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UNA NECESIDAD IMPERATIVA, UN ESTUDIO SOBRE TECNOLOGIA Y RENDIMENTO EN UN REGADIO EN EL TERAI DE NEPAL

presentado por

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In the Name of Need

The study of Technology and Performance in a Farmer Managed Irrigation System in the Terai of Nepal

M.Sc. Thesis by Diego Garcia-Landarte Puertas

December 2010

Irrigation and Water Engineering Group

WAGENINGEN UNIVERSITY
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The study of Technology and Performance in a Farmer Managed Irrigation System in the Terai of Nepal

Master thesis Irrigation and Water Engineering submitted in partial fulfillment of the degree of Master of Science in International Land and Water Management at Wageningen University, the Netherlands

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Table of Contents

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To whom I am very thankful for all the help provided and their endless hospitality, making this research experience possible.

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To my family and the ones that already left us,

You have always been there with endless doses of support and love. I love you truly. Vosotros sois mi base y mi corazón. Os estaré enternamente agradecido.

Acronyms

AMIS	Agency Managed Irrigation System
BC	Branch Canal
CIDP	Chitwan Irrigation Development Project
DOI	Department of Irrigation
FMIS	Farmer Managed Irrigation System
GA	General Assembly
IMT	Irrigation Management Transfer
IMTP	Irrigation Management Transfer Project
ISF	Irrigation Service Fee
KIS	Khageri Irrigation System
MC	Main Committee
O&M	Operational and Maintenance
RVDP	Rapti Valley Development Project
PIS	Panchakanya Irrigation System
VDC	Village Development Committee
VP	Village Panchayat
WUA	Water User Association

Table of Figures

Executive Summary

Technology is regarded as one of the main thrusts in agricultural modernization. It is also conceived as a way to cover certain necessities. Yet, its implementation in the irrigation sector has not been always satisfactory. In this regard, farmer's relationship with technology is seldom considered. This relationship can be a way to understand how agricultural practices develop and its influence in irrigated performance.

This study was carried out in Panchakanya Irrigation System, a Farmer Managed Irrigation System, in the southern plains of Nepal. It is an endeavor to understand the wider aspects of technology, how its introduction by rehabilitation programmes has shaped technological uses and the role of irrigation management transfer in resource use.

Similarly an analysis of performance, at various scales, attempts to address the multidimensional nature of this concept and its application in order to assess Panchakanya Irrigation System. Correspondingly the linkages between technology and performance are revised. Finally, the role of development strategies and resettlement policies in Nepal are taken into consideration so as to discuss how migration fluxes affected the irrigation system both at technological and social levels.

Chapter 1

Introduction

1 Introduction

Agriculture has been a major pillar in Nepalese economy and continues to be as 80% of the population depends on agriculture in order to subsist (IFAD, 2010)[1]. In this context, irrigation plays a primary role (D. R. Pant 2000) as most of agriculture is based on irrigated crops. Irrigated agriculture has followed the country's development, specially since the second half of the 20th century. Hence it is critical to understand how national policies have influenced irrigation.

This study is based on Panchakanya Irrigation System (from now on, PIS) located in Chitwan district, which lies in the southern plains of Nepal (commonly know as inner *Terai*). This system has been subject of three rehabilitation programmes over the last forty years. The last rehabilitation brought along a management transfer from the government irrigation agency (Department of Irrigation, DOI) to the Water User Association (WUA). In spite of these interventions, the target command area of 600 ha wasn't reached.

Chitwan district has experienced rapid developing growth over the last sixty years. Formerly a malaria infested forest, today it resembles a paradigm of resettlement policies and development strategies in Nepal. Moreover, local *Tharu* communities, which were the original inhabitants of the area and traditional irrigators of Panchakanya, have been outnumbered and not considered under the so called "planned" development.

1.1 Problem statement

The research problem is synthesized in the next statement;

Rehabilitation projects in Panchakanya Irrigation System, along with resettlement policies in Chitwan district, have had dissonant results leading to unaccomplished target goals and social alienation.

Rehabilitation projects introduced technology as a solution to unaccomplished objectives for PIS. Likewise, irrigation management transfer policy (launched in the mid 1990s) had as one of its objectives to enhance performance levels of irrigation systems. For this reason the present research focuses in the role of technology and its linkages to performance and agricultural practices in PIS. Below the research objective and research questions are presented.

1.2 Research Objective and Research Questions:

To analyze the intercourse between farmers and technology, and its consequences for the performance of a Farmer Managed Irrigation System and related agricultural practices in Panchakanya Irrigation System, Chitwan, Nepal.

The former research objective must be functionalized by research questions. The following questions address the main subjects the research is based on,

[1] The contribution of agriculture to the Nepalese gross demand product is 33.7% (2008).

- *How is irrigation technology adapted and functionalized by water users in Panchkanya Irrigation System?*

- *How does this influence performance and agricultural practices in Panchkanya Irrigation System?*

The main purpose of the research is to investigate farmer's relationship with technology and how this relationship is linked to agricultural practices and ultimately to irrigation performance. I have decided to study this topic as I consider technology a major factor in modern agriculture. Furthermore irrigation system performance may serve as a concept useful to assess technological uses and choices. In this sense, it is important to understand national irrigation policies as they shape which technology is used and how it is administered. Moreover PIS was one of the first irrigation systems turned over to water users (already 12 years ago). Hence it can illustrate the successfulness or weakness of policy approach. This study may serve to derive lessons on what went wrong and what right.

1.3 **Irrigation history in Nepal**

In contrast with other South Asian countries, Nepal doesn't have an extended modern irrigation history (Howarth & M. Pant 1987). However, indigenous groups developed small scale irrigation systems (irrigation in the Kathmandu valley has been dated back to the 5th Century).

Irrigation in Nepal has been traditionally managed by farmers in the so called Farmer Managed Irrigation Systems (FMIS)[2]. Regarding land ownership, land was granted to individuals under the *Birta* and *Jagir* systems according to social status (M. C. Regmi 1971). Land owners or *Jemdars* were entitled to administer and manage the land and develop canal systems (M. C. Regmi 1976). The state benefited from this system through tax revenue. In principle the state reserved the right to resume the grant or confiscate the land. Yet, there was a land tenure system named *Guthi* which assured the protection of benefiters from government expropriation or action. Other Irrigation systems which the state initiated were called *Raj Kulo*[3]*,* which were administrated under the *Muluki Ain*[4] law. These were land tenure systems structures in charge of administering agricultural land. In this sense PIS was part of this structure as a *Raj Khulo* irrigation system.

The year 1951 stands as an important benchmark in the Nepalese history. The autocratic Rana regime, a dynasty which ruled Nepal since 1846 A.D., fell and the country adopted a parliamentary system with the consent of the King Tribuvhan Bik Bikram Shah (1906-1955). From then on, new governments saw opportunities to boost the national economy and to increase food supply, especially to the Kathmandu valley, through agriculture and investments in (large scale) irrigation (Government of Nepal 1956).

[2] The terminology used to label irrigation Systems in Nepal will be discussed in Chapter 3.
[3] Literally meaning "King's canal"
[4] Royal law which defined customary practices in irrigation

The nowadays Department of Irrigation (DOI) was established in 1952 labelled as the Office of Irrigation. It was, and still is, the main governmental institution in charge of planning and development of irrigation in the country. The first developments of the office were small scale irrigation systems (First Plan period, 1956-1961; Second Plan period, 1962-1965 and Third Plan period, 1966-1970[5]). This approach gradually shifted to an increased role in irrigation from the agency side due to priority to large scale irrigation systems in the *Terai* which used to be a malaria infested dense forest (Khanal 2003).

Another political change marked a shift in agrarian development of the country. In 1962 the parliamentary system was eliminated and the partyless *Panchayat* system was established. This system was based at several institutional layers Village, District, Regional and the National *Panchayat*.. The *Jagir* and *Birtha* systems were abolished and land was taxed to individuals. This agrarian reform pursued higher tax revenue and a redistribution of land (M. C. Regmi 1976). This lead to the emergence of private property rights on land. The *Panchayat* system was abolished in 1991 after the *Jana Andolan* uprising[6] (a multiparty movement which took place at the beginning of the 1990s). Political parties were then allowed. Thus Village *Panchayats* were transformed into a democratically elected Village Development Committees (VDC, also District Development Committees, DDC and parliament) which is an institutional body still present in Nepalese governance.

1.4 Policy approach: Intervention and Irrigation Management Transfer programmes

By the mid-60's the government started to invest in large scale irrigation with the construction of several irrigation systems like: Chatara Canal (66000 ha), the Narayani Irrigation system (29700 ha) and Nepal West Gandak Irrigation system. In the next decade several donors (World Bank, Asian Development Bank, United Nations Development Program and International Fund for Agricultural Development) increased the funding and the construction on medium and large scale irrigation systems.

After finishing the construction (and/or improvement) of systems the DOI was the institution in charge of the management of irrigation schemes. However, the Irrigation Service Fee (ISF) collection was insufficient and the budget allotment for operation and maintenance (O & M) didn't cover the expenses (NPC 1994). This led to poor maintenance and deterioration of the systems. Moreover, major investments in public irrigation systems, also called Agency Managed Irrigation Systems (AMIS), had disappointing results meaning undesired performance levels (APROSC 1978a; 1978b; 1978c). Contrarily, FMIS were found to have better performance levels than AMIS (Martin 1986; Yoder 1986)(K. P. Bhatta et al. 2005)(N N Joshi et al. 2000)(Acharya et al. 1994)(Ostrom et al. 1992) Several reasons were pointed out (Ashutosh Shukla & K. R. Sharma 1997):

- Intensive management input by water users and flexible organization balancing technical deficiencies.
- Mobilization local resources at low cost.

[5] These plan periods were and still are a series of five year development programmes; 4th 1971-75, 5th 1976-80, 6th 1981-85, 7th 1986-90, 8th 1992-95, 9th 1997-02, 10th 2002-07 and currently 11th 2007-2012.

[6] In Nepali *Jana Andolan* means people's movement

- Property rights are effected through membership of WUAs
- Irrigation organization is water user driven.
- Leadership is visible for water users.
- Rules and roles pertaining water allocation, distribution, resource mobilization and O & M are meant to fit local needs.

FMIS can have either informal or formal[7] organization and sophisticated management structures regarding water control and regulation by chains of authority and communication (Baxter & Laitos 1988)(Howarth & M. Pant 1987)(Yoder 1994). Traditional irrigation systems are more adaptable and dynamic; however they can become less flexible if choices of technology and rehabilitation are inappropriate (Howarth & Lal 2002).

In the 80s the focus shifted to enhancing and improving existing irrigation schemes rather than building new ones. Several policies were put in place by the government through a series of reforms, the Basic Needs Program (1988), Water Resources Act (1992) and Irrigation Policy (1992). There were two lines of action, *turn over* programmes which pursued transferring full responsibility from the DOI to end users and *joint management* of large scale irrigation schemes between the DOI and water users, represented by Water User Associations (WUA)(see Figure 1). The reform had the objective to share O & M responsibility (trying to engage with water users in management), develop WUAs as institutions with partial or full responsibilities so as to provide an institutional framework, assure financial viability and increase the performance level of irrigation systems (Khanal 2003)[8].

Similarly the Irrigation Management Project (IMP) was launched in 1985. It was a project funded by the government of Nepal and USAID. One of the main goals was to improve irrigation performance both in AMIS and FMIS. It also intended to enhance institutional capability of WUAs, which were subject of training programmes. Capable WUA could then assume full responsibilities of irrigation systems. The project ended in 1994 but the Irrigation Management Transfer Project (IMTP) continued with the same programme scope.

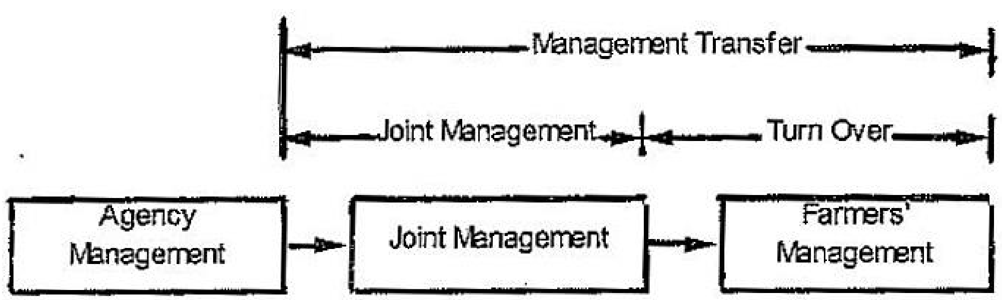


Figure 1: Framework for management transfer process by the DOI (Laitos & Rana 1992)

The figure above illustrates the irrigation management transfer policy framework of the late 80s and 90s implemented by the DOI. Laitos and Rana baptised the figure as the

[7] Formal organization implies a set of rules and norms enforced by an institution with a legal base.
[8] Some irrigation systems didn't succeed completely in turning over the management, so some remain as joint management.

"irrigation management continuum". The name shows how the irrigation agency[9] conceived the irrigation reform. The irrigation systems managed by the DOI would evolve from agency managed to joint management and ultimately turned to farmer's management. This linear process would start from the establishment of WUAs with partial responsibilities (e.g. tertiary level). Eventually WUAs would increase their responsibilities parallel to decreasing role of the DOI in a so called joint management basis. The final step would turn full authority and responsibilities to WUAs. The DOI would be in charge of prompt technical assistance. However water resources (such as rivers which supply irrigation systems) are kept under national property. Some irrigation systems were successfully turned over (like PIS) while others couldn't segregate from government's administration and remain as joint management (like Khageri Irrigation system).

1.5 Research location

The irrigation system where the field work was carried out lies in a central district of Nepal, namely Chitwan (Figure 2) This area is commonly known as the inner Terai which refers to the southern plains of Nepal (one of the three main physiographic areas of the country). Chitwan is located 139 kilometers southwest from Kathmandu. It lies between the *Mahabharat* range in the north and the *Chauria* hills in the south. The topography is mainly alluvial plains. The two major rivers are the Narayani (western Chitwan) and Rapti river (Eastern Chitwan, also know as Rapti Valley). Chitwan is characterized by a sub-tropical monsoon climate. During the monsoon season (June to September), about 75% of the annual rainfall (mean annual rainfall 2000 mm) is discharged. Sunshine is regular throughout the entire year. Soils have loam to sandy loam textures.

Figure 2: Location of Chitwan District

Until mid 1950s most of the district was forest. However there were local communities, namely *Tharu* and *Darai*, who inhabited the place long before this period. They could do so as they had a unique inborn resistance to malaria. Two parallel events triggered settlement in Chitwan. Firstly the Rapti Valley Development Project started in 1951 with

[9] The term agency refers to any governmental body involved in the irrigation sector.

the objective of a planned settlement by clearing forest and developing agricultural lands. Secondly, in 1953 heavy floods struck hundred of villages in the hills regions of Nepal. The government decided to support flood victims by encouraging immigration in the district. People were given land by clearing forest. However immigrants with high social status were granted land with better conditions (Shrestha et al. 1993).

1.5.1 Panchakanya Irrigation System Evolution

The field work was done in the *Panchkanya* Irrigation System (PIS). It is an irrigation system which has its origins in a *Raj Kulo* managed by a local *Tharu* community. The date about its origins remains unclear. Several papers (Adhikari et al. 2002) refer to it dating back more than 200 years[10]. Up to mid 1950s the system remained managed by local *Tharus* with a command area of 100 ha. In 1967 a major flood destroyed an irrigation canal called *Budhi Kulo*, also managed by local *Tharu*, which supplied seven nearby villages[11]. Consequently farmers from *Budhi Kulo* asked *Panchakanya* farmers to share the water source as it was ample. This proposal didn't succeed as *Panchakanya* farmers had previous water rights about the water source.

In 1974 PIS passed under the control of the Chitwan Irrigation Development Project, and thus under government control, for reconstruction and improvement. The works included a gated concrete headwork at the source, construction of 5 km earthen main canal, drainage structures and 7 gated outlets for branch canals and 8 direct outlets. The reconstruction works finished in 1979. The target command area was 600 ha. However this was never met as seepage losses were too big (Adhikari et al. 2002). The command area then was about 200 ha.

Subsequent construction works restarted in 1982 which carried out boulder lining of the main canal, development of branch canals and outlets and an intake in *Battar Khola*[12] to increase supply at the headworks[13]. The command area expanded to 400 ha (still the 600 ha target wasn't achieved) during monsoon season but rapidly decreased in the following years. This was due to two reasons: inadequate foundation of the main canal damaging the lining thus causing seepage losses; and poor O & M activities due to lack of funding (DOI task with no farmers' collaboration). By the beginning of 1990s the command area during monsoon season was 265 ha.

The IMTP started in PIS on 1994 as part of the 1992 irrigation policy. It had the objectives of turning over full responsibility of the irrigation system to an institutionalized body (namely an official WUA), and rehabilitating the system (and expanding its command area to 600 ha). Therefore an official WUA was established in 1994. The system was officially turned over to the WUA on December 1997. The IMTP (mainly through the DOI) continued to supervise irrigation management practices, O & M activities and carrying out training programmes for WUA members after turn over.

[10] It is believed that Panchakanya was under the supervision of Ratan Chowdhary (or Chowdhury or Chaudari; there are different ways to spell the name) who was an official of the *Praghanna*, which dates 222 years back.
[11] The Nepali word for village is *Mauja*.
[12] *Khola* means stream in Nepali.
[13] *Battar Khola's* intake is currently not in use.

1.6 Thesis structure

The present thesis is structured as follows. Chapter one gives the contextual perspective of the hypothesis and sets the research scope and objective, chapter two gives a detailed description of the concepts underlying the research and the methods applied, chapter three explains the characteristics and functioning of the PIS, chapter four addresses the main findings related to technology and the users relationship with it, chapter five focuses on performance of the system and agricultural practices applied, chapter six states the conclusions derived from the data collected and concludes the thesis with a reflection on the methodology applied and a small discussion on debates to which this research can contribute.

Chapter 2

Concepts and theories

2 Concepts and theories

The following chapter will describe in detail the main concepts underpinning the research, as well as the conceptualization leading to a concrete theoretical framework. The last part of the chapter will be dedicated to describe the methodology derived from such theoretical background.

2.1 Technology

As stated before, technology stands as a central term in the research. Hence a discussion and definition of the concept is mandatory. I will start the discourse with primitive technology, which in my view, illustrates the development of technology from its origins.

From immemorial times mankind has used and developed artefacts to improve life conditions. The first technological artefacts could be traced back to prehistoric times (2.5 million years ago) when men and women shaped stones to use them as tools and weapons. The wheel and the lever are inventions which could be baptised as the first engineering devices. Yet some Mesoamerican cultures didn't succeed in developing the wheel. Particularly interesting is the case of Aztecs who didn't rely on this invention while some children toys were found to be wheeled source. In Middle Eastern cultures the wheel was also marginalised and undeveloped. Were these cultures unable to developed such artefacts due to lack of knowledge? Or to put in another way, do they really need these inventions? Aztecs were proved to have advanced skills in art and science. Wheeled vehicles aren't the best choice in environments such as jungle or desert. In spite of that, western cultures see the wheel as a primary gadget of development. Here comes an important conceptualization of technology, Basalla (1988) argues that technology doesn't arise as a result of necessity; it is developed according to *perceived necessities*. He also argues that technology can be described in evolutionary terms, as part a evolution process and not as independent products of individual innovation. The Spanish writer and philosopher Ortega y Gasset goes beyond that line and defines technology as "the production of the superfluous" (1961). Hence, needs is a relative term which we adjust according to cultural and contextual factors. Marx (1867) also described technology along this line; he defined invention as a *social process,* which arises as a consequence of minor improvements and not few unique masterminds.

Attending to the Greek etymology of technology, it is defined as *teknho-* meaning art, skill or method; and *-logos* meaning discussion or treatment.

Summarizing, technology is meant to tackle perceived needs or issues which arise from our daily experience. However, technology is also shaped by social actors and adapted to social conditions in the so called social construction of technology (Bolding et al. 1995). Thus technological development is driven by two main forces, necessities claimed by society and the same society that shapes technology in its use. This continuous loop of technological development follows Basalla's theory of the evolution of technology (Figure 3: Evolution of technology).

For the purpose of a concise discussion, I will narrow down and discuss irrigation technology. Mollinga (1998) defines irrigation as a socio-technical phenomenon and depicts it under three dimensions: social requirements for use, social construction and social effects. Not mentioned yet, this definition also envisions technology as an influential driver of inter-social relationships.

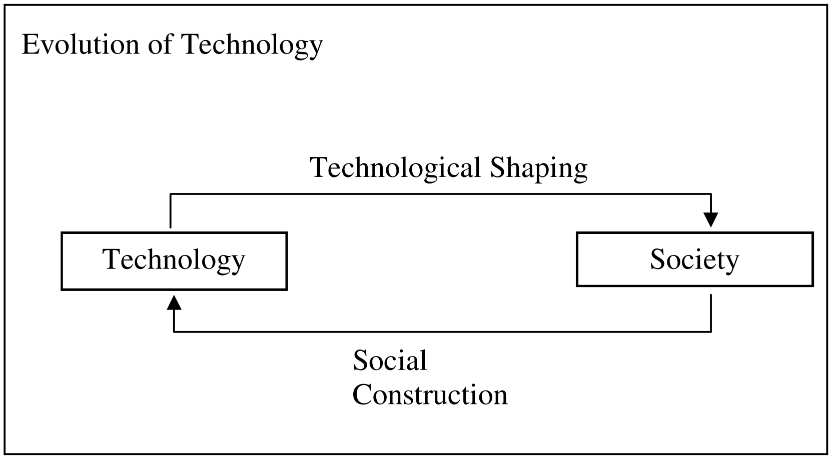


Figure 3: Evolution of technology

Moreover, Vincent (1997) conceptualizes technology as a capacity to transform and control. This capacity embraces a range of dimensions including artefacts, labour power, institutions and knowledge. It is interesting the inclusion of a *transformation process* embedded in the use of technology. Indeed technology is meant to transform certain goods or necessities.

