IRRIGATION SYSTEM GOVERNANCE AND CLIMATE CHANGE:

STUDY OF PANCHAKANYA IRRIGATION SYSTEM TO UNDERSTAND ITS ADAPTIVE CAPACITY AND CHALLENGES

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Masters of Science in

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By

Krity Shrestha

School of Environmental Science and Management (SchEMS)

Roll No: 13250016

PU Regd. No: 2012-1-25-0015

ENV 625: Thesis Work

Advisor: Dr. Anjal Prakash ,Program Coordinator, ICIMOD- HIAWARE

Co- Advisor: Dr. Bimal Raj Regmi, Governance Specialist, ICIMOD

Previous Degree: Bachelor of Science in Environmental Science

Viswa Niketan Science Campus, Tribhuvan University

Kathmandu, Nepal

June 2017

LETTER OF DECLARATION

I, Krity Shrestha, hereby, declare that this study entitled **"Irrigation System Governance And Climate Change: Study Of Panchakanya Irrigation System To Understand Its Adaptive Capacity And Challenges",** submitted in partial fulfilment of Master's Degree in Environmental Management to the SchEMS College affiliation of Pokhara University during the academic year 2017 has not previously formed the basis for the award of any degree, diploma, fellowship or any other similar titles. The study is a part of **"Understanding existing statutory and customary institutional mechanisms and their strengths and weaknesses leading to vulnerability and adaptation in Gandaki river basin"** and the methods and tools have been derived from the study itself which is led by Dr. Bimal Raj Regmi, ICIMOD. This study is a part of Research Component 2 of Himalayan Adaptation, Water and Resilience (HI-AWARE) Research on Glacier and Snowpack Dependent River Basins for Improving Livelihoods, implemented by International Centre for Integrated Mountain Development (ICIMOD) in Nepal together with Practical Action South Asia Regional Office. This work received the support of the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) with financial support from the UK Government's Department for International Development and the International Development Research Centre, Ottawa, Canada.

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Krity Shrestha

School of Environmental Science and Management (SchEMS)

Affiliated to Pokhara University

June 2017

CERTIFICATION

This is to certify that the thesis entitled **"Irrigation System Governance And Climate Change: Study Of Panchakanya Irrigation System To Understand Its Adaptive Capacity And Challenges"**, submitted by Ms. Krity Shrestha for the partial fulfilment for the degree of Masters in Science in Environment Management is based on the original research and study under the guidance of Dr. Anjal Prakash and Dr. Bimal Raj Regmi. This thesis is a part or full property of **School of Environmental Science and Management (SchEMS)** and Himalayan Adaptation, Water and Resilience (Hi-AWARE) Research on Glacier and Snowpack Dependent River Basins for Improving Livelihoods, implemented by ICIMOD in Nepal together with Practical Action South Asia Regional Office; therefore should not be used for the purpose of awarding any academic degree in any other institution.

_____ Date: _____

Dr. Anjal Prakash (**Advisor**)
Program Coordinator
ICIMOD

Date: _____

_____
Er. Gautam Rajkarnikar (**External examiner**)
Fellow
Centre of Research for Environment, Energy and Water (CREEW)

Date: _____

_____
Mr. Ajay Bhakta Mathema (**Principal**)
Associate Professor
SchEMS

ABSTRACT

There is limited understanding to date eliciting the issue of governance within Farmer managed Irrigation System (FMIS) and how this can be addressed in climate change adaptation with regards to capacity of institutions to deliver inclusive adaptation outcomes. The main purpose of this research is to understand the irrigation governance and mechanisms of water resource management in the changing climate context to increase the adaptive capacity of the FMIS.

The methodology for this study includes the Institutional Analysis and Development (IAD) framework which was adjusted for adaptation governance analysis. The action situation includes providers and beneficiaries of a collective adaptation good, whose interdependence is characterized by three sets of variables (biophysical conditions, community attributes and institutions). The study used household perception survey, key informant interviews and focus group discussion as key tools.

The FMIS is prone to climate change impacts such as variability in precipitation, rising temperature and increasing climate induced hazards. The farmers, dependent within the system, have reported loss of water discharge (about 50%) from the springs due to extreme variability in precipitation and increased temperature that can be attributed to climate change. The decreased access and availability of water has forced farmers to use ground water pumping as an alternative.

The extreme weather and climatic conditions have made the farming system more costly in terms of additional inputs. The evidences show that many farmers have shifted to other livelihood options other than agriculture. This has severely impacted the livelihood of the landless daily wage agricultural labourers as many of the labourers, especially women, have no other skills. In contrary, the institutional structure, currently in operation, is extremely weak in terms of mobilizing communities and poor in terms of providing equal access to all the farmers affiliated with the system. The institution is also unable to understand and strategize adaptive responses to deal with the growing impacts of climate change stresses.

The findings indicate that important factors shaping adaptive capacity of individuals, household and communities is their access to and control over water resources, access to water resource management knowledge and supporting networks and opportunities for enhancing capacity of institutions and individuals.

Key words: *Climate Change, FMIS, Institution, Irrigation Governance, Adaptive capacity*

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Krity Shrestha

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LIST OF ABBREVIATIONS

CIDP	Chitwan Irrigation Development Project
DFID	Department for International Development
DHM	Department of Hydrology and Meteorology
DoI	Department of Irrigation
EIA*	Economic Impact Assessment
FAO	Food and Agriculture Organization
FMIS	Farmer Managed Irrigation System
GCAP	Global Climate Adaptation Partnership
GCM	General Circulation Model
GDP	Gross Domestic Product
GoN	Government of Nepal
HMG	His Majesty's Government
IAD	Institutional Analysis and Development Framework
IDS- Nepal	Integrated Development Society- Nepal
IMTP	Irrigation Management Transfer Project

IPCC AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
NAPA	National Adaptation Program of Action
NCVST	Nepal Climate Vulnerability Study Team
PAC	Practical Action Consulting
PIL	Power Influence and Legitimacy
PIS	Panchakanya Irrigation System
UNEP	United Nations Development program
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WECS	Water and Energy Commission Secretariat
WFP	World Food Program
WUC	Water User's Committee

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CHAPTER 1: INTRODUCTION

The study **““Irrigation System Governance And Climate Change: Study Of Panchakanya Irrigation System To Understand Its Adaptive Capacity And Challenges”** is conducted with an aim to highlight the perceived impacts of climate change in the study area i.e. Panchakanya Irrigation System (PIS), which is a Farmer managed irrigation system (FMIS) and assess the governance of the system in water resource management and assess the adaptive capacity to future climate impacts. Agriculture is one of the major drivers of the national Gross Domestic Product (GDP) and the FMIS have been well recognized approach of irrigation system management in the country as well as in the international forums. However, there are various emerging challenges that these FMIS are facing in the recent years, which are further aggravated by the changing climate.

The “Introduction” chapter includes the background of the study, where we will look at the impacts of climate change in Nepal’s agriculture. We will then move to importance of irrigation systems in agriculture and focus in Farmer managed irrigations systems (FMIS) and into our study site- Panchakanya irrigation system. We will look at the history and evolution of Panchakanya irrigation; it’s most vulnerable groups and the importance of good governance in the functioning of the system. The second section will include the problem statement, followed by research questions and objectives of the study. Then, we will highlight the significance of the research and its limitations.

1.1. Background of the Study

1.1.1 Nepal’s Agriculture System and Climate Change

Nepal’s economic future is inextricably linked to the health of its agriculture sector. With around 80% of the total population dependent on agriculture for livelihood, this sector is crucial in terms of national GDP as well. Nepal’s largely rain fed agriculture sector in turn is inextricably linked with changing climate. According to Nepal’s National Adaptation Program of Action (NAPA) document, observed data indicate a consistent warming trend across the country with a rise in maximum temperatures at an annual rate of 0.04-0.06 degree Celsius; with higher temperature rise in mountain regions. Precipitation data shows a general decline in the pre monsoon rainfall, mostly in western and far western Nepal. Overall, general consensus is recognized on the following trends for Nepal: (1) significant warming, particularly at higher elevations, leading to reductions in snow and ice coverage; (2) increase

in climate variability and frequency of climate extremes including flood and drought; and (3) an overall increase in precipitation during the wet season but decrease in precipitation in the middle hills. (CA Sova, 2013)

According to IPCC Technical Report VI (2008), adverse effects of climate change on freshwater systems aggravate the impacts of other stresses, such as population growth, changing economic activity, land-use change and urbanisation (very high confidence). Globally, water demand will grow in the coming decades, primarily due to population growth and increasing affluence; regionally, large changes in irrigation water demand as a result of climate change are expected (high confidence) (Bates B. Z., 2008).

According to NCVST (2009), GCM projection suggests that Nepal's agriculture will face many challenges over the coming decades due to climate related variability. Existing problems such as soil degradation and increasingly limited water resources are likely to be exacerbated by climate change, increasing the difficulty of achieving food security for the growing population. The recently observed extreme severe weather events between 2006-09 including droughts and floods have significantly affected food production in Nepal (WFP, 2009). In addition, it has been suggested that warming of more than 2.5°C could reduce global food supplies and contribute to higher food prices (UNEP & UNFCCC, 2002).

