INTEGRATED ANALYSIS OF SMALLHOLDER IRRIGATION SUSTAINABILITY IN NEPAL: A CASE STUDY OF THE INTERPLAY BETWEEN INDIVIDUAL PERFORMANCES AND COLLECTIVE ACTION

by

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ABSTRACT

This study investigates institutional, technical and economic aspects of sustainability in irrigation systems, with an emphasis on the interplay between individual farmer's performance and features of collective action. Panchakanya Irrigation Scheme, located in Chitwan district of Nepal, was selected for the case study.

From primary data, a farmers' typology has been established, based on production strategies features (cropping systems and livelihood sources). Crop budgets and water delivery at farm level (secondary data) were established and jointly analyzed in order to assess land and water productivities. Statistical tests were performed and demonstrated significant differences in cropping systems and performances among farmers' types.

Production, gross income and net income are statistically significant between farmers' types. Type-II farmers (Full-time commercial farmers) are more intensified, productive and commercially oriented. Analysis shows that intensification, diversification and commercialization of crops seem to be the pathways to farmer's economic improvement. It was found that farmers who practiced cropping system having at least one vegetable or potato are generating higher net income than those practicing cereals, pulses and oilseeds. So cropping strategy is one of the major factors to raise their income. Furthermore, water productivity of vegetables and potato are higher than cereals and the net income per unit of water delivery (productivity) derived from these crops are much higher than cereals.

Qualitative analysis of collective action has focused onto system maintenance and water services, and was based on both farm typology and location along canals (head, middle, tail). Institutional analysis focused on the current status and capacity of the WUA, based on Ostrom's eight efficiency and sustainability principle. Also, WUA's capacity assessment has been performed and compared WUA's performance at present times and five years ago, as perceived by irrigators. Finally, semi-quantitative assessment of farmers' satisfaction of water services WUA operation was also carried out through direct interviews.

Results show that, while both institutional and capacity assessments performed at WUA level indicate that the scheme seems to perform adequately and even improved as a collective irrigation enterprise, individual perceptions reveal that tail-end farmers, regardless of their farming style, are more deprived of water than others in times of water scarcity. As a result, commercial ones resort to private pumping at own cost, and all are being significantly more reluctant to pay for canal water services. Such situation results in a weaker financial situation at WUA level.

The research concludes that a more appropriate water charging system should be developed, recognizing the different levels of irrigation water supply that exist within the scheme, and compensating tail-end farmers for low insurance of supply and higher pumping costs.

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LIST OF ABBREVIATIONS

APO	Asian Productivity Organization
CBOs	Community Based Organizations
CBS	Central Bureau of Statistics, Nepal
CPR	Common Pool Resources
DADO	District Agriculture Development Office
DAE	Department of Agriculture Extension, Nepal
DHM	Department of Hydrology and Meteorology, Nepal
DIO	District Irrigation Office
DOI	Department of Irrigation, Nepal
FAO	Food and Agriculture Organization of UN
GDP	Gross Domestic Product
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Assistances)
ha	hectare (unit of measurement of area)
HHs	Households
ICIMOD	International Centre for Integrated Mountain Development
IMF	International Money Fund
IMT	Irrigation Management Transfer
ISF	Irrigation service fee
MAF	Ministry of Agriculture and Forestry, New Zealand
MDGs	Millennium Development Goals
MoA	Ministry of Agriculture, Nepal
MoAC	Ministry of Agriculture and Cooperatives, Nepal
MoF	Ministry of Forestry, Nepal
MoPE	Ministry of Population and Environment, Nepal
MoWR	Ministry of Water Resources, Nepal
MSS	Mahila Sahayogi Samuha (Women Helping Group)
NPC	National Planning Commission, Nepal
NRs.	Nepalese Rupees
OECD	Organization for Economic Co-operation and Development
PIM	Participatory Irrigation Management
PIS	Panchakanya irrigation System
PIWUA	Panchakanya Irrigation Water Users Association
RNM	Ratnanagar Municipality
UN-DSD	United Nation Division of Sustainable Development
UNEP	United Nations Environment Program
VDC	Village development Committee
WARPO	Water Resources Planning Organization
WCED	World Conference on Environment and Development
WECS	Water and Energy Commission Secretariat, Nepal
WRI	Water Resources Institute
WUA	Water Users Association

UNITS OF MEASUREMENTS

1 bigha = 0.67 ha
1 katha = 0.05 bigha = 0.033 ha
1 US$ = NRs. 62

CHAPTER I

INTRODUCTION

1.1 Background

Irrigation plays a significant role in the economies of most developing countries. However, the food self sufficiency ratio, area of agriculture activity as well as proportion of population involved in agriculture had continuously decreased in the past three decades (APO, 2000). About 41% of world populations still have their livelihoods depend on agriculture. About 96% of the agriculture population lives in the developing world and 75% of which live in Asia. Asia has about 60% of world population and almost same percentage of world's irrigated area but only 26% of the global runoff of freshwater (FAO, 2005). Population growth, urbanization, globalization, commercialization of agriculture, labor mobility, movement of the rising generation out of agriculture, increasing competition for land and water, high future cost of irrigation scheme development and rehabilitation and environmental degradation are some changes that brought about profound effects on irrigated agriculture which led to the need for increased labor productivity, water productivity as well as crop production. These spreading problems have posed challenges in sustainability of irrigation systems which is leading to the food insecurity of the poor people.

FAO (2005) predicts that 60% of the additional food needed for the earth's growing population through the year 2050 will have to be produced from agricultural land. On the other hand water becomes a more limiting factor of production than land as agriculture now competes with industrial, domestic and environmental uses for water allocation. Thus it is clear that crop yield per unit of water will become more important than yield per unit of land. But in the past, large dams and surface irrigation systems were developed to ensure food security, the major goal of most of the Asian countries, and since 1965 the irrigated area has almost double. Irrigation systems were considered simply delivering water to the field without much attention paid to the management of the systems (Shivakoti et al, 2005). Due to shortages of government funds for operation and management (O&M), low ratio of fee collection, poor O&M of irrigation systems by government, response to manage the irrigation systems shifted towards renewed approaches involving the farmers, such as participatory irrigation management (PIM) and irrigation management transfer (IMT) (INPIM, 2001). Experience has shown that good management of irrigation systems is one of the main factors that have contributed to the development of agriculture in much of Asia.

In recent years, attention has increasingly being paid on the role of irrigation systems towards poverty alleviation. More attention is being given to the importance of changes in the management and institutional arrangement of existing irrigation system (Biltonen et al, 2005). Researchers on irrigated agriculture noted that agency-managed irrigation systems show low performance compared to farmer-managed irrigation systems (Shukla et al, 2002). Irrigation management is not only managing the infrastructure within irrigation system but successful irrigation management also includes the management of human relationships between irrigators, water users, organization officers, irrigation officials and others (Coward, 1980).

Once an irrigation system is built and handed over to the farmers we can't say that the farmers would organize themselves to distribute the water and maintain the system.

Institutional development is at least as important as the investments in physical infrastructure (Ostrom, 1992, cited by Penov, 2004). The sustainability of irrigation does not only depend on physical elements such as infrastructures and reliable water supply, it also depends on the interplay between individual performances by farmers in their own plots, the collective arrangements made, and an enabling environment. In that sense, not only the soundness and productivity of production systems by farmers and how they use irrigation water counts, but also the effectiveness of institutions and rules for water sharing or the undertaking of O&M tasks, access to input and output markets and services, and the like.

Technical efficiency is determined by individual farm- and farmer-specific characteristics. One of the characteristics is demographic characteristics, which dominate the decision making process of the farmer, and socioeconomic. The second is institutional characteristics, which influence a farmer's capacity to apply the decisions at the farm level (Obwona, 2006). Productivity increases not only depend on adoption rate but also needed is the effective use of available technology. The importance of technical efficiency (efficient use of technology) has to be realized in sustainable farming system which contributes to higher productivity with facilitating diversification to higher valued crops. Thus irrigation involves more serious collective action challenges in both water provision, use and maintenance infrastructure (Poussin et al, 2006), technical and economic performance of individual farmers (Perret et al, 2003) and the proper institution need to be in place (Shivakoti et al, 2005) . Which means, an irrigation system typically combines individual household based venture (farm technical production and economy) and collective features such as negotiations, collective decisions and action, sets of rules about water sharing and O&M tasks, conflict resolution systems, enforcement systems, and the like, owing to the collective nature of an irrigation scheme where people basically share water and infrastructures over a given territory.

1.2 Statement of Problem

Such territory with its resources, irrigation water and the infrastructures which were built by government and handed over to farmers are regarded as common pool resources (CPR) (Ostrom, 1992). As a socio-technical and economic resource, contexts in which irrigation management exists are changing more rapidly than the irrigation sector itself. Irrigation sector finds itself in a weak position to compete with other sectors for water and public support, owing to low productivity and internal rate of return lower than opportunity cost of capital (Malano & van Hofwegen, 2006, 11). The sustainability of irrigation is now the insistent challenge in the developing regions. Much work has been done on performance evaluation of irrigation at farmer level, such as cropping practice (timing, duration, and flow rate of water), area irrigated, and cropping patterns. This approach of assessment lacks the major part of socio-economic and institutional context of irrigation system. A second type of assessment has been done by irrigation economists, on monetary productivity of water, land, labor and inputs. Third, sociologists consider the institution and governance of irrigation system. The rule of the game in which the farmers interact, individual farmer's performance and the collective action that has been taken in the system is equally important for the sustainable development and management of irrigation systems. To incorporate these parameters in the assessment of irrigation system an integrated framework is needed. This research study is thus proposed to combine institutional, technical and economic analysis for investigating the sustainability of irrigation systems, and searching for indicators thereof.

1.3 Objectives

The main objective of this study is to investigate sustainability in irrigation systems, in the framework of institutional, technical and economic terms, and to investigate the interplay between individual farmer's performance and collective action in its different possible forms.

The specific objectives are:

1. To study farmers individual economic performance using typological approaches (farmers' typology).
2. To study the technical production systems at the farmers level.
3. To assess institutional capacity of Water Users Association (WUA) and broader social, institutional and organizational features within a scheme.
4. To identify relationships between individual performance and collective action.

1.4 Scope and Limitations

- Study was carried out in one of the irrigation system in Nepal which is undergoing devolution.
- Three dimensions of sustainability of irrigation systems viz; institutional, technical and economical aspects have been taken into consideration.
- Technical aspects have been considered at farm level like choice of crops, cropping intensity, crop rotation, productivity.
- Institutional aspect mainly focused on the management aspects of WUA and other community based organizations (CBOs) which are the role player in the system, and also on the sets of rules and norms at play in the different collective tasks undertaken.
- Economic analysis considered at farmer's level (like crop yield) as well as financial self sufficiency as a whole of the WUA.
- Most of the data was collected from primary source (farmer's interview). Well documented secondary data found at scheme level has also been taken into consideration.

CHAPTER II

LITERATURE REVIEW

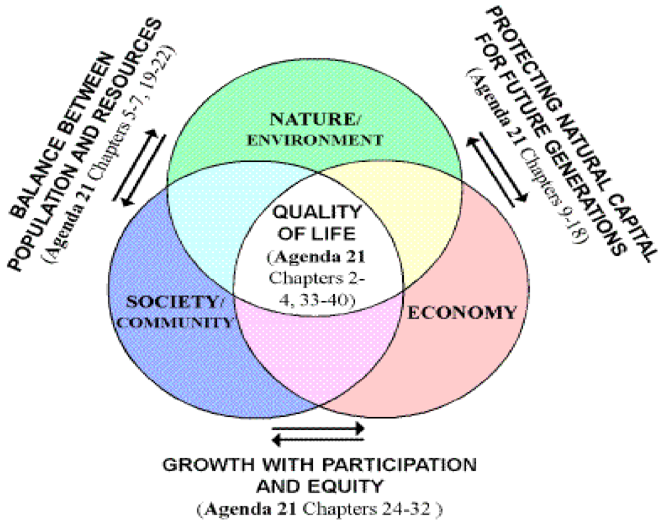
2.1 The Concept of Sustainability

Sustainability, in a simple meaning refers to the long term management of any development activities with proper operation and maintenance providing the maximum benefit to end users. The world is dynamic, with on going population growth, technology evolution, environmental crisis and globalization of markets being some contemporary issues. In ancient times the ecosystems self maintained naturally. On the course of time, population growth, rising living standards and consumption, expansion of market economics necessitate an increase in production and resources use.

In the development process to meet the demand of people many large interventions were made in the past with little concern of future adverse effects (human health and welfare, food and security, ecosystems' integrity and resources' depletion). It was because economic growth and industrialization were the most wanted change of the world. It is obvious that meeting the current demand is often seen as more important than meeting future needs. Only the intervention in large projects with a proper design of structure is not sufficient. The social acceptance, economic output and management of the projects are the factors for these projects to run for a long period. The word "sustainability" is not new. It is continuously used but the concept of defining it in changing context is different.

In 1987 the Brundtland Report, also known as *Our Common Future,* The World Commission on Environment and Development (WCED) defined *sustainable development* as – "*Development is that meets the needs of the present without compromising the ability of future generations to meet their own needs*". This definition explained two broad concepts within it. One is the 'need' which should focus to the world's poor. Without addressing the basic need of the poor people the sustainability is almost meaningless as there are still majority of people lies under the line of poverty. Second concept is to address both present and future needs. This concept focused the idea of limitations that is imposed by the development of technology and social organizations in line with environmental ability meeting those needs. The social and economic agenda must be defined within the periphery of sustainability. This in particular should be addressed in all countries either developed or developing sharing the central features and with a broad consensus on the basic concepts of sustainable development which needs a broad strategic framework to achieve it.

Agenda 21 (1993) paid attention to political system which ensures peoples participation in decision making. The agenda further emphasize on integrated idea of economic system, social system, and ecological base for development and technological system that can reach for a new solution. There should be appropriate international system that promote trade and finance and needs a flexible and self corrective administrative system. This multidimensional system can foster the sustainability system within the human environment interface. Sustainable development has the main three domain interrelationship: environment, society and economy. The sustainable development issues in Agenda 21 describe the interaction of these three domains as shown in figure 2.1.



Sustainable Development Issues in Agenda 21

Figure 2.1 Three-domain interrelationship of sustainability
Source: Agenda 21 (1993)

The quest for sustainable development means identifying types and intensities of development, and corresponding modes and levels of operation and management, that seem capable of being continued for as far as we can see into the future without significant diminution of their benefits and without causing significant harm to others (Abernethy, 1994). OECD (2007) defined the sustainable development agenda in the same way as Agenda 21. OECD stressed that meeting the needs of today without compromising the future ability of future generation is a crucial issue to be addressed. Sustainable development should thus focus on a broad view of human welfare. A coordinated framework and long perspective of the today's effect to the future is the need of today to be addressed properly. Abernethy (1994) has pointed out the broad frame of sustainability issues that need to be addressed in practical circumstances, which are: what is that to be sustained, which threats are most important, to which is the system most vulnerable or least resilient, how can we know whether we have achieved sustainability, how can we monitor sustainability, how can we evaluate the data providing by monitoring what changes or trends are occurring, and what management actions are possible or desirable to enhance sustainability?

The means of achieving sustainability is different in different prospects like water resources sustainability, social system sustainability, economic sustainability, and environmental sustainability and so forth. The Dublin principles (1992, cited by Plate, 1993) concludes with a quotation on fresh water resources management as: "*Fundamental new approaches to the assessment, development and management of freshwater resources are needed, which can only be brought about through political commitment and involvement from the highest level of organization to the smallest communities. Commitment will need to be backed by substantial and immediate investment, public awareness campaign, legislative and institutional changes, technology development, and capacity building programs. Underlying all these must be a greater recognition of the interdependence of all people, and of their place in the natural world.*"

According to Abernethy (1994), the concept of “sustainable development” is an integrating idea and a bridge between conservation and development. Development can be damaging, but also that in the current context of population growth and rising human goals, development must happen, and must prosper to meet the demand of the people. The value of the sustainability idea is conceptual and this gives an attitude and an orientation but the idea is inherently qualitative, and (since it refers to the future) imprecise. Attempts to define is too exactly could reduce its attitude forming value, without gaining anything much. He further argues that we cannot inspect a particular irrigation system, or a particular method, and simply declare “*yes that is sustainable*”. The external context may change in some adverse way (or in some positive way) that will modify our estimates of sustainability. We must always be vigilant, and try to ensure that management responds flexibility to any threatening external changes.

2.2 Sustainable Management of Irrigation Systems

Any development is undertaken towards the interest of the human kind, for the betterment of present and future generations. The sustainability of irrigation may be tested against the question as to how long it can benefit the people (economically and socially) without damaging the environment. For the irrigation system to run for a long time it needs significant financial contributions (either internally or externally; Malano & van Hofwegen, 2006). Many researchers have focused sustainability according to their scope of study and professionalism. Sociologist mainly focus the sustainable irrigation is a matter social acceptance, and on equity and participation. Political scientists focus on governance and institutions. Engineers focused on the operation and maintenance of irrigation system through the appropriate design consideration of infrastructure. Soil science and water scientist focused on the sustained fertile soil characteristics that are supportive to higher production and water quantity and quality as the key of sustainability of irrigation. Economists on the other hand have given priority to the return on investments.

Abernethy (1994) considers these attributes as objects of sustaining irrigation systems: Irrigation facilities, Production potential, Operational performance, and Irrigated agriculture. None of these seem to be appropriate objectives on their own. Sustaining the facilities is not enough, unless people are continuing to use them. Irrigation systems do not exist in isolation but it is a part of various larger systems like rural development system, ecological system, national food production systems and so forth. So defining the irrigation sustainability depends on the objective, the context in which it is proposed and established. The objective may be sustainability of productivity, efficiency and financial sustainability, sustainability of irrigation infrastructure etc. As of MAF (1997), farmers’ net profit should be sufficient enough with a sustainable industry making a long term profit through same sector; the scheme organization must provide sustainable and adapted services to farmers. Resources where farming depends must be used such that natural resources can be exploited without destroying the ecological balance of an area. Long term profit can be achieved through improved resources condition, by formulating and applying appropriate legislation and focusing to both domestic and international market demands. Farmers must able to demonstrate that there farming industry is running in a sustainable manner; they are participating in a decision making with proper understanding and informed and responsible management system. Irrigation system should supports farming system to increase the farmers’ net profit with minimal impacts to others.

Some researchers have concerns about the land that sustainable agriculture systems, producers make management interventions that lead to sustained productivity increases without degrading the land resource on which production depends. Although the debate in the definition and measurement of sustainability is in itself a long standing continuum (Dumanski et al, 1998) there is some consensus that the major dimensions of sustainability, physical, biological, economical and social must be integrated in some still undefined way to assess progress towards this goal. Cai (2001) citing Svendsen (1987) argues that sustainability in irrigation is not only to exploit irrigation water for supplying water to the plant, the most important is to mange water with applying a set of system concept for irrigation water management that is, applying a set of essential element that interact in interdependent fashion. Moreover, sustainability, by its nature, implies a dynamic system whose status is determined by a balance of opposing forces or trends

Many scholars argue that management of irrigation is a multi-facet socio-technical enterprise. Uphoff et al. (1991) gives clear perception about the sustainability of irrigation. He argues that "focusing on irrigation management should not be considered only as a socio-technical enterprise but also as an organizational-managerial one". Pavlov (2004) pointed out that management of irrigation system is getting increasingly acknowledged as an essential means to achieve successful irrigated agriculture. Many problems of the irrigation system are derived from weakness in the organization and management of the system rather than technical and operational defects. Thus irrigation management is the key demand of sustainable development of irrigation system. The degree to which irrigation management in Asia is sustainable in future will depend on how effective water users, policy makers, technical experts, researchers, NGOs and other stakeholders are, in designing future irrigation institutions that would cope with future complexities (Shivakoti et al, 2005).

In the past two conflicting goals of 'poverty alleviation and food security' and 'profitability and revenue collection' were set to achieve. Both objectives couldn't achieve in that era but national level food security had achieved to some extent. Upon the achievement of food security at national level, the agenda has broadened towards poverty alleviation and major issues were lift up to protect environment including improved livelihood of the majority of peoples. New era of globalization started where many governments faced a budget constraint to support irrigated agriculture. This result that governments have been reluctant to provide investment in irrigation sector but seeking the people's participation and resource mobilization at local level to maintain the investment in surface irrigation system (Coward, 1990). Where the investment has already done, government focused to maintain the system with peoples participation raising fund from people. Many irrigation systems were designed to encourage local people to organize themselves. Major financial and management roles assumed to handover to the farmers. This handover was difficult for farmers to assume responsibility of managing such huge system. The problems were arisen mainly because of lack of proper institutional set up of the farmers in those new development trends. (Barker et al, 2004).

2.2.1 Institutions in Irrigation Management

After realizing the need of proper institutions in irrigation management researchers then step up towards the search what kind institution to be in place. As of North (1990) institutions "are the humanly devised rules of behavior that shape human interactions". Challen (2000) pointed out that institutions possesses some general characteristics:

institutions are socially organized and supported, they includes both formal and informal conventions, they are slowly changing depending upon the activities how they guide and constrain, and they prescribe prohibitions as well as conditional permissions. The purpose of institutions is thus focused to develop a set of rules for cooperation. These set of rules should address the individuals and group interest with adjusting the conflicts arise from scarce resources.

The pattern of interaction among stakeholders affects the irrigation management and its operation and management. Institutions are the internalization of the norms and values built up with the development of the community. Likewise, rules and regulations are linguistics statements which are written or may not be written. It is commonly used and observed the users and the community, which may also be imposed from the outside formal agents. Also rules made by the farmers are not made in isolation. These are set of rules interdependent with configuration in nature (Sowerwine et al, 1994).

Institutions are a pervasive phenomenon with diverse origins as they affect various dimensions of human relationships and interactions (Saleth, 2004). Irrigation is a physical entity that without the use by people is meaningless. To use any natural or manmade resources, a set of rules is needed. There are various level and set of irrigation institution in the world depending upon the social, technical, cultural and sometimes religious systems of the locality. In the mid 19th century there were irrigation institution that were all concentrated to the national government. With the development trends, incapability of national government in managing the irrigation systems and the realization of participation of the people (who use the resources), the irrigation institution brought about the change to focus users groups or WUA.

FAO (2003) pointed out that "*where management is incapable of operating and maintaining a system to high standards, restoring its physical infrastructure alone will not lead to production improvements*". This statement is mainly focus to the institution so that physical infrastructure can be handled with set of rules with coordinated action among stakeholders. This of course needs the change in institutional arrangement to fit it with dynamism of the irrigation management concept and development. The change of institutional arrangement means that the institution can address the farmers' needs of improved performances in economic and environmental terms. Svendsen (1987) has made the essential identification of human institution as "the key to sustainability". He says "over a period of a few seasons, no piece of infrastructure is stable or sustainable without instructions to operate, repair, adopt and maintain it". When we try to determine whether a specific system possesses sustainability, we must determine the health of its institutions: their finances, their energy, their incentives, their objectives.

Vermillion (1998) argues the new idea about people's participation. Irrigation management can be achieved properly through farmers' participation which needs decentralization and devolution in irrigation management. This idea focused that the management should be handled by those who have immediate concern over it. The local peoples or user of common pool resource should be empowered enough so that they feel incentive to mange the system effectively and efficiently than does by centrally financed government organization.

"*The rules of the game*" in a society (North, 1990 cited by Grief, 2002) and "*the sets of working rules*" that "*contain prescriptions that forbid, permit, or require some action or* *outcome*" and that are "*actually used, monitored, and enforced*" (Ostrom, 1990 cited by Grief, 2002). An institution is composed of complementary man-made, non-technological factors exogenous to each individual whose behavior they influence and the regularity of behavior these factors generate.

2.2.2 Participation of Farmers in Irrigation Management

Basic definition of participation refers to the involvement of citizen in water governance. Farmer's participation in irrigation management is regarded as the key to sustainability. Realizing this fact developing countries are focusing on PIM and IMT. In the common pool resource like irrigation water and infrastructures individual farmer's performance and collective action both are equally important towards sustainability.

Participation is a function of direct interest, expectations, awareness, trust and solidarity. Therefore, participation in irrigation is increased involvement of peoples where they have control over resources (Cohen et al, 1977 cited by UNDP, 2000). Farmers participate in finding the problem, search the solution and decide and implement the decisions for their benefits. They monitor and evaluate the irrigation system and modify the rules and decision upon the changing context of their demand and environment. Physical involvement alone is insufficient to generate user's participation, and that development of user organizations is more important in motivating users to share responsibilities in irrigation management (Shukla et al, 2002).

Irrigated agriculture is one of the rich sources which provide wide range of lessons and experiences in user participation. World Bank (1996) states that participation of farmers at all level staring from project identification to the design and management ensures the sustainability of the irrigation system. Further, participation of farmers reduces the financial burden of government as well as improves efficiency of the system leading to equity among farmers and improved services condition. Self sufficiency of the farmer's organization in meeting the O&M cost will enhance the sustainability of the irrigation system.

There are thousands of locally managed irrigation systems in many countries, functioning at various management levels. A strong feeling of ownership is needed to ensure people's participation for proper operation and maintenance of the system. To have such feelings and sense of ownership they must participate from the very beginning from the identification, selection till to the construction (WRPS, 1978:84 cited Adhikari, 1987).

Shukla (2002) presented a good example (which was possible due to farmers participation) of farmers managed irrigation system in Nepal called Chhattis Mauja irrigation having full control of citizen (farmers) in irrigation management. The Chhattis Mauja Irrigation system, which serves 54 villages and provides water to 3,500 hectares of land was entirely designed and constructed by farmers and is now fully governed and managed in a complex, nested system by the farmers serves by this system. Very fruitful lessons were drawn from the study of the system. First, the irrigation in Chhattis Mauja has evolved with representation of all parts of the system boundary. Second, the rules governing the operation and management of the system were developed, tried, modified and tried again depending upon dynamism. Third, decentralization decision making and strong communication lines for the flow of decision has helped to improve compliance to decision. Fourth, the general assembly and general meetings provide an important open forum for exposing problems. And fifth, the certainty that hundreds of farmers will respond immediately when called to maintain the system has allowed flexibility in the planning and execution of maintenance. Thus more farmers' participation at all levels ensures the collective action in system management.

2.3 Review of Indicators in Sustainable Irrigation Management

Bell & Morse (1999) defined indicator as parameter, with a range of values that gauges a system attribute or process, thereby signaling a particular condition or trend. In other terms, it measures the state of the system for evaluating the effect of actions on resources and help to adjust the actions to meet the specified goals. It has been used by biologist in assessing ecosystem health since long time. More recently, indicators have been broadened to gauge aspects of societies, economies, institutions, cultures, and our living environment as a whole (Kellet et al, 2005). Some indicators are very simple and quantifiable that can be directly measured from available data sets as well as derived from other information where as some effects are qualitative and difficult to measure by simple direct indicators in that case more qualitative explanation will be needed to see the effect.

Dumanski et al (1998) have classified sustainability in three major classes under Framework for Evaluation of Sustainable Land Management (FESLM) in a discussion note of Performance Indicators for Sustainable Agriculture. These are:
i). Aggregate Indicator Ratings: the performance of each indicator for each pillar (for example: productivity, cropping intensity, availability of labor, net farm income, diversity and so on) is assessed in view of its limitations to sustainable irrigation management. Numbers are assigned from lowest to highest, then accumulated using additive or multiplicative procedures. Results are expressed in a sustainability classification.
ii). Conditional Sustainability: It is common that the sustainability analyses will show that some but not all requirements for the sustainability pillars are met.
iii). Index of Sustainability – Sustainability Polygons: This assessment is constructed by first arranging the indicators around a central focus like the spokes of a wheel. The performance of each indicator is then rated, and this value is positioned on the respective spoke. This classification helps to describe sustainability of irrigation systems but more specified framework for assessing the irrigation system sustainability is needed.

