution, three different types of methods are used depending on the water availability in the canal, cropping seasons and stage of crop growth, while general principles remains same as mentioned above.

Before paddy transplantation, particularly in the month of June, individual farmers make an application to the president of their respectively branch committees about a week prior to their tentative days for paddy transplantations. [8] After receiving all the applications from the farmers, the branch committees draw a schedule for irrigation and transplantation activities. In the mean time, the main committee (*mul-samiti*) calls upon all farmers to participate in Operation and Maintenance (O & M) activities for smooth delivery of water throughout the canal system. The schedule for paddy transplantation itself is carefully drawn with due considerations of water availability in the source, in the main and branch canals and also predicated arrival of monsoon. During transplantation, the farmers get their share of water just for the plots where transplantation is planned for, irrespective of their total irrigable land. Then based on the schedules designed and implemented by the branch committees, individual farmers make arrangements for the transplantation including labours, bullocks, plough, and seedlings.

It is important to note that, involvement in O & M activities alone does not guarantee automatic water appropriation during the paddy transplantation and failure to apply for water often leads to sanctioning particular when the demand for water is high. In circumstances where demand for water is high, the president of the branch committee has constitutional authority to stop non-applicants' transplantation programmes altogether.

[8] Farmers need water to make puddled field for paddy cultivation and the crop needs to be irrigated intensively both at initial and final stages of their growth.

Figure 7: Seasonal water availability in Phalebas area as Reported by Farmers



In general, the water supply in the canal is adequate during the monsoon season when the monsoon paddy is grown, while water adequacy decreases in winter and becomes severely shortage during spring season as reported in Figure 7 above. Considering this fluctuations in water supply in the canal, farmers have devised two additional water distribution mechanism based on rotational procedures.

The first method is locally known as '*paanch-palo*', a rotational distribution method, which is being implemented between July and November every year. In this method, each branch derives water for 12 hours before transferring the turn to the next branch and every 60 hours i.e. one and half days the turn repeats itself.

Table 12: Winter Irrigation Cycle in Phalebas Devistan (mid July- end of November)

Branch Name	**Turn**	**Command Ar in hectare**	**hours one cycle**	**Weekly Calendar**
Chaubiskuriya	1	34	12	7am -7pm (Sun)
Jogichaur	2	32	12	7pm (sun)-7am (mon)
Dee Area	3	14	12	7am (mon)-7pm (mon)
Kumal Gaun	4	26	12	7pm (mon)-7am (tue)
Saatkuriya	5	36	12	7am (tue)-7pm (tue)

The second method is locally known as '*tin-paalo'*, again a rotational distribution method, which is being implemented during period from November to March every year. In this rotational method, each branch irrigates for 36 hours before transferring the turn to the next branch and every 180 hours i.e. seven and half days the turn repeats itself.

Table 13: Spring Irrigation Cycle in Phalebas Devistan (Dec-March)

Branch Name	Turn	Command Area hectare	hours in one cycle	Weekly Calendar
Chaubiskuriya	1	34	36	7am (sun) -7pm (Mon)
Jogichaur	2	32	36	7pm (Mon)-7am (Wed)
Dee Area	3	14	36	7am (Wed)-7pm (Thu)
Kumal Gaun	4	26	36	7pm (Thu)-7am (Sat)
Saatkuriya	5	36	36	7am (Sat)-7pm (Sun)

Table: 14 Percentage of Farmers and their Cropwise irrigation methods in Phalebas

Water Distribution Method	Crop1 (N= 67)	Crop2 (N=67)	Crip3 (N=67)	Crop4 (N=61)	Crop5 (N=65)
Rotational	98.5 %	37.3%	72.7%	85.2%	20.0
Continuous	1.5%	-	-	-	-
Water Supply on Demand/Request	-	3.0%	1.5%	4.9%	-
Irrigate once to Moisten soil	-	25.4%	13.4%	-	21.5%
Do not irrigate this crop	-	-	11.9%	-	-
Do not cultivate this crop/No need t irrigation	-	34.3%	1.5%	9.8%	78.5%

Crop1: Paddy, Crop2: Maize, Crop3: Wheat, Crop4: Vegetables, Crop5: Legumes

6. Maintaining Equity and Minimizing Asymmetry

The data indicated that there has been a positive distributive implications of irrigation interventions in the Phalebas area in terms of actual water use and also in participatory terms. The irrigation infrastructures coupled with robust water distribution mechanism has contributed towards the enhancement the food security of the local farmers by more than 53.7 percent as shown in Table 15 below.