Further, Economic Impact Assessment of Climate Change in key sectors of Nepal (2014), the annual direct costs of current climate variability in Nepal, on average, are estimated to be equivalent to 1.5% to 2% (270 -360 million USD in 2013) of current GDP/ year; which can rise up to 5% in case of extreme floods. (IDS-Nepal, PAC and GCAP, 2014)

1.1.2 Farmer managed irrigation System (FMIS)

Irrigation management is not only one-dimensional activity. It has multidimensional activities. They include managing organizations, which operate and deliver water. It also deals with farmer's organization, agriculture credit, extension services and market conditions and water right issues. Hence, irrigation management is to be seen as social, institutional and technical activities. It is no longer considered irrigation management only as technical problem. Changes in irrigation management mean the establishment of multi-disciplinary irrigation department open to the farmer's participation in irrigation management. The irrigation management changes also have to respond to the irrigated agriculture and increasing productivity per unit of water. (Pradhan, 2000)

Nepalese farmers have, by and large, recognized the importance of water resources for centuries and have been constructing irrigation systems at their own initiative to intensify their agriculture production. Irrigation development in the country remained in the hands of the people for many years. This tradition has given birth to the FMISs scattered all over Nepal. These systems have developed their own rules, norms and procedures of management. (Pradhan, 2000) Irrigation development in Nepal has a long history. Numerous small *raj kulos* (canals) in the government sector first appeared in and around Kathmandu valley in the seventeenth and eighteenth centuries. In 2002, the irrigation potential of the country has been estimated at 2177 800 ha, including some 412 000 ha which are not cultivated, mainly in the *Terai* area. This potential is mainly for surface irrigation, but some 352 050 ha are potentially irrigable from groundwater in the Terai region, consisting of 292 600 ha from shallow tube-wells (83 percent) and 59 450 ha from deep tube-wells (17 percent). Irrigated areas in Nepal are often classified as public systems and farmer managed irrigation systems (FMISs). FMISs cover about 75% of the total irrigation in the country. (FAO, 2016)

FMISs in Nepal have operated successfully for centuries. Most FMIS diversion structures are constructed from brushwood and boulders, and are therefore temporary and often washed away during monsoon season. The FMIS canals are generally unlined and prone to damage. There is, typically, a large expenditure of labour every year to restore the systems or to maintain them. In spite of these physical limitations, FMISs have demonstrated managerial skills (at community level) that have kept them functioning and contributing significantly to Nepal's food supply. The total area of the FMISs was estimated at 850 676 ha in 1994. FMISs can be either entirely managed by farmers or assisted by specialized agencies. (FAO, 2016)

The importance of farmer-managed irrigation systems in Nepal can be viewed from several perspectives. At the household level, survival of many families in densely populated hill areas depends on the increased production made possible by their irrigation system. At the national level, at least 45 percent of the population's subsistence cereal requirement is being met by the increase in food production made possible by irrigation from farmer-managed systems. This estimate assumes a conservative annual increase in production of 2,000 kilograms per hectare (kg/ha) with irrigation as compared to rain-fed conditions. (WECS, and IIMI, 1990)

1.1.3 Panchakanya Irrigation System

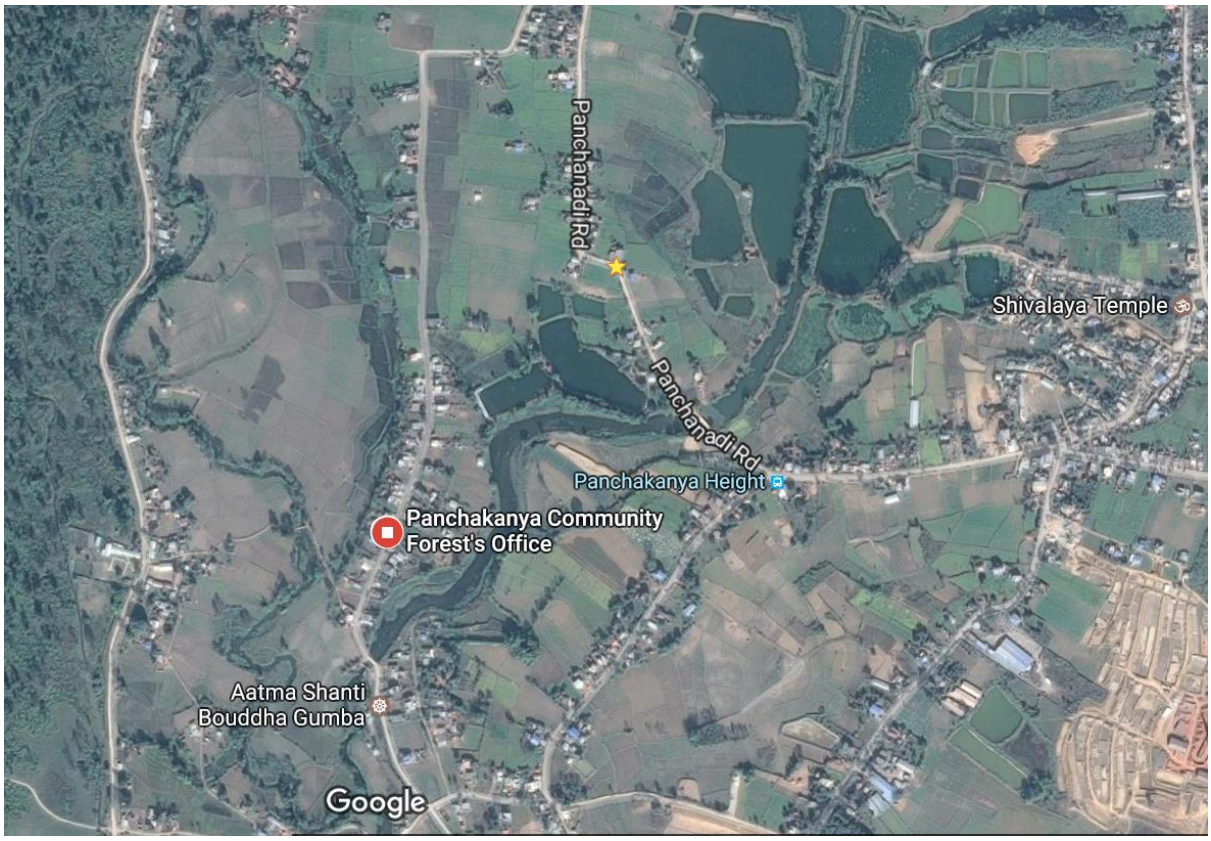
Panchakanya Irrigation System (PIS) is one such irrigation system that is managed by the farmers themselves. It lies in *Chitwan* Valley in southern Nepal. Chitwan valley lies in the Chitwan district of *Narayani* zone of central region. It has *Mahabharata* range in the north and Siwalik in the south, west and southeast. *Narayani* river separates it from *Nawalparasi* district in the west. It is about 140 km south of Kathmandu valley and has a subtropical monsoon climate with unevenly distributed high annual precipitation.

The settlement in Chitwan valley is relatively newer as it started after 1950s, with mostly migration from hilly region. Late paddy (lowland), maize (highland summer), mustard and wheat (winter crops) are the main crops in Chitwan valley, and the cropping pattern was traditionally two times a year. (HMG, Research and Training Branch, 1992)

The Panchakanya Irrigation System is a small (600 ha) gravity irrigation system fed by a spring. *Khageri* River, which in fact is a perennial drain formed with the confluence of five perennial springs in the catchment. The intake and the service area of the scheme is located in Ward Nos.1,4,5,6,7,8 and 9 of the *Ratnanagar* Municipality' that includes 17 settlements- *Gheghallli, Bhojad, Dhekllwa, Sisai, Tikallli, Nipani, Bhedi. Gadallli, Dhllsari Birla, Mohana, Debauli, Golhallli, Baghmara, Bargaon, Hardi, Narkalia* and *Nayaparsa*, under the command area.

Bharatpur-Hetauda section of East-West Highway passes through the head reach of the system, that crosses the main canal at *Krishna Mandir* (Krishna temple), about 8 km east of Bharatpur, the headquarter of Chitwan District. A number of earthen and graveled link roads connect all the settlements within the service area with the highway, therefore all parts of the service area are easily accessible on vehicle.

Figure 1 : Google view of Panchakanya Irrigation System (Command area also includes the other side of E-W Highway that is not shown here) Image



Agriculture in the valley prior to 1950s was limited around the scattered settlements of *Tharus* and *Darais*. The livelihood of the Tharus and Darais was based on rice growing; therefore they had built irrigation canals as a means of security against rainfall failure to support rice production during monsoon. Tharus, like elsewhere in the country, are pioneers of irrigation development in Chitwan valley.

Panchakanya Irrigation System is believed to have been developed by then Tharu landlord of *Sisa* and *Bhojad mauja* (villages) more than 200 years ago. The canal that time was earthen, that followed almost the same alignment as today's main canal, with temporary diversion structures built every year at about 100 meters downstream of the today's intake. The system then was supporting irrigation needs of almost 150 *bighas* (100 ha) of land during monsoon in these two villages. Other maujas of today's command area, which were also inhabited by Tharus were-*Debaun. Gothauli, Baghmara, Mohana, Bhedi, Gadauli* and *Nipani*. These villages had access to another irrigation canal, called *Budhi Kulos* (canals) that had intake in *Kair Khola* (river). This supports the claims of the people in the area that much of the today's command area of the system was under cultivation prior to the initiation of settlement of the migrants in 1950s when most of other areas of Chitwan were still under forest. Settlement of

the migrants in the command area of the system began as early as in 1952. An approximation of population composition in 1970 (2025/026 B.S.) and 1999 (2055/056 B.S.) made by some key informants indicate that the total population of the command area included 95% and 5% migrants in 1970 that was changed to 75% migrants and 25% in 1999.

In a major flood in Kair Khola in 1967 (2023 B.S.), Budhi Kulo that supported irrigation in almost 7 maujas was destroyed. In fact a channel of Kair River entered through Budhi Kulo during the flood that caused severe damages to arable lands in the area, rendering Budhi Kulo useless for subsequent irrigation. Since, there was ample supply at the source in Panchakanya Kulo. The users of the 7 maujas served by Budhi Kulo approached the Panchakanya users for access to irrigation. A proposal came from the users of these maujas in 1968 (2024 B.S.) to dig another canal intake at about 150 meters upstream of the today's intake of Panchakanya. This effort could not succeed because the users of then Panchakanya Kulo from Sisai and Bhojad mauja resisted the new canal construction due to their prior rights to water at the source.

During 1961-62 (2017 B.S.), construction of Khageri Irrigation System began with intake in Khageri River at *Tikauli* about 2 km downstream of the existing intake of Panchakanya. The aim of the scheme was to bring about 4000 ha of land under irrigation during monsoon in the western part of Chitwan District. The construction works were completed and the system became operational in 1968-69 (2024 B.S.).

Panchakanya Irrigation System continued to remain farmer managed system of Sisai and Bhojad villages until 1974. In 1974 the system was adopted under Chitwan Irrigation Development Project (CIDP) for rehabilitation and improvement. The construction works were started in March 1997 that included a gated concrete headwork at the source, construction of 5 km of earthen main canal, about 5.5 km of drainage works, 7 number of gated outlets for the branch canals (branch canals were not constructed in this phase of development), 8 number of gated outlets at several locations to distribute water from the main canal. The aim of this development was to bring 600 ha of land under irrigation. The construction works were completed in June 1979 with total investment of NRs. 36 Lakhs, however only about 200 ha could be irrigated during 1979 -1981 due to heavy seepage loss from the main canal and Jack of branch and tertiary level facilities for water distribution.