A sample framework for agricultural sustainability assessment at farm scale (Muller, 1998; cited by Kellet et al, 2005) includes environmental/biophysical indicators, economic indicators and social indicator. Each indicator is assessed based on certain criteria such as productivity, efficiency, resilience, biodiversity and satisfaction of basic needs. In the more similar way MAF (1997) developed a broad range of indicators to assess the sustainability of farms with irrigated agriculture in New Zealand based on the sustainability goals. Based on three major economic, environmental and social goals to achieve, indicators that addressed these goals are developed. These indicators include: economic, production, energy, labor, agriculture and fertilizer use, water, soil and air quality indicators. Both of these frameworks are focused on farm level and it missed the financial self sufficiency and the rules in use that is the perspective of institution in the irrigation system. Svendsen (2001) discussed about the financial self-reliance in WUA run irrigation system through fee collection. The fee collection system helps for efficient use of water thus he productivity of water would be increased which motivate farmers for the effective management of scheme. Thus fee collection ratio would be an indicator for the sustainability study of irrigation system.

Cai et al (2001) has divided sustainable indicators in to the four categories namely water supply system reliability, reversibility, and vulnerability; environmental system integrity; equity in water sharing; and economic acceptability while analyzing the irrigation water management in the Aral Sea Region, Central Asia . This framework describes in the basin level and all indicators like vulnerability and environmental system integrity can't be applied and assessed in an irrigation system level.

Above mentioned indicators described by different researchers focused on the system level in an irrigated agriculture. There are other researchers who explained sustainability indicators at farm level. Batchelor (1999) has explained sustainability indicators at farm level in broadly in four category, they are:

- Agronomic- includes crop husbandry and cropping system, crop rotation
- Technical-includes adopted technology in irrigation and advancement
- managerial – includes demand driven system, water distribution and scheduling systems
- institutional- water charging system and improving legal environment

These indicators are indeed very relevant in the individual farmer's level as well as system level.

Burton et al (2000) presented his view in different way. He described the objective made up of criteria and their corresponding indicators that are measurable. But measuring the sustainability is very difficult and some of the aspect can't be measured directly but it can describe in a qualitative manner. Perret et al (2003) defined indicator is a sign that can be easily observed or measured. Indicators enable measurements and evaluations to be made over time. They divide indicators in two broad categories that are quantitative and qualitative. Brief description of the quantitative indicators for the analysis of small holder farmers as mentioned by Perret et al (2003) is presented here.

i) Technical indicators: These indicators make it possible to appreciate the development of the technical aspects of a project, for example, if it is a production program, indicators to be considered are: the cultivated areas as per production, inputs used, labor used, production obtained.

ii) Economic indicators: Economic indicators allow the economic impact and the profitability of an action to be identified. It includes: input costs, labor cost and other variable cost (eg: operating cost), fixed costs (equipment), total production costs, and turnover.

iii) Organizational indicator: These indicators can help to develop a better understanding of the organizational problems associated with the operation of a project. The suggested indicator rely on: the diverse degree of participation in the economic activities, in the meetings, in decision making and in the level of information discussed and views expressed and the number of the member in the management committee or the board of directors, the turnover rate and the quality of its member.

iv) Indicator of social equity: They allow information to be collected on sociological realities and on the ensuring corrective measures that may need to be taken.

2.4 Institutional Analysis

Institutional analysis can be viewed from the comprehensive qualitative analysis. Ostrom (1994) talks about the conditions common-pool resource (CPR) institutions have to fulfill in order to exist for a long time and to be efficient. The conditions usually term as Ostroms' eight design principle are indicators in a sense that their existence shows a viable institution, while their absence underlines non- or poor-performance.

The condition or Ostroms' eight design principles are listed bellow:

a) Clearly defined boundaries- for both the individuals/ households to withdraw resource units from CPR and for the CPR itself.
b) Proportional equivalence between benefits and cost-The appropriation rules should be related to local conditions: they can restrict the time, technology, place or quantity of resource units based on the local aspects.
c) Collective choice arrangement- Most individuals influenced by the rules of operation can participate in modifying these rules.
d) Monitoring- The monitoring, the auditing of CPR conditions and that of the behavior of appropriators, should be accountable to the appropriators, and even appropriators can perform them. This is a low cost exercise, since observing the behavior of the other appropriators in a small community is relatively easy and at the same time it leads also to information transparency, by obtaining information on compliance rate.
e) Graduated sanctions- Those appropriators who violate the operational rules receive graduate sanctions from the appropriators and/or from the officials accountable to the appropriators.
f) Conflict resolution mechanisms- Appropriators and officials have rapid access to conflict solving in the low-cost, local setting.
g) Recognition of rights to organize- External governmental authorities do not challenge the rights of appropriators to create their own institutions.
h) Nested Enterprises- Irrigation system should have nested layers of organization within the system with clear roles and responsibilities.

The sustainability indicator comprises those indicators which show the community's capacity of planning, organizing and managing the activities in a sustainable manner (GTZ, 1996 Cited by Borbala et al, 2002). Institutional analyses can be viewed from the following broad indicators comprising matrix and five main indicators and can be presented in the form of spider web model (Pederson, 1996). They are:

i. Organization: This includes WUA objective clearly defined or not, how group decision is made, coordination within group and other stakeholders.
ii. Leadership: This indicator covers how group leadership is made, how group leaders are changed, women and other member inclusion.
iii. Management: This covers activities planning process, record keepings, conflict resolution and dependency of group to external assistance.
iv. Resource Mobilization: Fund collection, financial self sufficiency, fund allocation process, accountability and transparency, financial record keeping.
v. Representation and participation: Representation in group from geographical location, caste, ethnic group, head ender, tail ender and branch canal and level of participation of members in activities planning and implementation.

Primarily these indicators were developed for the capacity assessment of CBOs. These indicators are the pillar of matrix and sub indicators can be developed based on the purpose of study. For the purpose of this study of irrigation system some of the indicators for example leadership are not specific enough. Thus these indicators should be supported by revised sub indicators for this study. This approach mainly provides information on the status of particular groups at different times on the selected criteria. The result displayed in spider web configurations (or charts) doesn't reflect the reason for the particular organization situation. The explanatory note can be made based on the Ostrom's principle and other descriptive forms of analysis.

2.5 Technical and Economic Performance

Economy of the farmers that could derive from the irrigated agriculture is depends on many factors. Farmers are the decision maker at the farm level at which resource allocation decisions are made. Choice of crops, cropping system, crop rotation, allocation of labor, acquisition of land and capital and input supply and exploring markets to sell their products is factors on which decisions are made called the technical production systems which ultimately affect the economy of the farmers. Farm management decisions are made according to the division of roles and responsibilities among family members. Based on their respective duties, Farm Management Decisions are made. These may be broken down into: investment and marketing decisions; and production and conservation decisions (FAO, 1995). It is argued that technical efficiency is determined by individual farm- and farmer-specific characteristics. The term technical efficiency, generally, refers to the performance of processes of transforming a set of inputs into a set of outputs. As described by Obwona (2006) productivity can be improved in two ways; first is technology improvement by introducing new technologies; and the second is technique improvement by improving the techniques of input application for a given technology.

Choices in agricultural production techniques are determined by many factors. These include: climate, local production conditions, availability of appropriate technology, existence of essential infrastructure, farm programs such as crop insurance or price guarantees which affect the degree of a farmer's exposure to risk, and the fiscal and regulatory context in which farms operate (UN, 2000). Choice of plot area as per agricultural production, input used, labor used, cropping intensity, crop diversity, crop calendar (the succession crop in time) are the major indicators which measures the technical production system at farm level (Perret at al, 2003). Assessing individual farmer's performance is very tedious and time consuming. Perret and Touchain (2002) explain that within and irrigation scheme, diverse strategies may develop, depending on each household's history, composition, objectives. Keetelar (2004), quoting Perret (1999), also mention that in fact it can be supposed that there are as many strategies as farmers.

The strategy of each and every individual farmer is difficult to consider. On the other hand, in many cases the system cannot be considered as homogeneous in terms of strategy. Therefore, a typology that groups farmers with similar strategies and characteristics, with regard to a given objective could be an alternative and more workable compromise. Although not all farmers in system can be interviewed, it is nonetheless possible to represent the "average" situation of each farmer type (Keetelaar, 2004). So identification of typology of the farmers and sub typology (if needed) by judging his/her the quality and completeness would be a better option to analyze the technical and economic performance.

The economic performance at farm level can be viewed from the total revenue, production cost and gross margin. The crop budget analysis is one of the easy ways that indicates the farmer's performance at farm and scheme level. The purpose of these budgets is to serve as a management and decision-making guide for current and prospective producers of these enterprises. The analysis can be made considering the gross return, the input (seed, fertilizer, labor, and equipment) used and other fixed cost such as insurance, depreciation if any (Isaacs et al, 2005). For this analysis market price of product, quantity of produce, unit of land are needed. The output can be expressed in land productivity, net profit and return on investment (Perret et al 2003). The water productivity is more important than land productivity as fresh water is becoming scarce. Upon the data availability on water used in plot and scheme level, water productivity can be calculated.

Water productivity =Crop yield (Kg/ha)/Water supplied (m^3/ha)

The residual imputation method is a very useful approach for valuing water. This approach considers the crop production in a monetary term (net farm income which is gross margin less non water inputs) produced by unit quantity of water. Residual imputation method is only useful when water is considered as one of the main input for crop production. For the general case of n inputs and m outputs, by using a different nomenclature the residual calculation can be expressed as follows (Agudelo, 2001):

$$Xn \times Pxn = \sum_{j=1}^{m}(Yj \times Pyj) - \sum_{i=1}^{n-1}(Xi \times Pxi)$$

where,
Xi = quantity of input I, i= 1,2,…n;
Yj = quantity of product j, j = 1,2,…m;
Pyj and Pxi are the prices of the products and inputs respectively;
Xn = the water input
Pxn = shadow price, that is the net benefit imputed as the value per unit of water input

The total annual crop revenue less non water input costs is a residual, which is the maximum amount of the farmer could pay for water and cover costs of production. This monetary amount divided by the total quantity of water used on the crop is the value of crop that determines maximum average willingness to pay for water for that crop. This expression can simply represent by simple equation as follows:

Value of water = (Gross farm income-production cost)/ quantity of water used

This is actually the net farm income from a crop per unit of water used for that crop, where net farm income is gross farm income less input cost (non water input cost). This value of water is very useful in fixing the water charge in the irrigation system.

The system level financial performance is another part of sustainability of irrigation system. According to Nelson (2007), financial self sufficiency, maintenance budget ratio, fee collection performance, personal cost ratio is the widely used financial performance at system level.

Financial self-sufficiency: It is the ratio of income derived from irrigation water charges and other local income excluding subsidies to the total annual expenditures of the system. This ratio indicates whether the irrigation is financially sustainable within its own resources or not. The ratio is close to one means system is financially sustainable.

Fee collection performance: It is the ratio of the annual amount of water charges collected to the annual amount of water charges assessed. This ratio close to one indicates the higher performance of fee collection.

Maintenance Budget Ratio: It is the ratio of the average annual expenditures for maintenance to the average annual expenditures for both operations and maintenance. This ratio is used to notice whether maintenance is being neglected. The optimum value varies system to system. It mainly depends on the age of the irrigation system. According to Nelson (2007), the ratio found to be about 50% in the USA in the system older than 30 years. In Nigeria the ratio was found to be about 16%.

Personal cost ratio: It is the fraction of total annual expenditures of the system expended in personal cost. This ratio actually monitors the expenditure in personnel. This ratio depends on system complexity. The complex system demands high skilled and higher number of personnel which tends to increase the ratio. In many complex stem this ratio was found between 50% and 60% according to Nelson (2007).

Table 2.1 Some Comparable Values of Indicators

Indicator	Units	Values found from literature	Remarks
Crop Yield	ton/ha	Paddy 3.2 3.9 Wheat 1.4 2.5 Maize 0.6 2.2 Potato 6.0 16.0 Oilseeds 0.3 0.5	First figure: 1996 and second figure: 2002 Source-DOI (1996) Adhikari (2002)
Gross Margin	NRs/ha	Paddy 24900 Wheat 16700 Maize 9200 Oilseeds 9250	Source- DOI (1996) Figure are as of 1996
Net Income	NRs/ha	Paddy 10468 Wheat 6500 Maize -425 Oilseeds 750	Source- DOI (1996) Figures are as of 1996
Cropping Intensity	%	212-230	Source- DOI (1996)
Water Productivity	Kg/m^3	Summer paddy- 0.56 Spring paddy- 0.21	Gal Oya Irrigation Amarasinghe (1998)
Fee Collection Ratio		0.45	Adhikari (2002)
Financial self-sufficiency		Value should be near to one	
Maintenance Budget Ratio		Value 15-60% depending upon system is old or new in USA and Nigeria	Nelson (2007)
Personal Cost Ratio		Maximum of 50-60% in complicated system and less in simple structures	Nelson (2007)
Value of Irrigation water	$US\$/m^3$	Dry maize high yield = 0.03 Tomato extensive = 0.07 Tomato intensive = 0.33	Thabina Irrigation Perret et al (2006)

Table 2.2 Some Indicators of Performance in Irrigated Agriculture and Sustainability

Indicator	Definition	Variables	Units	Remarks
Crop Yield	Ratio of weight of crop produce to cropped area	Crop produced Cropped area	kg or ton ha	Standard formula Depends on crop type and input
Gross Margin	Income from selling product	Yield Selling price	ton/ha NRs./ton	Depends on crop yield and selling price
Net Income	Income after production cost deducted	Gross income Production cost	NRs NRs	Depends on production cost
Cropping Intensity	Average number of harvested crops per year	Harvested cropped area Gross area	Ha ha	Standard formula Abernethy (1994)
Water Productivity	Crop production per unit diverted irrigation supply at the field	Crop yield Water supplied field Irrigated area	Kg m^3 ha	Depends on crop type and location Burton et al (2000)
Value of Irrigation Water	Net income per unit diverted irrigation supply at the field (residual imputation method)	Net income Water supplied at field Irrigated area	NRs m^3 ha	
Fee Collection Ratio	Ratio of actual fee collected to fee assessed	Fee collected Fee assessed	NRs. NRs.	Value close to one is good Ijir and Burton (1998)
Financial self-sufficiency	Ratio of income from water user fees and other local income to the total annual expenditures	Water fees and other income Total annual expenditures	NRs NRs	Value should be near to one Nelson (2007)
Maintenance Budget Ratio	Ratio of the average annual expenditures for maintenance to the average annual expenditures for both O&M	Maintenance cost/ year O&M cost per year	NRs NRs	Depends on new or old system and type of system Nelson (2007)
Personal Cost Ratio	Ratio of annual personal cost to the total annual expenditures.	Annual personal cost Annual expenditure	NRs NRs	Depends on complexity of system Used to monitor whether overhead cost is more

CHAPTER III

METHODOLOGY

3.1 Methodological Approach

The basic purpose of this study is to assess institutional, technical and economic condition of irrigation systems, the ways these factors influence the sustainability of irrigation system from individual performance of farmers to collective action. The technical and economical analysis is performed on individual farmer's level. The farmer's typology then determined based on the farmers with similar strategies and characteristics. The crop budget analysis and productivity is analyzed based on the farmers interview and related secondary data. The collective action in system maintenance and water services has been analyzed based on the typology of farmers. In the institutional part, capacity assessment tools has used based on developed matrix to highlights the current status of WUA compared to previous years status. Ostrom's principle is used for more qualitative analysis of institutions. Nepal now is practicing the concept of IMT either partial or fully transfer. This research is case study based where three main aspects as mentioned above has been taken into consideration which ultimately recite individual farmer's performance (technical and economic) and collective sustainability (institutional aspect and collective maintenance).

3.2 Study Area

3.2.1 Country Background

Agriculture is the main source of livelihood for a majority of the population of Nepal. More than 80% of the population is engaged in agriculture, which is still the largest sector of the economy, having a share of around 40% of the GDP. It is characterized by a subsistence orientation, low input use and low productivity. The average agriculture growth rate stood at 2.48% and non-agriculture growth rate at 10.44% between 1994/95 and 2000/01, at current prices (NPC/CBS, 2001). The population is projected to reach over 38 million by 2025 and the corresponding requirement of food grain will be close to 12 million tons. The scope of further expansion of arable land has diminished, and, therefore, the increase in food grain production depends mainly on the growth in agriculture productivity. Potential does exist in Nepal to substantially increase food grain productivity. The average food grain productivity increased from 1.83 ton/ha in 1957 to 1.99 ton/ha in 2002. The productivity of paddy, which is the major staple food for a large majority of the population, grew from 1.9 ton/ha in 1957 to 2.45 ton/ha in 2002, whereas the potential to increase the productivity of paddy at the present level of technology in Nepal remains at about 4.0 ton/ha. Similar increase in productivity potential exists in other cereal crops such as wheat and maize.

Nepal has 2.64 million hectares (ha) of cultivable land and 66% of this land, ie 1.76 million ha, is irrigable. Around 60% of the irrigable land has some kind of irrigation facility, and less than one-third has round-the-year irrigation. Agriculture production was 7.2 million tons in 2003, which just meets the minimum requirement of the nation's edible grains. Out of this, only 3.3 million tons were from the irrigated agriculture (National Water Plan Nepal, 2005).

Figure 3.1 Map of Nepal showing Chitwan district

Analysis of the distribution pattern of irrigable land in different ecological regions indicates that about 26% (60 thousand ha out of 227 thousand ha) of the cultivated land in the mountains, about 35% (369 thousand ha out of 1,054 thousand ha) in the hills and almost all the cultivated land (1,338 thousand ha out of 1,360 thousand ha) in the Terai are irrigable. Potential to expand round-the-year irrigation exists in the Terai plains in Nepal. Out of 1.34 million ha irrigable land of the Terai, only 66% has received irrigation facilities. About 768,000 ha of the cultivated land in the Terai receive surface irrigation through some 2,000 schemes.

Table 3.1 Present Status of Irrigation Development in Nepal

Geographic Region	Overall Cultivated Area '000 ha	Total Irrigable Area '000 ha	Total Irrigated Area '000 ha	Irrigated as % of Cultivated	Year Round Irrigated Area '000 ha	Year Round Irrigated As % of Irrigated	Year Round Irrigated As % of Cultivated
Terai	1360	1338	889	0.65	368	0.41	0.27
Hill	1054	369	167	0.16	66	0.39	0.06
Mountain	227	60	48	0.21	18	0.38	0.08
Totals	2642	1766	1104	0.42	452	0.41	0.17

(Source: WECS, 2001)

3.2.2 Study Area Selection

Considering the irrigable area, coverage of irrigation and production potential, Terai area which is the main representative among three ecological regions of Nepal has been taken into consideration for the study. As per the Irrigation Policy, 2003 (2060 BS), the irrigation system in Nepal has been classified as follows -

a) Operated by the users
    i. Traditional irrigation system
    ii. System transferred by government and non government agencies to the users association
b) Operated by the government
c) Operated in joint management by the government and the users association
d) Operated in joint management by the local bodies and the users association
e) Operated in private level

Users operated system transferred by government agency has been considered for this study. Panchakanya Irrigation System (PIS) lies in Chitwan district which was handed over to WUA in 1997 is one of the irrigation system under this category. The system has about 600 ha of command area serving 1600 share households (HHs).

The PIS was chosen for this research considering the following factors:

- It is one of the WUA operated system after handing over by government
- It is the representative of smallholder irrigation system of Nepal.
- It lies in the Terai (southern plain) region which has the greatest potential of production as compared to the other ecological region.
- It offers accessibility for data collection.
- It is less affected by Terai violence so that field work could be conducted without such hindrances.

3.2.3 Description of Study area

Panchakanya irrigation System lies in eastern part of Chitwan district (figure 3.2) of central development region of Nepal. Looking upon its history PIS has developed by the then Tharu (an indigenous group) landlords about 232 years ago in 1775 (1832 B.S) to irrigate approx. 100 ha of land of Sisai and Bhojad mauja (village). It remained farmers managed irrigation system (FMIS) covering the original command of Sisai and Bhojad mauja till 1974. In 1977 it was undertaken by Chitwan Irrigation Development Project (CIDP) for rehabilitation and improvement. Afterwards, the system was under management of government till 1994 while Water Users Committee (WUC) was formed in the same year. It was under joint management up to 1997 and in the same year the system was fully transferred to Panchakanya Water Users Association. It aimed to irrigate about 600 ha of land covering ward no 1, 4, 5, 6, 7, 8, 9 of Ratnanagar Municipality (RNM).

The PIS is a gravity flow irrigation system. Intake structure is located at Panchanadi (the confluence of five springs) about 2 km north from Krishna Mandir of RNM along Narayangadh-Hetauda section of East-West highway. The total length of main canal is 5 km which has 8 branch canals (length 12 km), 31 sub-branch canals (length 8 km) and 10 numbers of direct outlets. A detail of canal network is given in fig 3.3 and fig 3.4.

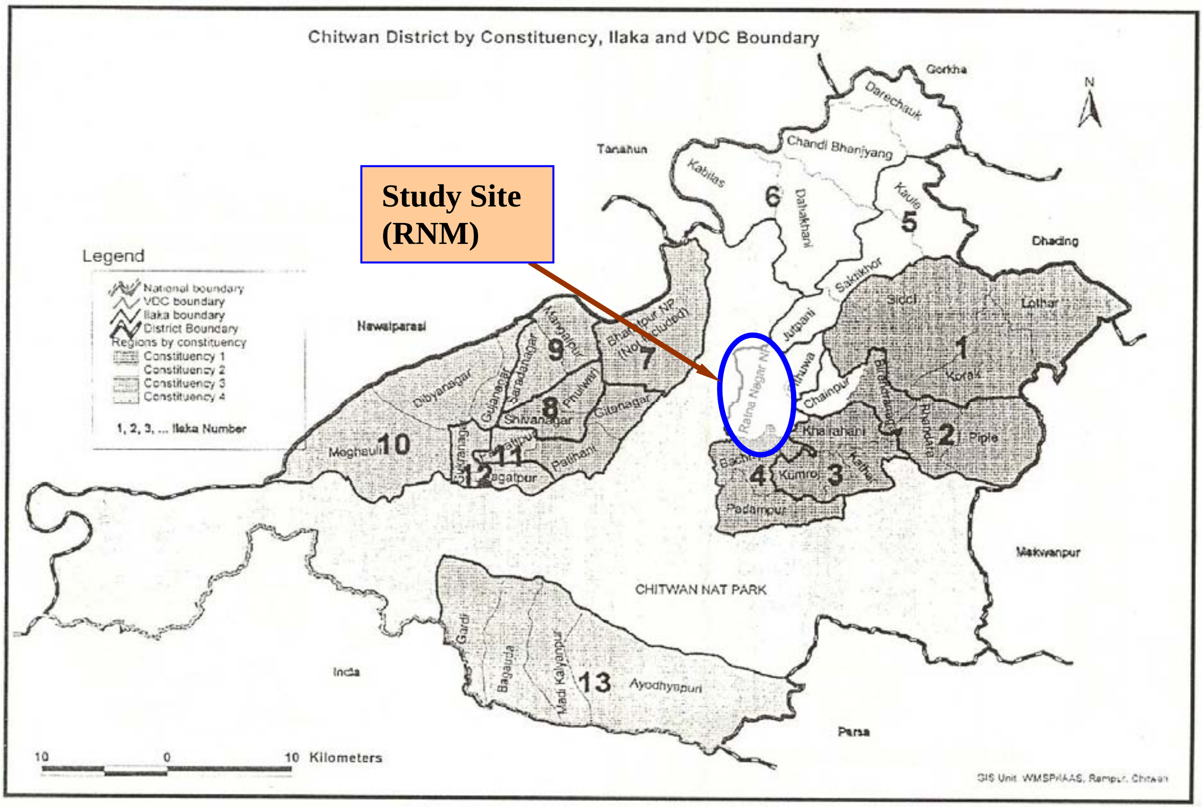


Figure 3.2 Map of Chitwan district showing Study Site

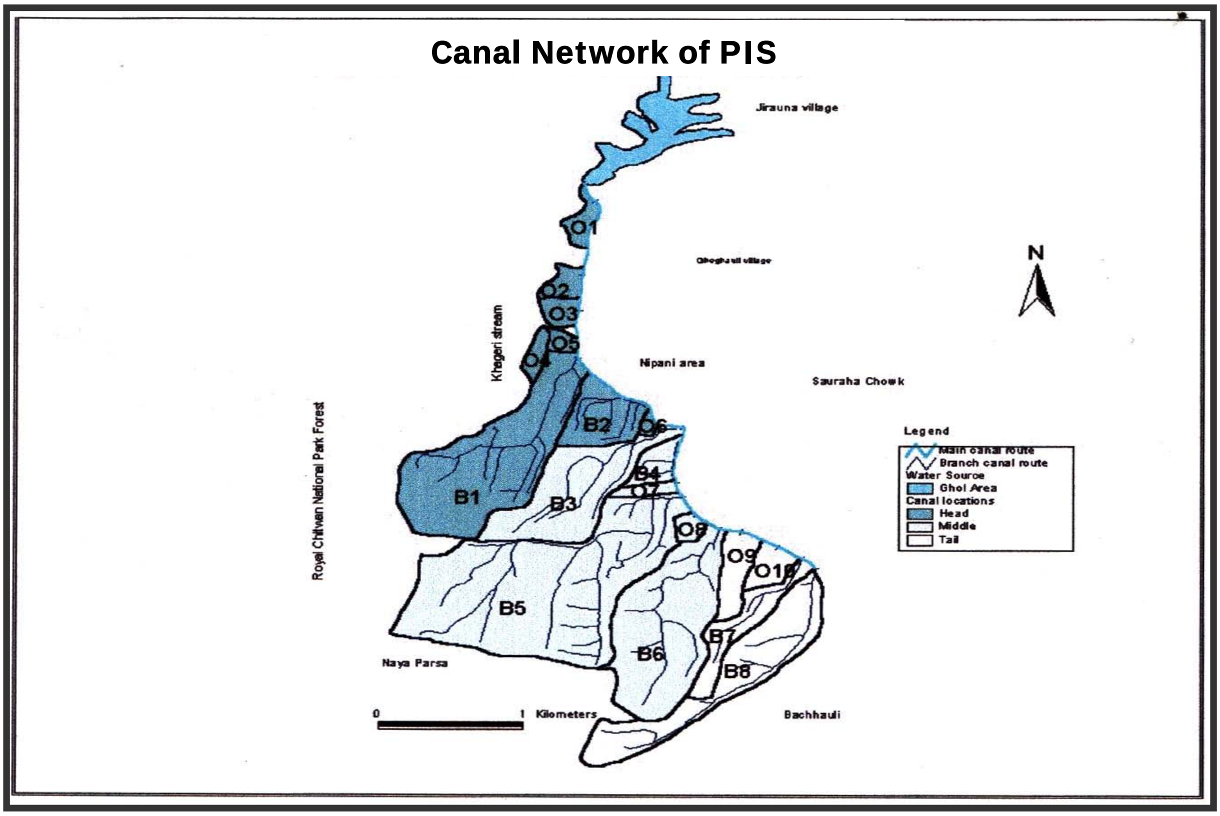


Figure 3.3 Panchakanya Irrigation Systems

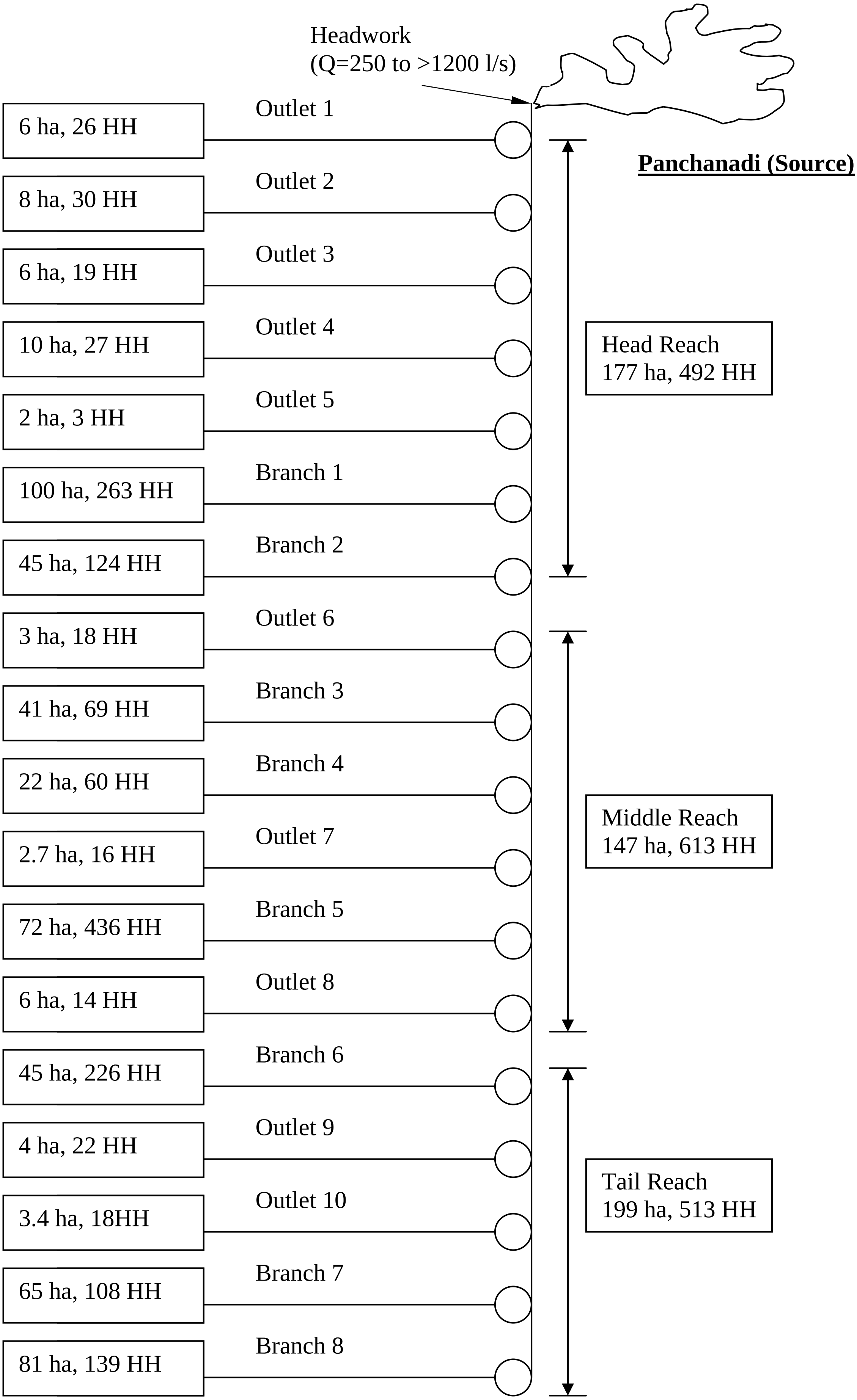


Figure 3.4 Panchakanya Irrigation System Layouts

Table: 3.2 Distributions of HHs, Command Area and Irrigated Area of PIS

Canal Reach	Branch/Outlet	Share HHs	Command Area ha	Irrigated Area ha
Head	O1-O5	119	32	30
	B1	239	100	80
	B2	114	45	31
Sub total		472	177	141
Middle	O6-O9	46	12	8
	B3	44	41	22
	B4	59	22	15
	B5	334	72	86
Sub total		483	147	131
Tail	O9-O10	39	8	14
	B6	222	45	47
	B7	81	65	23
	B8	99	81	33
Sub total		441	199	117
Total		1396	523	389