The other concept underlying in the former definitions is *control*. Through irrigation technology, we are able to control water levels, flows and distribution mechanisms. Yet, this control has various components, as Mollinga exposes, and certainly some limitations. Taking into consideration the hard system component of technology, it has fixed characteristics and capacities. Hence limitations are inevitable in any technological system. The question lies in how to deal with them and how we are able to exploit technology in its better way.

Richards defines technology as the human capacity to make or in other words, the science of *skill*. He follows previous conceptualizations about skill and its relationship with the physical component of the body (Richards 2009)(Dant 2005). As a member of the Durkheim school, Mauss (2001) defines skill as marvellous or sublime but with social constraints. Again, skill and technology are presented with certain limitations.

Summarizing, I define technology taking into account all the previous considerations which drive me to the next formulation: technology is the achievement of a certain need through a transformation process, which is executed by means of a certain level of skill, labour, artefacts and knowledge.

The perspective of technology as control has been left out from the definition as I consider it a consequence of the transformation process. Furthermore I believe that water control is a consequence of the technological process, this is, the coverage of a certain need. Hence need is the basic principle behind technology, and its achievement is what farmers aim to (rather than water control). Therefore, it is important to stress the significance of needs and who is in charge of setting priorities in order to fulfil them accordingly.

Irrigation technology fits the definition above as the water has to transported from the source to the crop root which entails the use of *artefacts* such as canals, gates, weirs, etc; the application of *skill* through *labour* in order to operate gates, distribute water evenly, measure flows, etc; and *knowledge* in order to know when is the time to irrigate, how to do it, use guidelines, commit O & M practices, etc. All of these dimensions, as exposed before shape social patterns and reciprocally influence technology.

2.2 **Performance**

Following up the discussion, performance appears as another concept which should be defined precisely. Picking up Robert Chamber's definition of performance (1988) it is defined not only as productivity but also expressed in terms of livelihood. He sets four different criteria (namely: area irrigated, water logging, tail-end deprivation and yield) with several indicators to assess these. On the other hand Small & Svendsen (1990) propose a specific framework to assess performance throughout irrigation systems. They separate the agricultural system from the irrigation system[14] and propose an input-output structure which depends on the purpose or outcome of such performance. The reason behind this distinction is the convolution of outputs and performance driven by agronomical and hydrological factors. Moreover they propose types (impact, output and process types), purposes (input in the production process, increase in agricultural production or to adequate and secure livelihoods) and models of performance (goal oriented or natural models). Furthermore, Molden et al. (1998) specify a set of external indicators to cross evaluate performance of irrigated agricultural systems. These external indicators are meant to relate the outputs of the system (agricultural production) with the input into that system (water). Thus internal processes are not analysed using this framework. They are intended to evaluate performance in irrigation systems throughout the world.

The complexity of this concept may be approached at different scales. At irrigation system scale, secondary and tertiary scale, plots scale and household scale. Thus several parameters are related to different scales:

- Irrigation system scale
    - Command area
    - Irrigated area
    - Waterlogging
    - Leadership
- Plot scale
    - Yield
    - Cropping pattern
    - Farm management
    - Farming problems

[14] defined as "a set of physical and institutional elements employed to acquire water from a naturally concentrated source and to facilitate and control the movement of the water from this source to the root zone." (source?) Under this definition they consider the irrigation system as an input of the agricultural system.

- Household scale
    - Composition
    - Alternative incomes
    - Education

- Water user scale
    - Adequacy
    - Equity
    - Timeliness
    - Tractability
    - Predictability
    - Convenience
    - Conflict

Irrigation system scale parameters are those related to the whole irrigation scheme. Irrigated area differs from command area as the former is derived from the latter. In other words, the irrigated area is equal or less than the command area (some plots may not be irrigated depending on water availability, crop chosen, etc.).

Plot scale parameters are those related to farm management (expenditures and profits), namely cropping pattern, inputs applied (fertilizers, workers, pesticides, machinery, etc.), yields obtained and groundwater used. Again problems faced by farmers are also included in the assessment.

Household measures relate to household composition (including gender, caste and age), alternative incomes and education received by members of the household.

Finally water user scale measures are those related to water delivery but subject of farmers' interpretation. This is mainly focused in the quality (in terms of stream size, predictability, equity, timing, and convenience) and quantity of water delivered (also related to stream size and volume). Conflicts related to water delivered are also included as a parameter.

The compound of all the above will function as performance measures which will be included in a general assessment framework.

2.3 **Agricultural practices**

Agricultural practices are the practices related to farming activities which are carried out by water users. These practices include not only daily activities, but also strategies developed to overcome deficiencies and sustain their farming activity. Moreover these are considered as dynamic actions which are adapted to requirements and goals to be met. Choices like cropping patterns, inputs applied [15], machinery used or production management will serve to depict what agricultural practices are carried out in PIS.

[15] By inputs I mean fertilizers, pesticides, herbicides, varieties, etc.

2.4 Frontier Land

Frontiers are normally seen as political boundaries between states which are delimited along geographical lines. However it can also refer to a buffer zone that non-settled areas form in between settled areas within a state. It is of interest to have a look into this concept when dealing with migration phenomenon. These buffer zones or frontier lands have three main purposes: a relief in demographic pressure exerted by already existing settled areas, an opportunity for agricultural expansion and as a redistribution strategy of dissident farmer or low class rural groups (Shrestha et al. 1993). Thus the frontier land is an opportunity for a state to develop migration policies and expand the agricultural sector. However it may pose some risks as migration fluxes are not so easy to control. Similarly low social classes have more difficulties as they lack of social influences and economic bases compared to upper social classes. Hence frontier land can endure social inequalities and even trigger encroachment of land by "illegal" settlers.

2.5 Technography: the binding theory

In essence technography is a tool to research technology. It is based on a realist approach which depicts a world stratified between the natural and the social (Sayer 2000). This approach underpins *causation* as a process where regularities aren't accountable for cause and effect processes. In other words, reality follows mechanisms, through certain conditions, which drive effects as part of an open system producing different outcomes. Therefore the junction of two or more elements derives, or *emerges*, in a new phenomenon which is not necessarily analogous in properties to its origins.

An example of this could be an irrigator who manages to get water through a canal to the field in order to increase the productivity of a crop. Whether he does increase the yield or not depends on various conditions like the crop variety, climate, plagues, market, etc. The action of irrigating the field doesn't mean an increase in productivity. It could increase it or diminish it according to the conditions above. Hence irrigation doesn't follow regularities, as suggested by the realist approach.

The reader could ask, why is this theory valid for this type of research? Why is it relevant? How can it help to endeavour the study? I will proceed to address these questions.

As stated before, farmer-technology relationship is one of the basis of the present thesis. Moreover from this relationship I will attempt to link its outcome to the performance of the irrigation system. The technographic problem lays on the description of the ties that link farmers to technology and the implications of it in farming practices and performance. How technological use affects different actors is another problem to be addressed. In order to do so, a definition of technology is mandatory as well as a general theory the whole process of irrigation and the use of irrigation technology.

I have chosen technography because it underpins the social dimension of technology and helps me to understand the consequences of its use in a complex arena as irrigation. Moreover irrigation technology management is an example of a task group. Task groups are an interaction also approached in technography. WUAs are instituted to coordinate people so as to develop group tasks such as water distribution, ISF collection, O & M practices among others. In my view, WUAs also attempt to bond skill and knowledge apart from logistical and institutional purposes.

A good entry point in the technographic analysis are O & M practices. The irrigation system has to be maintained periodically through these activities. Thus water users have to be coordinated and taught to carry out such job. The description of this task could serve to depict what type of relationship have water users towards technology and how the task group serves as a platform to maintain them together as part of the system. What mechanisms are embedded in such activities? What are the implications of design (of technology)? These are questions which the research will try to give an answer.

2.6 **Methodology**

Below the research methodology carried out during my field work is described.

2.6.1 Different strategies for different data

The nature of the research calls both for qualitative and quantitative data. The two main research arenas, technology and performance, were approached from different perspectives. As one of the objectives is to investigate the intercourse farmer-technology, a case study was selected. The second half of the research involved collecting sets of data regarding multiple aspects performance.

PIS was selected as the field work site since it was documented both by internal sources, namely WUA, and external sources, namely Institute of Agriculture and Animal Science (IAAS) and scientific papers (articles and a PhD thesis). Hence, these sources were also examined in order to complete the data collection.

Since the research was carried out in one irrigation system, it was an opportunity to experience daily life time with local farmers. I was given the opportunity to live with PIS WUA chairman, who helped me in my research endeavours and provided me with day to day farmer field reality. In this way I could not only access the system through him, I could familiarize with rural life, Hindu religion and local community which shaped my particular understanding of Nepalese culture and farm life.

2.6.2 Digital Imaging

The first stage of the field work was primary was an exercise on adaptation and acquaintance in PIS. The main canal and several branch canals were walked through[16].

A technological inventory was done using digital images. Each element of the main canal was catalogued and imaged with a digital camera. Similarly, atypical features, such as canal deterioration, were also recorded. Yet, imaging was a method of data gathering throughout the entire research. Field observations such as paddy fields (varieties), harvesting methods, machinery used, groundwater use, spring source, etc; were also subject of imaging.

[16] I had a motorcycle in order to travel along the irrigation system.

2.6.3 The Case Study

The research strategy selected to approach the technological analysis was a case study. The case study unit chosen was a Branch Canal. Due to ample water availability, easy accessibility and extended groundwater use, Branch Canal 1 was the election.

The methods of data gathering were field observations, interviews and WUA maps and records. Firstly farmers were interviewed using structured interviews. Afterwards different strata (committee members, secretary, chairman and former secretary) of the Branch Canal Committee members were approached and interviews were modified so as to gather data about institutional roles and tasks. Thereafter pump holders and well owners were also inquired about groundwater use. Finally the main canal operator was also interviewed.

Walkthroughs along the branch canal were carried out to corroborate maps in previous literature and those done during IMT by the WUA, as well as to get insights of field practices. Additionally, all wells within the branch canal were identified (and used to interview their owners). The former secretary helped me in this task as he could spot them in a sketch map I did.

A cadastral map was elaborated tracing the original map the chairman provided.

2.6.4 The survey

The second half part of the research focused in collecting data related to performance in the terms underpinned previously in this chapter. Due to the complexity of figures and their quantity, a survey was the research strategy applied. In order to have an evenly distribution of data, the survey was carried out throughout the entire system, namely BC1, BC2, BC5, BC7 and BC8. This is head, middle and tail sections of the irrigation system.

In this case the research method used was a questionnaire. Ten questionnaires per Branch Canal were filled up asking directly to farmers with the help of an interpreter. In total, fifty questionnaires were completed (see questionnaire template in annexes).

2.6.5 Literature review and WUA records

PIS has been subject of study by multiple authors (A. Shukla, K.R. Sharma, P.R. Khanal, etc.) and institutions (DOI, IAAS, WUR). Moreover PIS WUA has multiple records concerning, registration of shareholders, ISF collection, area under irrigation, crop distribution, shareholder land ownership, financial figures, water flows, amongst others. All of these records were provided by the WUA chairman. This compound of data sets and figures have been included in the present research as an alternative source of information. In particular, information regarding past events, like the IMT process or PIS history, were gathered through these sources.

2.6.6 Living with a Gate Keeper

A gate keeper is someone who has the control over the access of a certain "benefit", yet without owning it, which is desired by an external actor or "client" (Corra & Willer 2002). Thus PIS chairman could be considered as a gate keeper as he has full access to the system and can allow access to third parties. He is elected and forms part of an institutional body, hence without any ownership status over the system.

During the field work I was hosted by the WUA chairman. He rendered me all archives and data requested. Thanks to his position I could access the irrigation system. In the same way living with a farmer gives an opportunity to gather data through informal interaction with his household as well as the neighbouring the community.

Chapter 3

Panchakanya Irrigation System

3 Panchakanya Irrigation System

The following chapter describes PIS in detail. Firstly the immigration history of the district is revised. Further on a physical description will provide a general overview of the system. Additionally the institutional backbone will be described along with water management activities such as decision making, water allocation, ISF collection, O & M activities, amongst others.

3.1 Chitwan as a Frontier Land

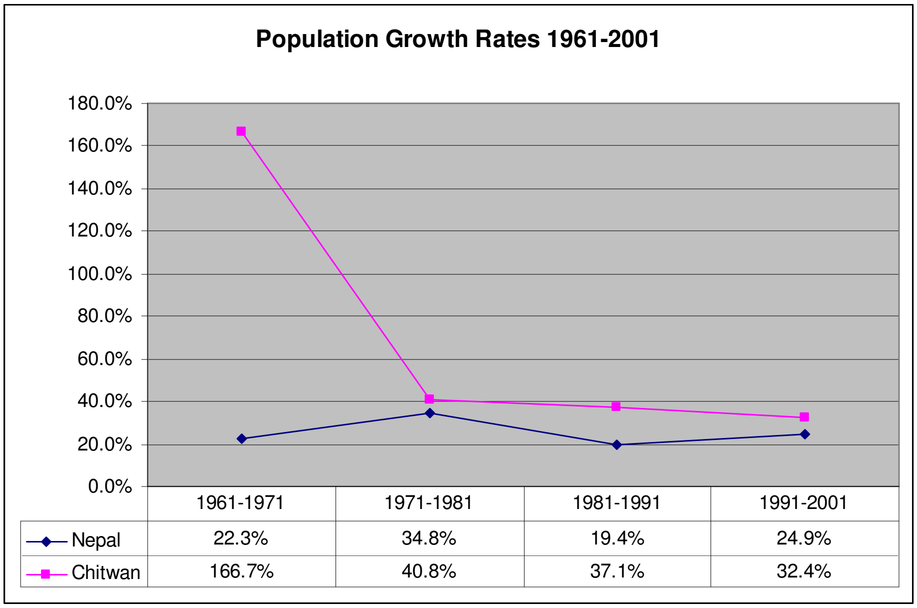
As stated previously, the Terai region was subject of planned development from the 1950s onwards. There were several settlement initiatives previous to this time. These concerned mainly land grants to royalty, nobility and high class social strata. However, the Terai remained mostly inhabited with a few scattered settlements in the forest. Moreover, the Terai was know as *kalapani*, meaning poisoning water, due to the presence of malaria[17].

From the 1950s onwards, there was a specific planned policy launched by the government focused on developing the region. A compound of factors encouraged settlement policies. The establishment of democracy (1951), the abolition of *Jagir* (1951) and *Birta* (1959) tenure systems, which turn most of lands to *Raikar* (state lands), paved the road to planned migration within Nepal (Ojha 1983). Similarly several development projects were launched: Five Year Development Plan (1956), the Malaria Eradication Programme (1958), and pertaining Chitwan district; the RVDP (1955). The resettlement policy had the intention of reallocating flood victims and landless migrants from the hill regions of Nepal into the Terai. Likewise it had the objective of developing further agricultural production and diminishing demographic pressure in the hills.

Chitwan was one of the districts which experience this type of planned development. Furthermore, the construction on the east-west highway encouraged further migration. Chitwan has a central location, and thus the highway connecting Kathmandu with the Terai (which is also the supply line for the country) crosses Chitwan just after the hills. Hence it has a privileged location regarding national connections.

Migration was encouraged as landless migrants were officially granted with plots. In the first years (1954-1956) there was no measure and migrants were given land according to all forest surfaces they could clear. From 1956 to 1960 the RVDP took over the legal endorsement of land distribution. In this period applicants were granted from 4 up to 100 *bighas*[18]. Nevertheless the RVDP was characterized by corruption: upper social classes (especially high caste), with connections to RVDP officials, were given land claiming they were landless and flood victims (Shrestha et al. 1993). This period was characterized by a rapid annual growth in Chitwan's population (see Figure 4).

[17] Also know as the "death valley".
[18] For correlation units: 1 ha = 30 *kathas,* 1 *bigha* = 20 *kathas*



	1961-1971	1971-1981	1981-1991	1991-2001
Nepal	22.3%	34.8%	19.4%	24.9%
Chitwan	166.7%	40.8%	37.1%	32.4%

Figure 4: Population growth rates in Nepal and Chitwan 1961-2001.

The RVDP finished in 1961 along with land allotment. The migrant influx in the region continued leading to subsequent illegal settlements as land wasn't officially conceded anymore. Therefore the government created the Nepal Punarvas Company (Nepal Resettlement Company) which took over the task of planning of further resettlement programmes. By mid 1970's land allotment had decreased from 4 *bighas* (2.66 ha) to 1.5 bighas (1 ha) and new conditions were imposed to applicants. These should prove they were natural disaster victims and/or landless. However, this procedure mistreated low class migrants as most of them were unaware or unable to issue such certifications (Shrestha et al. 1993).

Apart from favoring high classes, resettlement programmes couldn't accommodate all migratory influx since not all migrants could access land allotment. Therefore "illegal" settlements flourished. Alike, local communities (namely local *Tharus*) were not included in these resettlement strategies in spite of being the original inhabitants of the district. By the time I carried out the field work *Tharus* were still widely present in PIS. Population studies in PIS show that in 1970 95% (5% migrant) of the population was *Tharu*, in contrast with 1999 figures which disclose a turn over of 75% migrants and 25% *Tharu*.

In summary, over the last fifty years Chitwan has been subject of settlement programmes in an attempt to develop the district. If we recall the concept of frontier land, defined as non-settled areas within a state prone to be develop so as to relief population pressures and expand agricultural land (Shrestha et al. 1993); Chitwan can be interpreted under these terms as it has precisely experienced these events. Hence PIS, as part of Chitwan district, forms part of a frontier land. Furthermore, several characteristics, such as land distribution and ownership in PIS, as well as its continuous expansion are a consequence of PIS being a frontier land. This concept has been introduced so as to contextualize PIS recent development. Moreover as I will depict further on how plot size plays an important role related to performance. In addition social dispossession of land from local *Tharu* to external social groups is an issue which emerged as a consequence of resettlement policies.

3.2 Physical infrastructure

PIS starts at the *Panchanadi*[19] spring source. This perennial source supplied water to *Bhatar Khola*[20] before joining to the *Khageri* River. The source was shared together with the Khageri Irrigation System (KIS). KIS lied on the west side of Chitwan district and had a command area of 4000 ha with a canal capacity of 7140 L/s.

The spring source was encroached due to settlements upstream and fish ponds constructed years ago (2000). These ponds cover all of the five spring sources. Thus during spring season, when there is no rainfall and temperatures are extremely high, the spring sources could not provide water to *Bhatar Khola*. Therefore PIS water supply decreased. This issue started a decade ago and water users referred to it as one of the reasons of water scarcity in the system. PIS farmers claimed to have the right to *Panchanadi* source however, as reported by PIS chairman, the WUA constitution doesn't mention water rights over the spring source. Hence the WUA was not willing to take legal action in order to solve the conflict.

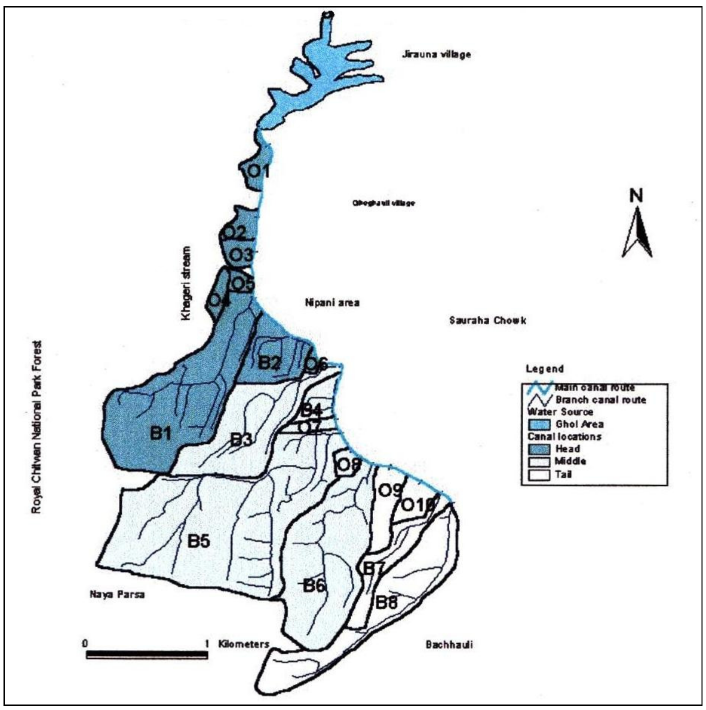


Figure 5: PIS water source, main canal, branch and outlet network map.
Source: (Adhikari et al. 2002)

The first structure downstream from the spring source was the headworks. It consisted of an overflow weir with a divide wall. The divide wall separated the overflow structure from a sluice gate which supplied the intake for PIS. The canal capacity for PIS was 1200 L/s. The headworks also contained a canal head regulator. This structure was used to measure the flow at the headworks[21]. Between the sluice gate and the head regulator there was an escape structure that diverted water back to the river in case of being open.

[19] *Panchanadi* means five rivers.
[20] *Khola* means stream in Nepali
[21] For more details see Image 1 and Image 2 in annexes.

This is, when irrigation service was not demanded[22]. If closed the flow went directly from the sluice gate to the head regulator and consequently to PIS main canal.

Image 1 PIS Headworks, note PIS intake's sluice gate (right).

PIS was a gravity system which consists of a 5 km main canal which supplies 8 Branch Canals and 10 direct outlets (these outlets irrigated from the main canal) (see Figure 5). Except for the three first direct outlets, the rest of the outlets and branch canals laid south from the east-west national highway (2 km down stream from the headworks). According to WUA files the total command area of PIS is 600 ha (for additional information see Table 6. There was a service road that follows the main canal from the headworks until the last branch canal.

Image 2 Escape structure (right) and Head Regulator (left)

[22] By the time I arrived in PIS the paddy rice was being harvested. Hence water service is not appropriate for rice harvesting so the escape structure was open.

The topography of the irrigation system played an important role in water distribution. The command area laid on flat land. PIS is a gravity system, hence water flow was obtained by gravity forces. Water levels of canals were higher than the fields. Fields were set so that water from canals drained from one plot to the next one. Plots located at upland were commonly named as *Bari* whereas the lower plots were called *Khet*. This factor will be discussed in the detail in the next chapters.