Second phase of construction works under Chitwan Irrigation Development Project (ClDP) for rehabilitation and improvement were taken-up under ClDP in 1982-83 with total

investment of 27 Lakhs that included boulder lining in the main canal, construction of branch canals and outlets and construction of an intake in *Ballar Khola* to augment dry season supply at *Panchanadi* headwork through approximately 450 m long underground Hume pipe waterway.7 With these improvements it was possible to expand the area under irrigation to about 400 ha. However, irrigation to this expanded area was possible only for few years. Since major parts of the main canal were constructed in filling, it began to collapse and the lining started getting damaged within few years after improvement. Beginning 1989-90 it became impossible to provide irrigation to even 100 ha of land during monsoon. The situation of Panchakanya continued to remain so until participatory process in irrigation management and rehabilitation and improvement of the essential structures was initiated in 1995 under Irrigation Management Transfer Project (IMTP). (Water management study program, IASS, 1999)

Before, IMTP program, due to deferred maintenance, the canal lining had broken at many places and heavy seepage used to occur and, because of dysfunctional gates, water control was not effective. The silting of the spring reduced the discharge in the source. Although the system was designed to irrigate 600 ha, it irrigated 267 ha only. (FAO, Indra Lal Kalu) Irrigation Management transfer Project (IMTP) was implemented in Panchakanya Irrigation System. Water user association was democratically formed in two tiers. A subproject management committee was also formed to represent the association for project implementation works such as signing the memorandum of agreement and the action plan, and decision-making on rehabilitation works. Various new technology and physical improvements had been introduced in the irrigation system; along with strengthening the institutional capacity of its user's which aided in efficiency of the system, as claimed by the IMTP. According to the FAO, the command area also increased to 447 ha after the IMTP implementation, which has been targeted to reach the initial 600 Ha command area in coming years. (FAO, Indra Lal Kalu)

Panchakanya irrigation System has been facing numerous environmental, institutional and climatic challenges. These challenges are impacting the users or farmers dependent on the system in many ways. Depending on the social and economic dynamics of the community and the households and their own assets and capital, every individual has different capacity to adapt with these impacts. In the PIS as well, different households, based on their ethnicity, caste, economic situation, landholding and access are differentially impacted by these changes. Apart from the household's intrinsic characters, the overall institutional governance

also impacts these vulnerabilities and adaptive capacities. Hence, it is very important to see these differential capacities and the governance of the system while looking at the adaptive capacity of the irrigation system.

1.1.4 Role of Good governance for institutional strengthening in the face of climate change

Governance is an emerging research field that strives to understand the role of institutional arrangements in adapting to climate change. The recent Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) emphasizes in its Summary for Policymakers that "governance structures and institutions to resolve conflicts" are needed to advance adaptation. More specifically, recent work on adaptation governance has highlighted the importance of institutions for the private provisioning of collective adaptation goods (Bisaro and Hinkel, 2016, p.354).

The origin of studying institutional governance comes from literature on common property and natural resource governance (Ostrom, 1990; Agrawal, 2008; Dressler et al, 2010, Gibson et al 1998) which presents robust arguments for institutions to be critical for enhancing the capacity of the communities, largely because of their role in resource allocation. Climate change literature suggests that institutions (both formal and informal institutions) are crucial element for adaptation (both anticipatory and reactive adaptation) to occur (e.g. Adger 2000, Smit and Pilifosova 2007, Agrawal 2008, Wildbanks and Kates 1999, Koch *et al* 2007). The literature on adaptation tends to use institutions in a number of different ways – to refer to policies, organizations, rules, governance and programs (Dovers and Hezri 2010). But in this research, institutions refer to rules and norms through which expectations about behavior are structured. The organizations here refer to specific manifestations of institutions in the civic, public, or private domains with persons and resources through which organizational goals are met.

The laws, rules, regulations, services and policies of institutions including the state, private and civil sectors and agencies from local to national to international level, all determine the livelihood strategy and ultimately the adaptive capacity of the people, particularly the poor (Dulal et al 2010). According to (Bisaro and Hinkel, 2016), collective adaptation can be thought of as one group of actors (providers) providing a collective adaptation good to either themselves or another group of actors (beneficiaries). Success of the adaptation initiatives at different levels will largely depend upon whether the intuitions are able to or they want to

make adjustment in their roles or their willingness to support the innovations (Tompkin et. al 2002). However, due to location specific nature of climate change, adaptation is argued to be inevitably local and therefore, local level institutions needs more attention in terms of research and study.

According to Agrawal and Perrin (2009), institutions influence livelihoods and adaptations of rural communities in three different ways. Institutions structure the distribution of climate risk impacts influences adaptation at the local level because local institutions with good governance can play an important role in reducing the ill effects and distribution of risks. Institutions constitute and organize the incentive structures for household and community level adaptations for their adaptation responses. As institutional incentives basically define the cost of collective action and the extent of transaction costs, it also helps to determine whether adaptation responses will be managed by individuals or managed collectively. Lastly, institutions mediate external interventions into local contexts which ultimately unfold the adaptation as they play a crucial role in the design and implementation of external adaptation related interventions such as providing knowledge, information and awareness; technical assistance; skills and financial support.

Similarly, Haanpaa and Peltonen (2007), through a macro level analysis of institutions, found a strong relation between institutions and adaptive capacity. The study highlighted the association of institutional vulnerability in different aspects of adaptive capacity to be: (i) formulating policies, legislations, strategies, and programmes; (ii) implementing policies, legislations, strategies, and programmes; (iii) engaging and building consensus among stakeholders; (iv) mobilizing information and knowledge; and (v) monitoring, evaluating and learning. There are similar examples in the developing countries which demonstrates the significance of institutions in driving climate change adaptation agenda.

While the literature on climate change adaptation has started to analyse the role of institutions at multiple levels in effective climate adaptation actions (see Agrawal 2008), there is an increasing need to understand how institutions, particularly the traditional and formal working on development and natural resource management sector, facilitate or constrain adaptation thereby determining vulnerability of individuals and community at local level. The governance issue, within the institutions, has emerged as a major challenge now in terms of effectively dealing with climate change risk and vulnerability at the community level.

Social factors such as ethnicity, gender and wealth often create inequitable institutions that included or exclude certain individuals or groups from certain practices (Bennett 2005). While, adaptation decisions are taken at household and institutional level, societal power relations (Agrawal 2010), governance and government policies guide the adaptation decisions (Adger 2003). The local institutions face the challenge of fair governance around the structure and composition of the institutions, decision making processes and outcomes, responsiveness to all voices of the society and accountability to the people (Adger and Vincent 2005).

Ostrom (2005) revealed that the actions and behaviours of individual in community settings are shaped by deeply embedded cultural and societal norms and rules. Some initial studies in Nepal has indicated the challenges of working with existing institutions for climate change adaptation. Regmi et al (2016) claimed that the exclusion of poor, women and disadvantaged groups in adaptation decision-making is influenced by the institutional environment such as social and cultural context of Nepal. In addition, cultural barriers such as higher caste, male and elite domination in the committees posed a difficult challenge in implementation of climate change adaptation projects and programmes in Nepal. Jones and Boyd (2011) also describe the institutional, cognitive and normative barriers to climate change adaption in a study in western Nepal. The institutional barriers presented include social and cultural rigidity which limits flexibility in actions.

1.2 Statement of Problem

In this regards, it is crucial to see how these FMISs have been coping with the changing climate and increasing uncertainties and its impacts at the time when more and more irrigations systems are drying up on one hand; while the population pressure in increasing in especially in the Terai region.

The governance of these institutions is also not strong, which in turn threatens the efficiency and sustainability of the system. The system has been facing various financial and institutional crises over the years after it has been handed over to the communities as FMIS. Additional to this, is the fact that government has been prioritizing shallow tube well and deep boring practices in the communities as the water from surface irrigation is not found to be sufficient. This has further led to decrease in the groundwater availability for ground water fed surface irrigation system on one hand while the option of deep boring is proving expensive for the farmers and causing them to move away from farming as livelihood option.

Hence, many people have started to leave their land fallow and shifted to other means of livelihood. This can also be linked with rapid urbanization especially in Chitwan's case where an increasing amount of land has been designated for "plotting". With the lands being fallow and climate change intensifying the cost and efforts for agriculture, the landless agricultural labourers are being more vulnerable.

There have been studies at the global and regional level on the climate change impacts on irrigations systems and consequent agricultural productivity. However, not much study has been done at local level as specific to a particular irrigation system, as to how it has been impacted by climate uncertainties and more importantly how the established farmer manged irrigation system, with its institutional setup is responding to the uncertainties. The context of impacts of increased boring practices in the sustainability of surface irrigations is a burning issue that needs more research on. Similarly, the increasing vulnerability of the landless daily wage agricultural labourers also needs to be studied at a local context.

1.3 Research Questions

Therefore, this study envisages soliciting information on the following pertinent questions:

1. How do the communities perceive climate change and its impacts in their communities and agriculture within the irrigation system?

2. How are the Water user's Association and communities adapting to these changes? Is the WUG successfully coping with these changes in terms of their investments and good governance for better adaptation?

3. What are the gendered vulnerability impacts on the landless female agricultural labourers within the sytem?

1.3 Objectives of the study

A major objective of the study is to understand the various factors that have resulted in the decreasing water availability for the Panchakanya Farmer Managed Irrigation System, and to establish clear attribution to the climate change phenomenon through both hydrological study and perception based study.

Another purpose of this research/study is to assist local and other stakeholders in their efforts towards transformative institutional innovations and increased capacity for adaptation to

climate change and other changes that they are facing. This research will generate evidences to support the argument that the success of reducing vulnerability and building adaptive capacity of communities depends on the inclusiveness and responsiveness of institutional structures and their internal governance.

The specific objectives are as follows:

1. To study the climate change perception within the Panchakanya Irrigation System

2. To identify and analyse the institutional structure and mechanisms with emphasis institutional structure, governance, interactions between various actors involved and the increasing gendered vulnerability

3. To assess how various local institutions and the action situation (provisioners and beneficiaries) manage (or fail to manage) the effects of climate change through coping or adaptive strategies within communities

1.5 Significance of the study

There has been various climatic and non-climatic changes in and around the system that has cumulatively decreased the water availability in the irrigation system and affected the agricultural production and cost of the command area. The research will study and document various perceptions behind the depletion of water in the system and its attribution to climate change.

This research will also fill an important gap in the knowledge base by gaining critical information about how different types of institutions are managing environment and climatic stresses at local level?, how inclusive and gender sensitive are the responses?, and how effective are the responses in terms of facilitating climate change adaptation at the local level?. This knowledge base can then be used to understand and improve institutional capacity for effective climate change adaptation and to inform more robust policy and adaptation strategies for implementing adaptation programs at local level.