Note: O= Outlet, B= Branch, HHs=Households

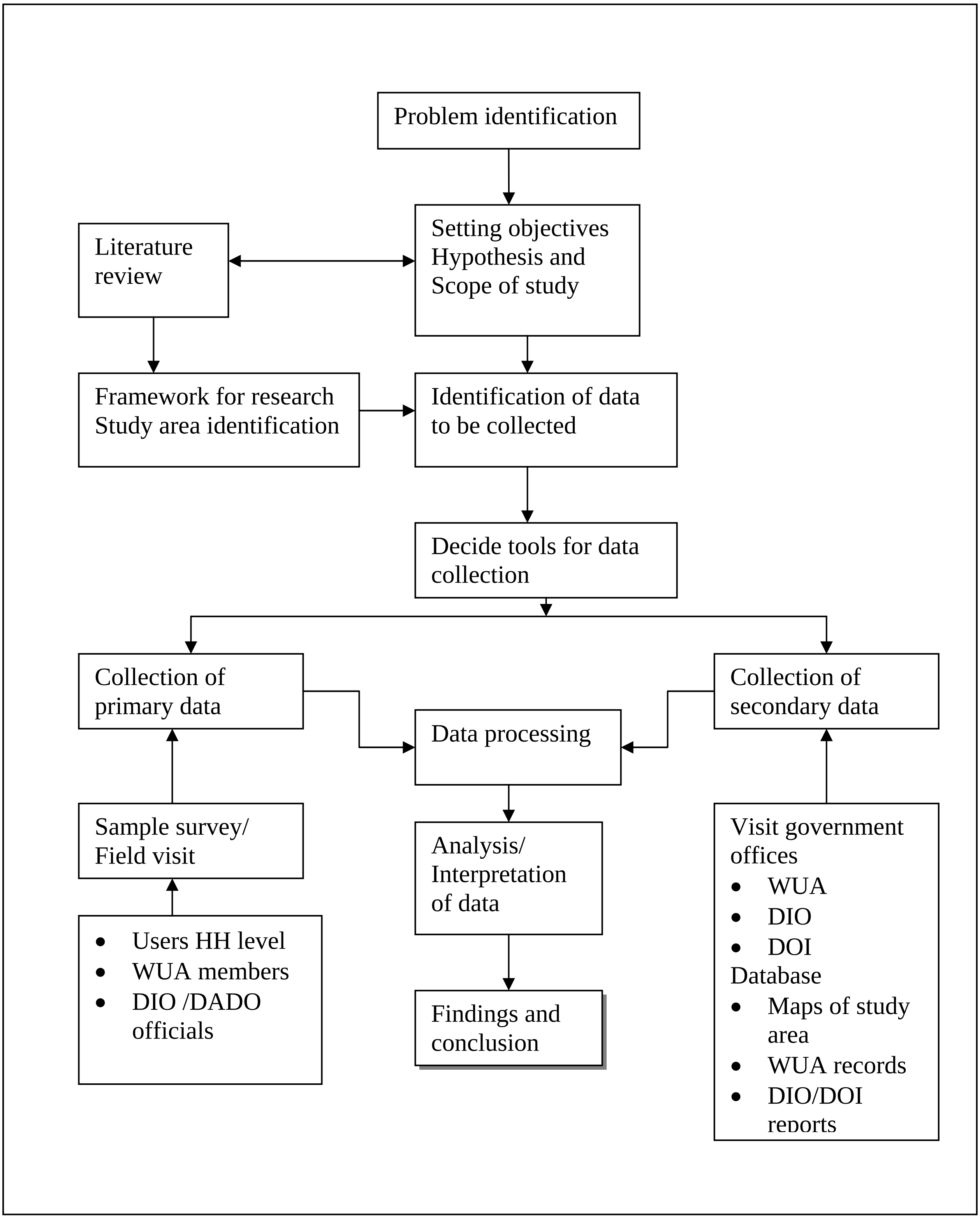


Figure 3.5 Research Methodology Flow Chart

3.3 Data Collection

3.3.1 Data Sources

Both primary and secondary sources of information are used in this study. Information related to history of irrigation, physical setting of the system, WUA, its laws, by-laws, financial status of WUA, fee collection systems were collected from office of WUA and its officials. Information related to economic aspects of farmers, cropping systems, water adequacy etc was collected through primary sources. Data collected are both quantitative and qualitative types. Data related to technical and economical analysis of individual farmers are of the quantitative types and institutional aspect, patterns of collective action, marketing system etc are based on qualitative data.

Published and unpublished reports, working papers, journals, newsletters are the major sources of secondary data. Average productivity, government policies, coverage of irrigation, irrigation history, maps, HHs, population etc are the main data those collected from secondary sources. Department of Irrigation (DOI), District Irrigation Office (DIO), Central Bureau of Statistics (CBS), Department of Agriculture (DOA), District Agriculture Office (DAO), Office of the WUA etc were the main secondary data collection centers.

3.3.2 Sample Size and Sampling Procedure

The PIS was designed to irrigate about 600 ha of land of RNP ward no 1, 4, 5, 6, 7, 8, 9 having 8 branches and 10 outlets. The sample size was worked out on the basis of stratified proportionate random sampling procedure considering all branches and outlets. Assuming the water availability and collective action may vary from head to tail end, system was divided into three parts viz; head, middle and tail reach (figure 3.4). From the WUA records of 1297 share HHs (excluding 99 HHs of Branch 8: branch 8 users are not using canal water since 2005) in the command area, a random sample of 260 (20% of total HHs) was taken into consideration. First, about 100 HHs of sample proportionately taken from head, middle and tail reach and covering all branches and outlets were interviewed for detail questionnaire and the typology of farmers was determined. In the second stage remaining 160 sampled HHs has taken into consideration for short questionnaire survey. Thus a total of about 260 HHs were interviewed.

3.3.3 Data Collection Tools and Techniques

Data collection has been made in keeping three main techniques viz; HHs Survey, Group Discussion (GD) and Review of literature from related organization. Review of literature was done using the published and unpublished materials of DIO, WUA, and other related organization like International Water Management Institute (IWMI) and Ministry of Water Resources (MOWR), Nepal.

Group discussion was applied in WUA main committee, selected branch committees and its sister organization like Women Helping Group (Mahila Sahayogi Samuha, MSS), Fresh Vegetable Cooperative, Ratnanagar. These group discussions were adopted to gather data about institutions, finding status of WUA and to triangulate the data collected from HHs level. Check list for these discussions is attached in annex-E.

HHs survey was one of the intensive field works which contains structured questionnaires focuses on the technical and economic performance of individual framers. The questions were pre-tested in the field and then adapted. Contribution of farmers in system maintenance, collective action that has been taken place in the system, willingness to pay for the water they used, perception of farmers about the rules in use, water adequacy etc. Two kinds of questionnaires were developed to conduct HHs survey: Long questionnaires and short questionnaires. The long question was developed to group the farmers considering different variable like location of farm, occupation of farmers, crop production, input used in production, extra sources of water used by farmers if any and agro-equipment they owned. Short questionnaires were then used for the farmers that have sampled for HHs survey. Both long and short questionnaires are attached in annexes-A and B.

3.3.4 Sampled Households (HHs) by Canal Reaches

As shown in the figure total farmland in irrigation system is stratified into three groups named head, middle and tail reach. The details of which with sampled HHs is given below:

Table 3.3: Sampled HHs Surveyed by Canal Reaches

SN	Canal Reach	Branch and Outlets Nos.	Sampled HHs Nos		
			LQ	SQ	Total
1	Head	Branch 1, 2; Outlets 1, 2, 3, 4, 5	35	60	95
2	Middle	Branch 3, 4, 5; Outlets 6, 7, 8	35	62	97
3	Tail	Branch 6, 7,8; Outlets 9, 10	30	38	68
	Total		100	160	260

Note: LQ=Long Questionnaire, SQ=Short Questionnaire

3.4 Data Analysis

Data collected were analyzed separately in two parts. One is economic and technical production system of the individual farmers, which gives the typology of cropping systems and typology of farmers. Each typology has different characteristics and explained based on the performance they achieved. The type of farmer has been determined based on the occupation and their commercial orientation in farming. Cropping system typology are those which shows the farmers cropping strategy with scarce water in to the head, middle and tail end. As willingness to pay is related to the water availability which depends on the location of farm, the relation of willingness to pay is described as per the farmland location. All these have been entered into statistical analysis framework to analyze through statistical significance.

The water adequacy according to their perception has been explained qualitatively to link farmers' type with water adequacy. Other is the institutional analysis of the system which includes the management perspective of WUA, the role of other CBOs on irrigation system maintenance and the rules in use in irrigation system. Ostroms principle is used to analyze the institutional aspect qualitatively.

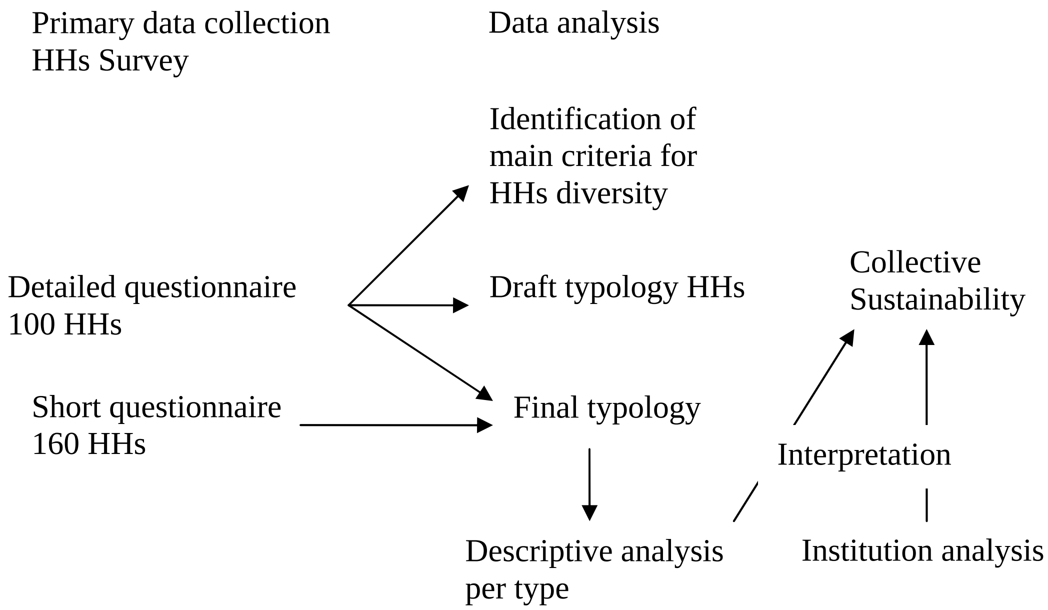


Figure 3.6 Framework for data collection and analysis (Concept drawn from Perret et al, 2005)

CHAPTER IV

ANALYSIS, RESULTS AND DISCUSSIONS

4.1 Descriptive information on PIS

4.1.1 General Information

Table 4.1 recaps some key information about PIS. Farmers have broad range of variation in age. The age of farmer rang from 23 to 84 years and average age is 50 years. Male is the dominant in decision making in farming where only 17% of HHs are female headed. Average land owned by the farmers is 0.54 ha where as the cultivated land per farmer including rented in land is 0.56 ha. The main crop in the scheme is Monsoon Paddy which is usually planted in the month of June or early July and harvested by October.

Table 4.1 Descriptive Information of PIS

Average age of farmer (years)	50 (12.56*)
Percentage of female head households	17
Average size of family	6 (2.32*)
Average farm size-owner land (ha)	0.54 (0.63*)
Average farm size cultivated by farmer (ha)	0.56 (0.63*)
Main crop	Summer Paddy
Crop calendar of main crop	Mid June (July)-Oct
Main marketing outlet	Local bazaar, Hawkers
Existing irrigation service fee (Rs/ha)-for main crop	150
Existing irrigation service fee (Rs/ha)-for other crop	75

* =standard deviation

Source: WUA records, Authors' Field Survey, 2007

4.1.2 Occupation

Subsistence farming is the main occupation of majority of the household head in the area. As the number of employments opportunity existed around the area, some farmers are also engaged in services.

Table 4.2 Occupation of Sampled Households

Main Occupation	Nos of farmers	
Full Time Farmer	177	(68)
Regular/Salaried Employee	34	(13)
Self-employed	35	(13)
Retired	13	(5)
Student	1	(0)
Total	260	(100)

Source: Authors' field survey, 2007.

Note: Figures in the parenthesis indicates the percentage.

It can be noted from table 4.2 that about 68% of HHs head are fully devoted in agriculture farming. Second largest populations of the HHs head (13%) were reported to be regular salaried employee either in the government or other private company and the same percentage of HHs head are engaged themselves called self employed. About 5% farmers are retired from their service and engaged in farming.

4.1.3 Migration

A large majority of sample HHs constitutes the immigrants from hill districts. Darais and Tharus has migrated hundreds years ago from other southern plain of the country. Other ethnic groups are settled in the area ranging from 2 years to more than 60 years ago. Out of total HHs surveyed 68% farmers are migrated from other districts while the rest 32% is local inhabitant. Majority of the immigrants (42%) had come to settle during the last 25 to 44 years ago where as 16 % had come earlier. For the last twenty five years onward 41% of immigrants come down to the area. The highest percentages of local inhabitant (38%) have settled in the tail reach where as most of the immigrants had settled in the head and middle reach.

4.2 Agricultural Practices

Agriculture is the bastion of a majority of the sampled HHs, providing both employment and livelihood. Agriculture practices are changing because of change in cropping pattern, landholdings, farm inputs and technology. This section tries to explain the existing land holding status of farmers and land tenancy system.

4.2.1 Land Tenancy System

Table 4.3 gives an overview of land tenancy system in PIS. A large proportion of the sampled HHs (65%) in the scheme is owner cultivated, operating only their own land themselves. Across the three farms location head reach has the highest percentage of owner cultivator 67% followed by 65% in tail and 64% in the middle. Second category of land tenancy of sampled household constitute owner cum tenant (17%). Pure tenant farmers are very few (2%) as shown by sampled households. Across the farm location 3 and 4% of middle and tail farmers are pure tenant. The sampled households constituted 9% as owner cum rented-out which means they operate their own land in addition to renting out to others. Of the total sampled HHs 7% totally rented-out their land to others. Almost same percentage of HHs in head, middle and tail fall upon this type of tenancy.

Table 4.3 Distribution of Sampled Households by Tenancy Practice

Tenancy Type	Percentage Distribution
Owner Cultivated	65
Owner cum Tenant	17
Pure Tenant	2
Owner cum Rented-out	9
Fully Rented-out	7

Source: Authors' field survey, 2007.

4.2.2 Land Holding Size of Farmers

Agricultural lands within the location constitute mainly two categories viz; Khet (wet lands) and Tandi (Bari). Khet further divided into two categories irrigated and rain fed. Table 4.3 gives the overall view of total land holding size with location of farm.

Table 4.4 Average Operational Land Holding Size

Location	Percentage of Farmers within Location				Average Holding Size (ha)
	Up to 0.5 ha	0.5-1.0 ha	1.0-1.5 ha	Above 1.5 ha	
Head	68	21	6	5	0.51
Middle	74	19	5	2	0.53
Tail	60	22	9	9	0.66
Total	68	20	6	5	0.56

Source: Authors' field survey, 2007.

Middle reach farmers have the highest percent (74%) of land falls on up to 0.5 ha holding size where as tail reach farmers has highest percentage 22%, 9% and 9% of land categories 0.5-1.0 ha, 1.0-1.5 ha and above 1.5 ha respectively. From table 4.3 it is noted that tail reach farmers have the highest average land holding size (0.66 ha) followed by 0.53 ha in middle and 0.51 ha in the head. The average land holding size of the sampled household is 0.56 ha.

4.3 Farmers Typology

Farmers' typology is established to highlight differences among farmers and farming systems. During the detailed questionnaires interview with farmers, two main criteria were identified for differentiating farming styles. One is the farmer's type based on the occupation of household head and other is location of farm. For both criteria the farming system and farmers performance was recorded. Broadly two types of farmers have been identified: full time farmers and part time farmers. There found diversity within each type of farmers in terms of their strategy in farming. So these two types further divided into more categories: full time farmers in three types and part time farmers in two types as shown in table 4.5. Typology of farmers is used in the latter part of this study to analyze the performance of farmers in their farm level and location-wise farmers' type is used to relate the collective action that has been made for the sustainability of the scheme. The typology of farmers is established based on occupation and cropping pattern adopted by farmers. Each typology is then described and differentiated by other parameters like agricultural production, gross and net income from production and number of crop species sold. Each basis (parameter) is tested using statistical analysis software (SPSS) whether there is significant difference or not.

i) Full time farmer-subsistence farming **(Type-I)**: These farmers are fully involved in farming. Most of the farmers of this group, plant the cereals, pulses and oilseeds. They have no commercial orientation which means they don't plant commercial crops which has greater value. The highest percentage (58%) of sampled HHs falls upon this type.

ii) Full time farmer-commercially oriented **(Type-II)**: These farmers are fully engaged in farming with very good performance in commercial farming. Instead of the cereal crops they grow commercial crops like potato, lady fingers, tomato etc which has very high market price and production compared to the cereals. Only 10% of sampled farmers fall in this group.

iii) Part time farmer- Regular salaried (**Type-III)**: These are farmers who have their regular job outside farming and partially involved in agricultural practices. Family members of this group involved in farming but the major decision is made by the household head. This category counts 12% of sampled HHs.

iv) Part time farmer- Own business **(Type-IV)**: Who are self employed either having small shops or work as hawkers or having poultry farming or work as wage labor. Family member of the household engaged in farming. It is reported from table 4.5 that, these farmers has second majority of sampled HHs (15%).

v) Full time farmer- Retired **(Type-V)**: Those who were employee in services before but fully involved in farming now are retired farmers. Retired farmers as per sampled household are found very less in the scheme (about 5%).

Table 4.5 Number of Farmer by Typology -Location wise

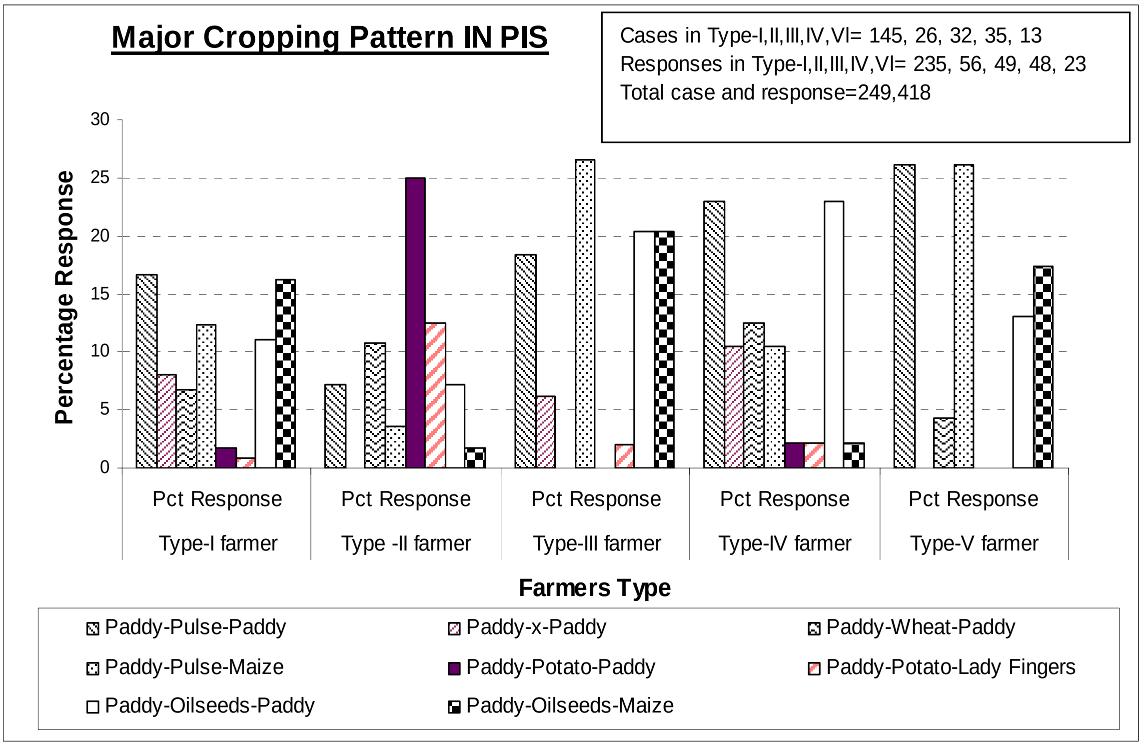
Type of Farmer	Location-wise nos of farmers			Total
	Head	Middle	Tail	
Full time farmer-subsistence farming	45 (47)	62 (64)	44 (65)	151 (58)
Full time farmer-commercially oriented	4 (4)	7 (7)	15 (22)	26 (10)
Part time farmer-Regular salaried	19 (20)	12 (12)	1 (1)	32 (12)
Part time farmer-Own business	18 (19)	13 (13)	7 (10)	38 (15)
Full time farmer-Retired	9 (9)	3 (3)	1 (1)	13 (5)
Total	95	97	68	260

Source: Authors' field survey, 2007. Note: Figure in the parenthesis indicates percentage within location and farmers type

From the table 4.5, it is noted that majority of Type-I framers (62 out of 151) have their farm in middle reach, majority of Type-II farmers (15 out of 22) in tail reach and majority of Type-III, IV and V in head reach.

4.4 Cropping Pattern and Crop Calendar

Paddy is the dominant crop grown in the PIS. Almost all farmers (97%) grow monsoon paddy while 50% sampled farmers grow spring paddy. The percentage of spring maize grower is found 47% followed by mustard, pulse and wheat (winter crops) 35%, 30% and 13% respectively.



Source: Authors' field survey, 2007

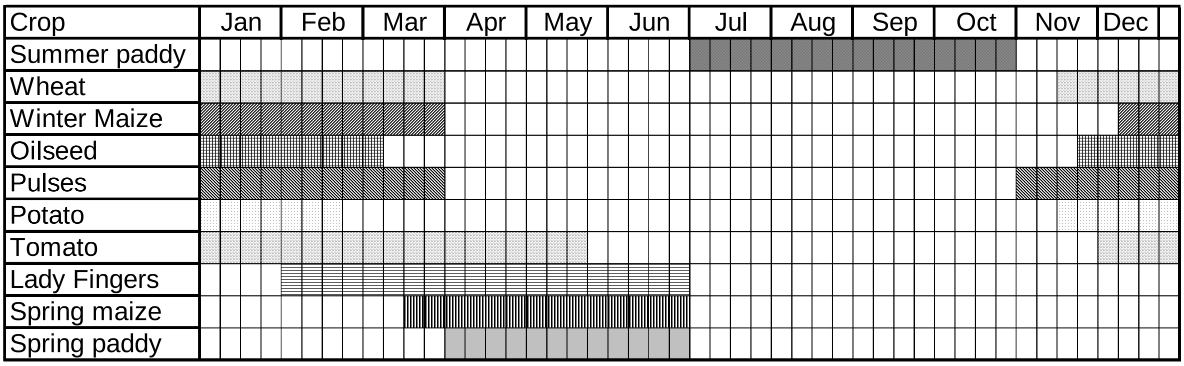
Figure 4.1 Chart showing major Cropping Pattern in PIS

Table F.1 (Appendix-F) shows the percentage of farmers using different cropping pattern in the scheme area. Of the 249 respondents (cases), there were 418 responses found because many farmers are practicing more than one cropping pattern even in a single plot of land. The major cropping pattern (16% of responses) in the scheme is paddy-pulse-paddy followed by paddy-oilseed-maize (15%), paddy-pulse-maize (13%), and paddy-oilseed-paddy (13%). Farmers adopting other patterns (paddy-wheat-maize, paddy-x-paddy etc) are in minority about 6% and less.

There are different dominant cropping patterns in five different farmers' type. As shown in the figure 4.1, paddy-oilseed-paddy (17% of the type) is the major pattern of Type-I farmers where as paddy-potato-paddy (25% of the type) is major cropping pattern of Type-II farmers. Similarly paddy-pulse-maize (27%) and paddy-pulse-paddy (23%) is the major pattern of Type-III and Type-IV farmers respectively. In the latter part of the report the profitability of each crop by type of farmers has been explained. The farmers, who have ability in choosing appropriate crop has seen more beneficial than those who couldn't choose the crop that has more production potential.

As cropping pattern also related to the availability of water in different canal section it is customary to analyze the strategy of farmers by location wise. It also found that cropping pattern differ with farm location viz; head middle and tail. As presented in Appendix-F (table F.1), paddy-oilseed-paddy is the major pattern of head reach where as paddy-pulse-maize in the middle and paddy-oilseed-maize in the tail reach. This pattern simply can reflect the water availability in the scheme location wise which is explained in the latter part of the report. As irrigated agriculture is related to water availability farmers from head to tail choose the crop so that water scarcity could be minimized. What is seen from this pattern is that as maize needs less water than paddy so that middle and tail farmers choose maize (spring crop) because availability of water in those reaches are comparatively less. This reflects that each category of farmers has diverse strategy in their farming system.