3.3 **Institutional structure**

During the second rehabilitation period (1982-1986) a small committee was established to represent farmers. By this time the irrigation system had about 100 ha of command area. Due to the insufficient command area the irrigation agency, through the Chitwan Irrigation Development Project (CIDP), decided to take it over for rehabilitation. Farmers then decided to create an informal committee to act as interlocutor between them and the irrigation agency. This committee was mainly in charge of coordinating O & M practices. Thus prior to IMT, there was an already existing informal WUA.

The IMT officialized the already existing informal WUA. A dual scheme was proposed in the first constitution (1994)[23]. The WUA would have two main bodies, each at a different hydraulic level. The main committee (MC) would be in charge of the main canal and entire system while nine branch committees would be in charge of seven branch canals[24] (one branch committee per branch canal), and ten outlets (one branch committee per five outlets)(see Figure 21). In this way all of the water users were represented. The MC consisted of 9 representatives (one per branch canal committee) and three administrators, namely the chairman, vice-chairman and secretary. The general assembly (GA) accounts as the main democratic body of the WUA. It was conceived to have 45 members, in line with the primary target command area of 450 ha (one representative per 10 ha). The first election was held in May 1994 after the constitution was drafted.

After IMT some amendments were introduced in the WUA structure. Since the rehabilitation introduced infrastructural elements and thus new water distribution procedures, the WUA had to adapt its structure. Similarly women inclusion in WUA representation was also a concern by donors and forwarded to the WUA.

Due to infrastructural improvements, water availability increased. Hence the target command area was expanded to 600 ha. Another issue was water distribution at the outlets. The branch canal committees in charge of the direct outlets failed to allocate water properly, so the WUA decided to create a committee per outlet. For all of this the WUA agreed (third election, 1998) to increase the GA composition from 45 to 110 members. This included command area (60 seats, one member per 10 ha), MC, branch canal committee and outlet committee representation. Twenty percent of the seats were reserved for female members in the GA (25% were occupied). For female representation trend check Table 1, Table 2 and Table 3.

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[23] A 13 member committee drafted the constitution in April 1994 with the help of a CIDP engineer.

[24] Only seven branch canals were included as branch canal number eight was not in use anymore.

Level of Commitee	Male members	Female members	Total
General Assembly	44	1	45
Branch Committee	44	1	45
Main Committee	13	0	13

Table 1: First official election of WUA (1994)

Level of Commitee	Male members	Female members	Total
General Assembly	44	1	45
Branch Committee	43	2	45
Main Committee	13	0	13

Table 2: Second WUA election (1996)

Level of Commitee	Male members	Female members	Total	Number of Committees
General Assembly	72	38	110	1
Branch Committees	32	8	40	8
Sub-Branch Committees	105	30	135	31
Outlet Committees	32	8	40	10
Main Committee	15	1	16	1

Table 3: Third WUA election (1998)

Yet there was an additional amendment (fourth election, 2001) which lowered the number of representatives to 89 in the GA, 15 in the MCs. However the structure was maintained as before.

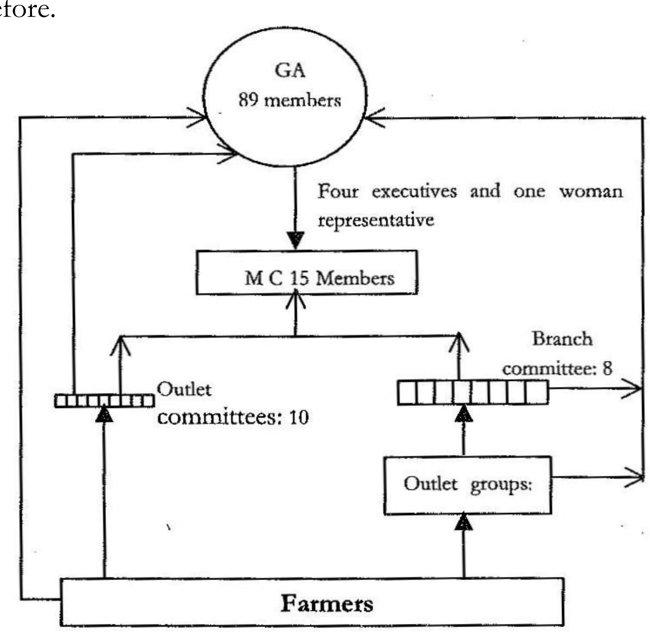

Figure 6: Current WUA structure Source: (Khanal 2003)

The GA was the main democratic body in the WUA. The chairman, vice-chairman and secretary were elected through the GA. On the other hand the MC was a reduced chamber where decisions were enforced and actions were functionalized. This is, it was the committee in charge of executing main systems functions, like calculating irrigation water demands or setting irrigation protocols. It reduced number made it easier to agree on decisions and coordinate all branch canals and outlet levels. Officially there were 16 members. However, as affirmed by the chairman, it was common that some members missed the meetings. The average attendance was 13 members during meetings. In addition, branch Canal 8 was not involved in the WUA as it didn't receive water from the main canal.

Branch canal committees were formed by 5 to 9 members depending on the branch canal command area. They consisted of a chairman, secretary and committee members. The chairman was responsible for the branch canal representation in the MC. Normally, candidates, with farmer support, presented voluntarily for chairman. Meetings were held for election, coordination of water tasks and O & M. Several interviews revealed that election of branch canal committee members was reached by consensus and not explicitly by a voting system. This was also the case for the rest of the branch committee members. There were also sub-Branch canal committees formed by 2 to 5 members (depending on size of sub-branch) with at least a chairman and another member. Sub-branch committees of more than 2 members include a secretary.

3.4 Share system, ISF and women representation

Water user representation in the WUA was issued through a "share system administration". This representation also ensured access to water for shareholders. The system was based on land area. One share equaled to one *katha* (0.033 ha, for details on unit correlation see footnote 18). Water users had to fulfill the following requirements: they had to be the owners or tenants of the service area, users had to pay 3 Rs. per share to acquire membership, after a land sale appropriation rights were reassigned to the new shareholder upon 20 Rs. fee payment, water users were obliged to pay the ISF and membership had to be renewed each year.

The ISF covered expenses on O & M of main and branch canals as well as water provision for crops. At the time of the field work, the fees were: 300 Rs. per ha for main canal maintenance, 300 RS. per ha for branch and sub-branch canal maintenance, 150 Rs. per ha for rice crop and 75 Rs. per ha for any other crops requiring water from PIS. These fees covered the salary of the main canal operator and maintenance practices for all the canal networks. The fees were proportional to land surface (irrigated surface for crop fields) and thus to water received.

Woman representation was a concern raised during IMT. This issue was problematic as women couldn't own land owner in Nepal. The matter was solved by an amendment in the constitution. The share system was modified so that any member of the WUA could pass partially or totally the share representation to another person, and hence the latter becoming member of the WUA. This measure would still require a concession from husbands or head of the household to females. Yet, it served to include women membership in the WUA.

3.5 **Water allocation**

The ISF guaranteed a water delivery flow of 3L/s/ha. For farmers with plot soil characteristics less permeable, the water delivery was 1,5 L/s/ha. The chairman assured that irrigation turns were normally 3 hours per hectare. In order to assure such delivery, the PIS followed a canal operation plan. This plan was based on flow measurements done by the canal operator. Yet, flow measurements were done at the headworks, which is 2 kilometers upstream from the first branch canal. Thus seepage losses were not taken into account. I interpret the value of 3 L/s as a rough estimation. In addition irrigation turns (of 3 h/ha) could be adjusted if the water delivery is insufficient.

In principle there were five gauging stations. However the canal operator declared to only measure the flow at gauging station at the headworks. The reading scale used for calibration at this station was found to be missing. Yet, the canal operator still recorded flow measurements every fifteen days (in irrigation periods). According to these measurements the canal operation plan developed as follows.

If the flow in the main canal was above 1000 L per second, nearly at full capacity, all branch canal gates and outlets were open. If the flow is between 500 and 1000 L per second, the irrigation scheme was split into two sections. Each section would receive 3 days of water service saving one day for areas where water availability was low. This pattern of water allocation was called "two section rotation system". If the flow was between 300 and 500 L per second, the irrigation scheme was divided in three sections. Each section would have seven days of water service during rice transplanting. If the flow continued at this level the turns would be of 4, 6 and 3 days after transplanting. This was known as "three section rotation system". Finally, if the flow dropped below 300 L per second, water would be divided among each branch canal with its own hourly schedule. This was known as "branch rotation system". Normally during monsoon season the flow was between 1000 and 1200 L/s. Thus all gates were open. During spring season the flow decreased to 250 L/s (for detailed flow figures see Figure 25 in annexes). During winter season irrigation was not so common as most of the crops grown (lentil, mustard, etc.) didn't require irrigation service. Hence, in practice there were only two operation plans, "open gates" during monsoon and "branch rotation" during spring.

There was an irrigation demand form that farmers are obliged to fill in (see translated form Figure 23). Nonetheless, several water users declared to not fill it in or were unaware of it existence. The irrigation demand form was collected by Branch Committees to estimate water requirements of farmers.

3.6 **Decision making**

As mentioned before the GA was the main democratic body of the WUA. It was composed of 89 members. Representation accounted for hydraulic levels (branch canals and outlets), command area (one member per 10 ha) and administrative levels (MC chairman, secretary, canal operator, etc). Executive members of the WUA (chairman, vice-chairman and secretary) are elected in the GA. Similarly GA members representing irrigated area were appointed and elected by branch and outlet committee members.

Decisions concerning the whole irrigation system were voted and decided upon, in the GA. As an example, constitution amendments were discussed and voted upon after IMT in the GA. Nevertheless, the chairman declared that most of decisions were reached by consensus and no voting was necessary. This was also the case in the MC and Branch Committees.

The MC was in charge of implementing decisions taken by the GA. Irrigation turns and water allocation procedures were tasks done by the MC. Records of ISF collection, cropping calendar and irrigated area were presented by each branch and outlet member. These records were used to estimate water requirements at each branch and outlet canal.

At branch level decisions regarding O & M practices, water distribution and individual sanctions were the responsibility of Branch Canal Committees. The secretary was in charge of keeping the records of ISF collection, irrigation demand form and cropping calendar. Meetings were announced by the branch chairman or secretary. The persons in charge of O & M practices were appointed in these meetings. Likewise, irrigation turns and water distribution schedule were announced during these meetings.

3.7 **O & M**

O & M tasks were carried out both at branch and main canal level. At branch and sub-branch level maintenance practices involved clearing of canals and cleaning activities. Most of branch and sub-branch canals were earthen sections. After the irrigation season these required of sediment removal and vegetation clearance. Branch and sub branch committees appointed people to carry out these activities. After IMT these practices were voluntary. As declared by the chairman and branch committee members, people were reluctant to offer themselves for unpaid labor. Hence, the WUA decided to pay the staff in order to carry out such practices (300 RS/h). Therefore, branch committees selected water users to carry out maintenance practices. At main canal level maintenance practices are similar to those at branch level. Yet, they involved mainly cleaning activities. People are appointed from each branch and outlet canal to carry out such activities.

Operation of canal gates was done by the branch chairman and secretary. Once agreed on the irrigation schedule to follow, they were the only persons allowed to operate the gates. They also supervised maintenance practices and irrigation turns. It is important to realize that as most of branch canals were earthen sections, it is simple to divert water from the canal to the adjacent fields. Normally farmers used a spade (or hands) to divert water into the fields by removing part of the embankment that separates the canal from the fields (Image 3).

Image 3: Common Branch and Sub-Branch canal features with earthen lining and embankment.

PIS had a canal operator who was carrying out his job since IMT. He was in charge of recording water levels and operating the gates. He was present in MC meetings but not entitled to vote. He learned his task through the IMT seminars and trainings and was appointed as canal operator given his skills and dedication. He received a monthly salary of 5000 Rs. This salary was increased over time, and in fact his job was also voluntarily after IMT. Apart from his duties in the field he declared to spend two hours a day doing office work[25]. He was also in charge of supervising maintenance practices at the Main Canal.

Maintenance practices were carried twice a year, after harvesting the monsoon crop and after the dry season (spring). My field work extended from the end of the monsoon season to mid-winter. Both the chairman and the canal operator were asked about maintenance practices at Main Canal. However, they declared that these practices weren't carried out after monsoon for two years in a row. The explanation given was lack of budget. They also said that maintenance practices were then carried out after the dry season, just before transplanting the paddy rice.

3.8 Rules and Regulations

The WUA constitution specifies that the GA has the authority to introduce constitutional amendments, approve rules and regulations and put forward policy decisions related to PIS.

There were series of obligations that water users must fulfill. These included payment of share, membership and maintenance fees. Water users were also responsible for weeding the embankments of their plots. Committee members were obliged to be present in meetings. Similarly secretaries of respective branch canals and outlets had to keep records of ISF collection and crop distribution.

[25] PIS has an office at Nipani, a nearby village.

Moreover, a series of rules and sanctions were specified. Sanctions cover the next matters:

- Late payment of fees
- Water theft
- Not contribution in cash or labor for O & M
- MC and Branch committee infringement of O & M responsibilities
- Violation of water distribution in branch and outlet canals (for branch committee members)
- Encroachment of PIS water source
- Pumping of water from canals
- Animal grazing and waste dump nearby the main canal

Some of these rules and regulations were not heavily enforced. I could see grazing in the surroundings of main canal and branch canals. Alike, PIS spring source had been encroached without any legal remedy. Water theft was uncommon, yet committee members interviewed declared that when it occurred they would try to raise awareness rather than sanctioning water users. The same occurs when water users didn't follow water schedules proposed.

The WUA records kept track about payment of fees. I could corroborate from the WUA records that this issue occurred. For this reason an additional fee was charged upon water users who delay their payment.

As an outsider I also had to pay a fee corresponding to my field work (5000 Rs.). There was a fee which explicitly addresses field visits and researchers.

3.9 Accountability and Financial supervision

PIS WUA kept a detailed record of a wide range of activities and financial data. The recording system began before IMT and thereafter improved through seminars[26]. These records were kept in the WUA office. The financial records were handled by the secretary and chairman. However the chairman declared that he was keeping all the records due to lack of trust towards his colleague. According to the Chairman the secretary was from a certain political party which he didn't approve. Moreover, he feared that these valuable documents could get lost, misused or even destroyed. During my field work I could prove that all these documents were kept in the Chairman's household.

According to the WUA Constitution all financial records had to get ratified but an external auditor. This auditing task was done once a year and has been current since IMT.

3.10 Cadastral system

PIS used a cadastral system to record land ownership. Detailed mapping of the spring source, Main Canal, Outlets and Branch Canals including plot distribution was carried out during IMT by the WUA and DOI officials. All plots were categorized by Branch or Outlets and assigned with a number. This number was kept in a file which specifies the

[26] Trainings were carried out in Administration, Financial Management and Financial Record Keeping.

plot size and plot holder. In this way the WUA could keep detailed records of cropping pattern and irrigated areas. Similarly, this system was also used to issue ISF forms and shareholder fees.

3.11 **Leadership**

In contrast with other systems irrigation systems in the Terai (e.g. Khageri Irrigation System, also in Chitwan), PIS had been able to turn over its management to a WUA. Most of MC members had been present in the committee since the official foundation of the WUA. The first WUA chairman of PIS was elected for four consecutive times. He was a leader highly respected by farmers. He was mentioned, by current MC members and DOI officials who were present during IMT, as one of the pioneers of PIS WUA. Due to his advanced age and delicate health he was substituted by the secretary (in 2002).

The new chairman was still in the position during my work field. Moreover, he provided me with accommodation and all the information and data regarding the irrigation system.

Farmers in PIS chose these men for the head of the WUA not only because of their dedication to the irrigation system and leadership skills, but also because they represented two different political views. The first chairman belonged to the Nepali Congress Party while the latter was a member of the Communist Party of Nepal (united Marxist-Leninist). Thus farmers liked two have a balance in political representation (Khanal 2003).

The chairman declared to be tired of his institutional job and wanted to hand in his responsibility to another member of the GA. He had in mind to appoint a woman as chairman of the WUA.

3.12 **Analysis**

Resettlement policies in the second half of the 20th century shaped the district's development. PIS beard the consequences of this process. This lead to rapid growth in the district's population. New comers outnumbered local population and land was not distributed (both size and ownership) in a proper and equitable way. Irrigation practices were affected as migrants started practicing irrigated agriculture. Migrants belonging to upper classes of society were in advantaged regarding land allotment. On the contrary, local inhabitants and migrants of low social status weren't treated with the same conditions, leading to inequitable land distribution. This also triggered "illegal" settlement. Thus Chitwan district resembles a paradigm of "planned" development with failures and successes. Nonetheless services such as education, health care facilities and road communications were successfully implemented.

The information presented in this chapter describes in detail the irrigation system studied. Its institutional structure was branched my committees which represented farmers in terms of land surface and hydraulic levels (main canal, branch canals outlets). This organization appears to adopt a "democratic" structure as all farmers had shares of the system and hence a right to vote. However voting didn't seem to be a common practice, hence I assume that customary methods of decisions making were still present. Likewise, the unofficial WUA probably had some mechanisms of organization which weren't taken into account in the IMT process. Additionally, rules and regulations were part of the institutional system, however in practice not all of them were enforced. The irrigation demand forms were also an administrative paperwork forwarded during IMT. It had the objective to collect water demands from each water user in order to come up with an estimation of each branch canal. Yet, in practice the forms were not filled by all water users. The same happened with the rotational systems. There were several operational plans contemplated for different canal flows. However there were only two operation plans applied. Taking into consideration all of the above, it seems as an institutional body has been embedded into this irrigation system. Hence the system's functioning resembled a modern institutional backbone combined with customary management.

Maintenance practices started as voluntarily after IMT. However the WUA had to change the approach and pay the persons in charge of carrying out such activities. This was also the case for the canal operator who hadn't any revenue for his job, but eventually started getting paid as time passed. Thus the WUA incentived people in charge of operation (canal operator) and maintenance by means of revenue. Hence collective action[27] seemed to be eroding over time. It may be interpreted as another symptom of how the WUA adapted some institutional structures to its own functioning.

In a similar way, the WUA legalizing process during IMT played and important role in technological relationships. As it was, the WUA represented a structured hierarchy with clear division of tasks, rules and responsibilities. Hence it acted as an interlocutor between water users and the system management, which in practice means between water users and technology. Furthermore, the next chapter will shed some light in this regard as it describes in detail the technological process involved in irrigation practices.

If we attempt to link the technological interface addressed before, with the performance of the system, we will have to take into account what is the role of the WUA as an institutional body, its evolution (as described previously) and how its establishment affected prior irrigation practices. Alike, we could add up another scale in the concept of performance including institutional performance. This should take into account how this body, as representation of farmers, was successful in responding to farmer's needs more than the system's (e.g. expansion of command area or canal lining) needs. Again we come across the importance of defining the needs, for whom and for what purpose.

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[27] Defined as "an Action taken by a group (either directly or on its behalf through an organization) in pursuit of members' perceived shared interests" (Scott & Marshall 2005).

Chapter 4

Focus 1:
Technology in PIS

4 Focus 1: Technology in PIS

The following chapter presents a technological analysis of PIS. The first sub-chapter addresses a short history of PIS from a technological perspective. Further on the current state of the infrastructure is described. Subsequent subchapters describe the broader aspects of technology, to conclude with a description of conjunctive use in the system and a final analysis on the information obtained.

4.1 Technological history of PIS

In the times when PIS was a *Raj Kulo* it was administrated by a *Tharu* Lord (200 years ago). The system covered two *maujas* (namely *Sisai* and *Bhojad*) and the irrigated area during the monsoon was about 100 ha. The canal used for water distribution was unlined. Its track was basically the current main canal course. There were temporary structures built every year, downstream of today's headwork, in order to divert water to the canal. These temporary structures prevented sediment load settlement (water from rivers in Chitwan carry high loads of sediments). Similarly flood recovery was easier with this type of structures. No branch canals or outlets were developed in this period. As noted previously other parts of today's command area were supplied by another canal (*Budhi Kulo*). The early system was completely managed by the *Tharu*.

In 1967 a flood destroyed *Budhi Kulo* and adjacent *maujas* were left out without a water source. In 1969 the Khageri Irrigation System (KIS) main canal was finished. This system has its source on the *Khageri* river. The PIS sources supplied a tributary of *Khageri* River, *Battar Khola*. Furthermore PIS farmers built an additional intake, to increase water availability, from *Battar Khola*. KIS farmers took legal action to protect the source of KIS, but the court favoured PIS, and there followed a settlement between the two parts on stopping diversion of water from *Battar Khola*.

In 1974[28] PIS had its first rehabilitation under the CIDP. It included construction of a permanent concrete headwork structure. The headworks were provided with an intake gate and a head regulator. Similarly an earthen canal was developed with a total span of 5 km. A service road was also constructed besides the main canal. Diversion structures were installed in the main canal. These included seven branch canal gates and eight gated direct outlets. Development of branch canals and outlets was not a priority at this time. Drainage works also were carried out throughout 5,5 km. The target water supply area was of 600 ha. However the command area rapidly decreased as siltation at the headworks, leakages and seepage losses started shortly after rehabilitation works (only reaching 200 ha of irrigated area).

The second rehabilitation was undertaken between 1982 and 1986. This included stone lining of main canal, development of a 490 meters underground pipe in the main canal and installation of cross regulators in branches 1, 4 and 5, a siphon near branch 1 and drainage structures at the tail end. The irrigated area reached 400 ha but decreased in subsequent years due to subsidence problems in main canal leading to damage in lining, ineffective O & M activities and unsuccessful water allocation. The irrigated area decreased to 267 ha.

[28] The rehabilitation works started in 1977 and ended in 1979.

The last rehabilitation carried out in PIS was during the IMT process. Main improvements focused in enhancement of existing headworks with a siltation flushing system, lining works along 4 km of main canal and readjustment of outlets and gates.

After deliberation of different technical solutions an escape structure[29] was installed at the headworks in order to provide a siltation flushing system. Nevertheless field observation both at full and medium flow discharge revealed that sediments were flushed only in areas adjacent to the sluice intake gate. Hence the siltation remains as an unsolved problem.