The study will also document how these various climatic and non-climatic factors been increasing the vulnerability of the system especially of the poorest and most vulnerable communities, which in this case are the landless marginalized daily wage agricultural labourers, who depend on daily labours on other's agricultural lands. .

1.6 Limitation of the study

Following are the limitations of the study:

- The study limits itself to the Panchakanya Irrigation System command area.
- The study will look at the attributions of climate change impacts on the water availability of the system based on the user's perceptions. The study will rely on secondary climate data trend and analysis to validate the perception of the communities.
- The study will also look at emerging coping mechanisms within the system by the users and associate both to see if it has been impacting the system.

1.7 Organization of the study

This study will be divided into five chapters, namely, Chapter 1: Introduction, Chapter 2: Review of Literature, Chapter 3: Research Methodology, Chapter 4: Result and Discussion and Chapter 5: Summary & Conclusion.

CHAPTER II: LITERATURE REVIEW

The literature review has been conducted with focus on irrigation system and impacts of climate change. Various national policies have been reviewed to see if there are any linkages in the policy landscape between these two. Then, the impacts of climate change on the irrigation have been reviewed and the role of institution and governance for effective adaptation has been highlighted. In the end, proper assessment methodologies for institutional capacity assessment have been reviewed such that it will guide the methodology for the research study.

2.1 Policy Landscape – Irrigation and Water Sector Policies of Nepal

According to the Constitution of Nepal (2015), it has been stated that every individual shall have the right to live in a healthy and clean environment and has made policy provisions to make multi-purpose development of water resources including conservation, management and use of natural resources which states that the State shall pursue a policy of prioritizing national investment in water resources based on people's participation and making a multi-utility development of water resources. The constitutional policy provisions also envision developing a sustainable and dependable irrigation system by controlling water-related natural disasters with the management of the river systems (GON, 2015). All these provisions are most significant to address climate change impact at different level. However, conceptualizing the implementation might be challenges due to lack of clear mention and mandate of climate change.

The discussion on climate change issues and water sector has been very nascent in Nepal. Some of the documents such as Water Resources strategy Nepal (2002) do address many issues which as relevant to climate resilience but have not proactively done so.

Water Resource Act (1996) is also silent on climate change issues even though it mentions that economic development of Nepal lies in proper utilization of water resources. However, Himalayan Climate Change Study Centre can be identified as an explicit climate change activity within the National Water Plan. Since 2005, there have been a number of government-led and sponsored studies looking at the impacts of climate change on the water sector. The most comprehensive of these is the 2011 study 'Water Resources of Nepal in the Context of Climate Change', which assesses the relationships for different sectors, including natural disasters, hydro-power and agricultural irrigation.

Amongst the National Plans, the sixth national plan utilization of unlimited water resources is very crucial to attain the agricultural and industrial development plan. The recent approach paper of the 14th five year plan (2017-2019) emphasizes the providing irrigation for agriculture land for the entire year. It also emphasizes improve multi-water use system for improving irrigation system in the rural areas. However, the plan is not explicit on the issues of dealing with climate change as it does not have activities and budget to address the existing issues of climate change within the sector.

The Irrigation Rules (2000) provides detailed guidelines for the overall governance of the irrigation system including the user's committee constitution, structure and working principles and modalities. It mandates that all the irrigation committees should function as per their registered constitution.

According to Water Resources in Nepal in the context of Climate Change (2011), the Water and Energy Commission Secretariat (WECS) indicates that many schemes have not reached their planned level of productivity and are not sustainable, financially as well as technically (WECS, 2003). In its plan for the future, the government wants the increment in irrigated area by constructing new schemes. At the same time, it is concerned about the efficiency, coverage area, cropping intensity as well as the recovery of the operation and maintenance costs of the existing irrigation schemes. Two types of activities would continue side by side for irrigation development – firstly, the modernization of the already constructed irrigation schemes and secondly, the construction of new schemes to provide irrigation for more land. The focus now is on modernization and the objectives of these works are:

- increase the performance of the schemes by providing more efficient water delivery,
- reduce the operation and maintenance costs by addressing the sediment control and transport issues,
- organize the farmers and impart training for scheme operation and maintenance and farm water management,
- provide agriculture extension services to increase productivity; and
- transfer the management of the scheme to the farmers depending upon their capability. (WECS, 2011)

In the report, WECS has identified key needs in irrigation system in terms of climate change which are as follows:

− Reorientation of the supply driven approach,

− Poor performance of irrigation schemes,
− Lack of effective implementation of the Agricultural Perspective Plan (APP),
− Farmer's dependency syndromes and sustainability,
− Problems of river management,
− Weak institutional capability,
− Symbiotic relationship between agriculture and irrigation (weak linkages); and
− Strengthening of Water Users Associations (WUA). (WECS, 2011)

The Irrigation Policy 2014, envisions increase in agriculture production through year-round and reliable irrigation facility in all the agricultural land of the country. In the document, the government has proposed 20 policies that aim for the development and extension of irrigation services through integrated river and watershed management at national and district level. Similarly, the policy documents aims to prioritize poverty alleviation. Most of the policies in the document aim for the irrigation system and facilities while some also aim to involve public, private sector and communities in the irrigation sector. In the working policies (*karyaniti-4*), the policy talks about direct involvement of the users through association of water users. It also talks about the handover of land where the source of irrigation si to the WUA itself for conservation and how the district irrigation division will facilitate the process by reducing the land tax in such cases. The policy prioritizes gender equity and social inclusion and poverty alleviation along with appropriate research and technology development. The policy is very progressive and forward however, there has been no specific mention of farmer managed irrigation system. (Government of Nepal, 2014)

There are numerous sectoral policies for water resource management but they don't explicitly mention climate change and adaptation. Irrigation has always been prioritized as an important sector but the irrigation design and standards don't take into account the climate change scenarios and projections making it less flexible in changing future. Similarly, if we look at the conflict of interest between surface irrigation and ground water use, policy remains silent.

2.2 Climate Change and Water Variability

Climate-driven water variability is a natural phenomenon that is observed across river basins, but it has been predicted that it will increase due to climate change. Apart from this, there are various local changes such as land use pattern change and other environmental change of this kind may aggravate political tensions, especially in regions which are not equipped with an

appropriate institutional apparatus. Increased variability is also likely to challenge regions with existing institutional capacity. (S Dinar, 2015)

One of the most forceful links made between climate change and water variability came out of a 2008 Technical Report of the Intergovernmental Panel on Climate Change claiming that increased precipitation intensity and variability is projected to in- crease the risks of flooding and drought in many areas, affecting food stability as well as exacerbating many forms of water pollution (Bates, B., Kundzewicz, Z. W., Wu, S., & Palutikof, J., 2008)These hydrological changes will in turn increase the vulnerability of certain regions and communities and present substantial challenges to water infrastructure and services that are already weakening with climate change impacts. ((IPCC, 2007); (Kabat, 2002); (Vorosmarty)

When looking at various changes, two factors temperature and precipitation changes over the years are most discussed. However, amongst the two parameters, Shrestha argues that precipitation records do not show significant trends as such. (Shrestha et al. 2000) found a cyclic pattern in the precipitation record in Nepal without any long-term trend. Goswami showed that there is evidence that extreme precipitation events are increasing, for example in the central part of India (Goswami et al. 2006) and some indication of a similar change in parts of the HKH, but statistically robust trends have not been observed for the mountains. Immerzeel (2008) in his research has also analysed historic trends using global 100 year monthly high resolution data from 1900 to 2002, and concluded that the precipitation did not show any clear trend and was mainly determined by the monsoon.

Overall the projections of future precipitation suggest increase in precipitation in the future, particularly during monsoon. There is a high degree of uncertainty about future rainfall patterns, but interestingly, all climate scenarios are showing an increase in precipitation in the future. Climate change is likely to increase the number of extreme events in the future, which will add more risk to the institutions and systems that manage water resources.

While comprehensive analysis of changes in the extreme events in the past and possible changes in the future is lacking, several studies indicate that such events are already increasing. (David J. Molden, 2016)

Panchakanya Irrigation System is fed by springs, which evolve as surface water source and is irrigated, the same prediction may vary as there are other factors such as infiltration rate, and

changes in land use that affects the spring shed dynamics than just the precipitation quantity and pattern. However, it is important that some relations should be established to see if there are direct linkages between variability in precipitation and lack of water availability in the Panchakanya Irrigation System and similar systems.

2.3 Climate Change and Farmer Manged Irrigation System

Irrigation has a huge contribution to the overall food security in the HKH countries. In South Asia, about 39% of cropland is irrigated, and irrigated agriculture accounts for 60–80%of food production (World Bank, 2013). Direct contribution of groundwater to irrigation has been increasing steadily and has now overtaken that of surface water in some countries. At present, groundwater contributes 79% of irrigation water in Bangladesh, 63% in India, 19% in Nepal, and 21% in Pakistan (FAO, 2012), and in general, irrigation in large parts of South Asia and the North China Plains is now almost exclusively dependent on groundwater (Shah, Singh, & Mukherji, 2006).

Irrigation, which has been considered as one of the possible adaptation strategies to climate change and variability, by Vaidya et al, as it can address uncertainty associated with the natural precipitation regime in places that rely on rain to irrigate crops. Irrigated agriculture may be faced with a double hit, however, since not only will agriculture require more moisture in a dryer climate, but there will also be less water available. Increased temperature and decreased humidity elevates the soil moisture deficit and hence dramatically raises the irrigation water demand. It is therefore likely that warmer and drier conditions will enlarge irrigation demand in agriculture. (RA Vaidya, 2014)

Climatic change and variability have contributed to delays in the onset of monsoon and winter rainfall, which means more intense and unpredictable precipitation causing flash floods and drought (James D. Miller, 2012). Higher evapotranspiration and temperature causes shifts in irrigation- water demand and crop choice (Elliotta J, 2014). This when combined with the technicalities of irrigation design system, makes it difficult for the managers of the system to understand and make adaptive changes. This is even more difficult especially in the case of farmer managed irrigation systems (FMISs) that are manged by farmers, as they are unaware of the technical issues of irrigation system, design and efficiency; and also lack capacity to understand and respond to changing climatic context.

It is very important to understand the extent of impacts these irrigation systems have been facing due to climate variability and if the local management group or committee have been able to assess and prepare for the impacts.