There are mainly three seasons for crop plantation: summer, winter and spring. The main summer crop is paddy. In winter season mainly wheat, pulses, oilseeds, potato, maize and vegetables are usually grown. In spring season major crops grown are paddy, maize and vegetables. The crop calendar of major crops is presented in Fig. 4.2.



Source: Authors' field survey, 2007
Figure 4.2 Crop Calendars of PIS

4.5 Farmers Performances

Individual farmer's performance is compared based on the typology, the farm size and the location of farm. Farmers' performance by typology has been verified based on production, gross income and net income of the product, cropping intensity and number of crop species (types) sold. Following sections deal the performance of farmers based on above criteria.

4.5.1 Production Based on Typology, Location and Farm Size

As explained in the previous section there are mainly five types of farmers identified. It was assumed that there is diversity in different aspects like cropping strategy, production, gross income and net income in this farmer's type. On the other hand the scheme was divided into three parts namely head, middle and tail based on the availability of water. It will be checked whether or not diversity exists in these three locations. The main objective of this section is to verify the diversity and performance of different farmer's type. Farm size is also taken as basis to check whether there is any significance difference in those parameters. Based on the collected data from field the crop yield was calculated by dividing the crop production on a plot by the area of plot.

The numbers of farmers in each group and each group of crop type is not same and some numbers are very less than 15. Nevertheless the statistical analysis is applied in each type of crop according to farmer's type. Although the estimates of various parameters are consistent, the F value estimates may be somewhat inaccurate due to small size of sample in some crops and farmers type. So these values shouldn't be viewed as formal statistical tests of the significance of the variables rather it is more appropriate to treat them as approximate values that help to show the diversity in farmer's type.

Table 4.6 summarizes the crop yield by farmers' type. Comparing the production within type of farmers, full time commercially oriented farmers have highest performance of crop yield in most of the crop where as retired farmers hold second position in terms of crop yield.

Table 4.6 Crop Production in PIS by Farmers Type

Crops		Crop Yield (ton/ha)						F-test
		Type-I farmer	Type-II farmer	Type-III farmer	Type-IV farmer	Type-V farmer	Wt. Av.	(ANOVA)
Summer paddy	N	145	26	29	35	13	248	df=4, 243; F=5.39; p value 0.000, *
	Mean	4.05	4.93	4.29	3.97	4.49	4.18	
Oilseeds	N	52	4	17	15	4	92	df=4, 87;F=3.95; p value 0.005, *
	Mean	0.41	0.88	0.61	0.79	0.94	0.55	
Pulses	N	41		11	7	9	68	df=4, 64 ;F=0.30; p value 0.87 ns
	Mean	0.44		0.59	0.33	0.60	0.47	
Potato	N	2	24	2	2		30	df=3, 26 ;F=2.68; p value 0.067, **
	Mean	8.25	14.60	9.75	9.50		13.51	
Wheat	N	23	4		5	2	34	df=4, 30 ;F=0.90; p value 0.474, ns
	Mean	2.34	2.63		2.21	0.86	2.28	
Lady Fingers	N		6				6	NA
	Mean		11.49				11.49	
Spring Maize	N	70	9	21	15	8	123	df=4, 118 ;F=0.34; p value 0.851, ns
	Mean	1.54	1.73	1.37	1.43	1.61	1.52	
Spring Paddy	N	74	10	17	22	6	129	df=4, 124 ;F=2.32; p value 0.060, **
	Mean	3.83	4.74	4.30	4.10	4.10	4.02	
Tomato	N	2	5	2			9	df=2, 5 ;F=6.21; p value 0.044, *
	Mean	13.67	19.60	18.00			17.75	

Source: Authors' data; Note: N= Nos of households, Wt. Av. = weighted average * =significant at 5% significance level, ** =significant at 10% significance level, ns= non significant, NA= not applicable

The comparison of crop yield among five different type of farmer shows that there is significant difference in the average crop yield in summer paddy, oilseeds, potato, spring paddy and tomato (table 4.6). The difference in average crop yield of other crops like pulses, wheat, lady fingers and spring maize among different farmers type is statistically insignificant. Of the nine types of crop is presented in table 4.6, Type-II farmers have the highest value of crop yield in all crops except oilseeds and pulses. Although the number of Type-V farmers are very less (5% of total sampled household), their performance in crop yield is found second position among the five types of farmer. These farmers are mainly oriented in paddy, pulses and oilseeds production. Type-I and Type-IV farmers are weaker in crop production. The reason behind the low yield of Type-I farmers and Type-IV farmers found from the interviewed data is that they are using very conservative system of farming and inappropriate input supply (seeds, fertilizer, pesticides etc). Among five types of farmers group it is found that Type-II farmers are more intensified in terms of commercial orientation and crop yields. *The overall average yields for Chitwan district in 2001/02 were: paddy 3.31 ton/ha, maize 2.15 ton/ha, wheat 2.04 ton/ha, oilseed 0.404 ton/ha and potato 13.94 ton/ha (CBS, 2001).* Comparing the crop yield between sampled household and the average of Chitwan district, paddy, wheat and oilseeds found more in PIS. Potato also seems close to the district average but maize yield is lower than the district average. Comparisons of these yields with the yield of 2002 as presented in literature review reveals that yield of the most of the crop has increased except in potato and maize.

Comparing the yield within PIS in different location, head farmers produce more than the other two sections (middle and tail) especially paddy and wheat. As shown in table 4.7, production of pulses, spring maize found higher in middle than other two sections. Tail farmers are oriented in cash crops like potato, lady fingers and tomato whose production is higher than the other two sections. Comparison of all crops between head, middle and tail of the scheme resulted that statistically there is no significant difference in their means.

Table 4.7 Crop Production in PIS by Location

Crop	Crop Yield (ton/ha)				Remarks
	Head	Middle	Tail	Wt. Av.	(ANOVA)
Summer paddy	4.23	4.21	4.06	4.18	ns
Oilseeds	0.56	0.50	0.59	0.55	ns
Pulses	0.52	0.52	0.21	0.47	ns
Potato	11.25	13.09	14.43	13.51	ns
Wheat	2.90	2.32	1.50	2.28	ns
Lady Fingers		12.00	11.40	11.49	ns
Spring Maize		1.61	1.24	1.52	ns
Spring Paddy	4.04	4.17	3.71	4.02	ns
Tomato	13.67	18.50	21.33	17.75	ns

Source: Authors' field survey, 2007. Note: ns= difference in mean crop production with location is statistically insignificant within 10% significance level

Table 4.8 presents crop production by farm size. Farm size has been stratified in the range of 0.5 ha and the mean of crop production as per land holding size is calculated. It reveals that small holder farmers (less than 1 ha) produce more than the large farm holder (greater than 1 ha). Large holding farmers have their good performance (higher than average) only in oilseed, spring paddy and potato production. Comparison of crop yield based on the landholding resulted that there is no significant difference in their means except summer paddy where small holder farmers have higher productivity.

Table 4.8 Crop Production in PIS by Land Holding Size

Crop	Crop Yield (ton/ha)					Remarks
	Up to 0.5 ha	0.5-1.0 ha	1.0-1.5 ha	> 1.5 ha	Wt. Av.	(ANOVA)
Summer paddy	4.35	3.90	3.67	3.77	4.18	*
Oilseeds	0.57	0.53	0.65	0.46	0.55	ns
Pulses	0.45	0.67	0.41	0.35	0.47	ns
Potato	13.71	12.00	15.00	12.00	13.51	ns
Wheat	2.42	2.16	1.68	2.40	2.28	ns
Lady Fingers	11.49				11.49	ns
Spring Maize	1.53	1.66	1.12	1.36	1.53	ns
Spring Paddy	4.05	3.89	3.88	4.43	4.03	ns
Tomato	17.71		18.00		17.75	ns

Source: Authors' field survey, 2007. Note: * = significant at 5% significance level, ns= non significant within 10% significance level, Wt. Av.=Weighted Average

4.5.2 Cropping Intensity

Water sources

The PIS is a small gravity flow irrigation scheme located in the central part of Chitwan district in Ratnanagar Municipality. Panchanadi, which is a perennial drain formed with confluence of five perennial springs in the catchments is the source of irrigation in PIS. The discharge varies from 250 l/s in the spring to as high as 1200 l/s in the summer (rainy season). The PIS lacks sufficient supply of water from the source in spring season and sometimes in the beginning of summer season. There are shortages of water in the scheme most of the time and especially in the tail-end reach of the command area- shortage of water is acute throughout the year when there is no sufficient rainfall in the year. The net irrigated area of the system falls substantially below the originally expected command area of about 600 ha. Even in the command area located at the head reach, there are areas which suffer from inadequate water supply. According to the results of field survey, significant number of farmers stated that the available water is inadequate for the crops during seed bed preparation and plantation of paddy and providing right time irrigation for the vegetables. This inadequacy is due to heavy seepage loss and improper maintenance work. Due to low flow in the spring season, farmers use ground water as well as some river water from Budhi Rapti River to supplement the canal water (number and percentage of farmers using pump for underground water extraction is presented in table 4.18). The water adequacy as perceived by farmers is presented in table 4.15 in the latter part of the report.

Cropping intensity

The overall cropping intensity which is computed as the percentage of total cropped area over actual cultivated area of the sampled household is estimated as 265%. The overall cropping intensity of the same scheme was reported to be 222% in 1996 (DOI, 1996). Table 4.9 presents the cropping intensity of the scheme with different canal reaches and as per the farmer’s type. It reveals that head reach farmers have higher cropping intensity (283%) as compared to middle (268%) and tail (236%) reaches. Cropping intensity is directly related to water availability in the scheme. With the canal reaches farther from the headwork or water source the cropping intensity found less which is the reflection of water availability towards the lower canal reaches decreases.

Table 4.9 Cropping Intensity in PIS by Farmers Type

Type of farmers	Cropping Intensity			
	Head	Middle	Tail	Wt. Av.
Type-I farmer	278	264	212	254
Type-II farmer	300	271	300	292
Type-III farmer	289	267	200	278
Type-IV farmer	272	280	233	268
Type-V farmer	300	267	300	292
Weighted average	283	268	236	265

Source: Authors’ field survey, 2007

Of the five types of farmers, Type-II has the highest cropping intensity in head and tail regardless of water availability. This might be due to higher percentage of farmers in the tail-end (most of the Type-II farmers have their farm in the tail reach) are using underground water to supplement canal water. Type-V farmers have same cropping intensity almost in all locations. In middle reach, Type-IV seems highest cropping intensity. In average Type-II and Type-V farmer has the highest cropping intensity.

Table 4.10 illustrates the cropping intensity of the farmers having different land holding size. Farmers having land up to 0.5 ha has the highest cropping intensity (276%). Land holders above 1.5 ha (254%) and land holder of the range 0.5-1.5 ha comparatively has less cropping intensity. Farmers having land holding greater than 1.5 ha have very high cropping intensity in head and middle reach where as tail-end farmers of the category has low cropping intensity. From interview it found that large holding farmers (area above 1.5 ha) in the tail reach leave their farm uncultivated in the spring season because of water scarcity which tend to decrease the cropping intensity in that reach. The representation of large land holding farmers is very less 13(5%) of sampled households of 260. Having less cropping intensity in the tail reach of all categories of farmers is due to scarce water in the spring season.

Table 4.10 Cropping Intensity in PIS by Land Holding Size

Landholding Size (ha)	Cropping Intensity			
	Head	Middle	Tail	Wt. Av.
Up to 0.5	287	276	259	276
0.5-1.0	263	233	200	235
1.0-1.5	280	240	200	238
Above 1.5	300	300	200	254
Weighted Average	283	268	236	265

Source: Authors' field survey, 2007

4.5.3 Production Cost and Net Farm Income

This section deals with the average production cost, gross margin and net farm income of major crops as per the farmers' type of the sampled household in the scheme as well as on the basis of farm location. The production of each crop of cultivated area, input given to the farm, average rate of selling price of product were recorded from farmers interview. The unit rate of input supply and selling price of product was then verified from vendors, WUA members and during group discussion with farmers. Then it was adopted for calculating the gross income from the product.

Gross Income = Selling Price * Yield per ha
Net farm income= Gross Income-Production cost
Production cost= variable cost (cost of fertilizer, seeds, herbicides, pesticides, labor, tillage, equipment hiring) + fixed cost
Fixed cost (land tax, water charge, depreciation and repair and maintenance cost) is not taken into account.

Table 4.11 Production Cost, Gross Margin and Net Farm Income of Different Crops by Location of Farm

Farm Location		Summer Paddy	Oilseeds	Pulses	Potato	Wheat	Lady Fingers	Spring Maize	Spring Paddy	Tomato
Head	GI	50729	16822	12932	90000	40530		17210	44488	
	PC	32097	15859	14873	62269	31530		17178	28794	
	NI	18632	963	-1942	27731	9000		32	15694	
Middle	GI	50525	15048	12900	104727	32523		17688	45816	
	PC	30694	10589	10731	77146	26308		11577	28946	
	NI	19831	4459	2169	27581	6214		6111	16870	
Tail	GI	48760	17775	5318	115424	21000	172286	13668	40792	330000
	PC	34757	18190	2222	71632	17800	59702	15335	26115	91000
	NI	14003	-415	3096	43792	3200	112583	-1667	14677	239000
Weighted Average	GI	50153	16464	11707	108112	31920	172286	16674	44243	330000
	PC	32490	14958	10473	71756	25706	59702	14998	28253	91000
	NI	17663	1506	1233	36356	6214	112583	1676	15990	239000

Source: Authors' field survey, 2007. Note: GI=Gross Income, PC=Production cost, NI=Net farm income, All figures are in NRs., 1 US$=NRs. 62.0

The variable cost of crop production varies by crop types and canal reaches. Paddy, oilseeds, pulses, maize and potato are the major crops grown in the scheme command. Table 4.11 shows production cost (exclusive water charge and other fixed costs), gross income and net farm income. Per hectare cost of production of summer paddy doesn't differ much by farm location. There is slight difference in spring paddy in production cost. The tail farmers rarely use compost fertilizer in the farm for spring paddy that's why the production cost seems less. Some times compost used by farmer in one season was accounted for the crop of that season but they were supposed to use the fertilizer for whole year. The variation in production cost mainly due to compost and the time for tillage which depends mainly on the soil type. But the soil type is not considered here for analysis. There is great variability in production cost, gross income and net farm income of oilseeds and pulses in different locations. It is because some farmers from the head reach where land is wet after harvesting the previous crop directly sows their seeds on the farm without tillage. Some farmers use compost and some doesn't. These two factors directly affect the production cost and crop yield. By these figure of production cost and discouraging farm income, oilseeds and pulses are the crop which could be rejected to plant in future. During the time of interview and group discussions, most of the farmers expressed their dissatisfaction in the production of pulses and oilseeds although the scheme area was very popular to produce those crops few years back. Among all the crops; tomato, lady fingers and potato are the most profitable crop. But too few farmers adopted these crops until the time of survey.

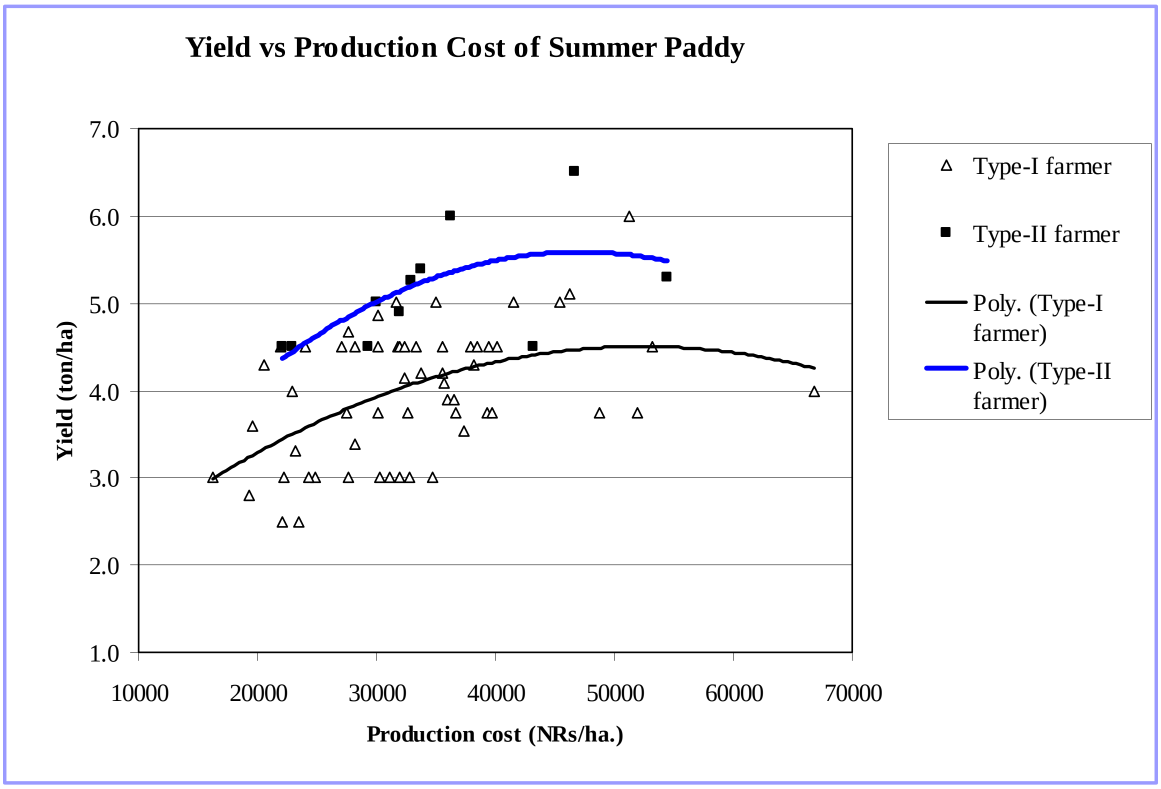
Table 4.12 presents the farm incomes based on the farmer types. Type-II farmers used more input among the farmer's type but the same farmer type is the most profitable in terms of net farm income. As shown in the table the production cost of summer paddy are NRs. 33112, 32644, 26706, 33323 and 33978 for Type-I, II, III, IV, and V respectively and their corresponding net farm income were found NRs.15440, 26465, 24811, 14310 and 19856 and the mean difference is statistically significance at 5% significance level.

Table 4.12 Production Cost, Gross Margin and Net Farm Income of Different Crops by Farmer Type

Crops		Farmers' Type						F-test
		Type-I farmer	Type-II farmer	Type-III farmer	Type-IV farmer	Type-V farmer	Wt. Av.	(ANOVA)
Summer paddy	GI	48553	59109	51517	47633	53834	50153	*
	PC	33112	32644	26706	33323	33978	32490	ns
	NI	15440	26465	24811	14310	19856	17663	*
Oilseeds	GI	12150	26325	18318	23580	28125	16464	*
	PC	13442	21538	15082	24525	22561	14958	ns
	NI	-1292	4787	3236	-945	5564	1506	*
Pulses	GI	10921		14659		14917	11707	ns
	PC	9143		19309		9832	10473	ns
	NI	1777		-4650		5085	1233	ns
Potato	GI		116807	78000	76000		108112	ns
	PC		76923	60350	59738		71756	*
	NI		39883	17650	16262		36356	ns
Wheat	GI	32778			30912		31920	ns
	PC	27427			21676		25706	ns
	NI	5351			9236		6214	ns
Lady Fingers	GI		172286				172286	NA
	PC		59702				59702	NA
	NI		112583				112583	NA
Spring Maize	GI	16929	19067	15054	15752	17738	16674	ns
	PC	15639	19835	12004	14811	12168	14998	ns
	NI	1290	-768	3050	941	5570	1676	ns
Spring Paddy	GI	42158	52184	47306	45045	45100	44243	*
	PC	28653	29112	35243	26100	28315	28253	ns
	NI	13505	23072	12063	18945	16785	15990	**
Tomato	GI		330000				330000	NA
	PC		91000				91000	NA
	NI		239000				239000	NA

Source: Authors' field survey, 2007. Note: GI=Gross Income, PC=Production cost, NI=Net farm income, * =significant at 5% significance level, ** =significant at 10% significance level, ns= non significant, NA=not applicable, All figures are in NRs., 1 US$=NRs. 62.0

Similarly in spring paddy Type-II farmers have almost double net income compared to all other farmers although the cost of production is nearly the same. It is because the strategy of Type-II farmers is better in giving the input either in combination of manures or in using improved variety of seeds. Except spring maize, Type-II farmers have higher net farm income in all crops. From this analysis it can be concluded that Type-II farmers more intensified (giving better input and producing more, adopting different high value crops) and strategic (choice of crop and cropping pattern).



Source: Authors' field survey, 2007

Figure 4.3 Chart showing crop yield vs. crop production cost of Summer Paddy

Crop yield and corresponding cost of production of summer paddy of two farmers type is presented in figure 4.3. The figure shows Type-II farmers perform better compared to Type-I. With increase in production cost up to NRs. 50000 per ha that is the input supply, the yield of Type-II farmers found increasing where as Type- I farmers yield seems increasing with production cost up to NRs.55000. The maximum average yield of Type-II farmers is 5.5 ton per ha when the production cost reached to NRs. 50000 but in the same production cost Type-I farmers' yield is approximately 4.5 ton per ha.

From the graph presented in Appendix-F (figure F.1) it is noted that Type-I farmers and Type-II farmers invest more in crop production. Type-III farmers stand in second position in crop production. Although the representation of farmer after the maximum yield is low, the decreasing trend of graph after reaching maximum doesn't reflect well what the optimum production cost for optimum yield is. This graph should be interpreted just to show the difference of crop yield as per farmer's type. In the same production cost, the crop yields of different types of farmers differ significantly.

4.5.4 Farmers Practices of Selling Agricultural Product

Market development gained momentum in Chitwan district and nearby market of the PIS after the influx of hill migrants in the area. This allowed farmers to sell their products. Farmers usually sell their product keeping some parts for their family consumption. Many farmers sell the product when the market value get rise even when the product is less than required for their daily consumption. Almost all farmers sell their product in the nearby market and often in the villages to the hawkers. Based on the interview, the number of varieties they sold and the gross income by selling the product as per farmers type is presented in table 4.13.

Table 4.13 Number of Crop Species Produced and Sold

Description	Type-I farmer	Type-II farmer	Type-III farmer	Type-IV farmer	Type-V farmer	Total
No of crop species sold	1-3	2-5	1-4	1-2	2-4	
Nos of farmers	103 (68)	23(88)	22(69)	25(66)	10(77)	183(70)
Total No of crop species produced	2-6	4-7	2-6	2-6	2-5	
Nos of farmers	151	26	32	38	13	260

Source: Authors' field survey, 2007

From the table it is noted that all farmers sold their product depending upon how many crop species they produced and the surplus after separating for their consumption. It shows that highest percentage (88%) of Type-II farmers sell their products followed by Type-V farmers (77%). Type-II farmers sell the product ranging from 2 to 5 species followed by Type-V farmers 2 to 4 varieties. This table doesn't explain who is most profitable; rather it explains which farmers are more commercially oriented and diversified. There is no mechanism in the PIS for marketing the goods collectively. Farmers individually manage to sell their products as and when needed.

4.5.5 Agricultural Support Services

There are so many kinds of support services available in PIS related to agriculture knowledge, market information, trainings, agricultural inputs, credit etc. Out of these support services farmers were asked about their participation in training and know how about the local level extension offices within the area.

a) Participation in Training

Altogether 243 farmers (out of 260) responded about their participation in training. 73% of Type-II farmers participated in training related to institution or water distribution or agronomy while about 50% farmers of all other type of farmers participated in training. Most of the farmers participated in training as shown in table 4.14 is related to institution and water distribution which was provided under IMT program.

Table 4.14 Farmers Participation in Training

Participation in training related to agronomy /irrigation	Type-I farmer	Type-II farmer	Type-III farmer	Type-IV farmer	Type-V farmer	Total
Yes	59	19	14	17	7	110
	(42)	(73)	(45)	(50)	(54)	(45)
No	80	7	17	17	5	133
	(58)	(27)	(55)	(50)	(38)	(55)

Chi^2 = 16.27, p =0.00. Figure in parenthesis indicates percentage

Source: Authors' field survey, 2007

Individual farmers' performance mainly related to the farmers skill in farming system and strategy. Mainly Type-II farmers (58%) have got the agronomic training (Appendix-F table F.2). The overall percentage of farmers getting this kind of training is very minimal (18%). Most of the Type-II farmers are organized themselves to find the support services either from individual approach or collectively through their group (leader farmer group). However, most of the subsistence farmers expressed that they don't have enough skill and knowledge about cultivation of commercial crops. This might be the barrier for those farmers to motivate towards crop diversification (commercial crops).

b) Know how about agriculture extension offices

One question was asked to farmers during interview about support service- 'where is your nearby government agriculture extension service office?' Almost all Type-II farmers answered right. More than 60% of all other type of farmers has no knowledge where was that office. Reality is that the agriculture extension office is located in the same building of WUA. It means that they are not acquiring the support service from the extension office. But all are known about the cooperative who supply seeds and fertilizer.

4.6 Summary-Farmers Performances

So far discussed in section 4.5, farmers' performance has described based on different dimensions: location, landholdings, cropping strategy, production and number of crop species sold. Different farmers' type has their own strategy in terms choice of crop and cropping pattern. Production per unit land based on the land holding size and location of farm is found insignificant where as production, gross income, net income are statistically significant by farmers type. So we can conclude that typological approach proves a relevant approach to identify and analyze farmers' performance and their strategy within the irrigation system. This approach would be helpful to WUA to search for farmers training need assessment and to formulate policies to address the different needs of the farmers to improve their performances.

Average national crop yield of paddy, maize, wheat, oilseed, potato and vegetables is 2.55, 1.82, 2.16, 0.74, 12.65 and 11.42ton/ha (MoAC, 2008) and corresponding Chitwan district average is 2.80, 2.80, 2.50, 0.60, 15.37 and 13.50 ton/ha respectively. Comparing these values with the average crop yield of PIS, crop yield of paddy is very high (4.18 ton/ha) than national as well as district average. Crop yield of maize, wheat, oilseed, and potato of PIS is 1.52, 2.28, 0.55 and 13.51 ton/ha respectively. Yield of maize is less in PIS than national and district average but yield of wheat is higher than national average and lower than district average. Oilseed has lower yields in PIS and yield of potato is in between national average and district averages. Yield of other profitable crops like vegetables are encouraging in PIS (higher than national and district average) and the net income derived from these crops are higher than cereals.

4.7 Farmers Perception on Irrigation Management and Water User Association

4.7.1 Scheme Management and Physical Aspect

Two kinds of canal operation system exist in the PIS: proportional system and gated system. Proportional system is used when there is plenty of water, all the gates opened and water distributed proportionally in all branches and sub branches. Gated system is used when there is scarce of water. Uniform service of gated system found in PIS where rotational schedule (time, discharge, frequency based on the land size) is imposed to the farmers.

In the previous section most of the performance of farmers was assessed based on the farmer's typology. It was noted that many of the performances of farmers were significantly different by farmers type where as there is no significant difference by location of farm. Different types of farmers are distributed in all locations of the canal reach and many of their collective action situations and water related issues directly related to the farm location. It is customary to analyze these water related issues and collective action situations by farm location. In this section, discussions are based on the water adequacy, water reliability, equity and flexibility of supply in different farm location.

Structured questions were used to get farmers perception about the water related issues. The farmers had been asked to rate their satisfactions level as very good, satisfactory, not satisfactory and poor. The interview was conducted for 260 farmers in all reaches but 246 farmers responded where as 14 farmers couldn't express about water adequacy. From table 4.15, it reveals that most of the farmers from head (65%) and middle (53%) are getting adequate water in all season. On the other hand most of the tail farmers (58%) are not satisfied with water adequacy in the spring season. As expected, water adequacy from head to tail is in decreasing order.