An agreement of the type of lining was made between farmers and the DOI. Farmers proposed removing the existing canal section and installing a squared section brick lining. Due to budget constraints only 1.2 km of the main canal could be rebuilt with the proposed lining. Hence a concrete lining was presented by the DOI as an alternative solution to tackle seepage losses. Finally this option was agreed and 4 km of the main canal were improved with concrete lining.

Finally gates and outlets were modified to make them "tamper proof", this is, with a mechanism against water theft. This was PIS WUA proposition. These gates were operated with a removable handle, which was not fixed to the gate's spindle. The spindle was stored at the canal operator's house. The canal operator was the person responsible of the usage and storage of this tool.

4.2 The State of the Art: A Technological Inventory

The analysis of the infrastructure at main canal level was carried out by walkthroughs and a digital image inventory. Due to the date of arrival, i.e. after the monsoon, both exercises were done with the main canal empty. Subsequent analysis of branches and sub-branches were not made due to time constraints.

The first walkthroughs served as an introductory overview of PIS main canal. It was interesting to observe the multiple sections the canal had in its total span. This was evidence of the multiple modifications done at main canal level. PIS had trapezoidal, rectangular, squared and circular sections along its main canal length.

The Headworks were found to be in good state. The overflow weir and sluice gate could still bear a 1200 L/s flow. However the siltation upstream from the weir remained a big problem. There was vegetation flourishing on the sediment which made operational tasks of the headworks very difficult due to clogging. As for the escape structure and head regulator, both structures were in good condition. As mentioned before the scale used for calibration of flow at main canal was missing. According to the chairman, people stole metal objects, such as this scale, to sell them afterwards. The canal operator still recorded main canal flows at this point. IMT technicians proposed five gauging stations along the main canal, precisely near BC 1, 2, 5, 8 and the one at the headworks. At the time of the field work these stations were not in use and the scales to measure them were also missing.

[29] Description of the escape structure is detailed in Chapter 3.

Image 4: Cross gate 2 with tamper proof gate.

There were ten outlets in PIS. The first five were before BC1 off-take. All of them had iron tamper proof gates[30] except for outlet 3 which didn't have a gate. The canal operator declared that in order to close this outlet he used a tin object to block the water flow. All outlets had the same mechanism, sluice gates elevated enabling the flow through underground circular pipes, which crossed the service road, and ultimately to the outlet canal. Outlet number 8 had a rectangular section at the off take instead of a circular one. The sluice gate of Outlet number 7 was severely deteriorated. It had holes at the bottom part of the structure due to rust.

Branch canals gates had the same system as the outlets. They had bigger circular sections and all of them were provided with distributary head regulators with sluice gates at the off-take. Branch canal 2 and 5 had further structures to divert the flow to sub-branch canals, namely two sub-branch canals per branch canal. Branch canal 5 had a small concrete reservoir with two sluice gates whereas branch canal 2 had a concrete diversion structure with two intakes without gates (Image 5). The state of the gates and concrete support were apparently good. However observation weren't taken at full flow which may reveal leakage problems. From the eight branch canals PIS WUA claimed to provide irrigation service, seven had off-takes from the main canal whereby branch canal eight didn't have an off-take. The main canal ended in BC 8 which received (in theory) directly from the canal. Yet, field observations found branch canal eight with intense vegetation, little canal cleaning and encroachment by surrounding households. This suggested that BC 8 was not currently in use.

30 In each distributary head regulators.

Image 5: BC5 sub-branch diversion structure

Apart from the head regulator, eight cross regulators were identified. These were located after BC1, BC2, between BC3 and BC4, after BC5, two between BC6 and BC7 and after BC7 (see PIS layout in Annexes). Three out of eight cross regulators were with no gates, and thus of no use. After cross regulator 4 (after branch 5) the main canal section shortened and shifted to a rectangular section. This was done for the purpose of providing a higher water level downstream.

The main canal also contained five drains located in the tail end of the system. These drains alleviated waterlogging areas on the right bank side (opposite from PIS command area) of the main canal. The drains crossed the main canal by underground alleys and provided additional water to PIS.

Several walkthroughs along the main canal revealed structural deterioration. Several parts of the main canal made of boulder and brick masonry were either collapsing or fragmenting (see Image 6). This was a recurring problem since the first rehabilitation. Similarly in the surroundings of Outlet 1 some tracks of the main canal section were seriously deteriorating.

Finally twelve foot bridges and three cross roads were identified. These structures provided communication lines between both sides of the main canal and the service road (which was in the left hand side of the main canal). Several settlements were adjacent to the main canal. The cross roads allowed traffic over the canal, in particular the east-west highway.

Image 6: Brick masonry deterioration in the mid part of Main Canal.

4.3 Case study begins

The second part of the technological analysis was approached from a case study perspective. The qualitative nature of the data pertaining all aspects addressed in the technological conceptualization was the rationale to apply a case study approach. Due to an extended irrigated area and ample water availability, branch canal 1 was selected as the case study area. It had an irrigated area of 75 ha with a total of 100 ha of command area. It provided irrigation service to 213 registered shareholders. Its total span is of 1359 m and 1255 m for all its sub-branches. Conjunctive use of surface and ground water was common in this area.

The first two hundred meters of the branch canal had a concrete lining while the rest of its length was earthen lining. There were three iron gates within the branch canal. Other gates were wooden with a removable sluice. All of these served to control the flow among the different section of the canal. The branch canal delivered water to several *maujas* namely, *Sisai*, *Dikhoa*, *Belatandi*, *Dhikwa* and *Jammunada*.

4.4 Technology as artefacts

Following the concept of technology as a process involving artefacts, skill, knowledge and labour; I shall describe the outcomes of the case study in these terms. The artefacts involving Main Canal level have been described above, yet there were also other artefacts used for irrigation purposes.

Water users interviewed declared to use basic tools in order to provide water to their fields. The most common hand tools were spade and sickle. The spade was commonly used to distribute water in the plot. It was also used to dig small field channels when the flow was too big and the water must be evacuated to the next field. Moreover they also divert water using stones and sticks. These were used to block water flows from the branch or sub-branch canal.

In the same way, water users unanimously declared to use their hands and legs as tools for irrigating. This was observed in the field. Many plots were set with furrows, mainly for winter crops. Normally these furrows don't covered every single alignment, thus farmers spread the water from furrows to adjacent areas using hands and plastic devices. Embankments are set to separate fields from adjacent plots and canals. However water was brought into the field through the earthen embankment by breaking it. Farmers declared to use their legs to open or close the break in the embankment.

Apart from these "tools" (e.g. legs and hands) described above, mechanization has been introduced. After rice crop season farmers plough their fields in order to obtain a thinner soil texture[31]. In the past this task was done utilizing oxen. Nowadays mechanization has largely displaced animal workforce. Thirty five horse power tractors were used to plough fields with nine tine tiller[32] or disc harrows implements (see Image 7). In spite of the average plot size being small, tractors could access plots by way of road networks which branch throughout the whole irrigation system. Field observations of ploughing activities disclosed improper use of heavy machinery. Tractor drivers didn't follow traffic control within plots and wheel sliding was common.

Image 7: Common implements applied for ploughing purposes: Disc harrows (left) and nine tine tiller (right).

Another important device used for farming practices was the rice thresher. There were two ways of separating the rice grain from the straw. In the traditional way rice plants are assembled forming cylindrical units which are then battered against the floor or straight surface detaching the grain from the straw. Nowadays farmers follow the same method with the exception that machinery was used to detach the grain. Rice packages are rubbed in a turning mechanical spin, containing spikes, which thresh the rice (see annex). Farmers normally rented out (per hour) this machinery.

[31] Rice seeds are firstly sown in the nursery garden and after they have geminated and produce a stem, are then transplanted to the field. The soil texture required is very small so farmers use wooden stick to hammer the soil and obtain a fine texture. The nursery garden has to be provided with enough water to maintain constant moisture in the soil.

[32] Also know as cultivator.

In order to fulfil high water demands, farmers relied on groundwater sources in addition to surface water. Thereby shallow tubewells were commonly used. Hence pumps were another artefact commonly used in irrigation activities. This is described afterwards in this chapter.

4.5 Technology as "Living Knowledge"

Knowledge is another aspect of technology. The first traces of irrigation knowledge in the region were held by the *Tharu* community. They were in charge of the early *Raj kulo* management

I make a division in natures of knowledge regarding irrigation technology. Activities carried out at plot level related to water distribution entail a specific type of knowledge categorized as "irrigation knowledge". If we take into account wider aspects of the irrigation system management such as O & M activities, calibration of water levels or water allocation procedures we should focus on "irrigation system knowledge". These two categories fall into the concept of irrigation technology.

Most interviewees declared to have learnt irrigation through "tradition", entailing family heritage. Parents and grandparents possessing irrigation knowledge would eventually transfer it to next generations. Other water users declared to observe other people carrying out irrigation practices and thus follow what they observe. Another common response was WUA trainings during the IMT process.

The IMT process carried out several training programmes (see Training programmes organized in PIS for capacity building of WUA in annexes). These trainings programmes mainly focused on irrigation system knowledge, namely administration management, O & M practices and capacity building. However some trainings also focused on field level issues such as the crop diversification training. After IMP the SAGUN-project also carried out trainings such as the process of equitable water schedule application (2005).

As the IMT process ended nearly ten years ago, some WUA committee members weren't present at the time. BC 1 secretary (which was elected five months prior to my field work) stated that he learnt to carry the job of secretary by observing the previous secretary. His function as secretary seemed to be the same, however his approach was different. When inquiring about sanctions to farmers he declared to be "very rigid" so as to enforce rules, meaning that if a farmer was found to be stealing water, he would be sanctioned by deprivation of irrigation turn. The former secretary (as well as the WUA chairman) declared to be flexible and try to "educate farmers" raising awareness of the benefits, for everyone, of following rules.

BC 1 chairman declared to have learnt to operate BC 1 gates by a main committee training and from the previous chairman. Again irrigation system knowledge of canal operation and maintenance was passed by previous or current WUA members.

In terms of water allocation water users declared to not calculate precisely, in volumetric terms, the amount of water needed in their plots. The common response was "the committee is in charge of it". A former agricultural department official living in a BC1 *maujha* exposed that all farmers tend to irrigate their fields until saturation point.

From the survey carried out later on, multiple farmers declared to not be keen on incorporating commercial farming, because they felt they didn't have enough knowledge.

4.6 **Technology as Skill**

Skill is another feature included in my technology definition. It is the combination of employing artefacts and knowledge for a certain purpose. Therefore, skill is addressed in the present study.

Once more water users stated to have acquired skill by tradition. Experience was also accounted as another dynamic factor related to skill. Repetition in water and agronomical related activities was a matter regarded as the main driver in developing skill. Note that most farmers followed the same crop pattern, spring and summer with paddy and winter with another crop, precisely mustard or lentil.

Participatory observation confirmed the assumption that the most skilfulness and laborious farming activities were rice sowing and harvesting. Mechanization has not been developed yet for rice harvesting (or sowing). For this reason a substantial amount of manual workforce was needed to do these farming activities. Hence farm households, especially those with elderly family members, were prone to hire workers to carry out these activities. During my field work I could observe groups of workers, low cast social group, coming from eastern Nepal and India hired for harvesting rice fields (and later threshing). Farmers stated that these workers were skilful and could carry out harvesting activities in a better way. Moreover not all farmers were employed fulltime in agriculture, many had other jobs. Thus there was a certain level of delegation of farming activities.

Some water users approached during the case study were confused about explaining their skill in irrigation and farming activities. This could be due to two reasons: unawareness of possessing skill or limitations of the methodology applied in order to gather this type of qualitative data.

4.7 **Technology as Labour**

The final technological feature included in the analysis is labour. This concept covers not only the labour at field level but also all the labour involved in providing water from the source to the field and execution of related farming practices.

Water allocation and scheduling was decided by the MC. Branch Committees were in charge of its execution. Branch committee members, namely the chairman and secretary were in charge of coordinating water users in activities involving O & M. Communication of water scheduling allocation and distribution procedures was done through meetings prior to water provision. Normally the secretary informed water users about these meetings. Recommendations were also forwarded in these meetings. These could be once or twice per month during irrigation period. These meetings were also the communication line for maintenance practices and where people were appointed for the task. Thus the meetings were operating as an institutional backbone in charge of coordinating and executing water provision procedures and canal O & M.

As described above workers were hired for rice transplanting and harvesting, field ploughing (tractor) and manure fertilizing. In commercial farming labour input is high compared to cereals or herbal crops (rice, wheat, lentil, mustard, etc.). Hence commercial farmers also hired workers to maintain these crops, however commercial farming[33] is not common at PIS.

4.8 **Conjunctive Use as a Technological Alternative**

Case study observations and interviews suggested extensive use of groundwater resources in BC1. There were twenty shallow tubewells spotted at BC 1. Commonly there was one pump per well, though some well owners declared to sometimes use more than one pump per well. Except for one pump-well holder (of which he shared with three other brothers who were registered), all other well owners declared to be registered in PIS and pay the fees (ISF) accordingly. This is reasonable as canal water is cheaper than ground water extraction, thus they used canal water as much as possible. Pump holders declared to use ground water sources in order to cover extra water requirements in scarcity periods, normally during spring (pre-monsoon). In addition ground water is used to accommodate precise water demands, mainly for vegetables.

In BC1 (as in other parts of PIS) the groundwater table was approximately at 10 meters below the field level. According to pump holders the water table did not dropped in spite of a perceived increase of groundwater use in BC 1 and the rest of the system during the last decade. However electricity could be a limiting factor as its supply was unreliable. Pumps were either electrical or diesel type. There was a special tariff for electrical pumps (3,6 rp = 1 kW/hr, with a standard consumption of 2 kW per hour for pumps of 3 to 5 hP) making its use more affordable.

There was no specific regulation on groundwater extraction by PIS. Any land owner had the right to dig a well and extract water. There was no need to inform the WUA. In this way the PIS chairman declared that ground water use was a relief as it decreased water requests within the system.

When questioning about costs related to digging a well and purchasing pumps, pump owners stated the big investment required for making ground water available. For this reason the operation of wells/pumps was normally shared by several farmers. Later the costs of purchasing and maintenance were shared as well as the water extracted. Likewise, well owners had a tendency to sell water to nearby farmers with an hourly rate. In this way they could pay maintenance costs and recover the investment made. This "water market[34]" was also providing water to small farmers without access to groundwater resources. PIS didn't exert any control on this market.

PIS owned three moveable pumps which were used by farmers who request them in times of water needs. These were used to pump water from wells (not from canals). Generally speaking groundwater use was generally extended in the system and its availability was not a constraint. As I expose in the next chapter, the tail end part of PIS depends heavily on this resource.

[33] I refer here to comercial farming as the practice of cultivating cash crops exclusively for economic revenue.

[34] I didn't perceive a competition among well owners to sell water. Rather it was water selling situation to neighbouring farmers

4.9 **Analysis**

The history of technological development described in the first sub-chapter depicts the intervention and rehabilitation course in PIS. In spite of failing to cover the target 600 ha, the second and third rehabilitation programmes kept the same system scheme. Main Canal lining, headworks improvement, development of Branch Canals and gate enhancements were the technical interventions made. This rendered a system with no tertiary level and with an unsolved siltation problem at the headworks. Technological choices, introduced in each intervention, have set turning points in resource use and technological blueprints, undermining previous failures and successes. Temporary structures developed by *Tharu* technology could cope with sediment load and extreme events such as floods. Hence, they understood the limitations of technology. On the contrary, the second and third rehabilitation programmes endured in patterns of technology (canal lining, permanent structures and development of branch canals) prove as inadequate considering the results of irrigated area and command area achieved. The denial of customary technologies and failures of rehabilitation programmes could be one of the main reasons why PIS has not yet achieved target goals set.

The technological inventory reveals an acceptable state of the PIS Main Canal infrastructure. After more than ten years the lining was in good condition yet some cracks indicate deterioration of masonry from the tracks of main canal not lined with concrete. This was a recurring problem since the first rehabilitation and it may be caused by poor construction materials.

Gauging stations were reduced in practice to one at the headworks (with the scale missing). The canal operator remained from the times of IMT and he was still able to record water levels. Thus seepage and leakages losses were not accounted for downstream flows at middle and tail end of the system. Likewise three out of the eight cross regulators were missing which indicated that not all of them were necessary for applying rotational systems. PIS was managed with five cross-regulators.

At field level there was a combination of mechanized and non-mechanized technological artefacts being used. Irrigation practices were carried out with hand tools and water flows were controlled by soil and rocks elements. Rice transplanting and harvesting activities were not mechanized meaning that a lot of workforce, with certain level of skill, was required. On the contrary ploughing of fields and rice threshing were carried out with the help of tractors and rice threshers. Knowledge regarding institutional management was raised during IMT process yet farmers acquired farming and irrigation knowledge through family and cultural practice. In this sense *Tharu's* irrigation tradition played a primary role as they still were widely present in PIS. A description of skill is difficult to develop as farmers were not aware of having it or are unable to explain it.

Labour was organized through a structured hierarchy established by the WUA. Users were informed (by branch committee secretary and chairman) of irrigation schedules and water allocation through meetings at branch canal level. The staff in charge of Maintenance practices was appointed by the Branch Canal chairman. The chairman and the secretary were the persons in charge of supervising these tasks as well as operating branch canal gates. External labour workforce played a role as many farmers relied on external workers to carry out farming practices.

Farmers didn't calculate the water required by their crops as they relied on the committee for this. Hence water requirements estimations were centralized by the WUA. The WUA was in charge of setting the irrigation protocol, schedule and quantifying water allocation. However in practice, water users tried to optimize their irrigation service as far as possible, namely reaching saturation points in soils. In this regard I have little evidence to prove it as it is complicated to extract qualitative data, and especially of this nature (data that implies that equitable water sharing is subject of farmer's will). In this sense if would be better to have witnessed irrigation service during spring season and record water delivery procedures. This speaks of the importance of carrying out the field work both at irrigation and non irrigation seasons.

Groundwater resources were used to fulfil extra water requirements. Far from being a enervating factor for the system, it helped to accommodate additional water demands in water scarcity periods. Well owners did not use this resource to escape from institutional commitments. Moreover groundwater use encouraged collective action among farmers in the sense that they had to get together to afford expenses. It also gave access through water markets to small farmers who were unable to purchase a pump or dig a well. Additionally, it provided more flexibility in irrigation practices as the resource could be used any time while canal water was subject of scheduling.

Recalling the conceptual ground of technology as means to achieve needs, we could look into the technological history to illustrate how perceived needs are the main factor of technology. Resettlement policies and "planned" development were the main thrust of migration in Chitwan, and subsequently in PIS. Migrant communities sought to settle and develop agriculture as means to live. Hence irrigation was vital in order to assure agriculture, and thus their livelihood. As a consequence rehabilitation programmes were welcomed, as they were seen as the best approach to expand the command area. The DOI also played an important role as its office was established in the 1950s, thus they had to prove their effectiveness in carrying out irrigation projects in order to fulfil national demands (Chitwan was envisioned as the food basket of Nepal). For this reason "modern" technology was introduced in PIS bringing along new patterns of resource use. Therefore the perceived need was expansion of command area and productivity. However as the time passed the technological intervention prove to be insufficient. Far from being a solution, PIS started to be a problem due to poor ISF collection, high costs of O & M and unachieved target goals (namely irrigated area). In the 1980s and 1990s there was a shift in management practices approaches forwarded both at national and international level. The new strategy was called IMT, the solution to low performance and a measure to empower water users. Training programmes taught farmers how to manage their water institution. Knowledge appeared to be necessary to manage PIS through a WUA. Thus needs changed, it was necessary to hand in the irrigation system to farmers. In exchange, agencies and donors would invest in infrastructure (technological artefacts) and render it to official irrigation institutions which represented farmers, WUAs. Once again a perceived need conducted a technological intervention. All in all, needs were perceived from a top approach, undermining water users necessities and past irrigation culture. This can be related, as we will see in the next chapter, to performance in its various scales, specially at household level.

Chapter 5

Focus 2:
Performance in PIS

5 Focus 2: Performance in PIS

This chapter addresses the second part of the research focusing on the performance of PIS. The data presented here was gathered through a field survey, WUA records and studies on PIS. The chapter is structured starting from system scale performance narrowing down to water user scale performance. Later WUA records and other literature data is revised and compared with the survey results. A sub-chapter is dedicated to farmer's perception of performance. Finally the last part analyzes the data presented and links technology and performance to end up with conclusions on the data presented in the chapter.

The analysis of performance follows the scaling order defined in the conceptual framework; this is, from system level to water user level (farmer's perception of performance). The fact that water user level performance is at the end of the chapter doesn't mean that is the less important, rather it is of interest to scale down on all aspects of performance to have a holistic view of what was the situation in the field, and from there approach the concerns and priorities of farmers. The way farmers perceive performance is the main entry point to analyse the link between the two research focuses, hence it is of primary importance to highlight its significance.

5.1 **The Survey**

A survey was carried out in order to collect data regarding system performance. Five branch canals (BC1, BC2, BC5, BC7 and BC8) covering the head middle and tail end of the system were selected. Ten shareholders of each branch were selected randomly. This was done using a list, provided by the WUA chairman, of every branch canal. All water users from each branch canal were catalogued with a number and a statistical programme (R) was used to generate the selection. A questionnaire was the method to gather the data (see annexes). In total, fifty questionnaires were collected. As many farmers own more than one plot, it was difficult to have a selection which was representative of the head, middle and tail parts of each branch canal. Similarly I considered of interest to have a random sample per branch canal in order to collect average figures of caste, household composition, plot size, etc. The selection of five branch canals, from the head middle and tail end of the system, was opted so as to ensure the survey's correlation to the entire system.

Some of the farmers selected were difficult to approach. Because many had part time jobs or were abroad, additional selections had to be made. I envisioned the survey as a way to estimate farm expenditure and related to household performance. However, during the questionnaire collection I realized it wasn't the best approach. The questionnaire took long to fill in as farmers had to remember lots of information about how much did the spent and in what way. In addition, I designed the survey taking into consideration production and economic matters. Yet, agricultural practices weren't aimed to cover these needs. As I will point out further on, subsistence matters were of a bigger concern to farmers. Nevertheless I was surprised how farmers, even those who were old, could reckon all the issues questioned like yields, economic expenditure, water delivery, etc.