2.4 Institutions and Climate Change adaptation

The likelihood of deleterious impacts, as well as the cost and difficulty of adaptation, are expected to increase with magnitude and speed of the global climate change (Stern, 2006). Hence, effective mitigation of climate change (IPCC, 2007c) is necessary to reduce the adverse impacts of climate change on water resources. However, we are already committed (Wigley, 2005) to further warming and corresponding water-related impacts. It is therefore necessary to adapt to changes in the volume, timing and quality of water. Climate change will affect current water management practices and the operation of existing water infrastructures, which are very likely to be inadequate to overcome the negative impacts of climate change on water supply reliability.

Traditionally, it has been conveniently assumed that the natural water resource base is constant, and hydrological design rules have been based on the assumption of stationary hydrology, tantamount to the principle that the past is the key to the future. Now, the validity of this principle is limited (Kundzewicz et al., 2007). Therefore, the current procedures for designing water-related infrastructure must be revised. Otherwise, systems will be wrongly conceived, under- or over- designed, resulting in either inadequate performance or excessive costs. For example, water quality systems may need to be re-designed to cope with less self-purification in warmer water with lower oxygen concentration, and increased turbidity may increase significantly the costs and challenges of treating water to potable standards (Miller & Yates, 2006). Necessary adaptation to climate change in the water sector goes beyond structural measures. It also includes forecasting/warning systems, insurance instruments and a plethora of means to improve efficiency of water use (e.g. via demand management) and related behavioural change, economic and fiscal instruments, legislation, institutional change, etc. (Z. W. Kundewicz, 2008)

Climate change has introduced large uncertainties into the estimation of future water resources, including flood risks. Uncertainty has two implications for adaptation practices. First, adaptation procedures need to be developed which do not rely on precise projections of changes in river discharge, groundwater, etc. Second, based on the studies done so far, it is difficult to assess water-related consequences of climate policies and emission pathways with

high credibility and accuracy. It is also widely recognized that improved incorporation of current climate variability into water-related management would make adaptation to future climate change easier. Water managers in some countries and regions are already considering explicitly how to incorporate the potential effects of climate change into policies and specific design guidelines.

Kudewicz further argues that an increasing involvement of water managers in adaptation in a number of countries is crucial. His assessment also drew three broader conclusions. First, the impacts of climate change, and the most effective ways of adapting to change, depend very much on local hydrological, economic, social and political conditions, and it is difficult to extrapolate results or conclusions from one catchment to another. Second, climate change is superimposed onto other pressures on water resources. Third, little can currently be said about the implications of climate change for the availability of safe water for the most vulnerable—the rural and urban poor in developing countries. (Z. W. Kundewicz, 2008)

Now, given the fact that institutions have a stronger role in climate change adaptation, to understand social structure or governance regime it is important to understand institutional structure. Institutions are core structural determinants of governance. Institutions are best understood as the "rules of the game" (North, 1990) which shape human behavior in economic, social and political life (IPPG, 2012). Most of the definitions of institution tend to highlight three critical inter-related components of institutions: a) Governance process (rules and rule making process); b) Actors (or participants) (and their interaction), and c) Outcomes.

Both institutions and organisations may be formal or informal. Formal institutions come in the form of laws, policies, regulations, guidelines, bureaucracies, codes and standards, etc., while informal institutions exist as customs, traditions, beliefs, values and cultural practices, etc. Informal institutions are the unofficial arrangements in societies or organisations (Obeng et al., 2013). They can be described as the unwritten rules that govern behaviour (Helmke and Levitsky 2004). Organisations, in general, are groups of individuals engaged in purposive activity (North 1990; Saleth 2006). Formal organisations are those with some form of officially recognised authority. On the other hand, informal organisations constitute the enforcement characteristics of informal institutions (Obeng et al., 2013). For the purpose of this research, the term institution includes rules and arrangement that govern behavior among and within organization and those are potential in supporting local communities for climate change adaptation.

The role of institutions in society is understood by theories derived from individual and social constructivist perceptions of value formation, behaviour and choice (Vatn, 2005, 2009). The individualist theory is based on neoclassical (or market-oriented, capitalist) economics (Goodland & Ledec, 1987) and assumes that the individual is autonomous and that choices and preferences are matters of individual interests (Goodland & Ledec, 1987; Romp, 1997). Assuming that individuals are autonomous, this theory believes rationality seeks to maximize individual utility (Vatn, 2010).

In contrast to individualist theory, the classical understanding of institutions is based on social construction theory which sees the individuals as socially created where choices reflecting the norms, values and expectations of being a part of institutions in society (Vatn, 2009). Definitions of institutions emphasize the process of social construction (Scott, 1995; Veblen, 1919). Social construction believes that individuals can't act rationally without institutional supports (Etzioni, 1988). When environmental goods and services are considered common resources, an institutional settings based on social rationality is an appropriate approach to manage and evaluate those resources (Ostrom, 1990; Vatn, 2009). Environmental and resource regimes are types of common institutions that can regulate actions against environmental degradation either through restriction on over exploitation of resources or reducing unintended side effects (Young, 2010).

Institutions, particularly, local institutions play an important role in climate change adaptation. The scholars argue that understanding the role of institutions is crucial to address global climate change as well as respond to these changes (O'Riordan and Jordan 1999). The adaptation literature is increasingly focusing on institutions as a means to deal with the uncertainties of climate change (see for example Adger 2000; Agarwal 2008, 2010). It is argued that failure of an institution to plan for changing environmental condition results in increased vulnerability and decreased adaptive capacity (Adger and Vincent, 2005). Institutions are important factor in climate adaptation because a) they control human-environment interaction; b) they change with the changing environment; and c) they mediate social responses to environmental change (Bakker and Downing 1999).

With increasing focus on local and rural institution on climate change adaptation, the institutional governance is of interest for both policy makers and practitioners in HKH. One of the most important factors shaping the adaptive capacity of individuals, households and communities is their access to and control over livelihood assets, access to basic services and

social networks, and stake in the institutional mechanisms which provide more livelihoods options (Adger et al. 2004).The inclusiveness within institutions becomes more important in terms of climate change adaptation at the local level as the poor and vulnerable household and groups can benefit from external support (Gupta et al 2010).

While, adaptation decisions are taken at household and institutional level, societal power relations (Agrawal 2010), governance and government policies guide the adaptation decisions (Adger 2003). Community-based adaptation has used local institutions and organizations to improve the adaptive capacity of vulnerable households and communities. Although community based institutions have been instrumental in mobilizing local communities (Ayers 2011; Ayers and Forsyth 2009), local institutions face the challenge of fair governance around the structure and composition of the institutions, decision making processes and outcomes, responsiveness to all voices of the society and accountability to the people (Adger and Vincent 2005).

A number of studies in Nepal have found that in community forestry institutions, elite domination is prevalent (Dahal and Chapagain 2012; Kanel and Kandel 2004; Ojha et al. 2009). Mansuri and Rao (2004) also argue that although adopting a decentralised targeting mechanism in community-based development initiatives can improve outcomes, it does not automatically solve the problem due to deep-rooted inequality in local institutional systems and culture. This raises the question of whether it is appropriate to use only existing institutions such as community-based groups as a vehicle to implement adaptation interventions, contrary to earlier findings (Agrawal 2010; Andersson and Agrawal 2011) that local institutions are significant in driving local adaptation and development agendas.

Local institutions have shaped how rural residents responded to environmental challenges in the past. They are also the mechanisms that will translate the impact of future external interventions to facilitate adaptation to climate change. Because adaptation to climate change is local, it is critically important to understand the role of local institutions in shaping adaptation and improving capacities of the most vulnerable social groups. There is still a lack of knowledge and evidences on whether or not the traditional and local institutions, under the current form of governance are appropriate to address vulnerability and adaptation at the local level.

The existing literature thus pointed out the need to develop deeper insights into how we can understand and improve institutional capacity to facilitate effective adaptation strategies at

the local level and across the river basins. There is a need for a good research that develops both methodological framework as well as evidences to improve the institutional governance for climate change adaptation in the Hindu Kush Himalayan region.

2.5 Adaptation, Vulnerability, Resilience and Adaptive Capacity

According to Smith and Lenhart (1996), adaptation is a process, action, or outcome that includes all adjustments in behaviour or economic structure that reduce the vulnerability of households and communities to changes in the climate system. Adger et al (2005, p.78) argue that adaptation involves building adaptive capacity, deeper transformation and resilience thereby increasing the ability of individuals, groups, and orgranisations to adapt to changes, and implementing decisions, i.e. transforming the capacity into action.

The concept of adaptation referred to measures that would provide technological choices to communities to respond to major climate-induced disasters. The UNFCCC definition of adaptation, for example in article 4.1(b) of the Convention, also mentions the implementation of adaptation measures through formulating and implementing national and, where appropriate, regional programmes containing measures to facilitate adequate adaptation to climate change. This technology- driven definition and scope also gave rise to techno-fix solutions to climate change (Ayers, 2011).

Climate change adaptation requires an appreciation of social relations and practices, and suggests that it is not sufficient to control climate change through technological solutions. Smit and Wandel (2006, p.282) defines the social dimensions of adaptation as ‘a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity’. According to Smith and Lenhart (1996), adaptation includes ‘all adjustments in behaviour or economic structure that reduce the vulnerability of society to changes in the climate system’.

Vulnerability refers to the susceptibility of a social or economic system to disruption, and flexibility refers to the degree of manoeuvre-ability which exists within systems or activities’ (Smithers and Smit 2009, p.24). Smithers and Smit (2009) refer to the issue of system scale in understanding human adaptation to environmental change. This social understanding of

climate change is significant for further understanding how individuals and the community adapt to the changing climate and deal with the impacts.

Adaptive action is defined by autonomous (passive, automatic, and spontaneous) and planned (active, structured, and strategic) action. Smit et al (2000, p.240) state, 'based on intent or purposefulness with respect to a climate stimulus, autonomous or spontaneous adaptations can be distinguished from consciously planned or deliberate international adaptive response to a stimulus (actual or anticipated). Adaptations in unmanaged natural systems are considered to be autonomous. Those initiated by public agencies are usually conscious but those by private individuals or communities may be autonomous or planned, or combustion of the two especially when adaptations are considered at different spatial or temporal scale'.