Table 4.15 Water Availability in Different Farm Location

Level of satisfaction	Head	Middle	Tail
Quite satisfactory	13	5	2
	14%	6%	3%
Satisfactory	61	48	10
	65%	53%	16%
Not Satisfactory	20	34	36
	21%	38%	58%
Poor		3	14
		3%	23%
	94	90	62
	100%	100%	100%

P<0.01

Source: Authors' field survey, 2007

Water reliability is another parameter which has been used to measure the service level in the scheme. In table 4.16 the percentage of farmers expressing the water reliability in four level of satisfaction is arrayed. Of the 35 interviewed farmers from head end almost all

(94%) felt that water is satisfactorily reliable. As compared to upper reach farmers, tail farmer felt less reliability of water supply meaning that they are not having water with confidence. From head to tail the level of satisfaction of farmers is decreasing. Tail farmers are not getting water at the time of need and as per planned schedule. The rotation of water starts from head to tail. The tail farmers affected by any delay in the head and middle reach farmers.

Table 4.16 Water Reliability by Farm Location

Level of satisfaction	Head	Middle	Tail
Very good	1	0	0
	3%	0%	0%
Satisfactory	33	20	5
	94%	59%	17%
Not Satisfactory	1	13	22
	3%	38%	76%
Poor	0	1	2
		3%	7%
	35	34	29
	100%	100%	100%

P<0.01

Source: Authors' field survey, 2007

In Appendix-F (table F.3, F.4), farmer's perception about water equity and flexibility is presented. These tables show that, head farmers have more flexible schedule than the lower reach farmers. This is not actually the case in PIS, but farmers perceive flexibility in terms of water adequacy. As there is rotational system in the scheme, farmers have lesser rights to choose their frequency, duration and timing of irrigation. More than 75% of farmers of all locations are satisfied with the equity of water share. Equity is defined in the sense that supply of water to users is in relation to their allocated share. This doesn't mean that water is adequate for farmers rather there rights is defined and get water as per schedule during the time of scarce. From the point of view of these four main parameters adequacy, reliability, equity and flexibility, tail farmers are not having good services from the irrigation scheme as compared to the upper reach farmers.

4.7.2 Respondents Willingness to Pay and Perception on Water Users Association

a) Water Charge Payment and Use of Pump for Groundwater Extraction

The respondents were asked whether they are paying water charge and have they are using pump/motor facility for extra irrigation or not. As far as the water charge paid is concern, it is noted from the table 4.17 that there is decreasing percentage of farmers paying water charge from head to tail. Conversely the percentage of farmers having pump is increasing from head to the tail (table 4.18). The higher the percentage of farmers paying water charges the lower is the percentage of farmers having pump and motor facilities and vice versa. It is noted that water adequacy is decreasing from head to the tail parts of the canal so farmers are using motor to extract ground water to supplement canal water.

Table 4.17 Water Charge Payment at Different Location

Water Charge paid or not	Head	Middle	Tail
Yes	91	86	55
	96%	89%	81%
No	4	11	13
	4%	11%	19%
	95	97	68
	100%	100%	100%

P<0.01
Source: Authors' field survey, 2007

Comparing the satisfaction of water adequacy from table 4.15 with above mentioned parameter, higher percentage of tail farmers is not satisfied with water adequacy compared to head and middle. These three parameters (water adequacy, water charge payment and farmers having motor) are comparable. When there is scarce of water, farmers look for the other option (underground water pumping) of water which ultimately decreases the percentage of farmers paying water charge

Table 4.18 Farmers Using Pump for Underground Water Extraction

Have using pump for underground water extraction?	Head	Middle	Tail
Yes	13	25	27
	14%	26%	40%
No	82	72	41
	86%	74%	60%
	95	97	68
	100%	100%	100%

P<0.01
Source: Authors' field survey, 2007

b) Willingness to Pay for Water Charge

As far as the willingness to pay is concerned, farmers were asked how much they are willing to pay if there were improved water supply and water related services. Currently each user pays Rs. 975/ha as ISF and maintenance charge when user cultivate three crops a year (two season paddy and one season other crop). The farmers' willingness to pay is presented in table 4.19. The percentage of farmers who are reluctant to pay more than existing water charge is decreasing across the farm location from head (29%) to tail (10%). Most of the farmers of all locations are willing to pay up to 20% increment in existing charges. When there is increase in water charge beyond 50%, farmers are reluctant to pay. Percentage of farmers who paid irrigation fee regularly is less in tail reach as compared to the head and middle reach (table 4.17). But upon the improved service condition percentage of farmers in the tail are more willing to pay which can be related to the water adequacy in the system. As water adequacy is less in tail reach so they are using more pumps to supplement their canal water. The percentage of farmers who are willing to pay about 150% more than the existing water fee is very less (8% of tail farmers); it reflects that some part of the tail farm has acute water shortages.

Table 4.19 Respondents Willingness to Pay under Improved Water Supply

Willingness to pay (more than existing water charge)	Head	Middle	Tail
Not willing to pay more	27	20	6
	29%	22%	10%
Willing to pay 20% more	57	41	28
	61%	46%	47%
Willing to pay 50% more	6	19	15
	6%	21%	25%
Willing to pay 100% more	4	7	6
	4%	8%	10%
Willing to pay 150% more		3	5
		3%	8%
	94	90	60
	100%	100%	100%

P<0.01
Source: Authors' field survey, 2007

c) Perceptions of Farmers on WUA

Sampled household were asked to express their view about some major issues related to WUA and its rule in the PIS. Farmers were asked about WUA relation with stakeholders, understanding of rules of PIS and its implementation. Table 4.20 shows more than 50% of farmers of all reaches are satisfied with WUA relation with them, mostly the head farmers (80%). They feel that WUA and branch committees are taking care of them. Similarly, respondents in all reaches (over 50%) are satisfied with the WUA relation with other agency (Appendix-F table F.5). It means that WUA trying their best to coordinate government agencies to have more programs for renovation work. However, farmers are not happy with the renovation frequency in the canal. Tail farmers are less satisfied compared to other reaches because they are not getting water as of their share. More than 50% of farmers of all reaches feel that the rules in use are clear and consistent theoretically. Compared to other reaches, middle farmers are less satisfied about the rules in the system; the reason behind that there exists some political displeasure between the leader of the WUA and some leader farmers group (Authors' observation during field work, 2007).

Table 4.20 Relationship between WUA and Farmers

Realtionship between WUA and Farmers	Head	Middle	Tail
Very good	2	2	0
	6%	6%	0%
Satisfactory	24	19	19
	69%	54%	63%
Not Satisfactory	2	3	5
	6%	9%	17%
Poor	7	11	6
		31%	20%
	35	35	30
	100%	100%	100%

P=0.43
Source: Authors' field survey, 2007

As far as the know-how of rules (Appendix-F table F.6) is concerned majority of the middle reach farmers (55%) are little aware about the rules of WUA while more than 40% of other reaches farmers are little aware. Most of the farmers are satisfied with rules are clear and unbiased (Appendix-F, table F.7). Here is some contrary between these expressions of farmers. The meaning here is that as far as they have know the rules, these are clear and unbiased.

Table 4.21 Whether Rewarding and Punishing Mechanisms are Satisfactory?

Rewarding nad punishing mechanisms	Head	Middle	Tail
Very good	2	1	0
	6%	3%	0%
Satisfactory	15	7	3
	43%	20%	10%
Not Satisfactory	9	6	3
	26%	17%	10%
Poor	9	21	24
		60%	80%
	35	35	30
	100%	100%	100%

P<0.01
Source: Authors' field survey, 2007

Farmers in all reaches are highly dissatisfied about the rewarding and punishing mechanism in the scheme, meaning that rules related to punishment and rewarding is not followed properly (table 4.21). Mostly tail farmers are dissatisfied with the rules that should impose against water theft. The water stealing cases are not recorded but tail farmers claim that water is often theft in upper reaches specially in case of scarce water. Head and middle farmers, where outlet structures are installed (outlet structures were supposed to open all the time as per the previous practice) often feel that they are privileged to have more water which creates problems to tail farmers.

4.8 Summary-Farmers Perception and Willingness to Pay

Water adequacy, reliability, equity and flexibility are the main parameters which show how good service is provided to the farmers in the scheme. It was found that tail farmers are not having good services from the irrigation scheme as compared to the upper reach farmers.

Tail farmers using more pumps compared to other reach farmers to extract ground water when there is scarce of water. It shows that farmers look for the other option (underground water pumping) of water in case of water inadequacy which ultimately decreases the percentage of farmers paying water charge.

Rules related to reward (for farmers whose performance is better) and punishing (for those who violates the rule) are not properly followed in PIS. These rules can be properly followed so that farmers are more responsible to participate in the scheme in many ways. It found that farmers in all location and of all types are very eager to see PIS to be more effective in implementing these rules.

4.9 Local Irrigation Institution and Institutional Performance

From the preceding section it was found that tail farmers are less satisfied with the service provided by the PIS. Farmers typology established in this report is not identified by PIS in the past thus there is no special rule in PIS to cater these farmers type differently. The collective action that has been taken in scheme has no clear link with typology of framers but have with location. Thus institutional performance is based on the overall assessment of the scheme (and location wise as found possible) rather than typology of farmers. Institutional performance is analyzed based on the key financial indicators (irrigation service fee (ISF) collection ratio, financial self sufficiency, maintenance budget ratio and personal cost ratio), Ostoms' eight efficiency and sustainability principles(clearly defined boundaries, proportional equivalence between benefits and cost, collective choice arrangement, monitoring, graduated sanctions, conflict resolution mechanisms, recognition of rights to organize and nested enterprises), WUA capacity assessment, water sharing rules and other collective action rules in the scheme. These all have been described in the following sections. Before getting entered to analyze these performances, institutional setup and the development of institutions are explained below.

4.9.1 Institutional Setup

The PIS has a long history about more than 230 years. From the beginning up to now it gazed many modality of execution and management system. On its initiation system was totally managed by farmers and it run for long period with local interaction and its own management system. About 200 years after its initiation (1974) it got government assistance to renovate the scheme. It continued for about 20 years with government support up to 1994 with management of government. Then with irrigation transfer project PIS was undertaken in joint management of government and users. Latter in 1997 the system was transferred to WUA. With its different modalities (farmers own management, joint management and again WUA operated after transferred by government formally) of management it run now as WUA operated systems.

Before the constituent amendment of 1997, a two tired structure of WUA was perceived with a main committee at the main system level and branch committee at the branch and outlet level. Any user, either tenant or owner operator, was eligible to assembly members were proposed to be elected from constituent branch and outlet on the basis of 15 bigha (1 bigha = 0.67ha)) of land under irrigation. Outlets having area less than 15 bigha under irrigation were combined with adjacent branch or outlets canals to ensure representation from that outlet in general assembly. At branch level, a five- member branch committee was proposed to be elected by the branch level assembly of the users including chairperson, secretary and three members. Women participation was emphasized at all branch and outlet committee. Depending upon the area under irrigation, required numbers of representatives for general assembly were proposed to be elected by the branch level assembly of the users. At the system level, a thirteen member main committee was proposed to be constituted including chairperson, vice chairperson, secretary and treasurer as functionaries elected from general assembly and nine chairpersons of the constituent branch committee were the ex-officio members in the main committee. The tenure of functionaries at each level of WUA was for two years.

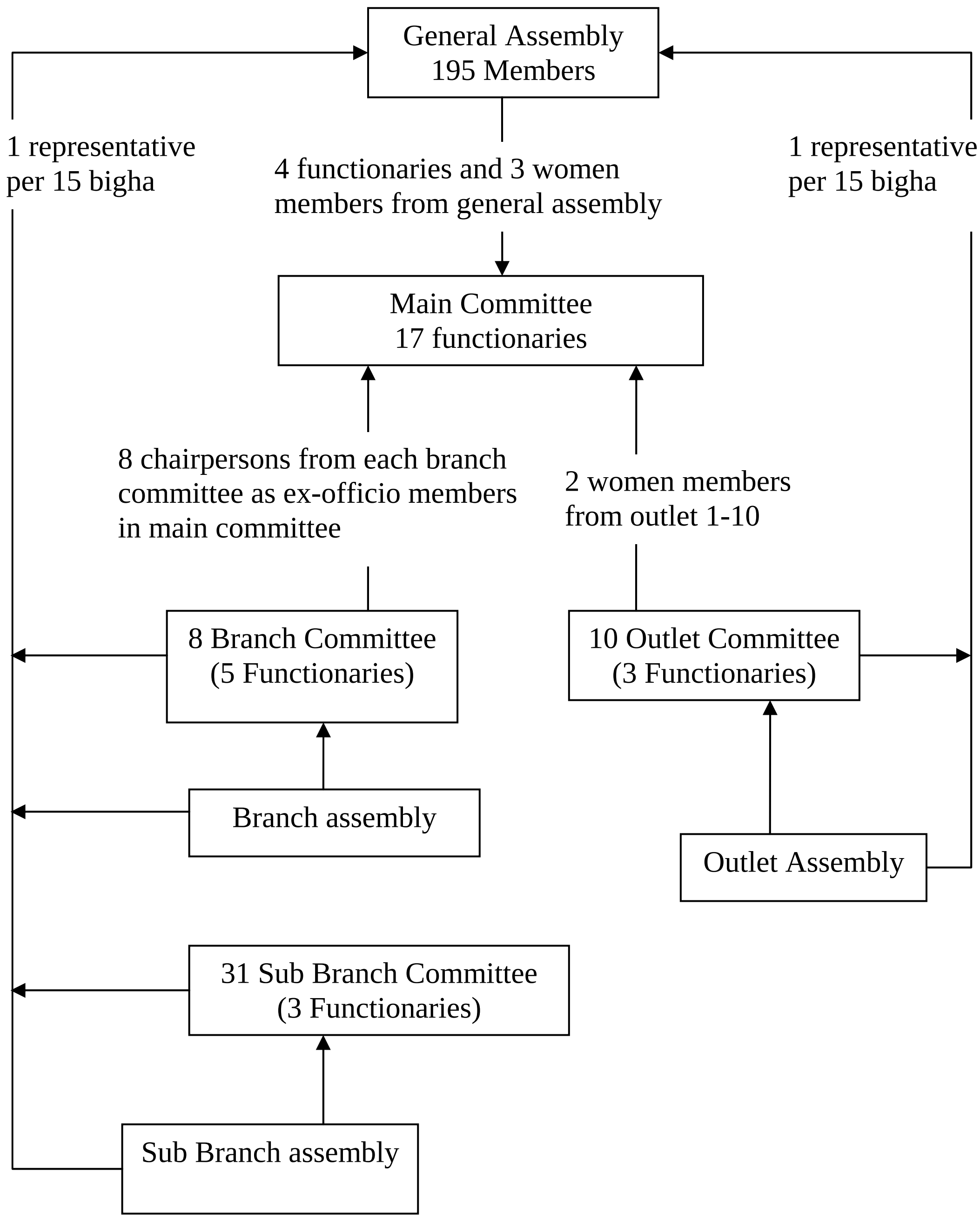


Figure 4.4 Organization Structure of WUA in PIS
Source: WUA Constitution (Second amendment 2005)

The organization structure was found to be inconsistent with the physical layout of the system and the hydrologic boundary. Therefore, an amendment in the constitution was proposed that was enacted by the general assembly of the WUA in 1997. In the constitution of 1997 the organization had two tiers of organization but with two levels at the lower level- branch committee and outlet committee at each branch and outlet. Instead of 13 members there were 16 members in the main committee and all other rules were remained same in that amendment. Later in 2005, second amendment of constitution was made in which the organization itself proposed to be more democratic and inclusive. Each sub branch level committee was proposed in addition to branch and outlet committees. The main committee has a total member of 17. These 17 members consists of 4 functionaries: chairperson, vice chairperson, secretary and treasurer elected from general assembly, 8 chairpersons of eight branches as ex-officio members, 2 women members elected from outlets 1-10, and 3 women members from all locations elected from general assembly. In the same time of constitution amendment WUA prepares its different regulation policies like administrative policy, financial regulation, operation and maintenance policy and irrigation service fee policy. These policies are considered very useful in day to day works and at all level of decision making process. Current organization structure of PIS is shown in figure 4.4.

Current representation of farmers in the main committee as well as in branch committee is actually same as the constitutional rules. Out of 17 main committee members, 5 (30%) members are from head, 7 (40%) from middle and 5 (30%) from tail reach. Of the four elected main functionaries chairperson and secretary are from middle, treasurer from head and vice chairperson is from tail. Other member representation is subjected to the constitutional requirements (ex-officio member from 8 branches committee and women member from general assembly and outlet committees). In terms of constitutional requirements in selecting the members in main committee, PIS can be regarded as one of the best performer (Authors' observation).

4.9.2 Financial Performance at Scheme Level

Fee collection Ratio: It is defined as the fraction of ISF assed over ISF collected. As shown in figure 4.5 the fee collection ratio is different in different reach. The overall trend of all canal reaches is similar except tail reach has higher variability. Head reach has the highest level fee collection ratio in all year, where as tail reach has the lowest.

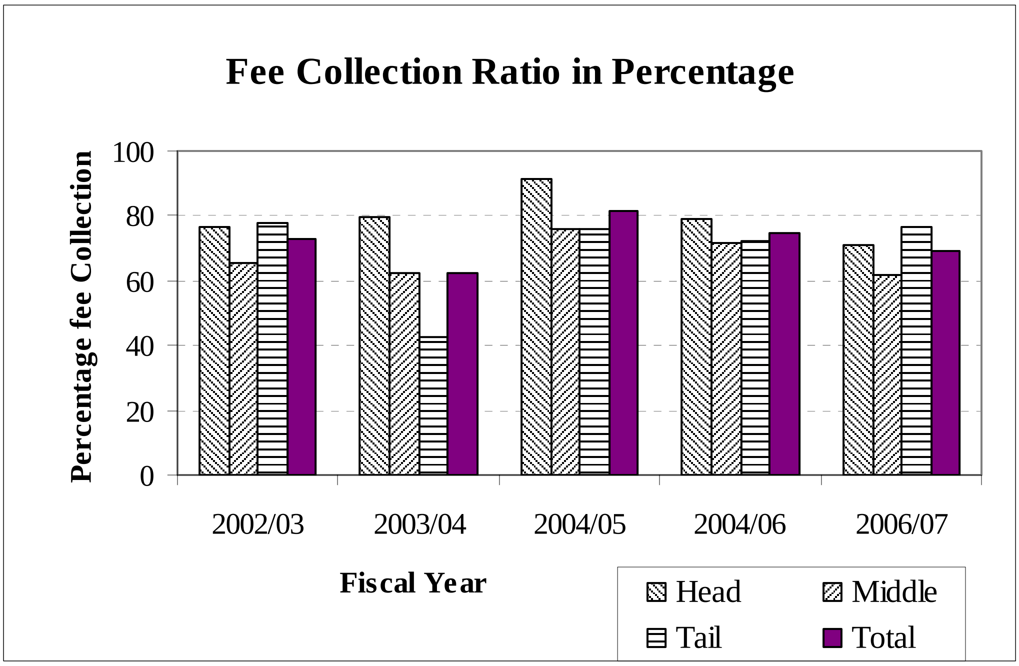


Figure 4.5: Fee collection ratio in scheme level through out different canal sections
Source: PIWUA official record

During the year of 2004/05 fee collection percentage is as high as 80%. This was because of due fee of the pervious year was collected in that year. The overall fee collection percentage is increasing from year 2002 to 2004 and little down towards the following years. Fee collection ratio is some how lower in the tail reach than upper reach in most of the year. Irrigation service fee collection is always related to the availability of water and also the cropping intensity. As water is inadequate in tail reach as of the interviewee responses, then they are reluctant to pay water charge. On the other hand inadequacy gets support to lower cropping intensity. When the number of crops planted per year is decreased ultimately the water fee collection result lowering than the assessed.

Financial Self Sufficiency: It is the ratio of income from ISF and other local income (not including subsidy) to the total annual expenditure. The ratio has been calculated from the data available in WUA records. For the five consecutive fiscal years from 2002/03 to 2006/07 the financial sufficiency were found 1.35, 0.49, 0.53, 0.99 and 0.76 respectively. Although it doesn't reflect the actual financial sufficiency of the scheme, analyzing the income and the expenses that incurred is important to notice. In the first year, the ratio was found more than one because no maintenance work had been done in the scheme on that year. Thus the saving of water charge maintains this ratio is as high as one.

Maintenance Budget Ratio: It is defined as the ratio of the average annual expenditure for maintenance to the average annual expenditure for operation and maintenance. Considering five years (2002 to 2006) expenditures, the average annual maintenance ratio of the scheme is 0.56. This ratio is used to check whether maintenance being neglected or not. The older the system the greater is the ratio. As the scheme was constructed about 30 years ago, this ratio seems within the range as compared to other country like USA although the system operation is totally different. The PIS is a small and very simple system in terms of operation, compared to big systems. The major part of the fund goes to maintenance rather than the personal cost, which tends to increase the maintenance cost.

Personal cost Ratio: This is the ratio of annual personal cost to the total annual expenditures. In PIS, as of the recorded balance sheet of WUA, this ratio found 0.22, 0.12, 0.14, 0.14 and 0.08 in the five consecutive years. As compared to the technically complex system (where the ratio is around 0.5) this ratio is very less.

4.9.3 Water Users Associations' Management Capacity Assessment

The core elements used in assessing the WUA capacity are: organization, leadership, management, resource mobilization, participation and water distribution. Each core indicator has three sub indicators with five level of performance (1 for weak to 5 for strong performance) as shown in Appendix-C. It is assumed that each sub indicator of an indicator has equal importance and each sub indicator of an indicator has only one rating lies within 1 to 5. Each indicator can have maximum 15 score if all sub indicators rated as strong performance (rating 5) and minimum of 3 score if all sub indicators rated as weak.

WUA members and Women Helping Group (Mahila Sahayogi Samuha) were the participants during assessments. Indicators and sub-indicators were presented to the participants to score each indicator according to their performance. Participatory discussion was made among participants during the rating of indicators. The rating was finalized based on consensus among participants. So this is a self evaluation of farmers based on the given indicators.

The same assessment was done about five years ago in 2002 with the help of other organization like SAGUN (Strengthened Actions for Governance in Utilization of Natural Resources (SAGUN) Program. There were five main indicators in the previous assessment. As per the objective of WUA, one indicator ‘irrigation structures and water distribution’ was added in this assessment as per the discussion with WUA members. The current assessment is comparable to the previous assessment. This capacity assessment tool can’t interpret absolute status of the organization rather it can compare the status of two time periods. This assessment is done to find the current status of WUA as a whole rather than dealing with canal locations and type of farmers. Present status of WUA with compared to previous (year 2002) assessment is presented in figure 4.6.

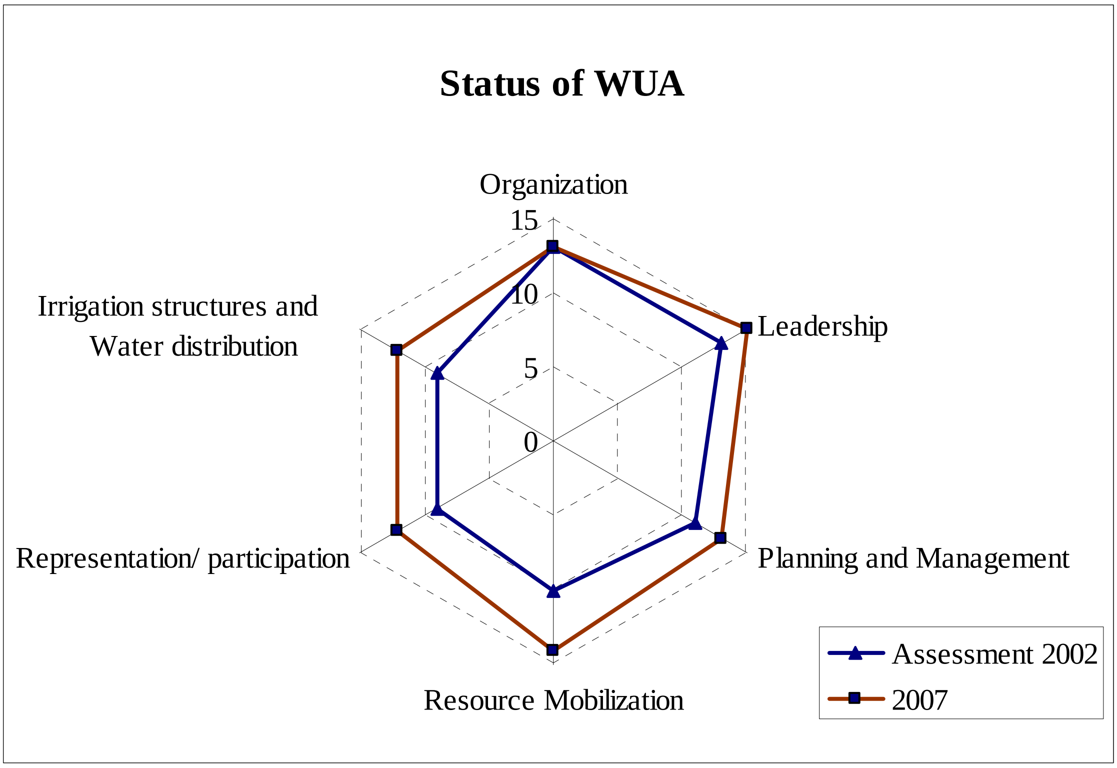
Leadership: Leadership within WUA was found much improved (score 15) from the previous condition of 2002 (score 13). It means that leadership functions are distributed to all members against leadership limited to very few people for long time before 2002. Now the leader selection is very inclusive with electoral system than before (Appendix-C). In current rules 33% women participation is the must and this rule is totally followed.

Resource mobilization: From assessment it was found that WUA becoming stronger in resource mobilization (score 14) than in year 2002 (score 10). It means that water charging system exists in PIS with fee collection ratio nearing 0.75, the fund is always used in intended and planned purposes and the financial recording system is transparent against fund is used ad-hoc in the past years. All members are regularly informed about the actual financial system now against financial system was unclear to both executive and ordinary members in 2002.

Organization: Based on the indicator used in the assessment and the rating of indicators by participants the organization part of WUA found static (score 13) as compared to previous assessment. Meaning that objective roles and responsibilities are well defined but more than 50% are unable to recall it, group decisions are made on the basis of general consensus with high participation by all members and good interactive relationship with all members, linkages to CBOs, VDC and agencies maintained good.

Planning and Management: As far as the management of WUA is concerned the assessment found that WUA have improved (score 13 now against 11 before) in their capacity in planning and management. The system of appropriate planning with action plan preparation with few exception implementation is done in due time. Regular meeting in WUA and its sister organization with decision keeping system and decision notes is always used in meetings for management and monitoring of activity implementation as an integrated praxis and management is independent from outside. WUA has capacity to undertake activities independently and act creatively and flexibility according to the circumstances.

Representation/Participation: Participation and representation within WUA found significantly improved (score 12 against 9 before). WUA set rules for all to represent fairly and all have equal opportunity to express their view in discussions but to some extent decisions process dominated by a sub group. Participation of member found average where some only participate in implementation and few members participate very little. Women participation is quite high score 5 as men compared to previous assessment



Source: WUA and farmers of PIS
Figure 4.6: Capacity Assessment of WUA

Irrigation structures and water distribution: This indicator embrace three main sub indicator concerning water distribution and water charging system as well as status of irrigation structures. The performance of WUA in this part is found improved (score 12) than before (score 9). Irrigation structures are old and about 50% of which are well performing that is not improved than before. The water distribution system is rotational with fixed schedule enforced to farmers from main canal to branch canal, branch canal to tertiary canal. The schedule was found appreciative but very few tertiary canals able to follow the schedule properly. All branches, outlets and sub branches committees have rules to collect ISF now against about 75% follow the rules before 2002.

This capacity assessment tool mainly focused on the management and organization of the WUA. It can easily present the performance of WUA in line with the set indicators. This tool is mainly used to see progress of different the time periods if same assessment has been conducted using the same indicator in all assessments. The rules in use in the irrigation are not reflected well by this assessment but give a general overlook of the WUA. The system of share, the rules of benefit and cost, the monitoring rules and type of organization, conflict resolution mechanisms, and modification of rules are the other important part to analyze irrigation institution to address these issues.