Table 15: Farmers' Reported households' sufficiently of food grains in Phalebas

Landholding Categories	Before Interventions		After Interventions		Over Difference
	Yes	No	Yes	No	
Large (N=14)	21.4%	78.6%	92.9%	7.1%	
Medium (N=11)	18.2%	81.8%	100%	0%	
Small (N=42)	0%	100%	40.5%	59.5%	
Overall (N=67)	7.5%	92.5%	61.2%	38.8%	53.7%

Also, more importantly, while in relative terms, food security continues to be a major challenge especially amongst the marginal farmers, but in absolute terms the small and medium farmers have become the real beneficiaries from the irrigation interventions as their food security is strengthened significantly. The increase in crop productivity as direct results of irrigation interventions and use of high yield variety (HYV) of crops and use of chemical fertilizers has multiple advantages including opportunity for crop sharing, lowering of food prices, and surplus production for marketing.

Table 16: Farmers Using HYV and Chemical Fertilisers in Phalebas (N=67)

Crops	Percent of Farmers Using HYV		Percent of Farmers Using Chemical Fertilisers	
	Yes	No	Yes	No
Crop 1	61.2	38.8	91	9
Crop 2	58.2	41.8	91	9
Crop 3	61.2	38.8	92	8
Crop 4	75.8	24.2	85.5	14.5
Crop 5	20	80	21.5	79.5

Increase in productivity per unit hectare land provided impetus for commercial scale cultivation by larger farmers while also increasing land lease out to small farmers. From Tables 15 and 17 it is clear that, even farmers with small landholdings are capable of entering into the markets now while before interventions, their food security was rather bleak. Increase in productivity as a results of efficient and equitable irrigation has increases the marginal farmers' ability to engage in crop share practices and enhance households' food security.

Table 17: Household's current food security

Landholding Categories	**Household Food Security**				
	Less than 3 months	Between 3 to 6 months	Between 6 to 9 months	Between 9-12 months	More than 12 months
Large (N=14)	-	-	-	42.9%	57.1%
Medium (N=11)	-	-	-	63.6%	36.4%
Small (N=42)	11.9%	21.4%	26.1%	28.5%	11.9%
Overall (N=67)	7.5%	13.4%	16.4%	37.3%	25.4%

In Phalebas area, farmers not only share the benefits of irrigation interventions, but also contribute towards, system operation and maintenance. In particular, the role of small farmers is notable.

Table 18: Crop share in/out in Phalebas Area

Landholding Categories	**Crop Sharing in**		**Crop Share out**	
	Yes	No	Yes	No
Large (N=14)	-	100	14.3	85.7
Medium (N=11)	9.1	90.9	9.1	90.1
Small (N=42)	33.3	66.7	2.4	97.6
Overall (N=67)	24.3	77.6	6	94

The data shows that the participation of all categories of farmers in deciding location and size and position of gahaks are generally high, the high level of participation of small farmers are crucial from an irrigation management point of view.

Table 19: Farmer Participation in deciding location and size of Gahak in Phalebas

Landholding Category	**Participation in deciding location of Outlet**		**Participation in deciding Gahak**	
	Yes	No	Yes	No
Large (N=14)	85.7 %	14.3%	71.4%	28.6%
Medium (N=11)	81.8%	18.2%	90.9%	9.1%
Small (N=41)	68.3%	31.7%	71.4%	28.4%

Farmers' participation in the design, installation and decision making process on the location and size of water division structures (*gahaks*) provide them assurance about the equitable water distribution and enhance their engagement with irrigation issues. The installation of proportional weirs enables farmers to derive their fair share of water while also making water availability more predictable. The data indicated that there is a direct relationship between water appropriation, and participation in O & M activities and payment of water fee as shown in Figure 8a and 8b