Adaptive responses are also characterised in terms of time as they can be either short-term or long-term in nature. Adaptive actions can take different forms, ranging from the technological, behavioural, and financial, through to the institutional, and informational. Smit et al (1999), Smit and Wandel (2006), Burton et al (2007), and Pelling (2011) state that adaptation happens at the individual household, the community, and at the regional, national, and international levels, and in diverse systems ranging from the social to the natural. This discussion signifies the importance of considering both autonomous and planned adaptation responses in the design of CCA-related policies and plans.

Adaptation can also involve a wide range of institutions and actors. Adger et al (2005, p.79) argue that adaptation to climate change involves various decisions across a landscape made by actors ranging from individuals, firms, and civil society, through to public bodies, and international agencies. In addition, Burton et al (2007) points out that, for an action to be a purposeful adaptation, the action should reduce sensitivity and exposure to climate change, and increase the resilience of a system. Mertz et al (2009, p.750) add that the uncertainty of climate change demands robust, innovative, flexible, and institutional policies and approaches, good governance, and inclusive structures that can help the poor and vulnerable in the developing world to better adapt.

There can be various types of adaptation that relates and reflects in various perspectives. Amongst these, one of the perspective deals with vulnerability.

The concept of vulnerability to climate change has originated in the risk, hazards, and disaster field. An understanding of the issues in risk and impact approaches gave rise to the idea of

vulnerability and the adaptive capacity perspective. This approach has gained wide attention in global environmental studies, and recently in studies of climate change, because vulnerability assumes that there are other social, political, and economic factors that determine how hazards affect people (Schipper 2004, p.97). The IPCC defines vulnerability as 'the extent to which climate change may damage or harm a system; it depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions' (IPCC 2007, p.72). Blaikie (1994, p.9) defines vulnerability as 'the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural hazard'. The common element in all definitions is that vulnerability has a socio-centric perspective (Schoon, 2005). Vulnerability reduction is also an attempt to link coping with the capacity of a system to handle stress or perturbations.

There are both biophysical as well as social dimensions to vulnerability. Wilby and Dessai (2010, p.181) argue that climate vulnerability is determined by a host of factors including wealth, social equality, access, and technology. Watson et al (1997), as cited by Ayers (2011), define vulnerability as a function of the extent to which a system is exposed to a hazard. Brooks (2003) explains that social vulnerability is determined by factors such as poverty, access to insurance, marginalisation, and housing quality. Kelly and Adger (2000, p.347) define social vulnerability as the capacity of individuals and social groupings to respond to, cope with, recover from, or adapt to any external stress placed on their use of resources. According to these authors, the extent to which individuals, groups, or communities are capable of making use of resources determines the ability of that particular population to cope with, or adapt to, stress.

Many authors conclude that poverty is a salient indicator of climate-related vulnerability (Huq et al., 2003; Ayers, 2011). According to Mertz et al (2009, p.747), the ability of people to control the variables that determine vulnerability might be translated into their capacity to adapt. This implies that if people have more livelihood options and resources, their adaptive capacity will be higher because they can easily respond to the impacts of climate change. Ayers (2011) believes that the greater the adaptive capacity, the less vulnerable people will be to climate change risk, and the easier they will be able to respond. Smit and Wandal (2006) argue that vulnerability reduction appears to be most effective if undertaken in combination with other development strategies and plans at various levels. For example, a combination of vulnerability reduction and poverty reduction will address both climate change and development (Oxfam 2010, p.14). This discussion implies that a vulnerability

reduction perspective brings climate change and development issues together because both look on the issues of poor and marginalised communities, and argues that the mainstreaming of CCA into development practice is important.

Despite a number of challenges, Cannon and Mahn (2010, p.623) argue that 'vulnerability is a more valid concept than risk and impact based approach since its social construction is valid under existing and new conditions, and is rooted in economic and political processes that can be analysed alongside those of climate and ecosystem'. This could be impressive if combined with other approaches and strategies, such as resilience approach. Smit and Wandal (2006) also suggest that vulnerability reduction appears to be most effective when undertaken in combination with other strategies and plans at various levels.

Resilience, on the other hand, is defined as the capacity of a system to absorb disturbances and to reorganise while undergoing change, so as to still retain essentially the same function, structure, identity, and feedback (Walker et al., 2004). Although the resilience terminology originated from ecology, it is now widely used to inform a social resilience perspective. Adger (2000, p.347) defines resilience as 'the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change'. This is significant because it assists with an understanding of response measures required at different levels in order to address the impacts of climate change and support community-based adaptation.

The capacity to adapt is a critical element in the process of adaptation. In case of uncertainty, adaptive capacity is a critical system property, for it describes the ability to mobilise scarce resources to anticipate or respond to perceived or current stresses (Engle, 2011, p 646). Building adaptive capacity is considered an important component of community-based adaptation because it has a strong local dimension with practical innovations that improve societal adaptive capacity to respond to the impacts of climate change (McEvoy et al., 2010, p.781). There are various academic definitions on adaptive capacity. The IPCC defines adaptive capacity as an 'ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages to take advantage of opportunities, or to cope with the consequences' (IPCC 2001, p.72).

A growing body of literature focuses on identifying specific social and economic conditions which influence the capacity of an individual or community to adapt. Adger and Vincent (2005, p. 400) argue that the capacity of societies to adapt to climate risk is based on their

level of socio-economic development. It is also dependent on their experience and knowledge. Lemos et al (2007, p. 24) mention that there is consensus among many scholars that adaptive capacity can be created by investing on information and knowledge, encouraging appropriate institutions that permits evolutionary change, and increasing level or resources such as income and education. The literature reveals that a critical element of building adaptive capacity should focus on empowering with vulnerable households and communities by increasing access to information, knowledge and technology.

The effectiveness of adaptive capacity, however, is governed by the successes of interventions and process targeted to improve the capacity of the system. Vincent (2007, p. 13) further argues that the challenge for emerging insights into adaptation lies on how to identify generic determinants of adaptive capacity at various scales. Grasso (2010, p. 22) explains that adaptive capacity is determined by social and political dimensions of a society or culture. Smit and Wandal (2006) further explain that the ability to build adaptive capacity at local level is influenced by factors such as access to resources, technology, information, infrastructure and institutional environment. There are some challenges in terms of practice. Pelling and High (2005) suggest that tendency or centralized and top down planning and decision making are in danger with restricting incentives for experimentation, reducing flexibility and capacity to adapt under uncertainty of climate change. The challenges highlighted here outline the need to find out innovation and learning by doing approach for driving community-based adaptation forward. (Regmi, 2014)

2.6 Institutional Analysis and Development (IAD) framework for institutional assessment

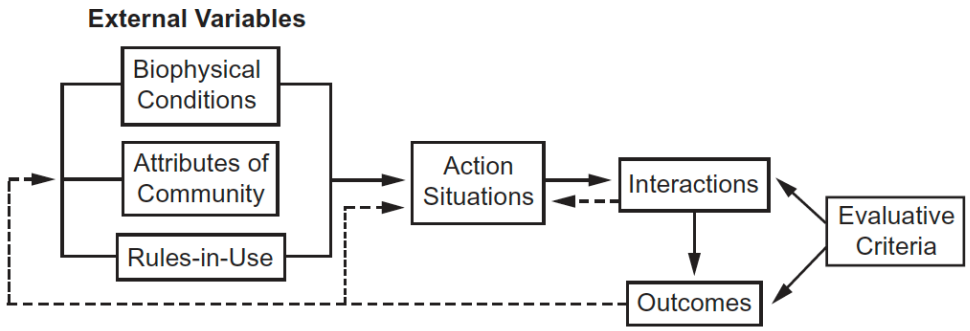
There are various mechanisms and framework proposed for institutional assessment. Ostrom (2011) suggest that IAD framework is useful in situation under which the actors act resulting in interaction and outcomes as well as in evaluating the outcomes. Keiser and Ostrom (2000) argue that in the theories explaining individual behaviour within an institutional setting have five components: a) the decision maker; b) communities affected by decisions made; c) events or goods and services that interacting individuals seek to produce or consume; d) institutional arrangement guiding individual decisions; e) decision situation in which individual make choice.

The IAD framework (Ostrom et al., 1994) talks about the external variables referred to as biophysical environment (climate change risk and impact), community attributes, and

institutions or rule. The framework further describes a conceptual unit called the 'action situation', which can be used to understand the behaviour of an institutional arrangement and the interaction leading to desirable outcome. The 'action situation' can be described through a set of following variables: a) Set of actors; b) Specific position to be filled; c) Allowable actions; d) Potential outcomes; e) Level of control each participant have over choice; f) Information available to participant about the action situation; g) and the cost and benefit of actions.

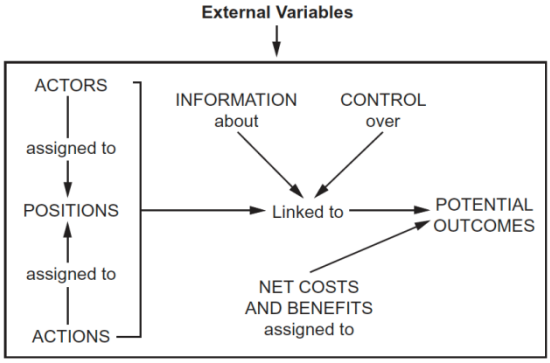
The IAD framework also gives four key parameters to map the 'rules of the game' Four key elements are: (1) actor's preferences regarding certain actions and outcomes, (2) the way actors acquire, process, and use information, (3) the decision criteria actors use regarding a particular course of action, and (4) the resources that an actor brings to a situation. According to Bisaro and Hinkel (2016), the action situation encompasses of as one group of actors (providers) providing a collective adaptation good to either themselves or another group of actors (beneficiaries).The IAD framework and the internal structure of action situation within the IAD framework are shown in figures below:

Figure 2 : Framework for Institutional Analysis.



Source: Ostrom (2011, p.10)

Figure 3 : Internal structure of Action situation.