4.9.4 Rules in Use in Panchakanya Irrigation System

In the previous section capacity assessment of WUA has been presented which compared the status of WUA about five years ago and now, focusing to planning and management, resource mobilization, organization, participation etc. To address the different issues related to legal aspects and rules, Ostrom's eight efficiency and sustainability principle (eight design principles) is used to describe the rules used in PIS in more detail with considering the constitutional and legal aspects. Eight design principles are widely used indicators to analyze irrigation institution, that their existence shows a viable institution, while their absence underlines non- or poor-performance. The rules–in-use in PIS including the rule forming arena and rule enforcing body is compiled based on the review of constitution of WUA, operational rules, minutes of meeting of general assembly and main committee and discussion with main committee functionaries. Based on the 'eight-design principle', each rule has been explained one by one describing kinds of rules, rules forming area and rules enforcing body as below.

i) Design Principle-1: Boundary Rules

Boundary rules are clear which define eligibility for appropriation. These rules are formed in WUA general assembly and enforced by main committee for all users at all level.

Rules in use:

- Owner operator or tenant in service area.
- Must obtain membership of WUA upon paying NRs. 10 to be renewed every year
- Must obtain share upon paying a share fee NRs. 60 per ha of land
- Appropriation right is transferred with the sale of land but buyer must get the share transferred to their name upon paying NRs. 20 one time.
- Appropriation right can be inherited
- Uniform appropriation rule for every one and every part of the system

ii) Design Principle-2: Rules for Proportional Equivalence between Benefit and Cost

Main committee forms these rules and enforced by canal management workforce to all branches and outlet level.

Rules in use:

- Must pay ISF NRs. 150/ha/crop for paddy and NRs. 75/ha/crop for other crops per season.
- Must pay NRs. 300/ha/year for main canal maintenance and same amount for branch canal maintenance.
- All off-takes from main canal open if available supply in main canal exceeds 700 lit/sec.
- If discharge in main canal falls to between 500 to 700 lit/sec, water will be rotated into two sections.
- If discharge in main canal falls to between 250 to less than 500 lit/sec, water will be rotated between sections as per the prior demand of water by farmers in different sections.
- Flow measurement in 15 days interval by members of canal management work force.

iii) Design Principle-3: Collective Choice Arrangement

- As explained in paragraph (ii), collective operational rules are equally distributed to all members.
- Modification of rules due to change in environment and other settings can be proposed by members and will be agreed upon in meetings through majority of members.

iv) Design Principle-4: Monitoring Rules

These rules are set to monitor the water distribution and to establish collective action situations to all users. Rules are formed by main committee, branch committee, and

general assembly and enforced by branch and outlet committee and members of work force.
Rules in use:

- Timed irrigation distribution based on area
- Adjustment in distribution possible only in case the users demand be critical
- Branch committee must keep the branch outlet users informed about physical conditions of branch canal and related structures
- users should submit the schedule of water demand to branch committee one month prior to cropping mentioning type of crop and area to be irrigated
- Branch committee responsible to monitor the schedule of water delivery within the branch and make adjustment in the schedule in case user's demand is not met.
- Branch committee responsible to monitor and identify unauthorized water use
- Accountability of users to keep the branch committee informed of unauthorized use
- The same monitoring rules to be done in main canal by main committee

v) Design Principle-5: Graduated Sanction

These rules are established to penalize against breach of rules and formed by general assembly and main committee and enforced by main committee, branch committee and sub-branch committees. Users who violate operational rules are likely to receive graduated sanctions from other users, from officials accountable to these users, or both.
Rules in use:

- Fine equal to membership renewal fee to be paid for the failure to get the membership renewed every year within due date
- Fine ranging from 25% to 75% of ISF for failure to clear ISF within three months of due date and equal to ISF for failure to clear after three months.
- Fine equal to the renewal of structure and s/he obliged to renew the structure incase of attempt demolishes, destroys or causes harm of any structures in the system
- Fine equal to NRs. 500 for the first attempt, NRs. 1000 for the second attempt and NRs. 1500 for the third for water theft. Incase of fourth attempt, main committee may decide to cancel the membership and deny access to water forever
- Fine up to NRs. 5000 for any attempt of not following schedule of water distribution communicated by WUA
- Fine ranging from 25% to 75% of maintenance fee for failure to clear maintenance fee within three months of due date and equal to maintenance for failure to clear after three months.
- All users obliged to use water as per demand within the schedule set by WUA.
- Fine ranging from NRs. 500 to NRs. 1000 could be imposed incase of attempt by any individual to cultivate on the canal banks in the land within the right-of-way.
- Fine up to NRs. 5000 on these individuals who attempts to bring their livestock for grazing on the canal banks or any land in possession of the system.
- Fine up to NRs. 5000 on those who attempt to throw dirt or household effluents in the main canal.
- Fine ranging from NRs. 10 to 100 could be imposed on the functionaries of the branch/outlet committee for their failure to discharge the duties as defined by constitution and rules and regulations of WUA.
- Denial of access to origination to those branch/outlet canals failure to pay collect repair and maintenance fee. Access could be granted only upon payment of fine equal to the fee due.

- Other penalty and punishment as mentioned in Water Resources Act 1992 incase of encroachment of land, any modification in the canal structure or unauthorized branch and outlets opening.

vi) Design Principle-6: Rules for Conflict Resolution

- Concerned branch/outlet committee responsible for resolving the conflict among the users pertaining to irrigation water use.
- Users eligible to file petition to main committee incase of failure of concerned branch/outlet committee in resolving the conflict.
- Users eligible to file petition to the main committee against any of the functionaries of the concerned branch/outlet committee.
- All branch/outlet committee may file petition to the main committee on all kinds of conflict pertaining to irrigation water use.

vii) Design Principle-7: Rights to Organize

- The PIS is a formal institution recognized by DOI to mange the irrigation system. Within the boundary of water resources act and irrigation policy and regulation farmers have authority to organize themselves set the rule and enforce with the constitution amendment and upon consensus of district water resources committee.

viii) Design Principle-8: Authority and Scope Rules

- As shown in the figure 4.4 the organization of WUA has three tires. Each tire has own authority and scope in water distribution.
- Each farmers and the group must submit water demand prior to irrigation to the immediate upper level of authority in case where there is water scarcity.
- Must withdraw at fixed time of slot.
- Must withdraw at pre-set turn.
- Must withdraw at fixed order.
- Must withdraw at fixed location.

Conformance of the rules in PIS and Actor Behavior

The PIS has well defined boundary rules that clearly set out criteria to be appropriator in the system. The boundary rules are uniformly applicable irrespective of location of users in the system. On the other hand a set of rules in the form of share registration fee, irrigation service fee and labor fee for repair and maintenance are in place to ensure proportional equivalence between benefit and cost. In PIS elaborated rules and mechanisms have evolved over time for water allocation and distributions. Water allocation schedules are prepared by the main committee by collecting demand from the users and all the users are obliged to irrigate under the pre-set allocation schedules. The allocation schedule decided by the main committee is also to be effectively monitored by the functionaries at branch level and main canal level by branch committees and main committees and *karyadal (work force for canal operation)* respectively. Any irrational behaviors of the irrigators or the functionaries of the main or branch committee are to be checked principally through elaborated payoff rules. Mechanisms of graduated sanctions exist in PIS for repeated violation of rules.

As explained earlier, PIS has strong boundary rules that are applied over the command area and the rules have been completely followed. From interview, it is concluded that the farmers seem to be quite tolerant and cooperative to each other regarding water scheduling system of the scheme. Even though farmers have their own specific day to irrigate, often when they don't finish irrigation their plots, farmers agree among themselves to finish their plots on consecutive day, thus in fact not respecting the water scheduling system. At time of water scarcity, the water scheduling rules are less flexible and WUA try to enforce all farmers to follow the schedule, but farmers cannot finish irrigation within the specified time, which result prolonged time of one irrigation rotation for three to four days from the planned schedule. This mismatched schedule resulted because of improper estimation of discharge, seepages and leakages in the canal. In reality, rules regarding proportional equivalence between benefit and cost are fair in principle but not well in practice. Tail-end farmers are not getting water equally as upper reach farmers although they pay water charge as others.

Monitoring rules are followed to some extent. As there are layer of responsible bodies within the system, they able to monitor the irrigation system according to their responsibility. The monitoring of structures is not much satisfactory as found from the interview. The collection of demand of irrigation water seems not properly achieved, because farmer in their own seem reluctant to submit demand when they feel that water is scarce. This is specially found in winter and spring season. In that case execution of scheduling is difficult to maintain.

From interview of farmers, it was found that most of the farmers of all reaches are not satisfied in the implementation of payoff rules specific to breach of rules. But fine against the delayed payment of ISF is properly implemented. In enforcing the ISF collection rules both farmers and WUA are responsible but for the action to be taken against water theft and unauthorized use of water is not properly followed. Farmers themselves and WUA are reluctant to raise the issues more seriously. Some parts of the structure like gauging station and other removable parts are stolen but no one want to report even when they found the case on spot. As far as the rewarding rules are concerned, WUA has weak performance in forming and implementing the rewarding mechanism as explained in section 4.7.2.

With very few exceptions in the time of scarce water sharing, PIS has no problem of conflict among users. Branch and outlet committees are able to resolve any conflict that arose in respective branch and outlet level. In the main canal level, main committee is active for conflict resolution. Looking at the organization of the PIS, the WUA forms a structure with nesting layers of organization and only responsible for water distribution. Other than that, there is no other form of organization within WUA to cooperate marketing of agriculture products. However, there is a potential for farmers to organize collective input investments and collective crop production for available markets. Nevertheless, WUA initiated to develop the vegetables wholesale market within WUA office compound in cooperation with Ratnanagar Municipality. The objective has still not materialized.

As explained in paragraph (vii), the modifications of rules are equally made in different time period as and when needed. The PIS is the government recognized organization so they can implement their plan and rules which comply with water resources act, rules and regulations.

4.9.5 Collective Action

i) Rules governing operation and maintenance

PIS had long been operated and managed with significant contribution and participation from farmers' side. About three decades ago prior to the intervention of government agency for rehabilitation, it was solely managed by farmers. . Even after taking over by the agency, the WUA of PIS played significant role for regular repair and maintenance of the system. The main committee set rules for cleaning and desilting each year usually in terms of labor contribution. The main canal had to be cleared by all system beneficiaries of the respective canal areas. For the purpose of convenience, the main canal was divided into different sections so that the farmers belongs to different reaches of the main canal could undertake the cleaning works. The branch canal had to be cleaned by the water users of respective branches. New measures were initiated latter to generate cash income and also labor contribution. Water charge was raised on the basis of land size in the command area at the rate of NRs. 40 per bigha per crop. Besides cash collection in the form of water charge, the beneficiaries' households were required to provide labor contribution for desilting and canal cleaning. For main canal cleaning, each farmer required to contribute one man-days per bigha where as 1 man day per 10 katha (1 bigha=20 katha) for branch canal cleaning.

That system creates injustice to small holder farmers and favored the big land holders in term of labor contribution. The rule was modified and WUA collected NRs 10/katha of the land from each user for main canal maintenance. Rule was different in the case of contribution to branch canal repair in which users paid NRs. 5/katha. The new rule related to users contribution to repair and maintenance of main and branch canals had removed inequity between small and big landholders because payment were made in proportion with land area. Those contributions were one time payment for one year and collected along with ISF.

After taking over the system by WUA the required amount of maintenance fund realized insufficient. In 2005 the rule was again modified to match the maintenance fund to be covered from ISF. Currently WUA collects NRs.10/katha of land for main canal maintenance and NRs.10 (increased from NRs. 5/ katha) for branch canal maintenance. With utilizing the collected fund from farmers, both main and branch canal maintenance is carried out twice a year. The main canal maintenance is carried out by main committee and branch canal by respective branch committee. Policy of cash collection so devised has also served as an effective tool to 'uncover hidden area' under irrigation for which users had tendency to apply water without paying cost of water share. So more area came under share and thus the rule helped to develop transparency in calculating area under share and also increased cash collection supported repair and maintenance of canal.

The rules governing the operation and management of the system were developed, tried and modified and tried again depending upon the dynamism. The rules were tailored to fit the changing needs and interest of the irrigators. This dynamism, of course, has helped in evolution of viable irrigation organization in PIS. But nevertheless, there are still rooms to improve to match actual farmers' needs of water adequacy and flexibility. From interview it is noted that most farmers who use motor to pump ground water for irrigation is not only due to water scarcity but also they use ground water to have a very flexible schedule for sensitive crops.

ii) Representation and participation of farmers

The WUA in PIS has evolved with representation from all parts of the system boundary. Further, representation in system level organization is proportional resource access of each branch canal defined by the share entitlements. Resource mobilization obligations are also tied to the entitlement of resource use. Such mechanism of linking representation, decision making, and resource mobilization with the entitlement of resource use has been basis of strong organization. From The capacity assessment of WUA as explained earlier shows that there is average participation of all members. Some of them only participate in implementation. Women members are encouraged to participate at all levels from sub branch to the main committee. With the initiation of women helping group (mahila sahayogi samuha) PIS brought about the significant change in system maintenance, creating awareness among farmers and collective action although that group is formally recognized by WUA but can't be seen at any place of organization structure.

iii) General assembly and general meetings:

General assembly and general meetings provide an important forum for exposing problems. The same is true with branch canals at the branch level meetings. Accountability of systems-level officials to the general assembly helped to check favoritism and fraudulent behavior. But the participation in the general meeting in the PIS found to be decreasing in recent year. This might ultimately have negative effect in the collective actions in the system. The low participation in general assembly in recent years is because of political situation of the country getting worsen which have negative impacts within farmers group to see the member with each other sometimes politically rather than of irrigation users for a common goal.

iv) Decision making and communication:

Authority for decision making in PIS is highly decentralized. A general assembly composed of 195 branch and sub branch members is the highest level decision making body. The general assembly is responsible for electing a main committee. The main committee and branch committees are responsible to enforce the rules and implementing decisions made by general assembly. Branch and sub branch level committee is elected through their respective assembly at that level. The decision made at the general assembly level is communicated through the members from respective branch and sub branches. Usually the karyadal works as the messenger for delivering the messages and notice to the committee members. At branch level, committee members communicate within themselves. As there are increased numbers of telephone over the area, nowadays communication in the system is getting easier than before. On the time of canal cleaning, main committee manage all the work of main canal. In branch and sub branch level, the respective committees inform all users either calling a meeting or by communicating members to members themselves to come for canal cleaning works.

v) Response of farmers to maintain the system:

Farmers contribute cash for maintenance of canal. Before cash collection system started, farmers used to contribute as labor for maintenance work. Although the cash collection is done for maintenance of canals, committees has given priority to the local farmers to participate in maintenance work. The committee then makes the payment to the farmers against the contribution as labor in pre determined rates. There is scarcity of labor in peak seasons, that's why committee forced to look for labor outside the command area.

As shown in table 4.17 the percentage of farmers paying water charge is decreasing from head to tail reaches. When looking upon the ISF collection the average ratio of ISF collection was found to be 0.72. These figures are encouraging but still there is a room to consider the farmers response for collective action in the system maintenance. When the ISF collection is less it ultimately has adverse effect in the canal maintenance. Willingness to pay of tail farmers is more than the upper reach farmers under the improved condition of the system. In year 2005 the ISF collection ratio was highest and didn't increase latter. Which indicate that the response from farmers for collective action decreasing. It is directly related to water adequacy in the system. Tail farmers are using pump to extract underground water as a supplement for canal water and to meet their flexibility. *It can be concluded that where the difference in water supply exists between head and tail farmers, there will be collective action problem. This problem can be solved by improved service condition, as shown in the willingness to pay where farmers are ready to pay ISF under improved service condition.* There are examples in PIS having very good collective action works through the improved services in some areas and creating awareness of farmers. In branch 6 of the scheme, about 30 farmers grouped together to install the motor to increase water supply reliability especially for the cash crops as well as for cereals in time of acute shortages of water. Women helping group who performed a very well awareness campaign within the scheme resulted that most of the encroached drain land was recovered in the year 2006. Similarly women group started to raise fund for PIS through selling grass of the right of way of canal in the same year. But the continuity of collective action is a great challenge. For the similar kind of collective action to be done in future, women helping group shall be activated as before by recognizing them as an integral part of WUA.

4.10 Farmers Performance and Sustainability of Scheme

As explained earlier PIS has proportional water distribution system based on the share of the farmers. One share is equivalent to one katha (0.033 ha) of land meaning that farmers having one ha of land own thirty share. Amount of water that can be available to farmers depends upon how much water is available in the headwork. The water available to the headwork is then proportionally distributed among farmers. As reported by Neupane(undated), the overall efficiency of the scheme was about 23% in the summer and about 51% in the winter and spring season. But by analyzing some data of flow measurement and accounting loss the overall efficiencies are found 24% in summer and 41% in winter and spring, which are used for water supplied at farm inlet and water availability calculation throughout the report. As reported earlier there are varieties of crops grown in the scheme area and farmers of different typology have their different cropping system. From farmers perception as explained in section 4.6.1 it was seen that farmers are not satisfied with the water adequacy in the scheme, mostly the tail farmers. Different researchers argue that, water productivity is more important than the land productivity as water is getting scarcer. In this section, the water supplied per crop, water productivity and farmers' role in collective scheme maintenance has been described.

4.10.1 Water Supplied and Water productivity

Water supplied (water supplied at farm level is considered water use) per crop in the scheme is calculated based on the availability of water in the headwork, the efficiencies of canal networks, and the scheduling of the water distribution used by WUA. The supplied water consists of two components: surface water supplied through the canal and underground water by pumping. Most of the pumps used by farmers are individual pumps, the extraction of underground or surface (river) water by pump is differ farmers to farmers. The pumped water is estimated based on the percentage of pump in the scheme. As reported by farmers during field work pump is used when there is insufficient surface water. Some farmers use pump in winter season although the canal water is sufficient enough to irrigate the crop. This is due to the farmers' preference to have on time irrigation for sensitive crops as the discharge, timing and frequency of canal water could have little control for these crops. This kind of water use in the winter crop through pump water is not taken into consideration. The mostly used pumped water for the spring season and for land preparation for summer rice has been taken into consideration for water use (water supplied at farm level) calculation. Total water diverted through the headwork for different season and the amount of water available for each farm location and each season is presented in Appendix-F (Table F.9).

a) Water available and water supplied

Before going into water available and water supplied it is customary to define these terms and to underline assumption for their calculations.

Water available

Water available is defined here to represent the amount of water that is readily available to supply at farm level after deducting the losses in the canal network. Following assumptions are made in calculating water available:

- The water distribution is proportional to the area of farm at all location.
- The canal efficiency is equally applicable now also although this was measured some five years ago.
- As per the operational rule water is available at all location in the pre determined rate and schedules.

Water supplied

Water supplied is defined as the amount of water that is diverted to farm from the farm inlet to irrigate the land. Following specifics are taken into consideration while calculating the amount of water supply at farm level:

- Except in paddy, farmers supply water in their farm based on number of irrigation that is in practice in the area.
- Number of irrigation taken for oilseeds, pulses, potato, wheat, tomato is 3, 1 to 2, 3, 3 and 4 respectively as found from farmers' interview and corresponding average depth of irrigation including percolation losses are approximately 100, 100, 100 to 150, 120 and 100 mm respectively.
- Farmers use continuous water supply in paddy in case of adequate water supply and at least 6 irrigations each 100 mm depth for a season in case of water shortages.
- In case water is not sufficient to apply number of irrigation as mentioned above, farmers use other source of water to supplement canal water. Farmers at all location use the same water application practice mentioned above.

Water available and water supplied in different crops for different canal location is presented in table 4.22. From the table it is noted that canal water available in the summer season for summer paddy is less than water supplied at farm level. The less availability of water is due to high loss in the conveyance and distribution network but for winter crops (oilseeds, pulses, wheat, potato, tomato) the water supplied is less than available. For spring crops (spring maize and spring paddy) water availability is less than the water supplied. The water deficit in all locations due to less availability of water is supplemented by pumping ground waters.

Table 4.22: Amount of Water Available and Water Supplied for Different Crops

Crop	Canal Water Available (m^3/ha)			Water supplied at farm level (m^3/ha)			
	Head	Middle	Tail	Head	Middle	Tail	Wt. Av
Summer paddy	6836	6076	5326	8042	8102	8877	8321
Oilseeds	14789	13917	12501	3000	3000	3000	3000
Pulses	14789	13917	12501	1500	1500	1500	1500
Potato	14789	13917	12501	4000	4000	4000	4000
Wheat	14789	13917	12501	3400	3400	3400	3400
Tomato	14789	13917	12501	4000	4000	4000	4000
Lady Fingers	5826	5478	4579	3500	3500	3500	3500
Spring Maize	5826	5478	4579	6854	7304	7631	7256
Spring Paddy	5826	5478	4579	6854	7304	7631	7256

Source: Canal Operation Plan of PIS and Authors field survey, 2007

b) Water productivity

Based on the water supplied at farm level in different crops per ha and the land productivity, water productivity of different crops for each type of farmers is calculated and presented in table 4.23. As the farmers of different types are distributed in all parts of the canal location, the water supplied is considered the weighted average of head, middle and tail reach. Thus the water productivity presented in table 4.23 is proportional to the land productivity, meaning that farmers having higher land productivity have higher value of water productivity and vice versa.

Water productivity of both summer and winter paddy of Type-II farmers has the highest value among the type of farmers which is similar to the higher land productivity of Type-II farmer. So comparing the water productivity with same water use within the scheme is no longer important. The more important is the weighted average value of land productivity. It was found that the weighted average water productivity of summer paddy is 0.50 kg/m^3, where as the water productivity of spring paddy is 0.55 kg/m^3. The amount of water used in these two types of paddy is different. It is customary to compare these values to the other system.

Table 4.23: Water Productivity of Different Crops by Farmers' Type

Crop	Water Productivity (Kg/m^3)					
	Type-I farmer	Type-II farmer	Type-III farmer	Type-IV farmer	Type-V farmer	Weighted Average
Summer Paddy	0.49	0.59	0.52	0.48	0.54	0.50
Oilseeds	0.14	0.29	0.20	0.26	0.31	0.18
Pulses	0.29	0.20	0.39	0.22	0.40	0.31
Potato	2.06	3.65	2.44	2.38		3.38
Wheat	0.69	0.77	0.00	0.65	0.25	0.67
Tomato	3.42	4.90	4.50			4.44
Lady Finger		3.28				3.28
Spring Maize	0.21	0.24	0.19	0.20	0.22	0.21
Spring Paddy	0.53	0.65	0.59	0.56	0.57	0.55

Source: Authors field survey, 2007

Table 4.24 presents the comparative values of water productivity of summer paddy (wet season) and spring paddy (dry season) in PIS with the water productivity of wet and dry season paddy (which is similar to summer and spring paddy in PIS) of Gal Oya left bank rehabilitation project in Sri Lanka (Amarasinghe et al, 1998). The land productivity of both seasons in both irrigation systems are nearly the same. The main difference is water use in dry season. Because of the large amount of water used in dry season the resulting water productivity in Gal Oya is very less 0.21 kg/m^3 as compared to 0.55 kg/m^3 in PIS.

Table 4.24: Comparison of Water Productivity of Paddy in PIS with Gal Oya

Scheme	Irrigated area (ha)		Water Supplied* (m^3/ha)		Land productivity (t/ha)		Water productivity (kg/m^3)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Gal Oya	16300	14000	7914	18357	4.00	3.90	0.56	0.21
PIS	356	185	8321	7256	4.18	4.02	0.50	0.55

Source: Gal Oya- Amarasinghe et al (1998); PIS: Authors' Field Survey (2007)

Note: Wet=wet season (summer) and dry=dry season(spring)

*= Water supplied at farm level

The climatic condition, the period of study and management system of these two systems are different. But nevertheless these values are comparable. This result shows that water is used more efficiently in the PIS. The water productivity presented in the table above doesn't mean that water productivity in the scheme is good but it is only encouraging. V*ery large amount of water is lost through canal seepage and leakages. This means more water can be used if the scheme is maintained properly.* When the water diverted from the headwork is accounted for this water productivity calculation this value might be very less.

The more focus should be given to use more water by maintaining the system properly, so as to increase amount of water in the field inlet to address the water need of all farmers.

4.10.2 Farmers Performance vs. Collective Scheme Maintenance

So far we discussed many aspects of farmers' performance in the preceding section. In this section the main focused has been given on income of farmers in terms of a cubic meter of water. Net income per unit of water is presented in the following section by each crop type and by cropping system.

a) Net income per unit of water by crop type

Net income per crop type is found by dividing the net farm income (table 4.12) by water use per crop type (table 4.22). In this calculation the water use in a crop is based on the weighted average of the water use in head, middle and tail reaches.

Table 4.25: Value of Irrigation Water in Different Crops

Crop Type	Net Income (NRs/m^3 water)					
	Type-I farmers	Type-II farmers	Type-III farmers	Type-IV farmers	Type-V farmers	Wt. Average
Summer paddy	1.86	3.18	2.98	1.72	2.39	2.12
Oilseeds	(0.43)	1.60	1.08	(0.31)	1.85	0.50
Pulses	1.18		(3.10)		3.39	0.82
Potato		9.97	4.41	4.07		9.09
Wheat	1.57			2.72		1.83
Tomato		59.75				59.75
Lady Fingers		32.17				32.17
Spring Maize	0.18	(0.11)	0.42	0.13	0.77	0.23
Spring Paddy	1.86	4.86	1.66	2.61	2.31	2.20

Figures in the parenthesis indicate negative value income
Source: Authors' field survey, 2007

Net income per unit of water in different crop type is presented in table 4.25. The negative value in the table indicates that net income is negative (production cost is higher than revenue). Lady fingers and tomato is the most profitable crop which generates highest income. Looking at the weighted average of each crop, potato generates highest income (excluding lady finger and tomato which is adopted only by Type-II farmers). In cereals spring paddy is the major crop which is adopted by all types of farmers generates NRs 2.20 per unit of water.

b) Net income per unit of water by cropping system

This is the combination of income of different crops per unit of water in an annual basis. This is actually valuation of water based on the *residual imputation method*. The total annual crop revenue less non-water input (variable cost) is a residual. This monetary amount divided by the total quantity of water used on the crop gives the net income per unit of water in a year which determines a maximum average willingness to pay (WTP) for that crop (Agudelo, 2001).

Table 4.26 illustrates the net income of different type of farmers per cubic meter of water per ha with different cropping systems. In the table, the net income per cubic meter of water used for each cropping system is presented in each type of farmers. The highest net income (NRs. 5.29/m^3) of Type I farmer is found in paddy-wheat-paddy cropping system where as paddy-tomato-paddy cropping system gives the highest net income (NRs. 67.79/$m^{3)}$ for Type-II farmer (table 4.26). Paddy-potato-paddy is the main cropping system in Type-III and Type-IV farmers which generate comparatively higher value of net income within the group. The highest value of net income generated within the group is a part to compare which cropping system is more profitable. But it is rather important to see the weighted average of all cropping system of each typology of farmers, which represents the income of majority of farmers within and between groups.

As shown in table 4.26, weighted average income of Type-II farmers is found NRs. 24.37/ m^3 which is close to the paddy-potato-paddy cropping system, meaning that majority of farmers adopt this cropping system within the type. This result of net income is due to the income generated by potato rather than paddy.

Table 4.26: Value of Irrigation Water in Different Cropping Systems

Cropping Pattern	Net Income (NRs/m^3 water)					
	Type-I farmers	Type-II farmers	Type-III farmers	Type-IV farmers	Type-V farmers	Wt. Average
Paddy-Pulse-Paddy	4.90		1.54	4.33	8.09	5.15
Paddy-Wheat-Paddy	5.29			7.05	4.70	6.15
Paddy-Pulse-Maize	3.22		0.30		6.54	3.18
Paddy-Potato-Paddy		18.01	9.06	8.40		13.42
Paddy-Potato-Lady Fingers		45.32				43.38
Paddy-Wheat-Maize	3.61			4.57		4.18
Paddy-Oilseeds-Paddy	3.29	9.64	5.72	4.02	6.55	4.83
Paddy-Oilseeds-Maize	1.60	4.67	4.48	1.53	5.01	2.86
Paddy-Potato-Maize		13.05	7.81	5.91		11.44
Paddy-Tomato-Paddy		67.79				64.08
Weighted Average	3.50	24.37	3.47	4.89	6.61	6.06

Source: Authors' field survey, 2007

The most income generating cropping system in all types of farmers is paddy-potato-paddy (excluding paddy-potato-lady fingers and paddy-tomato-paddy which is used only by type-II farmers) which accounts a net income of NRs. 13.42/m^3. Considering all farmers type and cropping system typology, a net income of NRs. 6.06/m^3 is generated which is very close to an average net income of paddy-pulse-paddy cropping system. It means that majority of farmers adopted this cropping system except Type-II farmers.