Fig 8a: Water Appropriation without participation in O& M activities

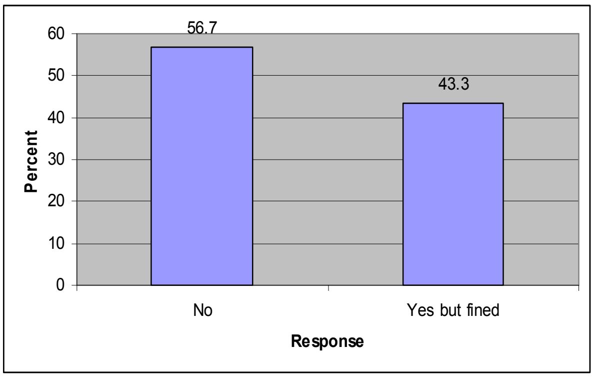


fig 8b: Water Appropriation without paying water fee

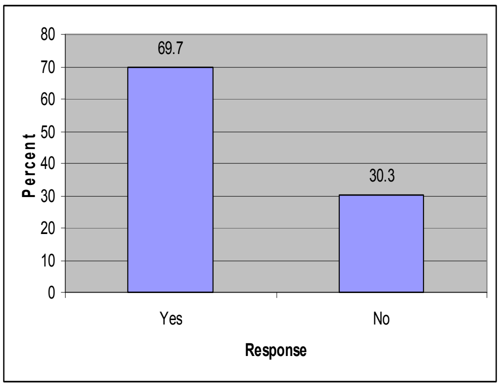


Figure 9: Reliability of Water Supply in Phalebas area as Reported by Farmers

Fig 9a: During Monsoon

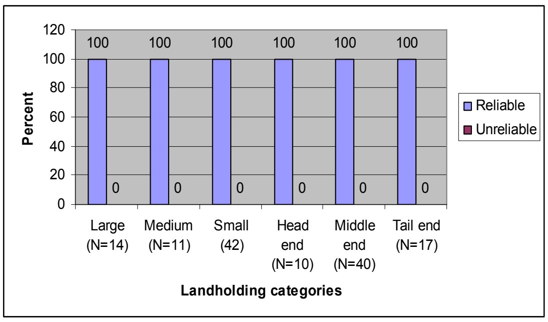


fig 9b: During Winter

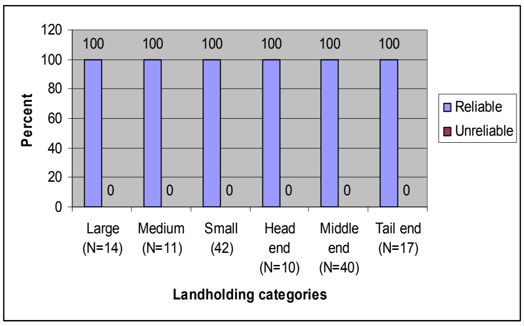
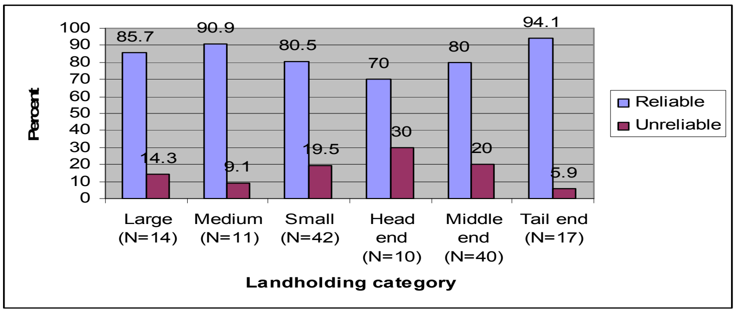


Fig 9 c: During Spring



[For land type: X^2 =.751; df =2; p<.001] & [for location: X^2 =4.800; df =2; p<.001]