5.2 Irrigation system scale performance

Firstly figures pertaining PIS as a whole are explained below. The data is presented per branch canal studied and with average figures for the entire system.

5.2.1 Average plot size and shareholding size

The table below illustrates the average irrigation shareholder size and plot size per branch canal. Shareholder size is the total land surface that each water user had registered in PIS (this is, the compound of all plots owned within the irrigation system). Plot size is the land surface per plot (as in the cadastral system). Obviously plot size is smaller as many farmers had more than one plot.

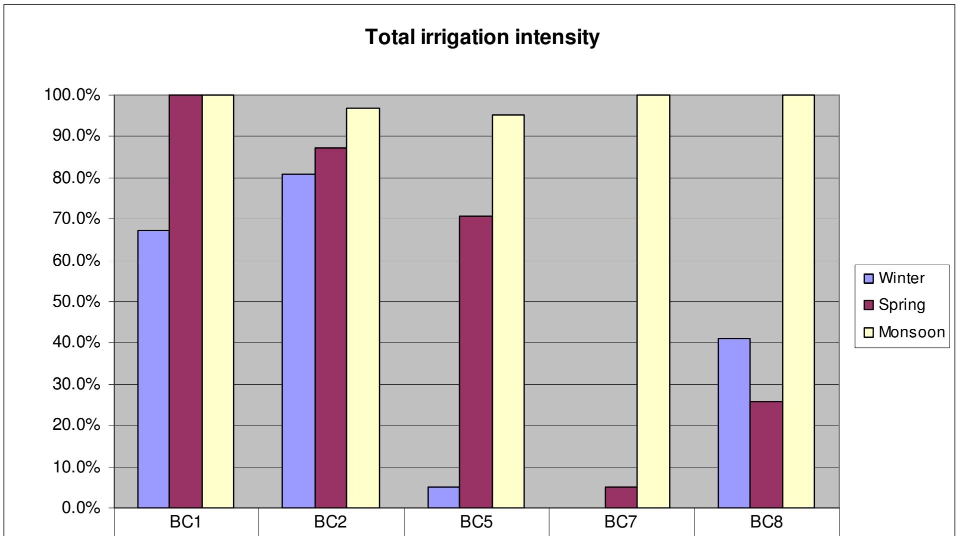
	BC1	BC2	BC5	BC7	BC8
Average shareholder size per branch canal	0.53	0.84	0.49	0.52	0.41
Average plot size per branch canal	0.38	0.36	0.32	0.31	0.37
				Average shareholder size	0.56
				Average plot size	0.35

Table 4: Average shareholder and plot size per branch canal and in average (figures in hectares).

Plot size remains constant whereas shareholder size varies among branch canals (especially in branch canal 2).

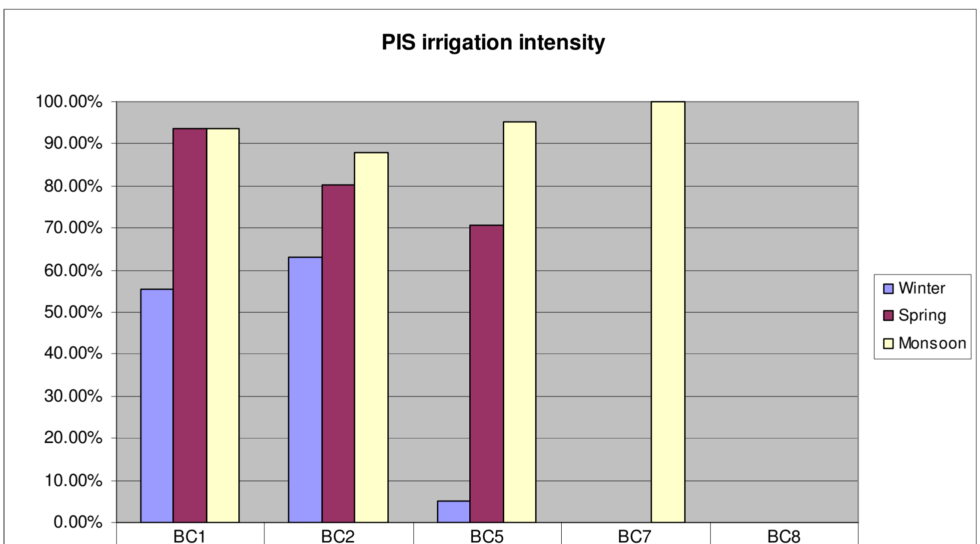
5.3 Irrigation Intensity

Irrigation intensity is regarded as an indicator of an irrigation system performance (Adhikari et al. 1999). I have made segregation between irrigation intensity of canal and ground water (Total irrigation intensity Figure 7) and irrigation intensity of PIS meaning only canal water (Figure 8). Similarly, the compound of the two graphs is presented in Figure 9. The percentages are calculated supposing three cropping seasons per year. Note how PIS irrigation intensity drops as we go to mid and tail end branch canals. This reduction of irrigation intensity is especially acute in winter and spring seasons.



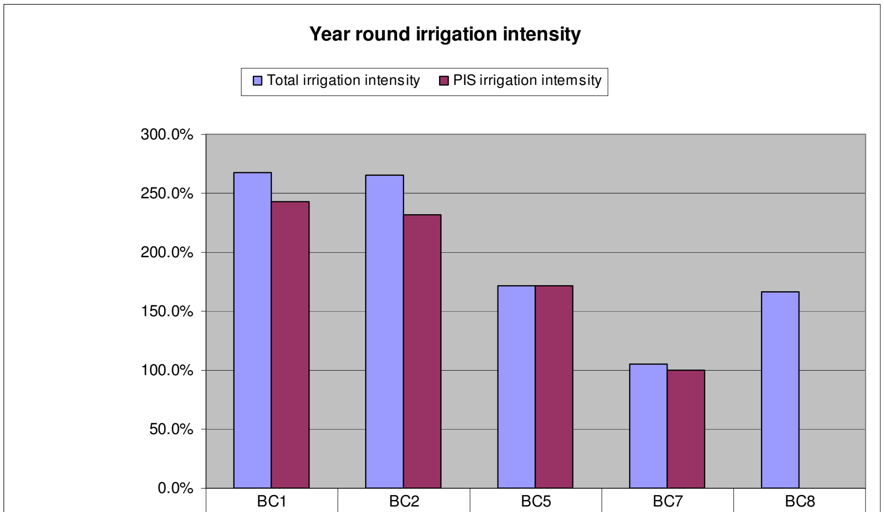
	BC1	BC2	BC5	BC7	BC8
Winter	67.2%	80.8%	5.2%	0.0%	41.0%
Spring	100.0%	87.3%	70.7%	5.2%	25.8%
Monsoon	100.0%	96.9%	95.3%	100.0%	100.0%

Figure 7: Total irrigation intensity



	BC1	BC2	BC5	BC7	BC8
Winter	55.35%	63.21%	5.20%	0.00%	0.00%
Spring	93.71%	80.15%	70.70%	0.00%	0.00%
Monsoon	93.71%	87.95%	95.30%	100.00%	0.00%

Figure 8: PIS irrigation intensity



	BC1	BC2	BC5	BC7	BC8
Total irrigation intensity	267.2%	265.0%	171.2%	105.2%	166.8%
PIS irrigation intemsity	242.8%	231.3%	171.2%	100.0%	0.0%

Figure 9: Year round irrigation intensity

At the tail end of the system, BC8, irrigation was sustained by groundwater resources with no use of canal water in BC8. Irrigation intensity decreases sharply from the head to the tail end of the system as fallow land in spring is a common practice in BC7 and BC8. I interpret it as farmer's strategy to optimize time and resources. It may also increase yields during monsoon as there is no repetition of rice crop in the cropping pattern (decreasing soil stress). In this sense PIS is not performing adequately as irrigation intensity is not evenly distributed throughout the system.

5.3.1 Waterlogging

Waterlogging is an issue that can affect severely agricultural performance (Chambers 1988). When questioned, 28% percent interviewees declared to have some problems related to waterlogging in their fields. Farmers suffering from waterlogging were evenly distributed throughout the system. Out of the 28% percent, 64% didn't have any drain. The average area affected was of 0,3 ha (per farmer with waterlogged plots). Likewise 68% declared to have drains in the field to tackle excess of water. Soil drains were the common method used whereas some farmers responded to have pipe drains.

5.3.2 Leadership

I included leadership as another aspect of performance as I consider it indirectly influences performance. In my view, a leader who is accountable and respected by farmers inspires confidence and security among them. Hence farmers encouraged to carry out their agricultural practices under this umbrella.

All farmers interviewed affirmed to know the PIS WUA chairman. Interviewees answer unanimously positive when inquired about the chairman's leadership. Apparently he was accountable to most water users (96% of interviewees). Even those who were not using PIS canal water service (BC8) considered him in positive terms.

5.4 Plot scale performance

The following section narrows down to field level performance. Most of the aspects addressed deal with agronomical aspects of performance in which irrigation plays an important role. The data presented below has been categorized as plot scale performance as they involve farm management activities such as cropping intensity, crop yield, cropping pattern, chemicals applied and ground water use. Similarly farmers were inquired about their major problem related to farming activities.

5.4.1 Crop Yield

Cropping yield has been used as an indicator of agricultural performance by agricultural engineers over the last decades (Chambers 1988). I have witnessed this approach as I was taught in this discipline during my higher education (Agricultural Engineer). Hence I have included it in the study. Cropping yields entail multiple factors, but water requirement of the crop is an important aspect in water demanding crops like rice (it is estimated that 5000 litres are necessary to produce 1 kilogram of rice). Yields presented below were calculated over the common crops harvested in winter spring and monsoon periods, namely mustard, wheat and lentil in the winter; spring and rice in the spring; and rice in the monsoon season.

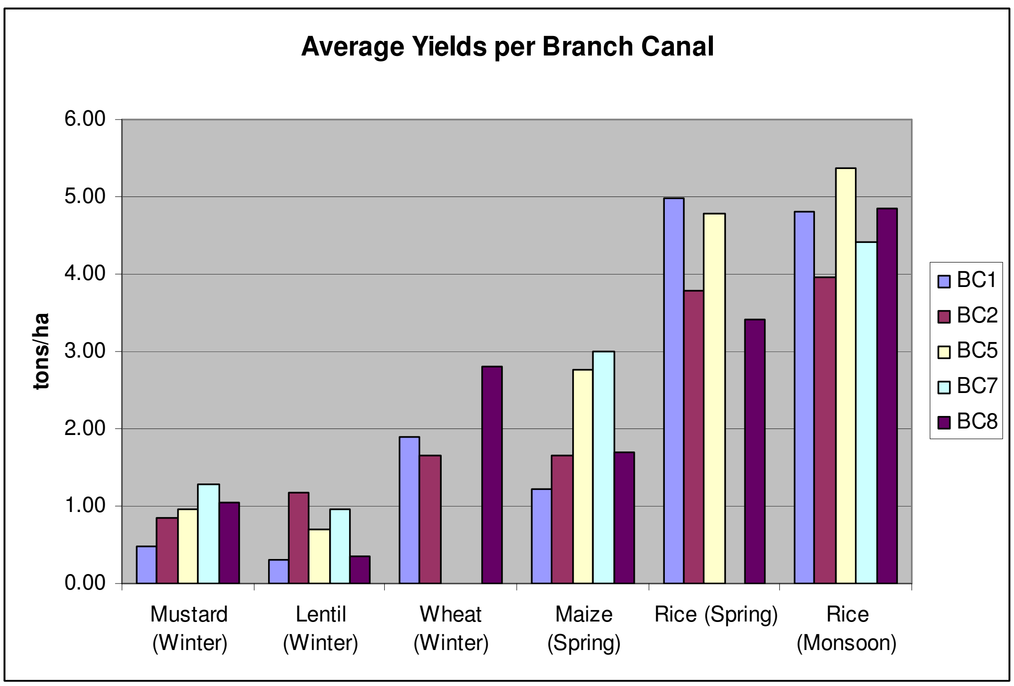


Figure 10: Average yield per Branch Canal

Rice varieties commonly used were BG, Mansuli, Sabriti and Hardinath, are all included in one category "rice" as no differences were observed amongst them. Note that average rice yields vary from 3,4 to 5.4 tons per ha. No apparent decrease in yields amongst branch canals was recorded .

Total average crop yields is presented in Table 5.

	Winter			Spring		Monsoon
	Mustard	Lentil	Wheat	Maize	Rice	Rice
Total average crop yield (tons/ha)	0.93	0.69	2.12	2.06	4.25	4.68

Table 5: Total average crop yield

As for Maize, hybrid and local varieties were the preferred varieties of PIS farmers. Lentil and mustard were grown in winter adding an extra input for households since oil was extracted from mustard and lentil was consumed in the daily diet. Studies point out average rice yields between 3 and 4.5 tons per ha for Nepal (A. Regmi et al. 2009)(Fujisaka et al. 1994)(Upadhyaya et al. 1993). The survey average yields were thus high if we compare them to the ones in literature. In my view, agro-climatic conditions as well as water allocation strategies are the causes of high yields.

5.4.2 Cropping intensity

Cropping intensity indicates the number of times a crop is grown, expressed in percentage, supposing three cropping seasons. It gives an idea of both irrigated and non-irrigated agricultural activity.

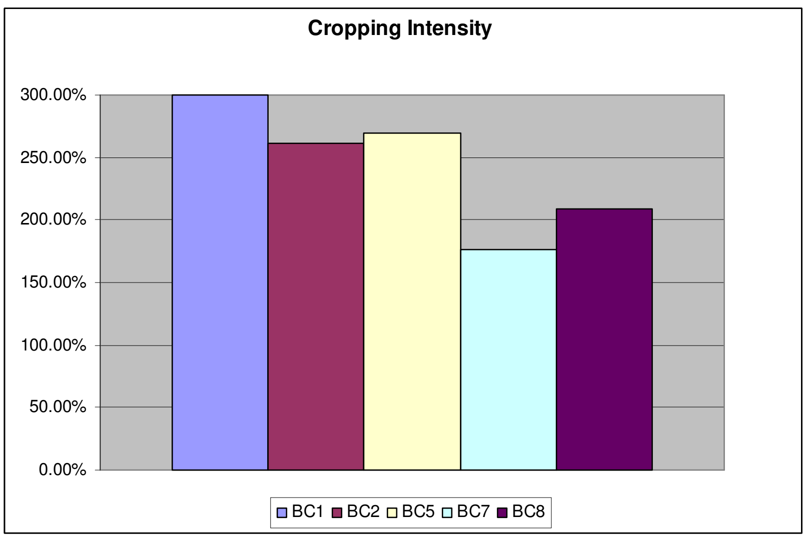


Figure 11: Cropping intensity PIS

Similarly to system level figures, cropping intensity decreased at middle and tail end of the system. The average cropping intensity for the whole system was 243.27%.

5.5 **Cropping Pattern**

The cropping pattern sheds light on the choices and preferences of farmers. These choices bring along specific agricultural practices farmers have to deal with. Moreover, they illustrate how they prioritize their preferences and thus needs. With proper irrigation service it is possible to have three cropping seasons. The common cropping patterns followed by farmers are given in the figure below.

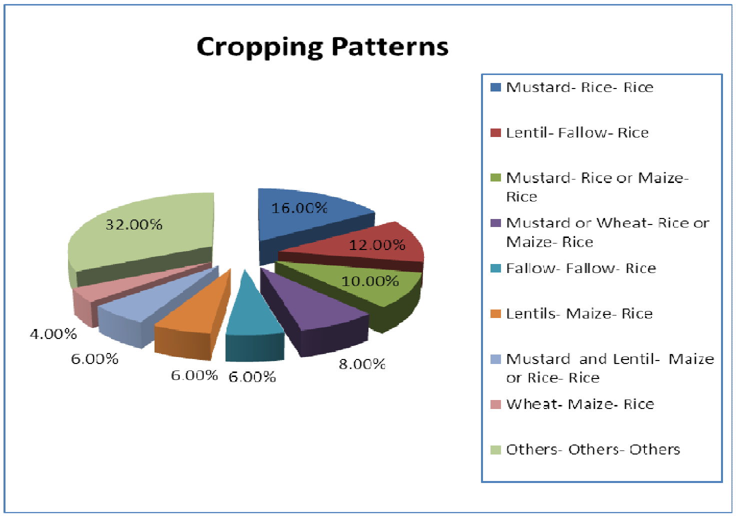


Figure 12: Most common cropping patterns in PIS

The table shows multiple combinations of cropping patterns with relatively few crops (namely: rice, mustard, lentil, maize and wheat). Nonetheless rice was always chosen as the monsoon crop. The legend indicates the pattern followed starting by the winter crop, and subsequently spring and monsoon (cropping seasons separated by dashes). I have made this segregation as all farmers sow and harvest in the same periods. Winter season starts in mid-November until mid-March. Spring season spans from mid-March to mid-July and Monsoon season bears from mid-July to mid-November. These dates are not fixed as some early varieties can be harvested several weeks beforehand. Normally, rice varieties sown in PIS have a life cycle of 120 days.

It is noticeable how farmers tended to vary from year to year their cropping pattern, altering winter or spring crop among two options (rice and maize in spring or mustard and lentil in winter). Moreover farmers without access to irrigation service in spring leave their plot as fallow land. Generally speaking the standard crops in winter were mustard, lentil and wheat (this one not so common). For spring season rice and maize were the preferred options (excluding fallow land as an option). Finally rice was unanimously chosen as the monsoon crop.

5.5.1 Farm Management

This section will describe agricultural inputs used in the field and the current situation of crop marketing[35] one by PIS farmers.

Manure and chemical fertilisers were generally used by farmers throughout the system. They were normally applied each season for each crop. Some farmers had manure from their own livestock while others purchased it or recurred to chemical fertilisers. Pesticides were also applied, especially for rice. For winter crops mustard was normally treated whereas lentil was not. Herbicides were widely used for rice crops in order to clear weed excess.

[35] I refer to crop marketing as the sell of extra production in the local market. This differs from commercial farming in the sense that the primary objective is not economic, rather household food coverage with an additional revenue from extra production.

I made an attempt to calculate farm expenditures and profits per farmer. However it was meaningless as many farmers keep substantial amounts of their crops in order to cover household needs. Hence in many cases profits roughly cover the expenditures or were not even enough to cover them. Moreover the market situation in Chitwan was not ideal as national or regional strikes were common (know as *bandhas*) making this market unreliable. Thus perishable goods were a risky choice as they could not be distributed right after harvesting. In addition, a government agricultural official declared "there is a marketing problem rather than a market problem" admitting a market constraint for Chitwan district. Hence, according to this view, farmers were discouraged to make other cropping choices. If we approach the market situation from a security perspective, we can describe why farmers did not practice commercial farming. Farmers perceived the market as unreliable, thus cash crops were seen as a high risk possibility. Alike, they prioritized household needs (meaning food) rather than economic revenue. I had the impression that many farmers perceived commercial agriculture (cash crops) as difficult and laborious. Hence the market situation didn't encourage this option, rather discouraged it.

5.5.2 Ground Water Use

Ground water use was extended widely throughout PIS. Therefore the survey gathered data regarding well - and pump ownership as well as ground water "markets".

From all the questionnaires completed, 36% of interviewees declared to own a well. Out of this 36%, 16% declared the well was shared with other farmers. On the other hand, 54% of interviewees stated to own a pump. This figure is higher than the former as some farmers, especially in BC8, pump water from streams or a river near the tail end. There was a pump that was purchased by 35 water users in BC8 which extracted water from a well. Other farmers from this branch canal extracted water from the river using also a common pump.

From all well owners, 44% acknowledged to sell water to other farmers. From all water users without access to a well or a pump, 44% recognized to buy water from other well owners in times of high water requirements. Alike, 35% of interviewees who did not own a pump declared to rent one in times of high water requirements for the crops.

5.5.3 Farming problems

Problems faced by farmers in their daily farming activities give hints of system's inefficiencies or farmers concerns about its functioning. The main farming problem revealed by farmers was strong competition for water (54% of interviewees). Plagues and diseases were also are a concern for 44% of farmers inquired. The third main problem was low quality and increasing prizes of seeds (10%). There are other difficulties stated as low quality of fertilisers (8%), lack of labour (4%), environmental problems (4%) or wildlife (2%). Out of all interviewees, 6% declared to not have any type of problem related to farming activities

5.6 **Household scale performance**

An irrigation system can be analysed from a household perspective adding another level of performance analysis. The data presented below address household composition in terms of members and age, cast distribution, additional incomes apart from farming practices, education levels and food needs coverage.

5.6.1 Household Composition

The average household composition was of 7 members per household. From the 50 households documented, 22 (44%) had members under the age of 18. In these households the average non-adult (under 18) composition was 2 members. The average adult number per household was 6. Normally the elder males were the head of the households. However in four households (8% of total), the females were in this position. This was due to death of husband or because he would be working abroad. The heads of the households were always the respondents of my questionnaires as they were in charge of decision making related to agricultural management issues.

5.6.2 Caste Distribution

The caste composition in PIS is characterized by two main castes, namely *Brahmin* and *Tharu*. However *Chetri, Darai* and *Newar* were also identified in the survey. The biggest caste group is *Tharu* summing up 46% of the total. Nevertheless, none of these *Tharu* identified themselves as *Tharu*. Instead, they recognize themselves as *Rajphut* (86.9% of all *Tharu*), *Rahut* (8.7%) and *Dutput* (4.4%) I learnt from my interpreter that they were *Tharu* groups. Also their characteristic households (houses with mud walls and straw roofs) and ethnic features gave hints of their caste. The average shareholding size of *Tharus* was 0.51 ha.