The most interesting facts found from this analysis is that those type of farmers who practiced cropping system having at least one vegetable or potato are generating higher net income than those practicing cereals, pulses and oilseeds. But pulses and oilseeds are regarded as higher value crops (the selling price of these crops is high) in Nepal, the lesser income found in this system is due to lower production rate. The lower production rate may be due to lack of proper management practice (agricultural practice like pest control, diseases control) of these crops or due to the change in soil characteristics in the area which is out of scope of this study.

Looking to water available in the system (table 4.20) and the net income generated by the different cropping system (table 4.24), all cropping system is viable in the scheme area. More potentially beneficial cropping system is one which contains at least one vegetable or potato. These crops need less water than cereals but give higher production and higher net income as compared to other crops. Assuming the soil type is supportive for vegetable and potato production, farmers can adopt these crops for their higher net income. As discussed in the preceding section, the numbers of farmers adopting these crops are very less. Of the total sampled farmers, only 18% has got training related to improved farming techniques. In this connection WUA can co-operate the agricultural extension offices to enhance the knowledge and skill of farmers through training.

c) Water charging system for collective scheme sustainability

The PIS is a user operated system after handing over by DOI in 1997. After taking over the scheme by WUA, the responsibility of the WUA has increased. WUA has to maintain the system well in their own efforts by mobilizing farmers in the scheme. Maintenance of canal, distribution of water, generating the resource for maintenance is the major responsibility of WUA. As every physical infrastructure needed high cost of maintenance, the major issue in system operation is directly related to the financial self sufficiency of the WUA.

Table 4.27 illustrates the current water charging system, annual water use per hectare of land and per unit cost of water in the scheme. The analysis of water use shows that unit cost of water in the scheme is NRs.0.054/m^3 (\$0.0008/m^3). Considering the weighted average net income derived from per m^3 of water supplied at farm level in the scheme, farmers now paying 0.89% of their net income. But this percentage is differing by farmers' type as shown in the table 4.27.

Type-II farmers are the most profit making type where they contribute 0.22% of their net income as water charge. Type-I and Type-III farmers are paying higher percentage (1.54% and 1.56% respectively) of their net income as water charge. Type-I farmers are the dominant type in the scheme whose percentage accounts 58% of the total farmers. The major decision and rules to be formed should consider this majority of farmers.

The average annual maintenance cost of the scheme is NRs 311717 (considering the past five years annual operation cost). The average maintenance cost per ha considering the present irrigated area of 356 ha, was found NRs. 876 (NRs 0.048/m^3). This per ha cost of operation and maintenance is less than the current annual water charge per ha in the scheme which is NRs. 975 (NRs 0.054/m^3). It means that the current water charge is sufficient to cover the maintenance charge. Reality is different, because the ISF collection ratio in the scheme is 0.72 which means average annual fund collected from ISF is NRs.

242790 which is less than the average O&M cost (NRs 311717). The O&M cost recovery from ISF collection is thus 77% and full cost recovery is 39%. O&M cost presented here is not sufficient to have a proper maintenance in the scheme. This cost is the only five years average of PIS which doesn't mean that this is sufficient for proper maintenance. Thus it is customary to see the standard O&M cost for irrigation schemes which is sufficient enough to maintain the system well.

Table 4.27: Present Water Charging System and Sufficiency for Scheme Maintenance

Total area of land (ha)	356
Average annual water supplied at farm inlet (m^3/ha)	18086
Annual current water charge(NRs/ha))	975
Current water charge per unit of water (NRs/m^3)	0.054
Water charge as a percentage of net income (%)	0.89
Type-I farmers	1.54
Type-II farmers	0.22
Type-III farmers	1.56
Type-IV farmers	1.10
Type-V farmers	0.82
Average annual O&M cost at scheme level (NRs)	311711
Average annual total expenses at scheme level (NRs)	612116
Water charge needed to cover O&M cost (NRs/m^3)	0.048
Water charge needed to cover total expenses (NRs/m^3)	0.10
Average annual O&M cost per unit land (NRs/ha)	876
Average annual expenses per unit land (NRs/ha)	1719

Source: Authors' field survey, 2007 and PIWUA record

Average standard O&M cost for the irrigation system in Nepal at 2007 price is NRs 1184/ha (FAO, 1999, Prasad et al, 1998, IMF, 2008); details of calculation is presented in Appendix F, table F.10. At this rate, total O&M cost for the PIS (356 ha) requires NRs.421504. To cover this O&M cost, water charge should be increased to NRs. 0.065/m^3 (23% increases from current water charge of NRs 0.054/m^3). But from current ISF ratio this O&M cost recovery will be only 57%. Thus effective ISF collection and increase in water charge is needed to sustain the system.

For the sustainability of irrigation, only O&M cost coverage is not sufficient. The average annual expense of the scheme was found NRs 612116 as shown in the table 4.27. To cover this expenses each hectare water charge should be NRs 1719, meaning that water charge should be increased by 76% from the current water charging rate. This 76% increase of water charge may not be acceptable for farmers, but from analysis of willingness to pay it found that most of the farmers are willing to pay 20% more of the current water charge. So increment in water charge is quite difficult to convince farmers. The option may be volumetric charging of water rather than charging for land. Volumetric charging system demand high level of scheme operation and maintenance which need to install new water measurement devices in the scheme. In effect, installation of new devices may add extra financial burden to WUA.

Canal water vs. Pump water: Farmers in the scheme are not only using the canal water but also the underground water by pumping. From interview it was noted that the farmers who are using ground water spends NRs 5670 per ha per year (excluding maintenance cost) when they plant three crops paddy-maize-paddy (summer-winter summer) in a year. Detail calculation of water used and water charge is attached in Appendix-F (table F.11). Farmers use three irrigations (3 times) each for summer paddy and winter maize and five irrigations for spring paddy which accounts a total water use of 12600 m^3 in a year. Those farmers who use pump throughout the year they pay NRs 0.45/m^3 as water charge which is nine times more than canal water (NRs 0.05/m^3). *This shows that farmers can pay more for water if service condition in the system is improved.*

From interview, it is noted that the farmers are willing to pay higher water charges for improved service condition (water adequacy, reliability, timing, duration and quantity).This high level of cost that farmers are paying shows that the farmers are still willing to pay higher water charge in case of acute water shortages. There are some differences in canal water and pumped water. Assuming the quality of water is same in both water, the timing, frequency and quantity control is very easy in pump water. Considering all these factors affecting water availability and ease in operation, a compromise level of water charging rate in the system in between these two rates of water cost can be established with more detail discussions between farmers and WUA.

4.10.3 Farmers Performance vs. National and Local Policy

The Agriculture Perspective Plan 1995 and National Agriculture Policy 2004 are the major policy in the country which aims to increase per capita agricultural growth, is conceived as a powerful engine of economic growth. Two main objectives of these policies are: To accelerate the growth rate in agriculture through increased factor productivity and to alleviate poverty and achieve significant improvement in the standard of living through accelerated growth and expanded employment opportunities. Irrigation is considered as the main input investment priority among four input investment priorities: irrigation, roads and power, technology and fertilizer. Policies related to irrigation support sector prevails in nation are Water Resources act, 1992; Water Resources Regulation, 1993; Irrigation Regulation, 1998; Irrigation Policy, 2003; Irrigation Guidelines; Water Resources Strategy and National Water Plan, 2005. Of these policies, Irrigation Policy 2003 aims to provide round the year irrigation facility to the irrigation suitable land by effective utilization of the current water resources of the country. Similarly PIS has aims to augment the water in the scheme area and distribute proportionately to the farmers. The land in the scheme area is rather fragmented and farmers cultivate many kinds of crops even in a small plot of land. This is the strategy of farmers that in multi-cropping system, farmers may benefit in any one of the crop if there would be greater problem of water and threat of crop diseases. On the other hand water distribution in complex cropping system is quite difficult for WUA. PIS with the support of government agencies could adopt land consolidation system (policy of land consolidation system is exists in the nation) in branch to branch canal basis so that water distribution would be easier and effective than the existing system and farmers would have specialized knowledge on the farming technology for the particular cropping system. From the top to the bottom, policies are in place to support farmers. Farmers of PIS are in the way to increase the productivity especially paddy and some vegetables. In case of the PIS, government was able to meet its main input investment priority of irrigation. Farmers in PIS perform better than the national average productivities. The current aim of government is to support production market but farmers are seeking support of government on the extension market and creating market opportunities to sell their product.

4.10.4 Some Emerging Challenges in PIS and Sustainability Issues

Asset Management-Improved service condition by controlling seepage and leakages

Each asset in the irrigation system is designed to attain a certain functions for a specified time. The performance of irrigation structures deteriorate with time and becoming less functional. To maintain the desired level of service in the scheme, it needs to be maintained up to date record of the status of all structures and improve less functional structures where ever needed. Some parts of the irrigation system are deteriorating more which demands renovation than maintenance which needs higher budget. But looking at current trend of budget, it can be noted that it will be difficult to renovate the system from the WUA resources. For the sustainability of irrigation, PIS needs more asset management attention starting from right now. Mainly there is high rate of seepages as well as leakages in the canal network, and there is prompt demand to maintain this. Farmers may have increased water availability and reliability after this issue has been addressed.

Water source protection

Encroachment of land in the water source catchments was the most debated topics during interview with farmers. In the water source area, there are number of fish ponds increasing and the developed by owners of the surrounding marshy lands leaving narrow width in either side of main water course and tributaries and which reduced the feeble water flow in the main water course (Adhikari et al, 2002). Although the team comprising government authority, WUA and the users observed and demarked the area belonging to this source, encroachment still not stopped. This problem obviously a big issues and require the quick response from the WUA and users to find a solution.

Exit from farming to non farm income

The upper part of the scheme area is getting urbanized day by day. Farmers of the area are more attracted towards the business than investing in agriculture. This may result to exit farmers from farming to non farming business. This of course affects the collective action to be taken in the irrigation system.

Tragedy of the commons

An active participation of beneficiaries is crucial for the sustainability of the project. It has been found that beneficiaries from branch canal no 3, 7 and 8 have not taken active participation in O&M work. Farmers of branch no 3 uses seepages water from branch 2 and 4. So they claim that they are not using water from the PIS. This result is due to improper management of canal network in the system. If the system is well maintained they are forced to pay water charge as seepage water may be stopped and they will not have water in their farm. Farmers in the branch canal no 7 belong to Tharu community and have small area of land holding and they are afraid of paying water charge. On the other

hand, the farmers of branch no 8 use to sell and buy pumped water from Budhi Rapti River. That's why they were not paying water charges and finally left PIS in 2005. This is the tragedy of commons due to scarce resource. They are paying about Rs 5670 per ha per year for pumped water where they used to pay Rs 975 per ha per year to PIS. This is very serious issue. There is a need to response these issues by PIS so that it can be sustained well.
When analyzing the sustainability of any entity we can't say that "yes it is sustainable". We analyzed the financial self sufficiency of the scheme and individual farmers' performance. Individuals' performance found better position in the scheme compared to national production and water productivity with other irrigation system. In system level the financial sufficiency is not good. To maintain this, PIS need to have a prompt response to address these emerging issues so that farmers of all type and location willing to participate for its sustainability.

Under increased ISF collection as explained in section 4.10.2, PIS can manage the system well to deliver water to farmers as and when needed. Farmers are willing to pay for improved service condition in irrigation system. More attention is needed to increase the existing water charge. Under acute water shortages condition farmers are spending a very high amount of money to pay for pump (under ground) water. The pump water is paid in a volumetric basis. Thus PIS also can adopt the volumetric water charging system, where WUA and farmers would be more responsible to provide and acquire water.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The overall objective of this study was to investigate sustainability in irrigation systems, in institutional, technical and economic terms, and to investigate the interplay between individual farmer's performance and collective action. Panchakanya Irrigation, located in Chitwan district of Nepal, was selected for the case study.

The technical and economic performances of individual farmers have been analyzed based on a typology of farmers. Farm budget approach was considered for analyzing economic performance of each established type and the cropping strategy, cropping systems, crop intensity were taken into account to analyze technical performance. The typology proves robust and significantly explains differences in crop yields, while land holding size and location are not explanatory.

Crop yield of paddy is higher (4.18 ton/ha) than national as well as district average. Crop yield of maize, wheat, oilseed, and potato of PIS is 1.52, 2.28, 0.55 and 13.51 ton/ha respectively. Yield of maize is lower in PIS than national and district average but yield of wheat is higher than national average and lower than district average. Oilseed has lower yields in PIS and yield of potato is in between national average and district averages. Yield vegetables are higher in PIS (higher than national and district average). Among the farmers group Type-II farmers have better performance in terms of crop production. In overall farmers in the scheme are in line with the production market which is the main objective of government aims to accelerate the growth rate in agriculture through increased productivity and to alleviate poverty and achieve significant improvement in the standard of living through accelerated growth.

To analyze institutional aspects two approaches were used: capacity assessment of farmers and Ostroms' eight efficiency and sustainability principle. The first approach was considered to see whether any progress within institution from the past up to now mainly in terms of their planning, management, resource mobilization and leadership. The second approach was used to analyze the institutional conditions, especially rules in use in the system in a more legal perspective. Then farmers' perception about scheme management and WUA was taken into consideration in order to analyze collective action problems in the system. Such analysis shows that significant improvement is noticed in the performance of WUA in water management. The institutional rules are tried, modified, and again modified depending upon the dynamism of environment.

Collective action situation within the irrigation system was further analyzed based on fee collection ratio, water charging system, willingness to pay for water and water productivity. The *residual imputation method* was used for valuing water as 'return to irrigation water' or 'economic value of irrigation water' (which is termed net income per unit of water in this research report). Water productivity of summer and spring paddy was found 0.50 and 0.55 kg/m^3. Similarly water productivity of vegetables lady fingers and tomato found very high (3.28 and 4.44 kg/m^3) compared to cereals where as water productivity of potato is 3.38 kg/m^3.

Tomato, potato and lady fingers are the major commercial crops which generates the highest value of irrigation water (Rs 59.75, 9.97 and 32.17 per m^3 of water respectively) in Type-II farmers. Apart from lady finger and tomato (which are adopted by Type-II farmers only) potato and spring paddy are major crops in which the value of water is found higher in between and within groups. Summer paddy, spring maize and spring paddy are major crops adopted by all types of farmers but has relatively low value of water (Rs. 2.12, 0.23 and 2.20 per m^3). Excluding the vegetables which are adopted by only Type-II farmers, paddy-potato-paddy is the main cropping system which generates NRs 13.42 per cubic meter of water whereas the weighted average net income generated in a year per cubic meter of water is NRs 6.06.

The average annual maintenance cost, average annual expenditure in the system and current water charging rate was analyzed. It found that O&M cost and full cost recovery from ISF collection (fee collection ratio 0.72) in the scheme is 76% and 39% respectively. If fee collection ratio is one in current water charge rate, it can recover the O&M cost but about 76% increment in water charge is needed to recover all expenses in the scheme. New possible water charging system to cover the operation and maintenance cost would be a solution towards financial viability of irrigation system. The study found that the collective action problem is escalating due to scarce resources (mainly in the spring season). Collective action is difficult to organize where: water supply is uniformly abundant and the difference in water supply is large between upstream and downstream farmers. Such is the situation in PIS, hence the problems involving tail-end farmers. In many irrigation systems, irrigators cultivating crops in the head portion of canal have more secure supply of water than those in the tail portion whether or not any allocation rule is in place. The water resource available at PIS is large but the availability of water in the field outlet is low. This is because the higher percentages of water become unavailable due to leakages and seepage in the canal (low conveyance and distribution efficiency).

5.2 Conclusions

Based on the analysis of Panchakanya Irrigation System in Nepal, the conclusions that can be drawn from this study are as follows:

1. Typological approach proves a relevant approach to identify and analyze farmers' performance and their strategy within the irrigation system. The typology established here is robust since statistically significant differences between types are established, on the basis of several independent variables.

2. Type-II farmers are more intensified, and commercially oriented. Farmers adopting vegetables or potato are more profitable than others types. So diversification towards high-value crops is one of the major strategies to raise their income.

3. Analysis based on the Ostroms' eight design principles found that almost all necessary institutional conditions to sustainability do exist in the PIS. Their existence shows that WUA is a viable institution. Similarly capacity assessment shows that their performance in terms of planning and management, organization, and resource mobilization is in progressive pathways.

4. However, in spite of a sound institutional framework, tail-end farmers are not satisfied with the water adequacy and reliability in the system, which force farmers to use

underground water which is too expensive than canal water. In reality water is not less in the headwork; the cause of water inadequacy is the low efficiency of canal networks.

5. Water productivity of summer paddy, spring paddy, was found 0.50 and 0.55 kg/m^3. Similarly water productivity of vegetables (lady fingers and tomato) found very high (3.28 and 4.44 kg/m^3) compared to cereals where as water productivity of potato is 3.38 kg/m^3.

6. Net income derived from a cubic meter of water in paddy-tomato-paddy, paddy-potato-lady fingers, paddy-potato-paddy and paddy-oilseeds-paddy is NRs 64.08 43.38, 13.42 and 4.83 respectively. Cropping system having at least one vegetable or potato generates higher net income than having only cereals, pulses and oilseeds.

7. Current water charging rate of PIS is not sufficient to cover all the expenses of the system (only 39% of annual expenses is covered from ISF collection). Farmers who are using pump water are paying very high cost of water (about nine times more than canal water) compared to canal water.

5.3 Recommendations

The PIS is a single-purpose irrigation organization in which WUA is mainly involved in water management activities. Farmers get water based on the availability in source. There is imposed schedule and distribution is supply-oriented. Majority of farmers are involved in subsistence farming. Thus it has become essential for them to expand and diversify activities. Following recommendations are made based on the analysis, findings of this study.

On the farmers side

- The analysis shows that intensification, diversification and commercialization of crops seem to be the pathways for farmer's economic improvement. Only a very small percentage of farmers are found commercially-oriented in the scheme (10%). In this context, subsistence farmers should intensify their farming through commercial crops to improve their livelihood. These crops need less water than cereals but give higher production and higher net income as compared to other crops. So in view of water availability and water use, commercial crops are more conducive to sustainability than cereals.

- For adopting the higher value crops, farmers should have skill and knowledge of improved technology. To enhance their knowledge farmers-to-farmers training might be beneficial. It needs coordinated action with each farmer's type. Farmers can learn themselves from Type-II farmers in the scheme.

- Collective action in the scheme is only possible from effective participation of farmers at all level. Farmers also responsible for having low fee collection ratio. So farmers requires to think more collectively than only having concern about their own business.

On the WUA side

- Currently, WUA is mainly involved in water distribution. It is essential to diverse its activities to other areas. WUA should coordinate commercial farmers (who can train other farmers) and other agency for providing related training to other farmers as well as to establish a competitive market to sell the product of farmers.

- In view of water shortages and dissatisfaction rising in tail end sections (shown by the lower fee recovery, and the need for more pumping), a more reliable and compromised solution should be assessed. Volumetric water charging system would be more equitable in terms of water use and water charge payment than current water distribution based on the land size. If not volumetric (costly to implement), at least land-based differential rates should be set up, tail-enders paying less than others, in proportion of the shortages they face more often.

- More attention should be given to the monitoring of water distribution and ISF collection. So branch committees should be properly trained and motivated to increase ISF collection.

- Farmers are not satisfied with the WUA's rewarding and punishing mechanism. In this context MSS and other CBOs will be a helping hand to WUA to implement this kind of activities creating awareness. Linkages to CBOs should be enhanced.

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APPENDIX A-LONG QUESTIONNAIRES

Long Questionnaires

Integrated Analysis of Smallholder Irrigation Sustainability in Nepal: A Case Study on the Interplay between Individual Performances and Collective Action

In partial fulfillment of the requirements of the degree of Master of Engineering at Asian Institute of Technology (AIT), Thailand, this questionnaire aims to assess the technical and economic performance of farmers in the irrigation system.

Your answer will strictly remain confidential and data treatment will be anonymous.

1. General information

Date	
Interview Ref. No.	

Respondent's Name		
Gender	Male ( )	Female ( )
Name household head		
VDC/Ward/village		
Main canal/Secondary/tertiary/ Tube well/pond pump set		

2. Household composition

Name	**Gender**	**Age**	**Main occupation**
1. Head			
2. Spouse			
3. Children in total			
4. Household members (adults & children)			
5. Children < 14 in household			
	Male/ Female		- Full time farmer, - Regular/ salaried employee , - Unemployed, - Self employed, - Retired, - Student/pupil

3. Land tenure system

Ownership pattern	Khet (Low land)		Bari (upland)	others*
	Irrigated	Rain fed		
Owner cultivated				
Rented in				
Rented out				
Total cultivated				

Note: Fully irrigated- year round irrigated with canal; Partially irrigated: irrigated for some parts of the year with canal; Rain fed: Totally depending upon the rain

* Area occupied by building, animals shed, orchard, kitchen garden

3.1. When has your family settled in the scheme? Year…………..

3.2. Do you pay any fees for land? Yes ( ) No ( )

3.3. If yes, how much per unit? Rs. ( ) Per …… To whom? ………………..

3.4. Do you pay any fees for water? Yes ( ) No ( )

3.5. If yes, how much per unit? Rs. ( ) Per …… To whom? ……………………

4. Cropping system

Crops	Khet (Low land)						Bari (upland)		Qty sold	Price/ Unit	Qty consumed	Market outlet
	Fully irrigated		Partially irrigated		Rained							
	Area	prod.	Area	prod.	Area	prod.	Area	prod.				

Area= ha/bigha; **Production=** Ton/Maund; **Price=** NRs/unit;
Market outlet= - Neighbors, Hawkers, Factory, City / town shop, Local shop, other
 # The average of quantity harvested for the last 2/3 years
 # Market price per unit will be checked with an extension officer, local shops

- What is your favorite or main market outlet? …………………
- Which crops are grown mainly for family consumption (thus hardly sold?) ……………………………………………………………
- What is the major problem you face regarding farming? ……………………………………………………………….

5. Farm expenditures / production costs

Crop name	Input type 1. Fertilizer 2. Seeds 3. Herbicides 4. Pesticides 5. Labor 6. Tillage 7. Other	Supplier 1. Local shop 2. Store in town 3. Coop. 4. Individual (friend, neighbor…)	Qty purchased (and used)	Cost per unit	Input market Description: distance, organisation	Marketing costs Transport Packaging Other
1	1. 2. 3. 4. 5. 6. 7.					

2	1. 2. 3. 4. 5. 6. 7.					
3	1. 2. 3. 4. 5. 6. 7.					
4	1. 2. 3. 4. 5. 6. 7.					

 # Inputs price per unit will be checked with an extension officer

What problems have you got about input supply? ………………………………

Do you own any large equipment (e.g. tractor, bakkie, implements)? Yes (   ) No (   )
If Yes, which? ………………………………

Do you hire them out? Yes (   ) No (   )

If yes, at which price?…………

How much do you earn from that hiring out (on average)? ……………………

6. Crop calendar

Crop	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1												
2												
3												

 # Planting and harvesting

7. Livestock

SN	Name	Nos	Remarks
1	Buffalo		
2	Bullock		
3	Goat		
4	Sheep		
5			
6			
7			

- When is food scarce in your household (month)?

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec

8. Finances

Other sources of income in household	**How many of each source?**	**From who?** (Government, children, neighbors, etc.)	**How much per month?** (Rs)	**How much per year?** (Rs)
1. Pension (Social Grant)				
2. Child Grant Support				
3. Own salary				
4. Other salaries				
5. Own business (bakkie / tractor renting)				
6. Other business				

- Are you using credit facilities? What kind?
- What was it for (farming, general maintenance, household purchases, food)?
- Have you got any debts outstanding?

9. Scheme Management/ Physical Aspect

(a) Who operates the regulating gates in your canal?

i) The agency people ii) people deputed by farmers iii) Individual farmers as and when needed iv) There are no regulating gates

(b) What is the basis for regulating water supply?

i) Decided by agency people ii) As decided by farmers and agency iii) as requested by farmers, individually iv) There is no basis at all

(c) How is the discharge/timing/duration of water supply fixed?

i) Decided by agency people ii) As decided by farmers and agency iii) as requested by farmers, individually iv) There is no basis at all

(d) To what extent water is delivered with designed uniformity?

i) Very nicely ii) Satisfactory iii) Not satisfactory iv) Poorly

(e) How do you rate the water adequacy?

i) Very good ii) Satisfactory iii) Not satisfactory iv) Poorly

(f) How do you rate the water reliability?

i) Very good ii) Satisfactory iii) Not satisfactory iv) Poorly

(g) How equitable is the water supply?

i) Very good ii) Satisfactory iii) Not satisfactory iv) Poorly

(h) How frequently are water supplies measured?

i) regularly ii) Often iii) Sometimes iv) Never

(i) Who takes the water measurement?

i) Agency people ii) People deputed by farmers, collectively iii) Individual farmers, if he/she ever needed to do so iv) No one

(j) Who monitor the channel operation?

i) Agency people ii) People deputed by farmers, collectively iii) Individual farmers, if he/she ever needed to do so iv) No one

(k) Did you get enough flexibility to cope up with variation supply?

i) Very good ii) Satisfactory iii) Not satisfactory iv) Poorly

(l) How did you decide over sharing the water?

i) Based on land holding ii) Based on contribution made to maintenance work iii) Both i) and ii) iv) There is no arrangement

(m) Do you apply water in economic and socially acceptable manners and to your management ability?

i) Very nicely ii) Satisfactory iii) Not satisfactory iv) Poorly

(n) Do you experience problems or conflicts about water sharing?

Yes [ ] No [ ]

(o) Do you experience water shortages?

i) Never ii) Sometimes iii) Often iv) Always

(p) In the frame of an improved water supply and water related services, how much would you be ready to pay/ ha /year for such supply and services?

i) a given amount per year per ha (specify in Rs. if possible……..…)

ii) An amount depending on your farm income (specify in % for instance………..)

(q) In your opinion, if farmers had to pay, who should pay for water services?

i) Everyone in the scheme should pay for water services, regardless of what he/she does

ii) The ones that are making money

iii) The ones who are irrigating

iv) Ones who are irrigating a lot?

v) None / only the government

10. Water User's Association and management committee:

a) Is there an informal or formal organization of water user in the command area? i)Yes ii)No iii)We are trying for it iv)We do not want to have it

b) If yes, how is the relationship of the organization with the agency? i)Very nicely ii)Satisfactory iii)Not satisfactory iv)Very poor

c) How is the relationship of the organization with individual farmer? i)very nicely ii)Satisfactory iii)Not satisfactory iv)Very poor

d) Where does the control of water pass from the agency into hands of the farmer? i) At the local command area level ii)At the individual farm level iii) At the headwork's itself iv)Not clear

e) Who is eligible for membership in the organization? i) All farmers ii) Only land owners iii)Tenantsiv) Only few active and socially influential farmers

f) Are the organizational rules known by all farmers? i) All ii) Most of the farmers ii) Few of them iv) None

g) Where the organizational staffs do comes from? i) From local farmers ii) From local people but not the farmers iii) Outside the farming community iv) The agency office

h) To whom the organizational staff responsible? i) To local farmers ii) To agency people iii) To locally influential people iv) To no body

i) How are the resources mobilized to sustain the organization? i) by collecting irrigation service fee ii) By taxing general farmers on a flat basis iii) By raising fund from villagers iv) No mechanism

j) Are the organizations' rules clear and consistent? i) Very nicely ii) Satisfactory iii) Not satisfactory iv) Poorly

k) Do farmers perceive the rules clear and unbiased toward their group? i) Very nicely ii) Satisfactory iii) Not satisfactory iv) Not at all

l) Do the rules have rewarding/ punishing mechanisms? i) Very nicely ii) Satisfactory iii) Not satisfactory iv) Not at all

m) Are the irrigation rules supported by the norms of the local groups? i) Very nicely ii) Satisfactory iii) Not satisfactory iv) Very poor

n) How often the efficiency of water distribution practices affected by the system maintenance and conflict management procedures? i) Very often ii) Sometimes iii) Rarely iv) Never

o) Did you get any training related to institutional development? Yes [ ] No [ ] , If yes

Do you know about these structures?……..