<u>Figure10: Equity of Water Distribution in Phalebas area as Reported by Farmers</u>

Fig 10a. During Monsoon Season

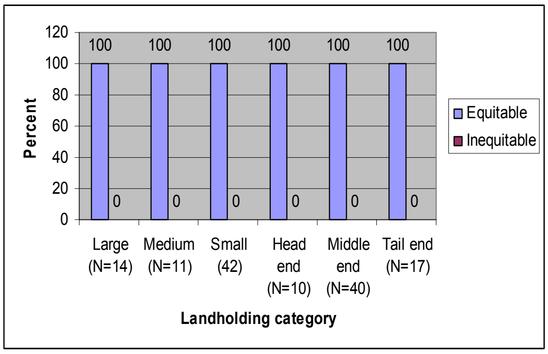
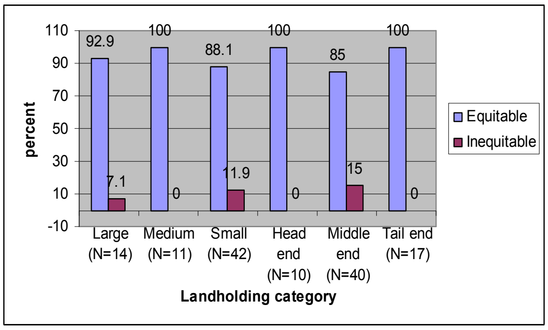
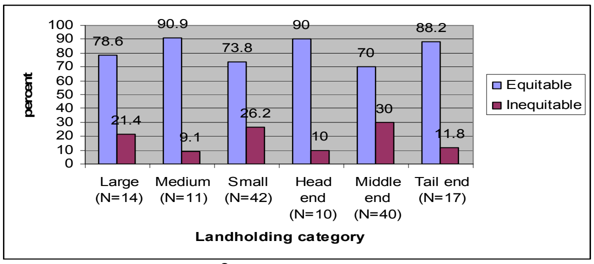


fig 10b: During Winter Season



[For landtype: X^2 =1.587; df =2; p<.001] [for location: X^2 =4.448; df =2; p<.001]

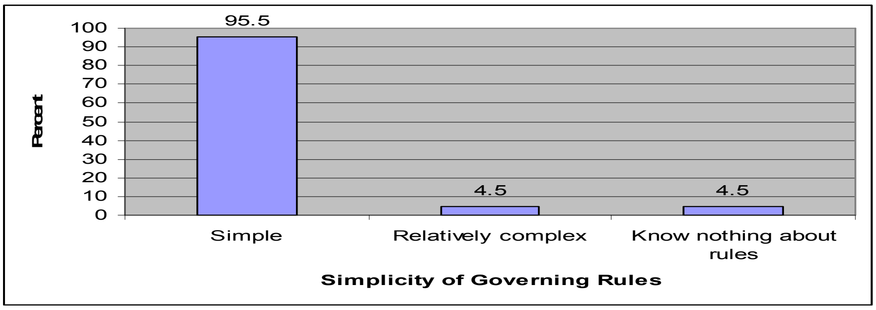
fig 10c: During Spring Season



[For land type: X^2 =.751; df =2; p<.001] [for location: X^2 =3.321; df =2; p<.001]

Farmers understanding of the rules used for water governance are presented in Figure 11 below which shows that more than 95 per cent of the farmers found the rules for irrigation governance to be simple and easy to understand and follow.

Figure 11: Simplicity of Irrigation Governing Rules as Reported by Farmers



The use of weekly calendar for water distribution makes water availability more predictable as farmers would know the precise timing, duration and frequency of their turn for irrigation. Figures 9a, b, and c below present the reliability of water supply from the canal in three cropping seasons as reported by the farmers.

Indeed, as a direct results of robust distributional mechanism through water scheduling, more farmers from tail end considered their water supply to be reliable particularly during the water scant spring seasons. Similarly, Figure 10a, b and c presents the results of equity in water distribution in Phalebas area.