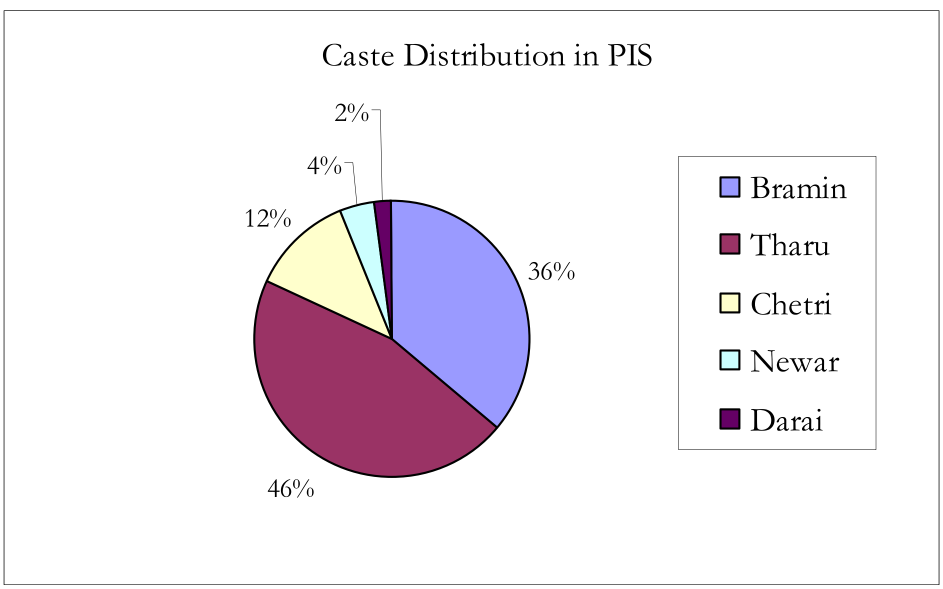


Figure 13: Caste distribution in PIS

Brahmin was the other big caste group in PIS. They counted up to 36% of the total. Their average shareholding size is 0.66 ha[36], the biggest in the whole system. The other three caste groups identified were *Chetri* (12% of all PIS) and *Newar* (4% of all PIS) and *Darai* (2% of all PIS). Their average shareholding size was 0.32, 0.74 and 0.57 ha respectively. I have excluded *Newars* and *Darais* as the groups with biggest shareholder sizes as only two interviewees were identified as *Newars* and one as *Darai* making this measure statistical not significant[37].

5.6.3 Alternative Incomes

Given the average plot size in PIS, many farmers had part time jobs apart from agriculture in order to meet basic/ economic needs. From the figures obtained, most of farmers had an additional source of income in the household, namely 74% declared to have another job or receive another source of income. Out of this 74%, 72,2% had a salary (employed in another job) as additional income, 16.7% had a private business, 8.3% earn some income through dairy farming, 2.8% earn a pension and the remaining 2.8% earn some extra money working in the fields (agricultural labour).

5.6.4 Education

I have used education as an indicator of household performance given that Nepal had a literacy rate of 56.5% (IFAD, 2010). All the interviewees corresponded to the head of the household at the moment. The literacy rate among them was of 63.3%. From the remaining 36.7%, 20.4% recognized to be completely illiterate while 16.3% stated to know “a little bit” how to read and write. Most of interviewees were elder people or passed their 40s.

The rate of school-going children under the age of 18 was of 97.8%. I observed multiple schools and uniformed students attending classes within the boundaries of PIS. Alike, nearby towns (*Bharatpur* and *Narayangar*) had multiple colleges and schools.

More than half of the households (51.3%) with sons or daughters over the age of 18, sent at least one of their members to University.

5.6.5 Food requirements

As most farmers in PIS practice subsistence agriculture, the survey included food necessities and its coverage in PIS in the performance analysis. This was a sensitive issue (many farmers were reluctant to recognize food scarcity in their households) and the question had to be adjusted during the survey. In first place farmers were inquired about food scarcity periods in the household. All of respondents stated to no suffer from food scarce periods throughout the year. Hence the question was modified, asking if the harvest of crops and the profits obtained from them were enough to cover food needs in

[36] Brahmin were not the caste group with biggest mean shareholding size. Yet I have concluded to exclude the biggest shareholder size caste group, *Newar*, following statistical criteria. See further explanation at the end of the paragraph.

[37] It is not adequate to compare averages made of 20 random selections with one selection, and extrapolate results.

the household. Out of 33 (the first 17 were interviewed with other question) interviewees, 20 (60.6%) answered positively. The rest differed by saying that they needed another source of income to meet food requirements.

5.7 Farmer's perception of performance

Performance is a concept prone to multiple interpretations. It is of high interest for this research to analyse in which way farmers value irrigation performance. Svendsen & Small (1990) proposed a framework to assess farmer's perception of performance. This framework follows a criteria based on some indicators. These are categorized in three groups: depth related measures (adequacy, equity and timeliness), farm management related measures (tractability, convenience and predictability) and water quality related measures (temperature, sediment content, salt content nutrient content, toxics and pathogens). I have selected, as criteria in the survey, the first two groups including a question about conflict in water sharing. The results collected here are purely farmers' considerations about these indicators. This criterion was chosen as an entry point to farmer's perception of performance. The complexity of the this concept drove me to analyse these indicators, informal conversations and personal beliefs in order to come up with an idea of the priorities farmers have to assess performance.

Water quality related measures were unfeasible to include in the study as I didn't have the means to collect such data. Water users not receiving irrigation service (BC8) were excluded from these questions as they could not answer these questions related to irrigation service.

After addressing these indicators, I will formulate what in my opinion is the major parameter farmers apply to judge performance in PIS.

5.7.1 Adequacy

Adequacy is defined as the amount of water delivered to a field with a certain depth. The questionnaire was filled asking to farmers if they considered the amount of water received per season was enough. The Figure 14 shows the results obtained.

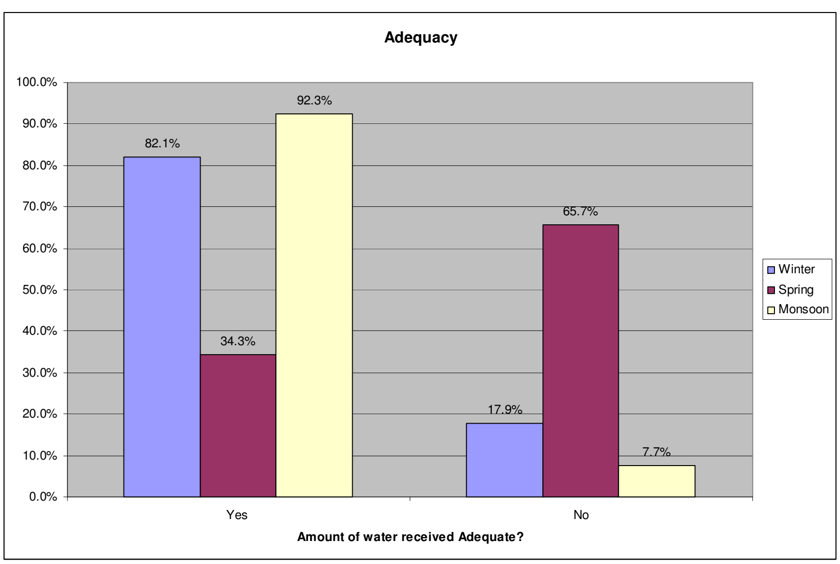


Figure 14: Adequacy satisfaction in PIS

During winter and monsoon seasons most farmers (82.1% and 92.3% respectively) farmers considered to have enough water for their crops. As for spring season only 34.3% considered to have sufficient water service.

5.7.2 Equity

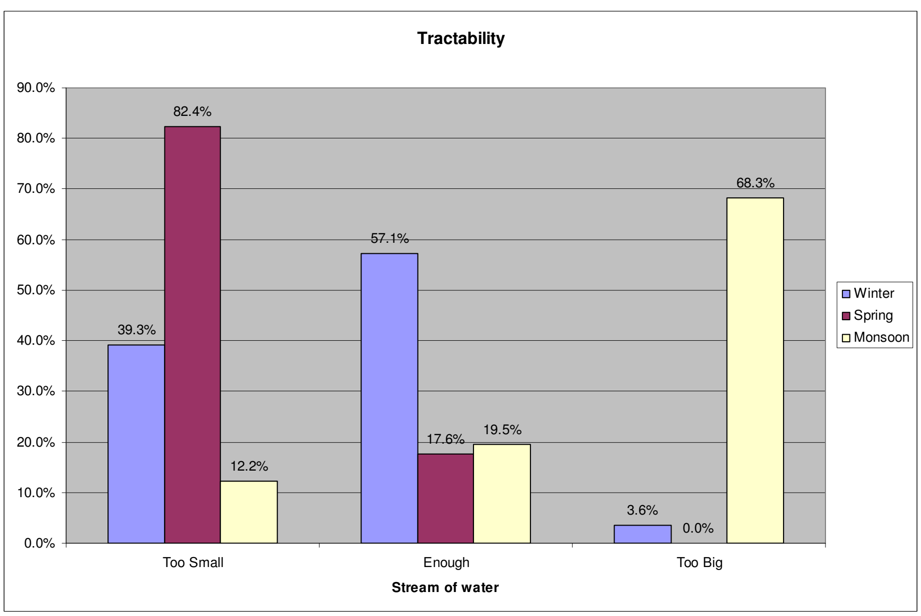
Equity is another important aspect of irrigation performance, especially if take into account a system managed by a WUA (more accountable for farmers) and not an external agency. Among all respondents, 92.7% believed to receive the same amount of water as the rest according to irrigation turns.

5.7.3 Timeliness

Timeliness refers to water distribution when required by the crop. Irrigation service can be enough in volumetric terms, predictable for the farmer or equitable but if water doesn't arrive at the moment crops need it, it can have a negative impact on crop yields. In this regard, 31.7% affirmed to receive water service at proper times for their crops whereas 58.7 % responded negatively and 9.8% stated water service was seldom on time for their crop needs.

5.7.4 Tractability

Tractability is understood as the volume of stream of water delivered at plot level. If the stream received is inappropriate, the irrigator may encounter difficulties in distributing water uniformly on the field. The results obtain through the questionnaire are presented on the figure below. Water users were questioned on this issue following three criteria on volume of water stream, too small, enough and too big.



During spring season, when water competition is strongest, the majority of water users considered the stream water delivered too small and during monsoon season too big. Only during winter the stream seemed to be with the adequate water depth.

5.7.5 Convenience

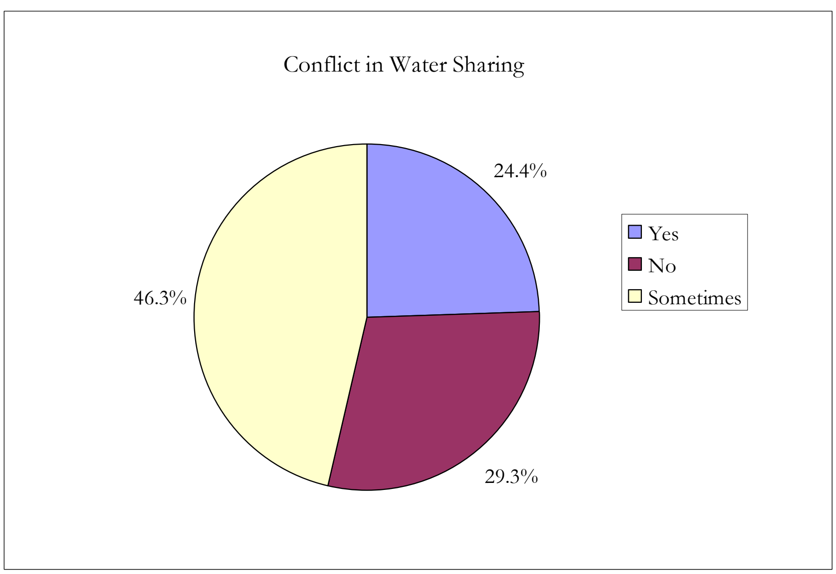
Convenience is a term related to suitability of entry water service in a farmer's field. If the shareholder has part time job and water is arriving when he is working, the service would be inconvenient. In this regard 46.3% of interviewees assured to receive water service at convenient time. This included night irrigation.

5.7.6 Predictability

Predictability is an indicator of the accuracy of an irrigation system to deliver water according to the schedule proposed, and is thus predictable. Once more, the questionnaire had to be modified as all farmers assured that water delivery followed the routine the WUA planned (first 17 questionnaires). The question was modified enquiring if they knew when they would receive the water. The resulting percentage was 50% answering positively (out of 24 respondents). There were 9 respondents which didn't receive irrigation service at all (all in BC8).

5.7.7 Conflict in water sharing

Conflict among water users can arise as a consequence of multiple reasons. It can be understood as a "limitation" of an irrigation system. Water users were questioned about conflicts in water sharing. The results are given in the figure below.



In this case the minority of respondents answered to not experience any type of conflict regarding water sharing (29.3%). The majority of interviewees assured to suffer occasionally conflicts (46.3) while 24.4% were certain to bear conflicts during irrigation periods. In most cases, the nature of conflicts was on water turns. Those with plots at the end of the turn had problems with water delivery. Some farmers declared when water delivery was not on time, they had to go upstream to allow the flow (opening closed gates or removing soil or sticks that could block the stream) into their fields. Afterwards they complained about finding the water flow blocked again. Moreover farmers were heavily dependant on crop choices of upstream farmers. If a farmer with the plot at the end wanted to have a crop with a high water requirement than those upstream, he or she would have to convince the upstream farmers to have the same crop choice or dig channels in their fields in order to allow the excess of water flow into their fields. Farmers of surrounding plots[38] normally negotiate crop choices so that all water requirements are similar.

5.7.8 An interpretation of farmer's performance

Based on the previous information and from formal and informal conversations with farmers, I tried to understand how farmers perceive performance. At personal level farmers want to cover household needs, thus assuring rice crops was critical specially in monsoon season. Therefore strategies to secure water had this primary objective. Farmers normally sow rice in a small nursery garden besides their households. Afterwards when the seed germinated and there was a stem strong enough, rice was transplanted to the field. It was in this moment when irrigation service was critical as the transplanted rice had to be placed in a saturated soil. If this was the case the success of the crop was very high. Hence their concept of system's performance was based in this specific water delivery.

If we scale up and take into account PIS as structure involving water users, the perception of performance shifts. Bearing from this scope equity was the underlying concept for a PIS farmer. Collective action was implemented (through customary irrigation practices) extensively several decades ago (if not centuries). Therefore there was a wide perception of being part of a community linked to the resource. As water users now are in charge of managing the system they tried to do it in the most equitable way. This was an idea picked up with all committee members. The statement: "everybody should receive the same amount of water" was a recurrent phrase spoken by MC members, branch committee members and standard water users. As no external agency was accountable for system's management, water users internalized the responsibility to distribute, and right to receive irrigation service in the most equitable way.

5.8 **WUA figures and comparison**

The chairman of PIS WUA provided me with multiple records of the irrigation system. These records were the compilation of ISF collection (which were kept exclusively for PIS) and irrigation demand forms of every branch canal and outlet. The following figure illustrates the total shareholder area and crop documentation over the last ten years. Recalling, the ISF was calculated based on surface under irrigation and crop. Hence the

[38] In this regard in many cases neighboring farmers are relatives as land is normally inherited evenly among male descendents. Thus a plot can be divided into equal parts.

WUA was able to estimate the surface of each crop (namely, monsoon and spring rice; spring maize; wheat, vegetables and other crops for winter).

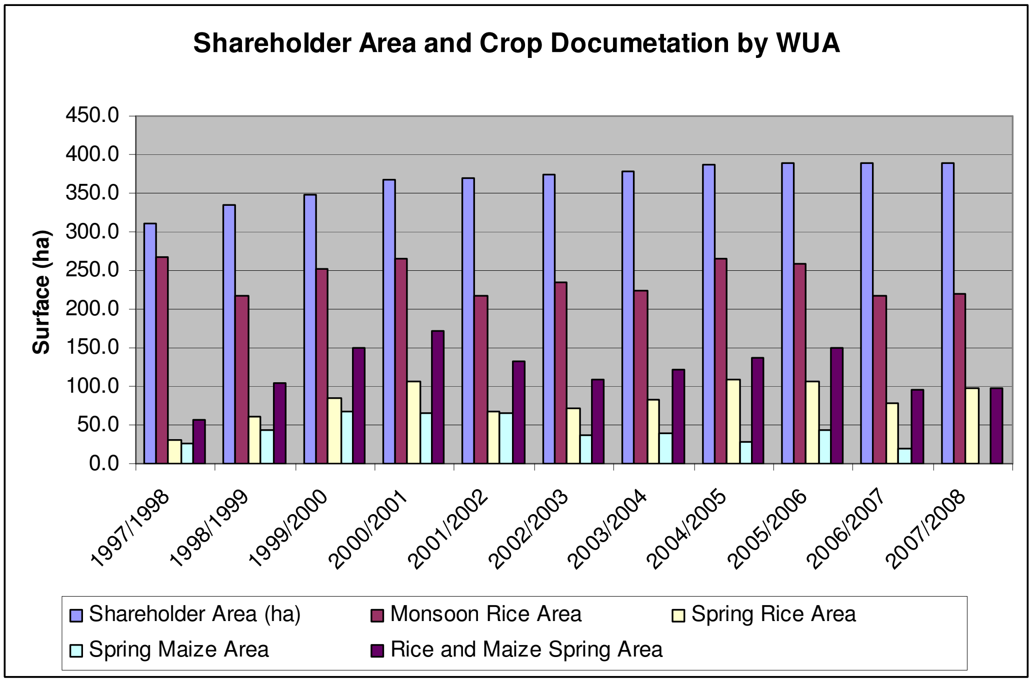


Figure 15: WUA Records

Analysing the previous figure, there has been an increase over the last ten years of shareholder area. From 1998 onwards (when IMT process got to its end) there has been a steady increase of 77.7 ha (from 311.7 to 389.4 ha) in shareholder area. However if we count monsoon rice as an indicator of the command area (100% of water users plant rice during monsoon), we can observe that it didn't increase. The area provided with irrigation service by PIS monsoon has been fluctuating between 266.4 (1997/1998) and 219.4 ha (2007/2008). If we pay attention to irrigated area of PIS (assuming the only crops are rice and maize) during spring we can observe it has been fluctuating between 56.4 (1997/1998) and 172.47 ha (2000/2001). The last record accounts 97.7 ha of irrigation service during spring. In this sense I recall how ground water resources played a primary role on increasing PIS command area.

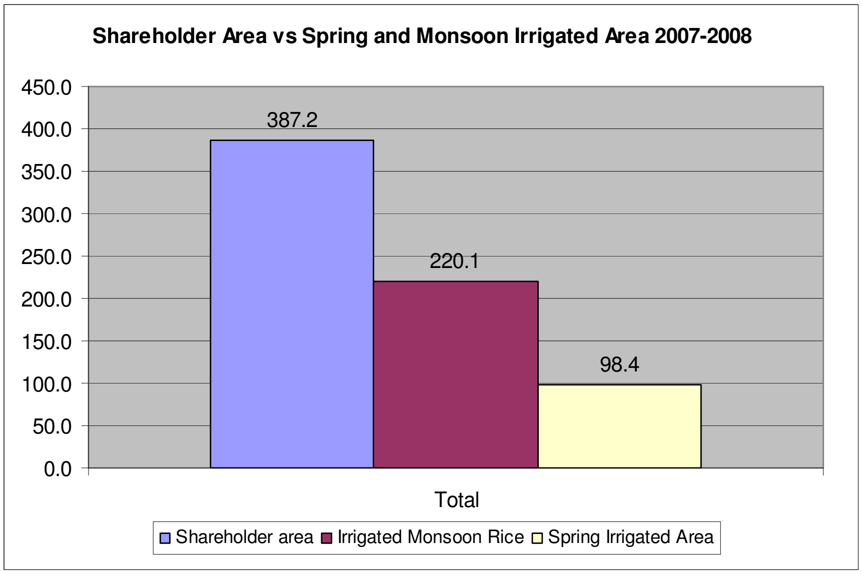


Figure 16: Shareholder Area vs Spring and Monsoon Irrigated Area 2007-2008

The figure above illustrates the comparison between shareholder area, irrigated monsoon area and spring irrigated area. There was a gap of 167 ha between the shareholder area, this is, the total area that contributes with ISF; and the irrigated monsoon rice (area equal to collected monsoon rice fees). This may indicate either a deficit in fee collection or a sharp difference in command area (shareholder area) and irrigated area. This gap was even bigger in during spring season (288.8 ha) For detailed differences among branch canals and outlets see Figure 17. In practice, BC8 doesn't account as irrigated area. Major differences are observed in BC1, BC5, BC6 and BC7.

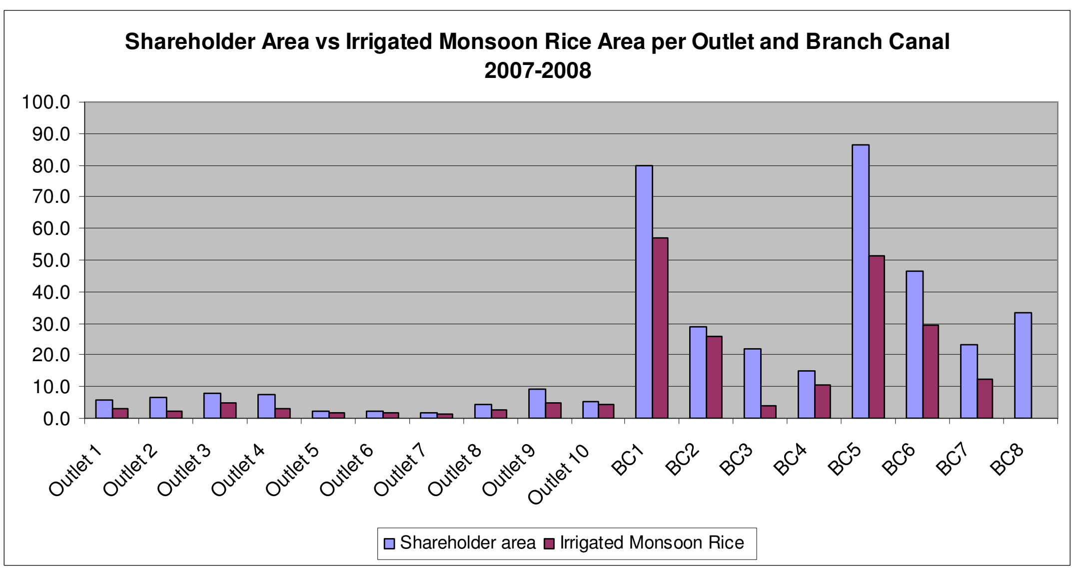


Figure 17: Shareholder Area vs Spring and Monsoon Irrigated Area per Outlet and Branch Canal 2007-2008

5.9 **Analysis**

All the data exposed in this chapter illustrate how PIS was performing in different seasons, at different levels. At system's level the findings suggest that plot size was relatively small. The average plot size (0.35 ha) speaks already of how heavily dispersed the command area was. Per shareholder the figure increases to 0.56 ha. Shareholding size decreased since the IMT, which was 0.67 ha (ICON 1996). This could be caused by inheritance as land was divided among all sons of the family. Another reason could be land market transactions. I could witness how land purchasing was carried through several brokers, without any legal endorsement. In some cases there were two or three intermediaries between the buyer and the seller. This is one of the reasons of increasing prizes of land in PIS.