Source: Ostrom (2011, p.10)

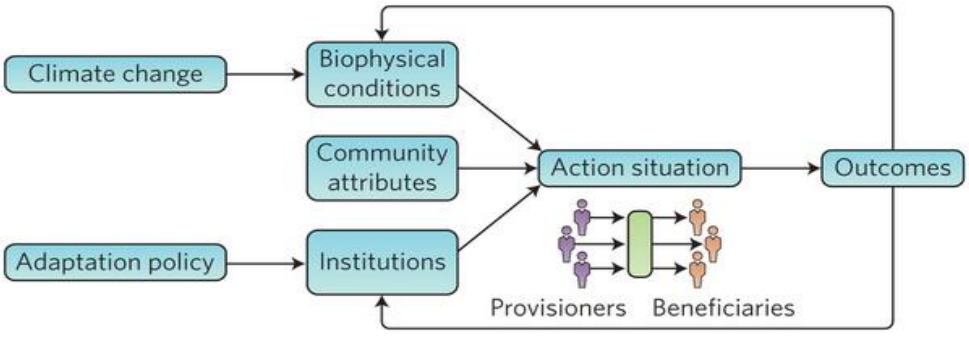
Since institutions are created, changed (or destroyed) by people, it is necessary to focus on different actors in order to understand institutions (Ostrom 2011, Bakker and Downing 1999). Therefore, to get the information we need to talk to people who are the actors governed by institutions. Accordingly, this research employs 'actor-oriented approach'. The aim here is to understand by the interests, characteristics and actions of different types of actors in a given context. The underlying assumption is that institutions are socially constructed within the daily life of various actors and reality can only be understood by visiting and interacting with their life worlds (Long and Long 1992).

CHAPTER III: METHODS AND MATERIALS

From the literature review, it is clear that there are extensive impacts of climate change on irrigation system and onto the communities' dependent on the irrigation system. Climate change affects the functioning of institution in different ways. The biophysical impact will pose challenges to institutional functioning. There are various levels of impacts on institution. According to Ostrom et al (1994), the 'rules of the game' contain tour key elements which are: (1) actor's preferences regarding certain actions and outcomes, (2) the way actors acquire, process, and use information, (3) the decision criteria actors use regarding a particular course of action, and (4) the resources that an actor brings to a situation. According to Bisaro and Hinkel (2016), the action situation encompasses of as one group of actors (providers) providing a collective adaptation good to either themselves or another group of actors (beneficiaries).

The Institutional Analysis and Development (IAD) framework, as proposed in figure 4, is relevant as an analytical tool to understand existing statutory and customary institutional mechanisms and their strengths and weaknesses leading to vulnerability and adaptation in Gandaki river basin. In other words, this framework will be used to determine the adaptation practices of institutions including actors, processes, resources, outcomes, policies and political discourses that affect inclusive adaptation outcome delivery by local institutions.

Figure 4: The Institutional Analysis and Development (IAD) framework adjusted for adaptation governance analysis.



The action situation includes providers and beneficiaries of a collective adaptation good, whose interdependence is characterized by three sets of variables (biophysical conditions, community attributes and institutions). Climate change affects the situation through its impact on biophysical conditions and adaptation policy through its effects on institutions (Adapted from Bisaro and Hinkel, 2016, p.355).

According to the nature of this research, mixed method will be used as it is the most appropriate research method for this study. This method provides an opportunity to view different facet of a phenomenon thus providing rich information to understand the phenomenon better (Clark and Creswell 2008).The research will use literature review, questionnaire survey (quantitative method), interviews and focus group discussion (qualitative methods) and key informant interview for collecting data and answering the research question.

Case study is being widely used in studies relating to institutional analysis. Case study is an established research method to understand complex social phenomenon in social science (Yin, 2009). Feagin et. al. (1991) argues that case study is a useful strategy in understanding larger social complexes of actors, actions and motives in their natural settings. Case study is relevant for this study in order to explore interrelationship between actors, institutions and external forces affecting the institutions, actors and the decision- making process that either impede or encourage the adaptive capacity of the local communities.

The case study will look into the Panchakanya Farmer Managed Irrigation system that is run by user led Panchakanya Water User Committee (WUC). A mixed method approach will be applied for data gathering, which will improve robustness of data and facilitate data triangulation. The biophysical attributes of the climate change will be analysed by secondary sources which will be used to validate the perceptions collected through household survey questionnaires. Further for the community attributes and institutional attributes, semi-structures interviews; questionnaire survey; focus group discussions; and collection of secondary data and policy documents and analysis will be done. The following section discusses the major methods in detail.

3.1 Climate Trend Analysis Review and Perception mapping

Secondary review of the thirty years of precipitation and temperature will be reviewed for trend of changing climate in the region. For this literature review will be done and best available climate data (minimum, maximum temperature and precipitation) of thirty years will be referred. The perception of community/users on climate change will be validated with the climate trends reviewed. The information collected from the group discussions will also be validated to give a robust trend scenario for the Panchakanya irrigation system.

3.2 Field work

3.2.1 Key informant interview: In order to get the information needed, key informant interview will be conducted. Key informant interview is one of the most common interviewing techniques in qualitative methods. Key interviews will be conducted at national, district and local level. The interview will cover topics including information about the role of organisation/ group (institutional setting) and role of the respondent, factors affecting their role, policies and political discourse shaping their work, resources available for performing their activities, networking with others, climate change issue within institution and involvement in adaptation, their scope of work, outcome of their work, level of engagement with community in order to elicit issues of inclusiveness and targeted interventions.

3.2.2 HH Questionnaire Survey: Information required for this research needs to be collected from actors that are governed by the formal and informal institutions. Among many, one of the most important actors includes those who will be directly or indirectly affected by the rules. Questionnaire survey will be carried out at the household and community level in order to understand how different local institutions existing in the study locations are either impeding or enhancing their ability to adapt in a changing climatic condition. The outcome of household survey will help in carrying out comparative analysis of the governance context i.e. paradigms, institutions, actor networks and practices of any issue enabling and/or constraining coping and/or adaptive strategies undertaken by women and men within households across river basin.

The study will be using questionnaire that will include questions including socio-economic attributes, perception and knowledge about climate change and impacts, their capacity to adapt to current and future climate variability as well as past experiences, past and present decision making procedure, their involvement in decision making procedure. The Questionnaire survey will also be a means to answer the issues of inclusiveness and will be carried out within the community in each study locations.

3.2.3 Focus group discussion: Many focus group discussions will be conducted during the study for the purpose of specifically understanding the climate risk and impact and identifying strength and weakness of existing statutory and customary institutional mechanisms leading to vulnerability and adaptation in the Panchakanya Farmer managed Irrigation System. The focus group discussion/s will be conducted with community members from stratified groups including ethnicity, gender and wealth; staff members from local

institutions covering aspects of the strength and weaknesses of a) types of institutions (formal, informal); b) Governance process (rules and rule making process); C) Actors (or participants) and their interaction (their interest, power, position and legitimacy), and c) Outcomes.

Focus group discussion will also be used to understand climate change risk and vulnerability at the local level. The participatory vulnerability assessment (such as risk matrix, seasonal calendar, impact matrix) will be used in this research: (i) in understanding the implications of climate change on people's livelihoods; (ii) examining both hazards and conditions of poverty and for analysing the interactions between them; (iii) promoting multi-stakeholder analysis; and (iv) understanding the role of institutions and policies in adaptation. Household survey will complement the data generated from focus group discussion to understand more in detailed on household level vulnerability. Similarly, another focus group discussion will be organized with the most vulnerable communities' dependant within the system to understand particular impacts.

Some of the tools proposed during FGD for assessment

- Stakeholder analysis. This tool is a Social Analysis System tool which is often called Power, Interest and Legitimacy (PIL): It helps in analysing the power, interest and legitimacy of stakeholders and actors with regards to climate change adaptation in order to determine the collaboration and conflict among various actors and organizations.

- Force Field Method: Force-field analysis is an influential development in social science. It provides a framework for looking at the factors (*forces*) that influence a situation. It looks at forces that are either driving movement toward a goal (helping forces) or blocking movement toward a goal (hindering forces). The principle was developed by Kurt Lewin. (Wikipedia, 2016). For this research, the participants will be asked to list the major problems and asked to list the potential solutions they think are happening within the institution. They are asked to put in a XY axis, such that "1" indicates the least effective and "5" being the most effective. As the participants plot the problems and the solutions, in the graph, the gap between the problems and solution/measures represents the adaptation gap.

- Trust Mistrust Exercise: In this exercise, the participants are divided into two groups say A and B and then asked to list down the main problems group wise. Then they have to prioritize it secretly in their own groups. The two priorities from the two groups are subtracted. Then

each group is asked to prioritise the identified issues on the basis of next group's perception. This perception will be more of guesswork. After that, various tools are used to calculate the trust of A over B and B over A. It helps the two groups to understand and consider the difference in perception and priorities while planning adaptation options.

- Historical timeline: During this exercise, the participants are asked to note down important years and dates in the institutions across a year grid. The dates and important events are noted. It can give detailed insights into an institution's history as well as important developments and crucial happenings. This tool can also reflect the critical moments and extreme events.

- Grain exercise: In this exercise, few key indicators of good governance are written down on a chart paper and participants are given certain grains for the exercise. The participants are then asked to put the grains to the indicators they think happens within the institution. They may put more number of grains for the indicators that they believe are stronger in the institutions and less number of grains for the indicators they believe are weaker or not present altogether. For eg: They can put 4 grains to the indicator they find highly satisfactory while only 1 grain for the indicator they find unsatisfactory. The participants can be divided into groups to see the different perceptions on the indicators during the exercise.

- Problem identification and prioritization: Here, two different groups or gender are asked to list down main problems for them and prioritize them. Later the prioritized problems are compared with each other to find the commonalities and differences in perceptions and needs.

3.4 Sample size

A total of 7 key informants will be interviewed. The informants will be purposively selected based on their experiences, age, role in the institution and contribution to the field of climate change adaptation. The research participants will be selected from each well-being group representing 33% of total households from each group (Table 1). The respondents for HH survey will be based on their gender, ethnicity, socioeconomic condition, proximity within the irrigation system (headend / tail end users) and landholding size. The research participants will be randomly selected from each group using a stratified random sampling and lottery method.

The criteria for stratification include representing village settlements, diverse ethnic groups and wealth being categories.

Table 1 Sample size selection for field work

Institutions	**Municipality/ District**	**Key informant interview (number)**	**Household survey**	**Focus Group discussion (Number)**
Panchakanya Farmer managed Irrigation System, Ratnanagar, Chitwan	Ratnanagar, Chitwan	7	33%	7

3.5 Data entry, analysis, interpretation and communicating data

The qualitative data will be analysed using descriptive statistics and qualitative data will be analysed through content analysis. Result from both the methods will be combined and data will be communicated by using tables and graphs where necessary. The relevant software for data analysis will be used. For example, Excel and SPSS, will be for used data coding and entering.