A series of Chi-square tests was performed to examine the relation between equity and landholding and locations and between water supply reliability and location and landholdings. The results of Chi-square test indicated that there was no association between those variables in all seasons (see Figure 9 &10). Existence of no association between locations and landholdings and farmers' perception of equity and reliability of water distribution indicate that in general farmers' view of irrigation performance is satisfactory. This in turns helps to foster positive incentives for infrastructure maintenance and participatory irrigation management.

During the monsoon season, all the farmers, irrespective of their landholding and location perceived that their share of water is equitable and reliable. This is partly because the water supply in the canal is abundant and no water scarcity is experienced by the farmers. However, during the winter and spring seasons, farmers reported to have experienced unreliable and inequitable distribution of water. Nonetheless, as Figures 9b, c and Figures 10b, c show that the farmers at the tail end still have equitable and reliable water distributions.

A one way ANOVA between groups analysis of variance was conducted to explore the impact of farmer type on annual total number of hours irrigation water used. The respondents were divided into three groups according to the location of land). There was a statistically significant difference at the $p<.05$ level in the total hours irrigated for the three categories of farmers [$F(2, 66) = 3.6$, $p=.031$. The effect size, calculated using eta squared, was 0.1. Post-hoc comparisons using the Tukey HSD test indicated that the mean hours irrigated for Head enders ($M= 692.79$, $SD= 708.1371$) was statistically different from Tail enders (M= 116.727, SD= 81.5293). Middle enders (M=361.971, SD= 593.4055) did not differ significantly from either head enders and tail enders.

Table 19: Mean landholdings, Annual Mean Hours Irrigation and Hours Irrigated per Ropani

Landholding Categories	**Mean land (s.d.)**	**Mean annual hou irrigated (s.d.)**	**Mean hours per hectare of land**
Large	22.67 (8.9863	577.72 (641.1721)	25.48
Medium	12.0 (2.1794)	296.61 (504.9502)	24.71
Small	4.75 (2.1105)	286.67 (532.7921)	60.35
Head ender	14.3 (11.4217	692.79 (708.1371)	48.44
Middle ender	8.88 (6.8176)	361.97 (593.4055)	40.76
Tail ender	8.85 (9.6448)	116.72 (81.5293)	13.18
Overall	9.68 (8.4615)	349.12 (556.7542)	36.06

However, similar one way ANOVA tests for type of farmer (Small Farmer: less than 0.45 hectare; Medium Farmer: 0.45 to 0.96 hectare; Large Farmer: more than 0.96 hectare) and total number of hours irrigation water used did not show any statistically significant results at the $p<.05$ level in the total hours irrigated for the three categories of farmers [$F(2, 66)=1.5$, $p=.227$. The effect size, calculated using eta squared, was 0.045. Post-hoc comparisons using the Tukey HSD test indicated that the mean hours for neither group were statistically significant.

7. Conclusions

Against the background of pessimistic conclusions in commons literature that irrigation systems are elite-enterprises and some degree of external coercions are always essential to bring distributive justice, this paper has illustrated that the distributive justice can still be achieved through the use of local knowledge bases. In the Phalebas area, the local farmers' use of indigenous water division technologies and consistency in water distribution methods has helped to enhance participatory irrigation management and achieve distributive justice across both landholding types and locations.

The data has shown that generally farmers in Phalebas area perceived to have reliable and equitable water supply from the irrigation canal, which in turn has helped to garner much needed incentives for maintaining infrastructure and effective irrigation management. Furthermore, in real terms, small farmers appear to have achieved a generous irrigation water supply, while head-tail inequality still continues to be a challenge.

Nonetheless for equitable distribution of water and other responsibilities effective participatory irrigation management with a clear and robust institutional framework to guide management should be designed and implemented. There should be a genuine participation of farmers in irrigation management irrespective of their locations and landholdings in all stages of design, installations and operation and maintenance activities. The participatory irrigation management provides not only a sense of ownership but also ensure rule compliance in return. Importantly, the costs of involvement in operation and maintenance activities should be incommensurate with the benefits from the canal. Simple and clear rules for water distribution, and graduated sanctions for non-compliance help to enhance self governing efforts of FMIS.

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