Irrigation intensity was unevenly distributed throughout the system. At tail end branches irrigation intensity decreased severely, even more if we count only PIS irrigation service. Ground water resources and the subsequent ground water market emerging played an important role in accommodating water requirements with better water availability at the tail end.

At plot level there was high yield average throughout the entire system (for rice yields comparison see (Upadhyaya et al. 1993) and (Fujisaka et al. 1994). Similarly the average cropping intensity was also high (243.3%) with more than two crops per year. Cropping patterns are basically similar with variations among few crops but maintaining the same structure. Farmers did not try with other ones as they had to assure household needs and there wasn't a safe market to rely on. Also commercial farming entailed more work input, investment and knowledge. There was an extensive use of groundwater resources and groundwater market throughout PIS. This served as thrust in system's performance as it complements extra water demands and accessibility. If we look into farming problems competition for water was the main concern of water users. The encroachment of the spring source was regarded in many cases as the main cause. However one third of water users (34.3%) stated to have enough water during spring season. This could be due to the belief of limitations of water supply.

At household level, the data disclosed a standard household size of seven members. Household members under 18 were sent to school (97.8%) improving literacy rates of previous generations (63.3% of head of household members are literate). In this regard Chitwan district encouraged literacy as the access to schools and colleges was ample. In my perspective this was a successful goal achieved through development in the district. Similarly, the conditions related to irrigation practices in PIS also helped in this regard. As most plots were of reduced size, labour force was not so high, and farming and irrigation practices could be carried out without child labour. Yet, low caste workers coming from eastern Nepal and India were still a necessary work force.

Looking into caste distribution it is observable that two major caste groups, *Brahmin* and *Tharu,* covered 82% of the total. If we take into account that *Tharus* were the indigenous population of PIS, we can observe how they have been almost "overtaken" by *Brahmins* (48% of *Tharu* vs 36% of *Brahmin* population).

The survey also disclosed that 74% of interviewees were part time farmers, which reveals that the irrigation system was unable to sustain on its own most of the households (40%

of interviewees declared to not earn enough from crop revenue and harvesting to meet food requirements). In my perspective this is a clear indicator of PIS performance in terms of household needs, taking into consideration that water users practice subsistent agriculture. When an irrigation system, independently of the causes, is unable to sustain water users needs; we have the certainty to assure its target performance hasn't been met, at least at household level. This indicates how development strategies and envisioned needs in PIS have failed in covering farmers' own necessities and thus livelihoods.

If we pay attention to the criteria set to assess farmers' performance, equity emerged as the biggest concern. Similarly adequacy was only met during monsoon. Conflict about water sharing also appeared to be an underlying struggle water users have to deal with, specially with farmers owning land at the end of the turn. This may indicate how simple technologies (field to field irrigation) may bring along certain trade offs in performance. Field to field irrigation has several strengths like no energy input, low O & M input of irrigation structures (as tertiary level doesn't exist), high agricultural productivity (relatively high yields corroborated by the survey's results) and recharge of groundwater levels (favouring groundwater extraction). However it brings along certain trade offs. Due to the fact that water users had to agree on crop choices, since surrounding fields had to have similar water demands, cropping patterns were limited. Moreover, this dependency was especially acute for tail end farmers as they were the last ones to receive water. This was one of the issues causing frictions among farmers. Tail end farmers which weren't receiving the expected (according to the agreed irrigation schedule) water service often had to go upstream and check who was blocking the water flow and discuss the issue with upstream farmers. Yet, in some cases being at the tail-end was an advantage as water arrives in any case due to seepage and percolation of upstream fields. All in all, this is an illustration of the limitations of field to field irrigation method (which is widely extended throughout the country) rather than a critique.

If we pay attention to the three figures in section 5.8 we can observe how the command area didn't reach the 600 ha the WUA claims. Similarly the irrigated area PIS provides in monsoon and spring seasons was between 220 and 250 ha and about 100 ha respectively. Hence, the target goal wasn't achieved after the IMT process. This could be attributable to the encroachment of PIS spring source as a cause of deduction in water supply. Yet, we could interpret the target goal as unrealistic as it has never been reached (not even closely). Perhaps this target goal was over estimated to justify more investments or rehabilitation programmes. In this sense the chairman declared that the WUA was studying the possibility of implementing a lift system from the Rapti River in order to increase water supply.

Chapter 6

Conclusions

6 Conclusions

This chapter will bring to a close the research study. In first place I will summarize the main findings of the information presented, with an analysis based on the concepts underpinned throughout the entire report. Secondly an answer to the research questions will be formulated, which will try to address the research objective. Finally a discussion about the outcomes of the research will end the report.

6.1 Summary

The findings described in Chapter 3 point out how the PIS functioned and what was the role the WUA plays in it. As addressed in the analysis, the WUA was an intermediary body between farmers and technology[39]. Moreover we can deduce an evolution of WUA in order to adapt to what is an institutional backbone (which was mandatory in order to carry out the IMT) to previous customary irrigation management (as well as agency management). Furthermore the IMT was the last step of a series of policies applied to the irrigation system. It supposed a thrust in the institutional capacity of the WUA, especially at human agency level. Yet, it is of interest to analyse who was interested in this irrigation management transfer. The DOI could hand over an inefficient irrigation management to water users, who in exchange got investments in infrastructure which pursued irrigated area expansion. As we have seen in the performance focus, the irrigated area is still far from the target command.

Resettlement policies in Chitwan district have brought positive and negative consequences for PIS. Firstly, natural inhabitants (and irrigators) of PIS were not taken into account in "planned" development policies. Migrant communities rapidly outnumbered local *Tharu*, which witnessed how the district was promptly developed. This caused inequitable land distribution. This reason along with inheritance customs and land transactions caused small average plot size. This led to PIS as an irrigation system where farmers had to practice subsistence agriculture, and in most cases as a part time job. In this regard household needs were not entirely covered by the irrigation system, which indicates low performance at household level. If we focus in the ethnic issue, *Tharu* community in PIS was widely present (48% of survey respondents were *Tharu*) at the time of the research in PIS. Yet the second largest caste group (Brahmin, 36%) had bigger land holding average size (0.51 ha for *Tharu* compared to 0.66 ha of *Brahmin*). Thus *Tharu* community suffered social alienation[40]. In this regard PIS development didn't help to solve it, which also speaks about the "ethnic performance" of the irrigation system. Similarly previous *Tharu* irrigation culture was undermined by policy makers and rehabilitation promoters. Yet this customary irrigation culture, symbolized in knowledge and skill description of technology, still played an important role in irrigation technology.

[39] By technology I mean the whole process that technological use implies, this is, involving artefacts, skill, knowledge and labour. This is grounded in the technographic perspective the conceptual framework describes, implying that technology involves a process where the outcome emerges as a consequence of a transformation process involving the four dimensions of technology defined, plus complementary factors (which could be social: policy, migration, market system, poverty; or asocial: agro-climatic conditions, crop varieties, water availability, plagues, etc).

[40] Etymolgy, of alienation: from latin *alienare* meaning "transfer of property".

In contrast, the development of Chitwan district encouraged high literacy rates as schools and colleges were abundant. Similarly health care services (hospitals) were also accessible and road infrastructures connected the district with Kathmandu and India. Hence the result of 60 years of development in PIS provided dichotomy in its outcomes.

The technological focus of the research pointed out several analytical results. The study has described how technology, introduced through rehabilitation programmes, stood as choices selected according to perceived needs. These choices implied not only infrastructure, but also patterns in resource use and organization. In this sense PIS experienced different technological approaches. First were *Tharu* with non permanent structures and a customary *Raj Khulo* irrigation. After came the agency with canal lining, permanent headworks and off-takes to supply branch canals. Finally, farmer managed in an IMT context with a supply based scheme based on WUA institutional capacity was the latest approach. At the time the research was carried out, the WUA was in charge of the system's management, organization and government. Water distribution was a task which was executed through a branched hierarchy structure involving different hydraulic levels (Main Canal, Branch Canal, Sub-Branch Canal and Outlet levels). At water user level, technology implied skills and knowledge acquired through "tradition". Likewise, groundwater resources, and associated technologies, played an important role in complementing PIS deficiencies. Well and pumps were means to accommodate extra water demands. Furthermore this source could be used (in most cases if there is fuel or electricity available) at demand moments not having to comply with an irrigation schedule. Additionally, well owners were able to sell water to other farmers thus expanding water supply and making it affordable to small farmers. In any case, groundwater resources weren't a source of friction between water users and PIS, rather a complement to the system. It was noticeable how farmers at the tail end of the system joined together to purchase pumps and overcome a deficient or even non-existing water service. Hence, we could interpret groundwater technology, or simply technology, as an endeavour of collective action.

Focusing in the performance analysis, the research has showed diverse results at different scales. At irrigation system scale, irrigation intensity showed irrigation service deficiencies as the last two branch canals don't receive water during spring season. In the same way the WUA records reveal a command area (387.2 ha) which didn't meet the target 600 ha goal. If we pay attention to irrigated area the value decreases considerably (220.1 ha). Thus at system level we cannot assure optimal performance levels. At plot level, average yields are relatively high if we compare them to other Nepalese systems. In a similar way, average cropping intensities were close to 300% (which is maximum if we consider three cropping seasons) in branch canals with year round irrigation service, and close 200% for branch canals with little or no irrigation service provided by PIS. In this sense groundwater resources played an important role. The main concern for farmers at plot scale was water competition (54% interviewees). This indicates how they perceived challenges related to farming activities and how they set priorities in order to tackle them. I have already discussed household performance and its relation to development policies in PIS. Yet it is important to stress the fact that in PIS, subsistence agriculture is practised. Hence, for water users the primary objective is securing rice production[41], thus they based their performance values based on this concern.

[41] As an estimation, a standard household requires 1 ton of rice to fulfil food demand for one year.

The strengths and limitations of field to field irrigation were mentioned in the analysis of performance. Trade-offs related to this type of technology were also addressed. It is interesting to stress that this type of irrigation technology is widely extended throughout the Nepal. It resembles both hill and *Terai* customary irrigation practices. I interpret it as a technological choice which water users rely on in order to secure water provision, and thus agricultural production.

Finally a division between conceptualizations of performance ought to be made. At system level WUA members were primary concerned about equity among water users. Thus this is the main indicator of good irrigation system functioning. On the other hand water users also share this view, however household needs were of higher consideration for them. Hence their perception of performance was monopolized by subsistence and securing coverage of household needs, namely food.

6.2 **Answer to Research Questions**

Following the former analysis, an answer to the research questions formulated at the beginning of the report is given. These are as follows:

- *How is irrigation technology adapted and functionalized by water users in Panchkanya Irrigation System?*

Technological adaptation by PIS farmers have been marked by a historical development of technologies introduced in the irrigation system. Over the last 60 years PIS was engaged in multiple technological interventions which shaped its relationship with farmers. At the time this research was carried out, the last technological spin-off (symbolized in the IMT process) marked farmers' relationship with technology. The presence of a WUA as interlocutor between water users and technology was an important factor in technological uses and choices. Yet irrigation knowledge referred by farmers as "tradition" still played an important role in irrigation practises. Thus there was a combination between a set of artefacts and labour related to an institutional management body, namely the WUA, and skill and knowledge still present from customary irrigation. Hence an "institutionalization of irrigation technology" in PIS is complemented by customary irrigation knowledge. The mixture between the "old" and the "new" is what in essence marked farmers technological relationship.

- *How does this influence performance and agricultural practices in Panchkanya Irrigation System?*

As concluded in the analysis, subsistence agriculture is the underlying principle behind farmers' consideration of performance. Hence technology was the way to secure water provision and thus agricultural production. However at institutional level, performance was envisioned as equity among water users. Hence these two conceptualizations of performance are reflected in the combination of the "old" and "new" technologies referred above. The WUA sought equity among water users, therefore it was structured and administrated accordingly. Therefore the "new" technological pattern was related to this conception of performance. On the other hand we have farmers with a primary concern in subsistence. Hence the "old" technology was focused in securing agricultural goods. Two different perceptions of performance were accountable for two different natures of technological use by farmers.

6.3 Discussion

If we base the outcomes of the research on the concept of technology, we could approach the discussion taking into account which were the needs considered as a priority. National demands on agricultural production and accommodation of migrant communities were the main causes by which Chitwan district was developed. The Terai was considered as the potential food basket of Nepal. Yet, 60 years of planned development, under a series of policies, have caused a highly populated region, self sufficient in terms of crop production but unable to export surplus production to the rest of the country. Migrant communities were indeed accommodated in the new land gained to a malaria infested forest. International agencies helped to eradicate malaria and built road connections. However natural inhabitants of PIS saw how their traditional irrigation system was taken over by the migrant community. Continuous expansion of command area was then the main necessity claimed by PIS farmers (already mixed with migrant and local communities). This claim was encouraged by multiple rehabilitation programmes undertaken by the DOI. The IMT process, which was encouraged by both national actors, DOI and an informal WUA, as well as international donors and scientific community (for related IMT literature see (Acharya et al. 1994)(N N Joshi et al. 2000)(Pradan & Gautam 2002)). Yet, land distribution and inheritance patterns were either not taken into account or undermined. In the case of PIS it was a critical factor in irrigation performance, considering the outcomes of this research. Given this context I suggest to have more grounded consideration of what should be the objectives of irrigation reforms and the feasibility of its implementation. Alike, the successfulness of certain reforms or policies in some irrigation systems do not mean that they will have the same outcome in other irrigation systems throughout the country (meaningless to say in other countries).

In the particular case of PIS I would consider what would be the feasible command area (definitely not 600 ha) as well as the weaknesses of land distribution. From that point on, a consideration of which type of technologies are suitable and the purposes it are meant to fulfil would be the next step. Moreover groundwater resources could be considered a system's resource, hence an organized use could be an alternative to water decreasing supply at the spring source.

The performance analysis shows how varying are indicators depending of the scale from which we observe them. Thus there are always certain limitations in the use of indicators which should be considered. In this regard scientific literature tends to compare different irrigation systems with sets of indicators in order to judge irrigation performance (Molden et al. 1998)(Sakthivadivel et al. 1999)(Small & Svendsen 1990). It may be of academic interest to compare irrigation systems, however the use of indicators to describe their performance are not the best approach. Especially if we apply economic figures to systems which are not pursuing profit, rather subsistence (as PIS does).

Apart from scientific discussions, it is important to discuss weaknesses and strengths of the methodology applied. Qualitative research was a difficult enterprise, particularly considering translation constraints. Informal interaction can not only reveal important data, it can also open new scopes in issues *a priori* not considered. In this regard translation was a handicap when it comes to informal interaction. Regarding research strategies, the case study was of particular challenge. The reason was the qualitative nature of the case study. It appeared to me, at the time of field work, as if the outcomes weren't relevant. However, after some time the information collected gained relevance.

The survey was carried out through a questionnaire. This is a more "straight forward" approach of data collection. Quantitative data is promptly gathered. Yet, it is more rigid strategy as the questionnaire had to be the same for all interviewees (for statistical reasons). Issues envisioned at the beginning prove to be not so relevant (like the calculation of farm expenditure). All in all the case study is more difficult to carry out, but the outcomes may be more relevant than those from the survey, especially in interdisciplinary research.

I had the opportunity to live for three months with the WUA chairman. He helped me enormously (otherwise this research wouldn't have been possible). I could experience day to day farming life and Nepalese culture. However it also generated a personal bias in the way I understood PIS. Hence, it was also important to take some time after the field work in order to analyse the data.

Annexes

Branch/Outlet Number	Farmers	Registered Farmers	Command Area (hectare)	Irrigated Area (hectare)	Non-irrigated Area (hectare)
Branch No. 1	263	213	100	75	25
Branch No. 2	124	94	45	45	0
Branch No. 3	69	35	41	41	0
Branch No. 4	60	57	22	22	0
Branch No. 5	436	311	160	160	0
Branch No. 6	226	193	45	45	0
Branch No. 7	108	73	45	45	0
Branch No. 8	139	99	80	80	0
Outlet No. 1	26	24	6	6	0
Outlet No. 2	30	30	8	8	0
Outlet No. 3	19	19	8	8	0
Outlet No. 4	27	27	10	7	3
Outlet No. 5	3	3	2	2	0
Outlet No. 6	18	18	3	2	1
Outlet No. 7	16	14	3	3	0
Outlet No. 8	14	13	6	6	0
Outlet No. 9	22	21	10	10	0
Outlet No. 10	18	17	6	6	0
Total	1618	1261	600	571	29

Table 6: Total farmer, shareholder and Area of PIS (Source WUA)

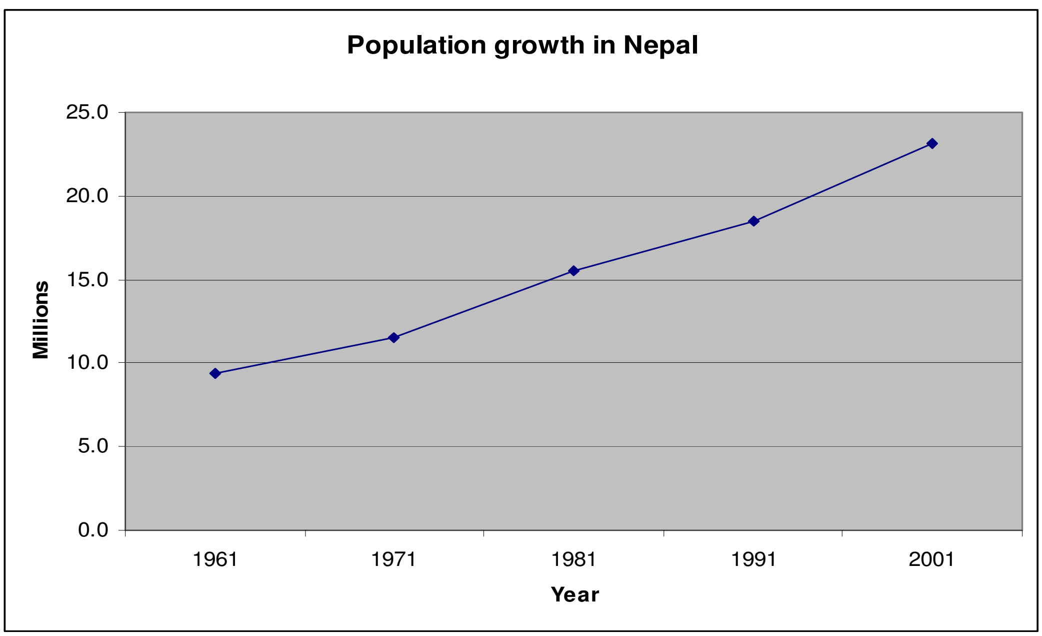


Figure 18: Population growth in Nepal (1961-2001)

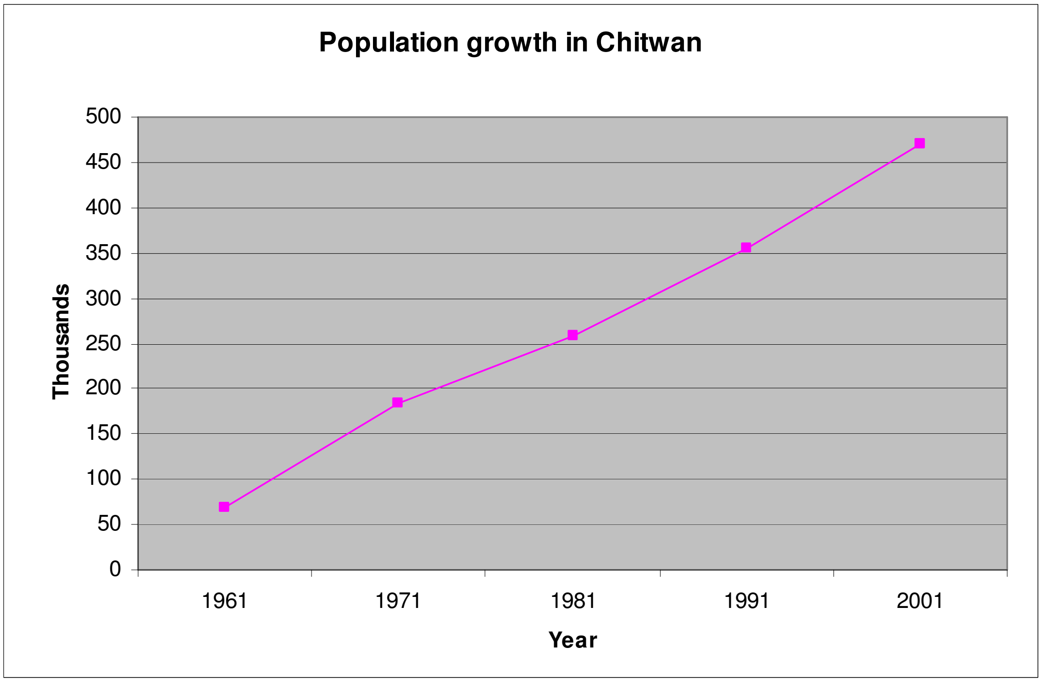


Figure 19: Population growth in Chitwan District (1961-2001)

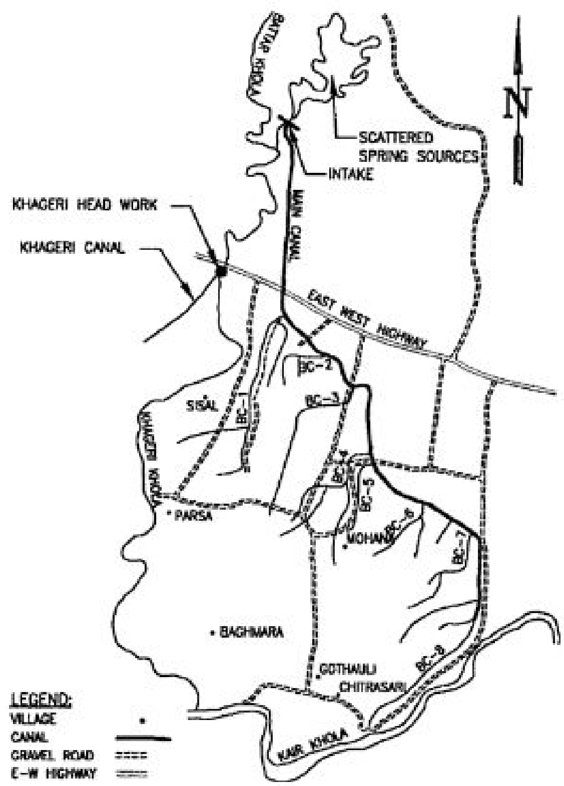


Figure 20: PIS map (1998)

Table 2; Target and Achievements of Planned Resettlement Programmes under Nepal Resettlement Company

Plan Period	Settlement Target[a]		Achievement[b]	
	Area in Hectares	Families	Land Area Distributed, ha.	Families Settled
Second Plan: 1962-65	20,240	6,000	1,140	714
Third Plan: 1965-70	13,900	6,000	2,850	1,149
Fourth Plan: 1970-75	18,750	6,000	7,760	4,260
Total:	52,890	18,000	11,750	6,009
Fifth Plan: 1975-80	50,000	22,500	3,350*	1,945

*Progress from 1975 to 1977 (including settlements in projects initiated in 1977).