Do you know the chairmen?……….

Any opinion on that?

Do you know how the committee is selected?..............

11. Concluding the interview

What are your major problems?...

as a beneficiary of the scheme ?………….

as a member of the community ?………….

What proportion of plot holders actually farm today:

Less than a half	[ ]
About half of them (5 over 10)	[ ]
More than two third of them (about 7 over 10)	[ ]
Almost everyone (about 9 over 10)	[ ]

- Please tell about your commercial farming (current status, opportunity and constraints)

………………………………………………………………………………………………..
………………………………………………………………………………………………..
………………………………………………………………………………………………..

- How do you see the future as a farmer in the scheme and what are your prospects?

- As a farmer in the scheme, has your situation improved over the last 2 years? Why?

………………………………………………………………………………………………..
………………………………………………………………………………………………..
………………………………………………………………………………………………..

- Do you have any final general comments you would like to make?

………………………………………………………………………………………………..
………………………………………………………………………………………………..
…………………………………………………………………

APPENDIX B-SHORT QUESTIONNAIRES

Short Questionnaires

Integrated Analysis of Smallholder Irrigation Sustainability in Nepal: A Case Study on the Interplay between Individual Performances and Collective Action

In partial fulfillment of the requirements of the degree of Master of Engineering at Asian Institute of Technology (AIT), Thailand, this questionnaire aims to assess the technical and economic performance of farmers in the irrigation system.
Your answer will strictly remain confidential and data treatment will be anonymous.

1. General information

Date	
Interview Ref. No.	

Respondent's Name		
Gender	Male ( )	Female ( )
Name household head		
VDC/Ward/village		
Main canal/Secondary/tertiary/ Tube well/pond pump set		

2. Household composition

Name	**Gender**	**Age**	**Main occupation**
1. Head			
2. Spouse			
3. Children in total			
4. Household members (adults & children)			
5. Children < 14 in household			
	Male/ Female		- Full time farmer, - Regular/ salaried employee , - Unemployed, - Self employed, - Retired, - Student/pupil

3. Land tenure system

Ownership pattern	Khet (Low land)			Bari (upland)	others*
	Fully irrigated	Partially irrigated	Rain fed		
Owner cultivated					
Rented in					
Rented out					
Total cultivated					

Note: Fully irrigated- year round irrigated with canal; Partially irrigated: irrigated for some parts of the year with canal; Rained: Totally depending upon the rain.
* Area occupied by building, animals shed, orchard, kitchen garden

a. When has your family settled in the scheme? Year…………..

b. Do you pay any fees for water? Yes ( ) No ( )

c. If yes, how much per unit? Rs. ( ) Per …… To whom? ……………………

4. Cropping system

Crops	Khet (Low land)						Bari (upland)		Qty sold	Price/ Unit	Qty consumed	Market outlet
	Fully irrigated		Partially irrigated		Rain fed							
	Area	prod.	Area	prod.	Area	prod.	Area	prod.				

- What is your favorite or main market outlet? …………………
- Which crops are grown mainly for family consumption (thus hardly sold?) ……………………………………………………………
- What is the major problem you face regarding farming? …………………………………………………………….

5. Farm expenditures / production costs

Crop name	Input type 1. Fertilizer 2. Seeds 3. Herbicides 4. Pesticides 5. Labor 6. Tillage 7. Other	Supplier 1. Local shop 2. Store in town 3. Coop. 4. Individual (friend, neighbor…)	Qty purchased (and used)	Cost per unit	Input market Description: distance, organisation	Marketing costs Transport Packaging Other
1	1. 2. 3. 4. 5. 6. 7.					
2	1. 2. 3. 4. 5. 6. 7.					

 # Inputs price per unit will be checked with an extension officer

What problems have you got about input supply? …………………………………

Do you own any large equipment (e.g. tractor, bakkie, implements)? Yes (   )   No (   )
If Yes, which? ………………………………

Do you hire them out? Yes (   )   No (   )

If yes, at which price?…………

How much do you earn from that hiring out (on average)? ……………………

- When is food scarce in your household (month)?

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec

6. Finances

Other sources of income in household	**How many of each source?**	**From who?** (Government, children, neighbors, etc.)	**How much per month?** (Rs)	**How much per year?** (Rs)
1. Pension (Social Grant)				
2. Own salary				
3. Other salaries				
4. Own business (bakkie / tractor renting)				
5. Other business				

- Are you using credit facilities? What kind?
- What was it for (farming, general maintenance, household purchases, food)?
- Have you got any debts outstanding?

7. Scheme Management/ Physical Aspect

(a) How do you rate the water adequacy?

i) Very good   ii) Satisfactory   iii) Not satisfactory   iv) Poorly

(b) How equitable is the water supply?

i) Very good   ii) Satisfactory   iii) Not satisfactory   iv) Poorly

(c) Who monitor the channel operation?

i) Agency people   ii) People deputed by farmers, collectively   iii) Individual farmers, if he/she ever needed to do so   iv) No one

(d) Do you experience problems or conflicts about water sharing?

Yes   [   ]   No   [   ]

(e) In the frame of an improved water supply and water related services, how much would you be ready to pay/ ha /year for such supply and services?

i) a given amount per year per ha (specify in Rs. if possible……..…)

ii) An amount depending on your farm income (specify in % for instance………..)

(f) How your scheme is maintained for maximum utilization of water?

....

If the scheme is not maintained well, who should be responsible for this?

....

If you hear the word "collective action", do you spontaneously have positive or negative feelings4? Why?..
....

What collective action can be made for proper maintenance and sustainability?

....

What will be your role for system to be sustained? What will be the better way?

....

8. Water User's Association and management committee:

p) How is the relationship of the organization with individual farmer? i)very nicely ii)Satisfactory iii)Not satisfactory iv)Very poor

q) Where does the control of water pass from the agency into hands of the farmer? i) At the local command area level ii)At the individual farm level iii) At the headwork's itself iv)Not clear

r) Are the organizational rules known by all farmers? i) All ii) Most of the farmers ii) Few of them iv) None

s) Do the rules have rewarding/ punishing mechanisms? i) Very nicely ii) Satisfactory iii) Not satisfactory iv) Not at all

t) How often the efficiency of water distribution practices affected by the system maintenance and conflict management procedures? i) Very often ii) Sometimes iii) Rarely iv) Never

u) Did you get any training related to irrigation? Yes [ ] No [ ] , If yes

Which kind of training?......................................

9. Concluding the interview

What are your major problems?...

as a beneficiary of the scheme ?…………

- Please tell about your commercial farming (current status, opportunity and constraints)

……………………………………………………………………………………………..................................
....

- How do you see the future as a farmer in the scheme and what are your prospects?

....
....

- As a farmer in the scheme, has your situation improved over the last 2 years? Why?

………………………………………………………………………………………………..
………………………………………………………………………………………………..

- Do you have any final general comments you would like to make?

………………………………………………………………………………………………..
………………………………………………………………………………………………..

APPENDIX C- INDICATORS MATRIX FOR CAPACITY ASSESSMENT OF WUA

Indicators Matrix for Capacity Assessment of WUA

Indictors / Score **A. Organization**	**1**	**2**	**3**	**4**	**5**
1. Are WUA objectives and roles defined and understood?	Objectives and roles are not defined and cannot be revealed	Objectives and roles are rudimentarily defined-members are not clear	Objectives and roles are defined, but some conflicts exist, more than 50% are unable to recall these.	Objectives and roles are defined and understood by most members	Clearly defined objectives and roles which are understood and taken as orientation by the whole group
2. How are group decisions made?	No decisions made (only relatively structured discussions)	A few decisions were made by one or two individuals, low immediate support from all members.	Decisions are made by one or two individuals but initiated and supported by majority	Decisions are made by majority of group members with attempts to integrate the minority	Decisions reached on the basis of general consensus, high participation by all members.
3. To what extent does WUA coordinate with members, other CBOs, VDC and DIO, DADO?	WUA works on its own. Messages are not conveyed to other members. No contact to other groups, VDC or agencies maintained.	WUA mainly works on its own. Messages given to some members verbally. Only sporadic contact o other groups and VDCs.	WUA has some contact to some members; messages are sent verbally but regularly. Some coordination with other groups and VDCs regularly and no linkages with other agencies.	Relationship and contact to members' good, relatively good coordination with other groups. Sporadic contact to other agencies (DIO, DADO).	Good interactive relationship with all members. Linkages to CBOs, VDCs and agencies are maintained good.

Indictors / Score **B. Leadership**	**1**	**2**	**3**	**4**	**5**
1. How are group leadership need met?	No leadership (apparent or hidden at all)	Leadership concentrated on one person.	Some leadership sharing with a few individuals.	Leadership seems creative and flexibly.	Leadership functions are distributed or rotated.
2. How are the groups leaders selected and changed?	"Self election" of the most powerful. No institutional mechanism followed for leadership change.	Nominated by predominant sub-group; changes only in line with this nomination principle. No procedure followed for selection.	Leadership selection based on members discussion but strongly influenced by some individuals and with generally with low participation.	Leader selection based on all members discussions with relative high participation. No standard followed for selection but reformation might have taken place as per group demand.	Voting by all group members (one man one vote), mechanisms for leadership changes according to standards.
3. Are women and other oppressed caste included as leaders (leadership diversity)?	Not at all, no members of such category. Tendency to discourage their participation.	Women and such castes are formally included as members only. No explicit encouragement of their participation.	Few of such members included and acknowledged by community.	Women and such caste are adequately represented, as members due to explicit strategy and acknowledgement of having of such members.	These members are included according to their share in overall membership. These holding positions are acknowledged and encouraged.

Indictors / Score **C. Management**	**1**	**2**	**3**	**4**	**5**
1. How are the groups activities planned and implemented?	No specific planning of activities or action. No orientation with apparent objectives and goals of group. No action plans prepared.	Rudimentary planning but activities are not really related to "plans"; implementation is slow, often not completed. No action plans prepared.	Average planning and implementation performance. Only few activities has been planned and initiated. Attempts to make action plan only by the external support.	Appropriate planning with action plan preparation. With few exceptions implementation is completed in due time.	Appropriate planning, action plans prepared independently; implementation according to agreed plans with enough flexibility for adjustments, if required.
2. Is meeting conducted and minuting done and applied by the group?	No system of meeting and keep minuting.	Irregular meeting and often incorrect minuting. Not used for further planning and monitoring.	Irregular meeting and little minuting of main decisions only. No plans written down, but verbally conveyed and adhered to. Minute often kept by leaders. No regular attempts to use in management.	Regular meeting and correct minuting of main decisions and plans; used in management.	Good meeting and minuting system. Minuting is always used in meetings for management and monitoring of activity implementation as an integrated praxis.
3. To which extent external assistance needed?	Management completely dominated and imposed by outsiders. Pushing is needed to mobilize people.	Management highly dependent on assistance from outsiders (DIO, DADO have to call for meting)	Regular assistance from outside in major management issues (make plans and technical advice)	External assistance needed for guidance upon special request by group only.	Management independent from outside; capacity to undertake activities independently and act creatively and flexibility according to the circumstances.

Indictors / Score **D. Resource Mobilization**	**1**	**2**	**3**	**4**	**5**
1. Is fund collected internal (water charging systems) and external?	No fund collected. No water charging systems.	Some fund collected for specific activity. No specific rules of water charging.	Water charging system exists but rules not followed. Fund collected randomly for specific system maintenance.	Water charging system exists and rules is followed but the fee collection ratio is nearly 0.75.	Water charging system is totally followed and fee collection ratio is nearly 1.
2. Is fund used for already planned purposes?	Not at all.	Fund used for specific activities as per the agency demand.	Apart from using fund as per agency demand, group fund is often used ad hoc with no plans or not used.	With few exceptions fund is mainly used for planned activities. Some times fund is kept for emergency use.	Fund always used for intended and planned purposes.
3. How accountable and transparent is the financial recording systems?	No system for accountability.	System exists, but doesn't generate reliable information and are poorly managed and adhered to. Not accessible for other than leaders.	System exists but information only partly reliable and not up-to date. The actual financial situation seems some what unclear to both executive and ordinary members.	System exists and produces reliable information but only some members are informed about the actual financial situations.	System exists, well documented and all members are regularly informed about the actual financial situations.

Indictors / Score **E. Representation and participation**	**1**	**2**	**3**	**4**	**5**
1. How are the geographical locations and different caste, ethnic and income groups represented in the group?	Poor representation. Not all clusters, branch and sub branch canal and income groups are represented.	All cluster represented but not ethnic and economic groups proportionally represented.	All formally represented but to fulfill the quota only.	All represented but discussions and decisions are dominated by a sub group.	All represented fairly. All have equal opportunity in discussions and decisions.
2. What is the participation of members?	Participation is generally low. Majority of members have no interests.	Only few (often leaders or active villagers) actively participate in planning and implementation. Other members are difficult to motivate and mobilize.	Average participation of all members. Some only participate in implementation and only few participate very little.	Most members participate in annual planning and implementation. Some in implementation only but easily mobilized.	Equal and active participation from all members in all aspects.
3. How actively are women participating?	No women participate	Some women participate but only as per quota system promoted by agencies.	50% women participate actively but in implementation mainly and not influential in decision making.	Few women actively involved in all aspects while major part of women are mobilized for activity implementation	All women participate as active as men in all aspects.

Indictors / Score **F. Water Distribution**	**1**	**2**	**3**	**4**	**5**
1. How are the canal structures in the irrigation system	Poor status. Most of the structures are not working.	Only 25% of structures are functional	About 50% structures are functional	About 75% structures are functional	All structures are in well condition
2. How you distribute water?	Without any schedule and only by judgment	Schedule used in main canal and rest of the part without schedule.	Main canal and branch canal have schedules but not in sub branches	With 50% sub branch follow schedules	All branch and sub branch have water distribution schedules.
3. How irrigation service fee collected? Have any rules?	No system at all	Have policy but no implementation	About 50% branches follow rules	About 75% follow rules	All have rules and implemented

Indicators Rating for WUA Capacity Assessments 2002/2007

	Organization		Leadership		Planning and Management		Resource Mobilization		Representation/ participation		Irrigation structures and water distribution	
	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007
Sub indicator 1	3	3	4	5	3	4	4	4	3	4	3	3
Sub indicator 2	5	5	5	5	4	5	3	5	2	3	2	4
Sub indicator 3	5	5	4	5	4	4	3	5	4	5	4	5
Total	13	13	13	15	11	13	10	14	9	12	9	12

Note: for explanations of each sub indicators (sub indicator 1, 2, 3)-Refer the tables in page C1-C6

<u>Appendix-D:</u> Checklist for group discussions

Facilitator's Name:…………………………………………… Date:………………………

- Name of Institution/organization
- Year of Establishment
- Legality of organization
- Process of formation
- Organization structure
- Cropping pattern
- Input supply in farming
- Market outlet
- Rate of crop selling
- Water adequacy, water schedules
- Equity in water supply
- Rules are followed by users
- Rules are clear and unbiased
- Conflict management
- Participation of farmers in maintenance and decision making
- Irrigation fee collection
- ISF and burden of economy to farmers
- Is ISF sufficient to maintain canal
- Training
- Major problem in system
- What collective action has been done to resolve problem
- Constraints for collective action
- Relation with main committee
- Other comments/suggestions

Appendix-E: Input/ Output Matrix

Objectives	Activities	Indicators	Outputs	Assessment Tools
1. To assess institutional capacity of Water Users Association (WUA) and broader social, institutional and organizational features within a scheme.	●Assess capacity of WUA in a framework of Spider Web Model ● Identify other local organization within the system ●Describing collective action rules at play (water sharing and maintenance)	●Organization/ Planning ●Management ●Leadership ●Representation ●Resource mobilization ● Marketing of Products ●Enforcement ●Acceptance/ flexibility	●Institutional capability of WUA ●Relation and role play of these WUA and CBOs ●Marketing systems ●Description of the set of rules for collective action	●Primary data ●Spider web tool ●Focus group discussion ●Ostrom's principles
2. To study the technical production systems at the farmers level.	●Analyze diversity of cropping systems ●Crop budget analysis	● Cropping intensity ● Crop Production ●Inputs productivities	● Documented Cropping systems typology and a comparison of cropping systems	● crop budget crop calendar ●Focus group discussion ●Questionnaire survey ●Secondary data
3. To study farmers individual economic performance using typological approaches (farmer's typology).	●Farm budget analysis ●farming system analysis	● Farm income ●Farm inputs productivities	●Farmers typology ●Farming system assessment	●Amalgamation of crop data at farm level ●Interpretation of data ●Statistical Analysis
4. To identify relationships and functional links between individual performance and collective sustainability.	●Identify links between farmers type and collective features	●Contribution to overall production by each group ● Financial contribution by each group (willingness to pay) ●Contributions to maintenance by each group ●Relation type / behavior regarding collective rules (eg water sharing, conflicts within types or with other types)	●production performance ●Economic performance ●Financial performance ●Level of collective actions	● Observations Interpretation analysis ●Calculation/ modeling

APPENDIX F-SUPPLEMENTARY TABLES AND FIGURES

Table F.1 Cropping Pattern in Head Middle and Tail

SN	Cropping Pattern	Head		Middle		Tail		Total	
		Count	Pct Resp	Count	Pct Resp	Count	Pct Resp	Count	Pct Resp
1	Paddy-Pulse-Paddy	38	23	22	16	8	7	68	16
2	Paddy-x-Paddy	9	5	8	6	10	9	27	6
3	Paddy-Maize-Paddy	2	1	4	3	1	1	7	2
4	Paddy-Wheat-Paddy	7	4	15	11	7	6	29	7
5	Paddy-Pulse-Maize	24	14	24	17	7	6	55	13
6	Paddy-Potato-Paddy	3	2	9	7	7	6	19	5
7	Paddy-Potato-Lady Fingers	0	0	2	1	9	8	11	3
8	Paddy-Wheat-Maize	2	1	13	9	9	8	24	6
9	Paddy-vegetable-Vegetable	0	0	3	2	3	3	6	1
10	Paddy-Oilseeds-Paddy	41	24	10	7	2	2	53	13
11	Paddy-Oilseeds-Maize	37	22	11	8	15	13	63	15
12	Paddy-Vegetables-Paddy	2	1	2	1	1	1	5	1
13	Paddy-x-Maize	3	2	2	1	2	2	7	2
14	Paddy-Wheat-x	0	0	2	1	1	1	3	1
15	Paddy-Oilseeds-x	0	0	3	2	3	3	6	1
16	Paddy-Maize-x	0	0	4	3	3	3	7	2
17	Paddy-Pulse-x	0	0	3	2	9	8	12	3
18	Paddy-x-x	0	0	1	1	10	9	11	3
19	Rice-potato-Maize	0	0	0	0	5	4	5	1
	Total response	168	100	138	100	112	100	418	100
	Total count	95		93		61		249	

Pct Resp =Percentage Response

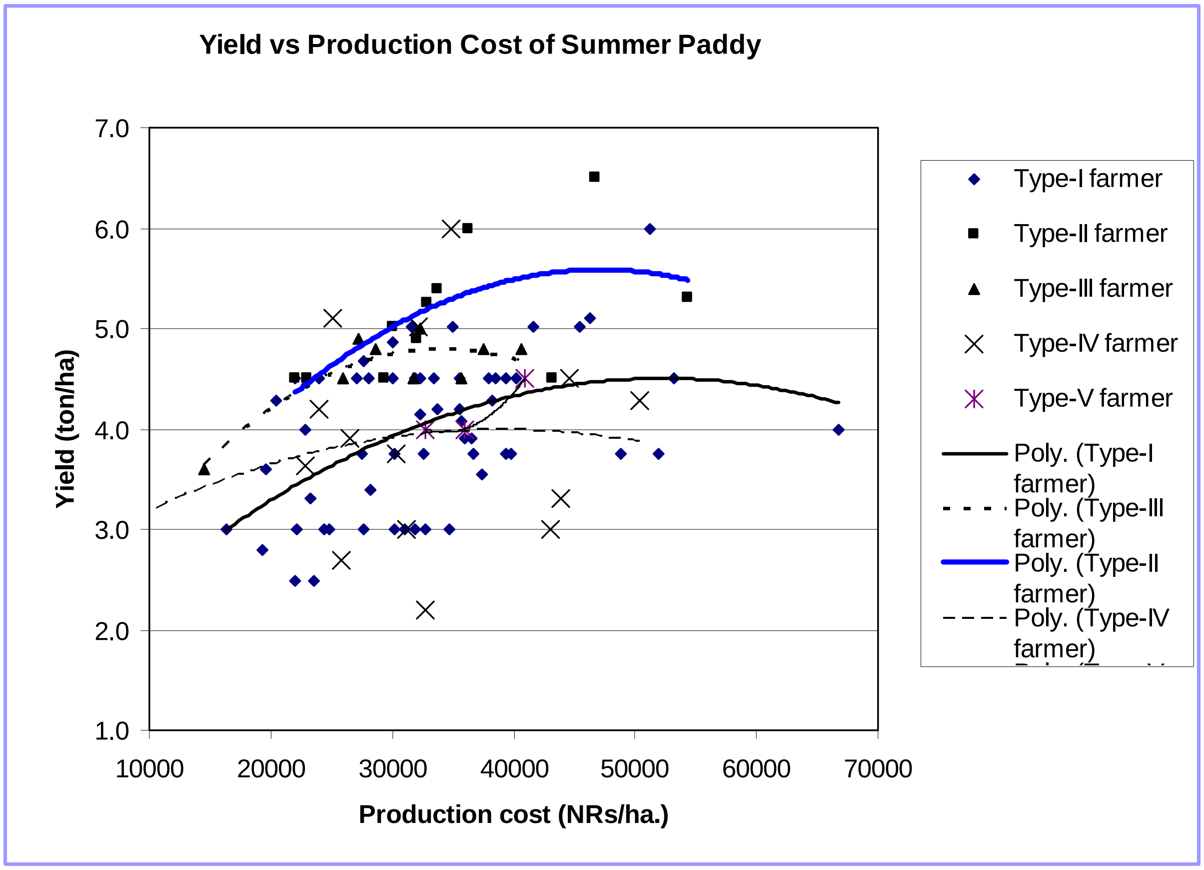

Figure: F.1 Graph showing crop yield of paddy with production cost

Table F.2: Farmers Participation in Training

Participation in training related to agronomy/irrigation	Type-I farmer	Type-II farmer	Type-III farmer	Type-IV farmer	Type-V farmer	Total
Training related to	59	19	14	17	7	110
irrigation or agronomy or both *	(42)	(73)	(45)	(50)	(54)	(45)
Agronomic	13	15	7	5	4	44
training **	(9)	(58)	(23)	(15)	(31)	(18)
No of farmers responded	139	26	31	34	13	243

Figure in parenthesis indicates percentage
* = *institutional, water distribution or agronomic training*
** = *agriculture production and farming practices training*

Table F.3 Farmers Perception on equity of Water supply

Level of satisfaction	Head	Middle	Tail
Very good	1	2	0
	1%	2%	0%
Satisfactory	88	73	47
	95%	81%	77%
Not Satisfactory	4	15	12
	4%	17%	20%
Poor	0	0	2
		0%	3%
	93	90	61
	100%	100%	100%

Chi^2 = 12.68, p =0.00

Table F.4 Farmers Perception on water Flexibility with variation in Water supply

Level of satisfaction	Head	Middle	Tail
Very good	0	1	0
	0%	1%	0%
Satisfactory	86	73	29
	93%	81%	48%
Not Satisfactory	6	16	30
	7%	18%	49%
Poor	0	0	2
		0%	3%
	92	90	61
	100%	100%	100%

Chi^2 = 41.0, p =0.00

Table F.5 Relationship between WUA and Agency

Realtionship between WUA and Farmers	Head	Middle	Tail
Very good	2	2	0
	6%	6%	0%
Satisfactory	24	19	19
	69%	54%	63%
Not Satisfactory	2	3	5
	6%	9%	17%
Poor	7	11	6
		31%	20%
	35	35	30
	100%	100%	100%

Chi^2 = 0.61, p =0.43

Table F.6 Know how of Organization's Rule by Farmers

Know how of the organizations' rule	Head	Middle	Tail
Mostly known	6	2	3
	7%	2%	5%
About 50% known	40	35	29
	43%	41%	50%
Few of rules known	45	47	25
	49%	55%	43%
None	1	2	1
		2%	2%
	92	86	58
	100%	100%	100%

Chi^2 = 0..6, p =0.93

Table F.7 Whether Rules Perceived Clear and Unbiased?

Rules are clear and unbiased	Head	Middle	Tail
Very good	1	2	0
	3%	6%	0%
Satisfactory	24	15	18
	69%	43%	60%
Not Satisfactory	6	10	4
	17%	29%	13%
Don't know	4	8	8
		23%	27%
	35	35	30
	100%	100%	100%

$Chi^2 = 2.10$, $p = 0.14$

Table F.8 Whether Rules Are Clear and Consistent

Rules are clear and consistent	Head	Middle	Tail
Very good	1	1	1
	3%	3%	3%
Satisfactory	28	18	19
	80%	51%	63%
Not Satisfactory	4	6	4
	11%	17%	13%
Don't know	2	10	6
		29%	20%
	35	35	30
	100%	100%	100%

$Chi^2 = 2.44$, $p = 0.11$

Table F.9 Amount of Water Available at Headwork and Field Inlet

Description	Summer			Winter			Spring			Summer	Winter	Spring
	Head	Middle	Tail	Head	Middle	Tail	Head	Middle	Tail			
Area of land (ha)	140	131	101	78	75	60	140	106	55	372	310	254
Total water diverted from head work (m^3)	3603812	3384359	2613893	2654692	2537005	2008835	1867545	1419103	696781	9602064	7200531	3983430
Total water available in field inlet (m^3))	953569	796001	537939	1155322	1039157	744940	812756	581265	249726	2287509	2939419	1643747
Water diverted from head work (m^3/ha)	25834	25835	25880	33982	33976	33711	13387	13374	12776	25850	33890	13179
Water available at field inlet (m^3/ ha)	6836	6076	5326	14789	13917	12501	5826	5478	4579	6079	13736	5294
Overall Irrigation Efficiency (%)	26	24	21	44	41	36	44	41	36	24	41	41

Table F.10 O&M Cost at the Price of 2007 from Data Given Of Previous Years using Money Inflation Rate

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Annual money inflation rate	8.9	7.7	8.1	7.0	6.7	11.4	3.4	2.4	2.9	4.8	4.0	4.5	8.0	6.4
O&M cost- Larger scheme [1]	400*	430	465	498	531	592	612	626	645	675	702	734	793	844
O&M cost -Larger scheme [2]	700*	753	814	871	929	1035	1070	1096	1128	1182	1229	1285	1387	1476
O&M cost - FMIS [3]			621*	664	709	790	817	836	861	902	938	980	1059	1126
O&M cost - AMIS [4]			711*	761	812	904	935	957	985	1033	1074	1122	1212	1289
Average				698	745	830	858	879	905	948	986	1030	1113	**1184**

Sources: 1,2 = FAO, 1994- Aquastat; 3,4 = Prasad K. C., 1998-ISF in Nepal; Money inflation Rate = IMF, 2008

Note: * = Base data from the given source, Cost in NRs.

Table F.11 Pump Water Use and Water Charge

Crop	Nos of irrigation	Depth of water (mm)	Volume of water (m^3)	Water charge (Rs)
Summer paddy	3	120	3600	1620
Winter maize	3	100	3000	1350
Spring paddy	5	120	6000	2700
Total per year			12600	5670