Sources:

a. Ministry of Economic Planning, Trivarsiya Yojana, 2019-22 (Three Year Plan, 1962-65), (Kathmandu, 1962), p. 217; and Third Plan: 1965:70 (1965), p. 67; National Planning Commission, Fourth Plan: 1970-75 (Kathmandu, 1972), p. 64; Panchau Yojana: 2032-37 (Fifth Plan: 1975-80) (1975), p. 146.

b. Official Records of the Nepal Resettlement Company; and Nepal Resettlement Company, Nepal Punarvash Company: Ek Parichaya (Nepal Resettlement Company: An Introduction) (Kathmandu, 1978 [2035]).

Table 7: Target and achievement of Planned Resettlement Programmes under Nepal Resettlement Company

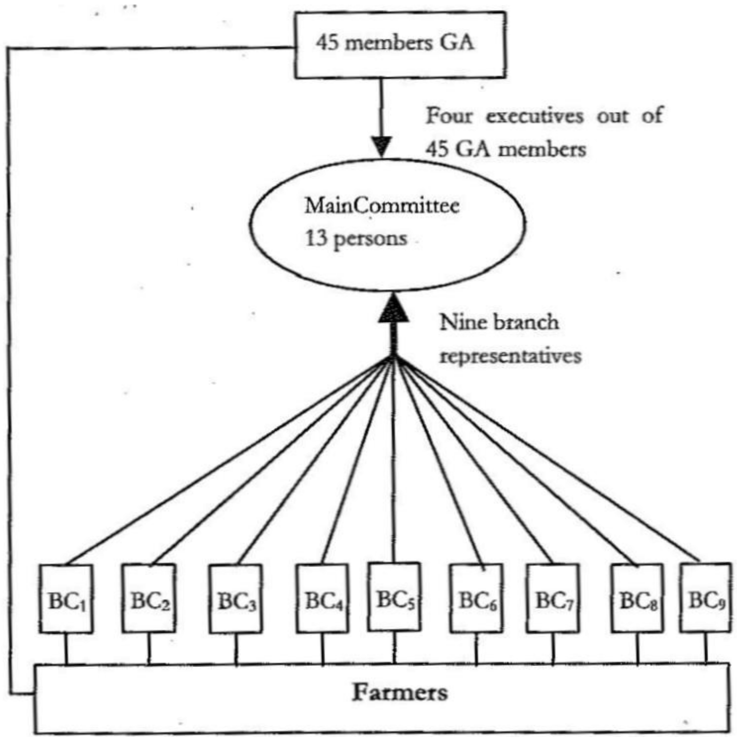


Figure 21: PIS proposed WUA structure. Source: (Khanal 2003)

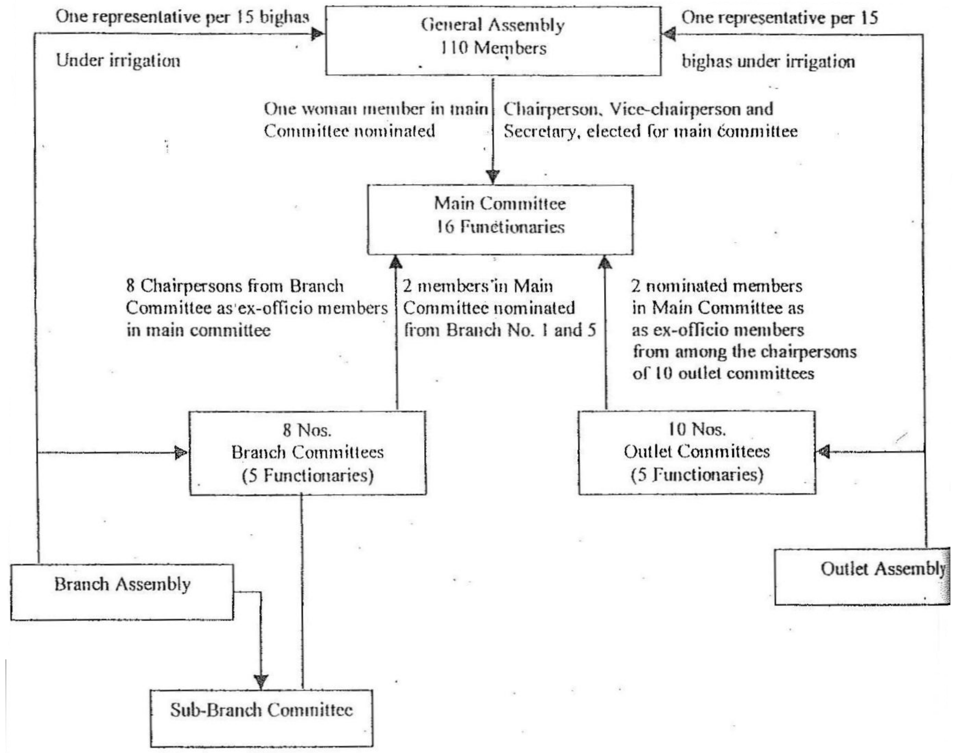


Figure 22: WUA structure modified as per Constitutional Amendment after third election (1997)

Box- 8. Irrigation Demand Form

To…………………
……………………

Subject: Irrigation Demand

Sir,

Kindly make available irrigation water for …………………… hrs ………… Minute as stated hereunder

S.No.	Name of User	Branch / Outlet No.	Crop(s)	Area	Irrigation Need (Time/Frequency)	Remarks

Demand made by……………
Date:

Approved by …………..
Designation ……………
Date:

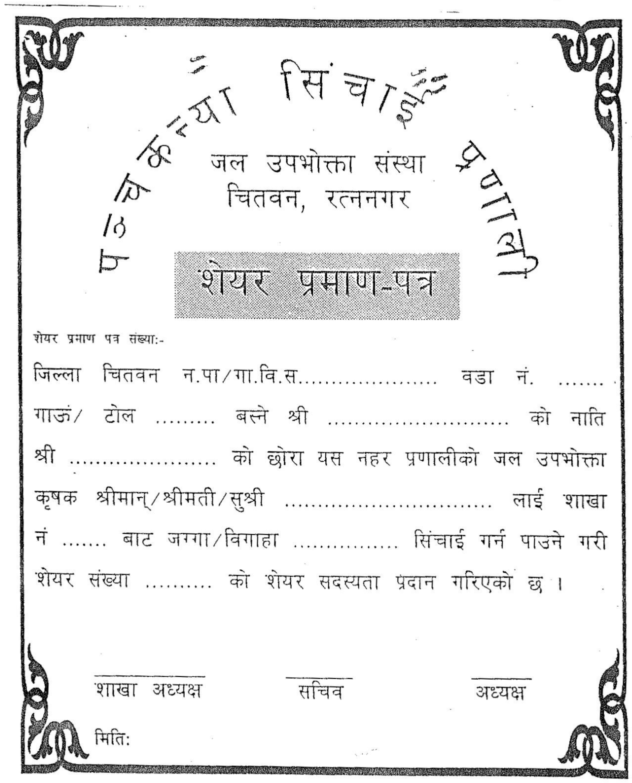
Box-9. Irrigation Water Allocation Format

S.No.	Date	Branch/ Outlet No.	Area	Total Period of Irrigation		Crop	Remarks
				Beginning Date and Time	Closing Date and Time		

Secretary …………..
Date:

Chairman ……………..
Date:

Figure 23: Irrigation demand form



पञ्चकन्या सिंचाई प्रणाली
जल उपभोक्ता संस्था
चितवन, रत्ननगर

शेयर प्रमाण-पत्र

शेयर प्रमाण पत्र संख्या:-

जिल्ला चितवन न.पा/गा.वि.स.................... वडा नं. ....
गाऊं/ टोल .... बस्ने श्री .... को नाति
श्री .... को छोरा यस नहर प्रणालीको जल उपभोक्ता
कृषक श्रीमान्/श्रीमती/सुश्री .... लाई शाखा
नं .... बाट जग्गा/विगाहा .... सिंचाई गर्न पाउने गरी
शेयर संख्या .... को शेयर सदस्यता प्रदान गरिएको छ ।

शाखा अध्यक्ष सचिव अध्यक्ष

मिति:

Figure 24: Share System Certificate

<u>Training programmes organized in PIS for capacity building of WUA</u>

1. Administration and financial management training (1994)
2. Share system development and share administration training (1994)
3. Construction management training (1995)
4. Awareness training on Irrigation Management Transfer Process (1995)
5. Monitoring and Evaluation Sensitization training (1995)
6. Construction management and quality control training (1996)
7. Mass awareness workshop on Participatory Irrigation Transfer (1997)
8. Water flow measure capacity building training (1997)
9. Women users sensitization training (2001)
10. Training and Role and Obligations of women users in Irrigation management transfer programme (1997)
11. Training and financial record keeping (1997)
12. Canal operation and maintenance training (1998)
13. Leadership development training. (2001)
14. Crop diversification training (2001)
15. Water flow / discharge measurement training (2000)
16. O & M of branch canal (2002)
17. Trainers' training (2002)
18. Women sensitization training (2000)
19. Training to women water users for capacity building (2000)

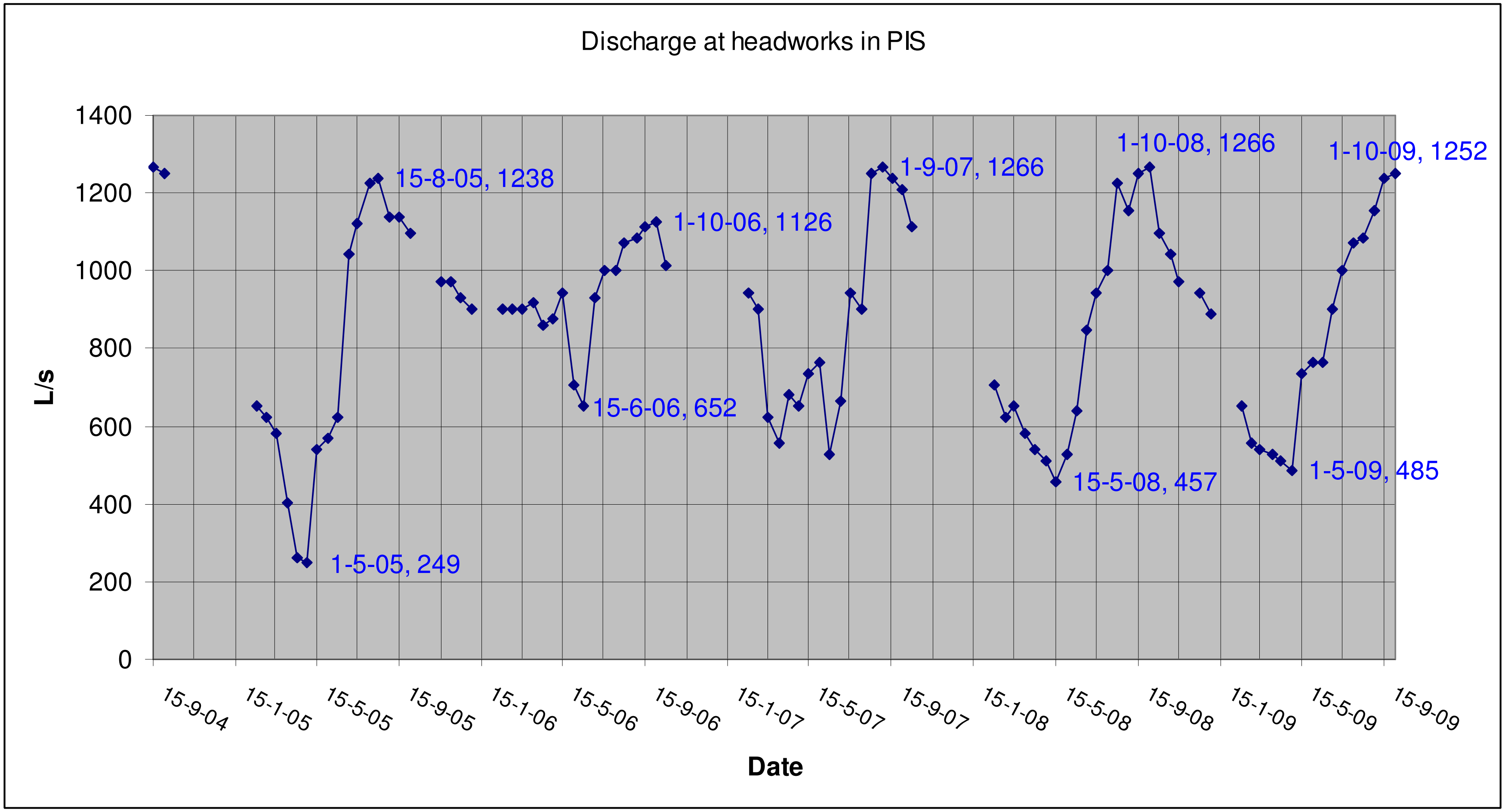
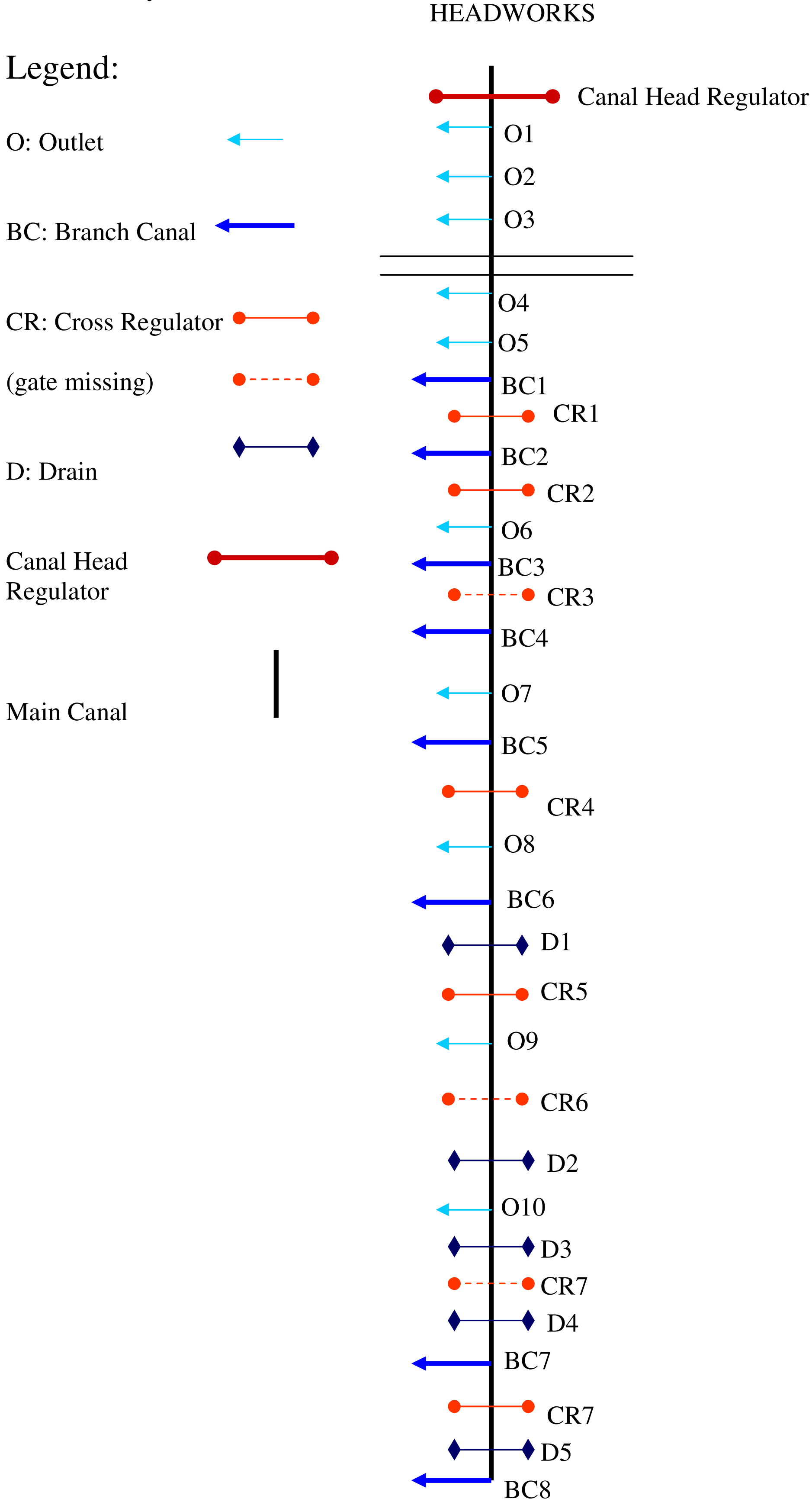


Figure 25: Discharge flow chart in PIS 2004-2009

<u>PIS Main canal layout</u>



Questionnaire updated 1/12/09

All answers will remain confidential and the data treatment will be anonymous.

General Information

Date	
Reference number	

Interviewee name		
Gender	Male	Female
Name of the household head		
VDC/Village		
Branch canal / outlet number		

Household Composition

	Yes/No Number	Gender	Age	Occupation
Head of the household				
Spouse				
Children (under 18)				
Other members				
Cast				

Land surface

	Khet (lowland)			Bari (upland)			Total
	Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3	
Land surface							

Irrigated Area

Irrigated Area	Khet (lowland)	Bari (upland)	Total
Winter			
Spring			
Monsoon			

- Do you leave some land fallow? Yes ( ) No ( )
  How much? .... When? ....
- Do you pay the fees? Yes ( ) No ( )
  If not, why not?

Cropping calendar

Crop	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec

- Why are you choosing these crops and not others?

- Do you think you could plant crops which could give you more money? Yes ( ) No ( )
- If so, why aren't you planting these crops?

GW use

- Do you have a pump? Yes ( ) No ( )
- Do you have a well? Yes ( ) No ( )
- If yes, do you share or sell the water to other farmers? Yes ( ) No ( ) At what prize? per hour: ……. In total (average): ………
- If no, do you buy water or rent a pump to irrigate your field? Yes ( ) No ( )
- If yes, is it you own well or shared with someone?
  If shared, among how many people?.....

Cropping system

		Winter			Spring			Monsoon	
Crops									
Khet	Area								
	Production								
Bari	Area								
	Production								
Irrigated	Canal								
	Pump								
Qty sold									
Prize									
Qty consumed									
Market Outket									

Farm expenditures/production costs

Crop	Input type (yes/no)						Seeds	
	Fertiliser	Herbicides	Pesticides	Tillage	Labour	others	Quantity	Cost per unit/total
Total costs year round								

- Do you own any other machinery (tractor, rice harvester, etc.) Yes ( ) No ( )
  If yes, which? …………. How much do you earn from hiring it out? per hour: ……. In total (average): ………

- Do you hire or rent any? Yes ( ) No ( )
  If yes, which? …………. At what prize? per hour: ……. In total (average): ………

- The crops harvested and the profit obtained are enough to cover food needs in your household?

Literacy/ Education

- Do you have children? Yes ( ) No ( )
- If yes, how many? …….. Do they go to school or college? Yes ( ) No ( )
- Do you know how to read and write? Yes ( ) No ( )
- Do you have any sons or daughters attending (or had attended) university studies? Yes ( ) No ( )

Output measures:

Depth related measures:

- Do you think the amount of water received is enough in:

  Winter Yes ( ) No ( )
  Spring/summer Yes ( ) No ( )
  Monsoon Yes ( ) No ( )

- Do you think you that all farmers receive the same amount of water? Yes ( ) No ( )
  If not, Why not?
- Do you think you receive the water at the proper times for your crop? Yes ( ) No ( )
  Sometimes ( )

Farm management-related measures:

- The stream of water received in the field is:

	too little	enough	too big
Winter			
Spring			
Summer			

- Do you think the time when you receive the water is convenient or you prefer other times? Convenient ( ) Other time ( )

- Do you know the time when you'll receive the water? Yes ( ) No ( )
- Do you experience any problems or conflicts with water sharing? Yes ( ) No ( )
  Sometimes/a little bit ( )

Waterlogging

- Do you suffer from waterlogging? Yes ( ) No ( )
  If yes, how much area?.......
- Do you have any drains in your field? Yes ( ) No ( )
  If yes, what type?........

Income

- Do you have any other source of income? Yes ( ) No ( )
  What type?...........(pension, grant, salary, business, etc)

Concluding issues

- Do you know the chairman? Yes ( ) No ( )
- Do you think he is a good leader? Yes ( ) No ( )
- In your opinion what is the main problem you face about farming?

Do you see any constraints or opportunities for commercial farming?

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