CHAPTER IV: RESULTS AND DISCUSSION/ DATA PRESENTATION AND ANALYSIS

4.1 Socioeconomic characteristics of the sample population for HH questionnaire survey

35 Households within the command area of Panchakanya Farmer managed irrigation System were interviewed for the study. Of the 35 interviews, majority (57.1%) respondents were from Mohana area, while 25.71% respondents were from Debauli area. The remaining respondents were from Maubale Tole (11.42%) and Krishna mandir area (5.7%). 48.57% of the respondents were female while majority of the respondents (51.42%) were male.

Majority of the respondents in the area did not know how to write (34.28%) while around 25.71% were literate. 14.28% of the respondents had studied up to 5th standard and equal number of respondents had completed SLC while only one respondent (2.8%) had completed 12th standard education.

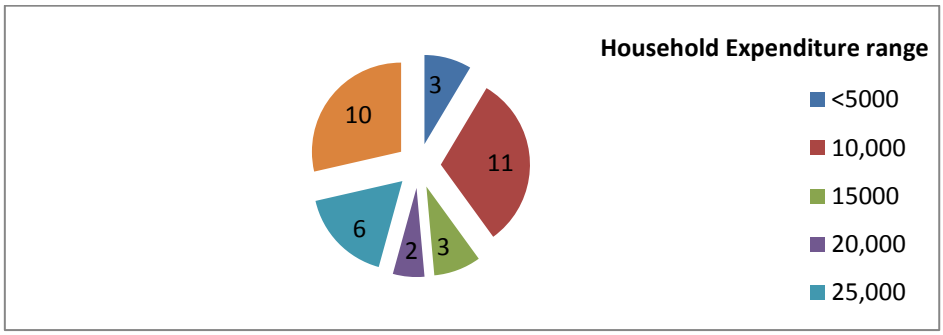
Regarding the ethnicity, majority of the respondents belonged to the Brahmin/ Chettri (51.42%) while 40% were Tharus along with one Damai (Dalit) respondent and two newar respondents. All the respondents were Hindus.

When asked about the income source, 77.14% responded that agriculture was their primary source of income while 14.28% depended on service as their primary income. 8.57% responded that remittance was their primary source of income. Many of the famers also depended on remittance, local business and service as their secondary source of income. However, for the people who did not consider agriculture as their primary occupation, listed agriculture as secondary source of income. Hence, all of the respondents were farmers and were dependent on the irrigation system in one way or the other but agriculture is not the sole primary occupation and there are other sources of income as well.

When asked if any of the family members had been abroad , 40% of the respondents said yes and shared that they mainly migrated either for education purpose (to America, Australia, Gulf countries) or for labour work in Gulf countries.

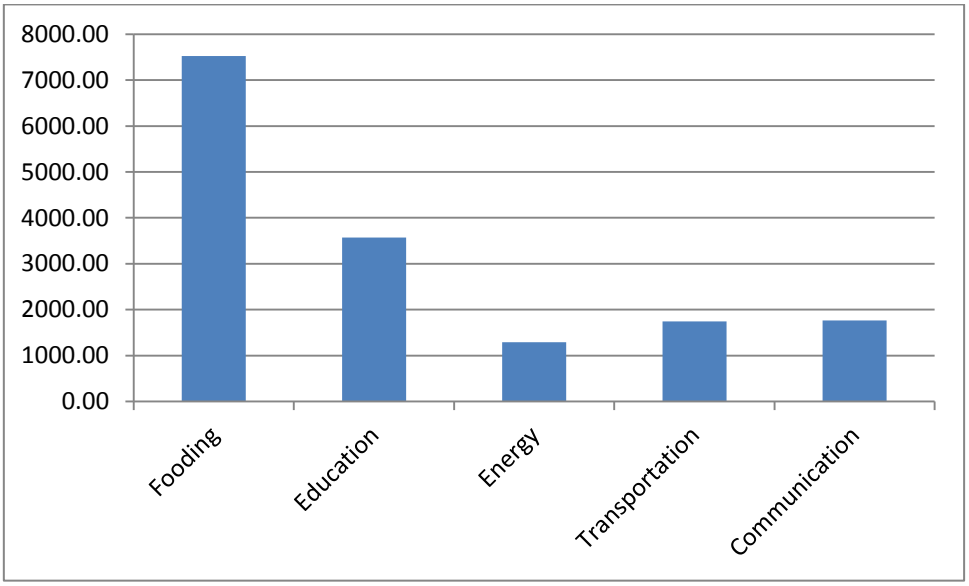
As per the interviews, 31% shared that they spend less than 10000 NRs per month, while 28.57% spent more than 25000NRs per month. 8.57% of the respondents spent less than Rs 5000 per month. When the respondents categorized their household expenses,

Figure 5: Household expenditure range of sample population



If average of the total expenses in all major expenses categories is taken, the expenses can be subcategorized per HH as below. In addition to this, some HH respondents also shared that there has been increase in energy expenses as they have to hire the diesel pumps and or electric pumps for irrigation in their fields. They have not considered it as a HH expenditure as of yet.

Figure 6: Major areas of expenditure and expenditure amounts (in average)



When asked about house ownership, all of the respondents have their own house, where 8.5% is owned by female, 2.8 % (1 individual) had the house in joint ownership and hence, majority of the house were owned by the male members of the household. Around 75% of the households responded that their agricultural land is irrigated while around 25% of the household also possessed land that was not irrigated by the system. Most of the agricultural

land are owned by male members of the household while only small portion (around 18.5 *kathas*) of the agricultural land is owned by females (5.71%). Hence, female land ownership is very less within the command area. Regarding the landholding, 32% were big landholders while the remaining were medium and small landholding farmers.

4.2 Climate Change trend and Perceptions

4.2.1Temperature and Rainfall

Practical Action Nepal conducted a study on the Temporal and Spatial Climate variability of Nepal (1976-2005) and according to the report released in 2009, in 30 years, the annual mean temperature trend was observed to have increased in Chitwan. Similarly, the mean temperature during post monsoon was also increasing in Chitwan. As per the observed data, Nepal receives the highest monthly precipitation in July and the lowest in November. The analysis shows that 79.6 per cent annual precipitation occurs during monsoon season whereas 4.2, 3.5 and 12.7 per cent, occur during post monsoon, winter and pre monsoon seasons respectively. The annual precipitation pattern is dominated by Monsoon. The central part of Nepal including Chitwan showed positive trend for annual precipitation. (Practical Action Nepal, 2009)

From a research conducted by Bibek et al, forty years of climatic data (1968–2007) from a weather station at the National Maize Research Program, Rampur were collected and analysed using non-parametric Mann–Kendall test and regression analysis. Chitwan has a subtropical climate, i.e., cool dry winter and a hot humid summer with annual mean minimum and maximum temperature 16.7 and 30.8 °C, respectively, and an average annual rainfall 2,666 mm. However, in recent years, Chitwan has experienced increasing extreme events and variability in temperature. Analysis of rainfall data from NMRP weather station did not reveal a clear trend in the annual and seasonal rainfall of Chitwan (p value = 0.58). However, variation in mean annual temperature and significant positive trend for both minimum (p value = 0.014) and maximum temperature (p value = 0.018) was observed (Fig. 3). The upward trend in minimum temperature after 1985 was unambiguous. The highest maximum temperature (39.1 °C) was recorded I May, 1995 and the lowest minimum temperature (5.3°C) was recorded in December, 1974. Thus, there were extreme years (i.e., years with very high or low temperature indicating climate variability) where the farming community experienced changes in the local climate. More than 82 % of household survey respondents reported increased temperature and warmer summers in last 15 years. Rain

water is the main source of irrigation in Chitwan. Despite no clear trend in rainfall data, the timing and pattern of rainfall have changed over the last 40 years as experienced by farmers. The occurrence of extreme events and increased variability in temperature has increased the vulnerability of crops to biotic and abiotic stresses and altered the timing of agricultural operations; thereby affecting crop production. Despite growing attempts of local communities to adapt to changing climate and variability, further planned adaptation aimed at a larger scale and longer duration is necessary to sustain the livelihood security of small-holder farmers. (Bibek Paudel, 2014)

From the household survey, about 82.85% of the respondents believe that there has been increase in temperature patterns in the last 10 years. Similarly, 97% of the respondents believe that there have been significant changes in the rainfall pattern in the last 10 years. They feel that the decrease in rainfall event is much more significant impact as it is visible and directly related with their agriculture pattern. Some (8%) of the respondents also shared that the amount of rainfall during a certain period has increased but the number of rainy days has decreased. Similarly, almost 89% of the respondents have agreed that the summer temperatures have significantly increased over the years, while winter temperatures have also increased over the years. Hence, there are more hot days in a year than the last 10 years, while the number of cold days has decreased. Around 11% of the respondents however believe that though summer is hotter than in previous decade, winter is still the same. It will be important to note that these respondents mainly belonged to higher age group. In regards to the changes in timings of the monsoon season, around 88.57% of respondents shared that the monsoon has delayed over the decade.

During the focus group discussions as well, the participants shared that they have experienced increase in hotness/ temperature along with shift in rainfall, change in duration, change in amount: intense rainfall in short duration. Rainfall, now, starts *Asaar* end now, before it used to be *Asaar* 15. The calendar for nursery (*Byad*) preparation was from *Jestha* 5-6 now it has shifted to end of *Jestha*. They have observed 15-20 days delay in monsoon with no/ less winter rain.

4.2.2Water Availability

When asked about the main sources of water for irrigation and drinking purpose, almost all (100%) of households, were dependant on the well water for drinking purpose and canal

water for irrigation. Over the last 10 years, the respondents shared that the water table has lowered significantly and almost 34.28% of the respondents had shifted to tap water for drinking purpose. This can be attributed of the depleting ground water sources due to increase in deep boring practices within the command area. In the last decade, the canal water has also decreased, and even though the farmers are still largely dependent on canal waters , as many as 10% of the respondents have already shifted to deep boring for irrigation completely, as the canal water was not sufficient for them. Almost all the houses, at the tail end, used ground water for deep boring to in addition to the irrigation water from the canal.

During the focus group discussions and key informant interviews similar scenarios have been reported. The main committee also shared that there must be more than 100 boring pump sets operating within the system area, by the farmers themselves to compensate the irrigation water deficit.

4.2.3Climate stresses and Extreme Events

During the HH survey, communities were asked to identify the hazards that were prevalent in the area and asked if they were changing over the period of 10 years. The hazards that were found to change its frequency were noted on the basis whether it had been increasing over the years or decreasing. The hazards thus obtained were quantified and prioritized. Following climate stresses and extreme events were prioritized by the respondents that occurred in and around the command area.

Figure 7 : Change in climate stresses and hazards as per the respondents

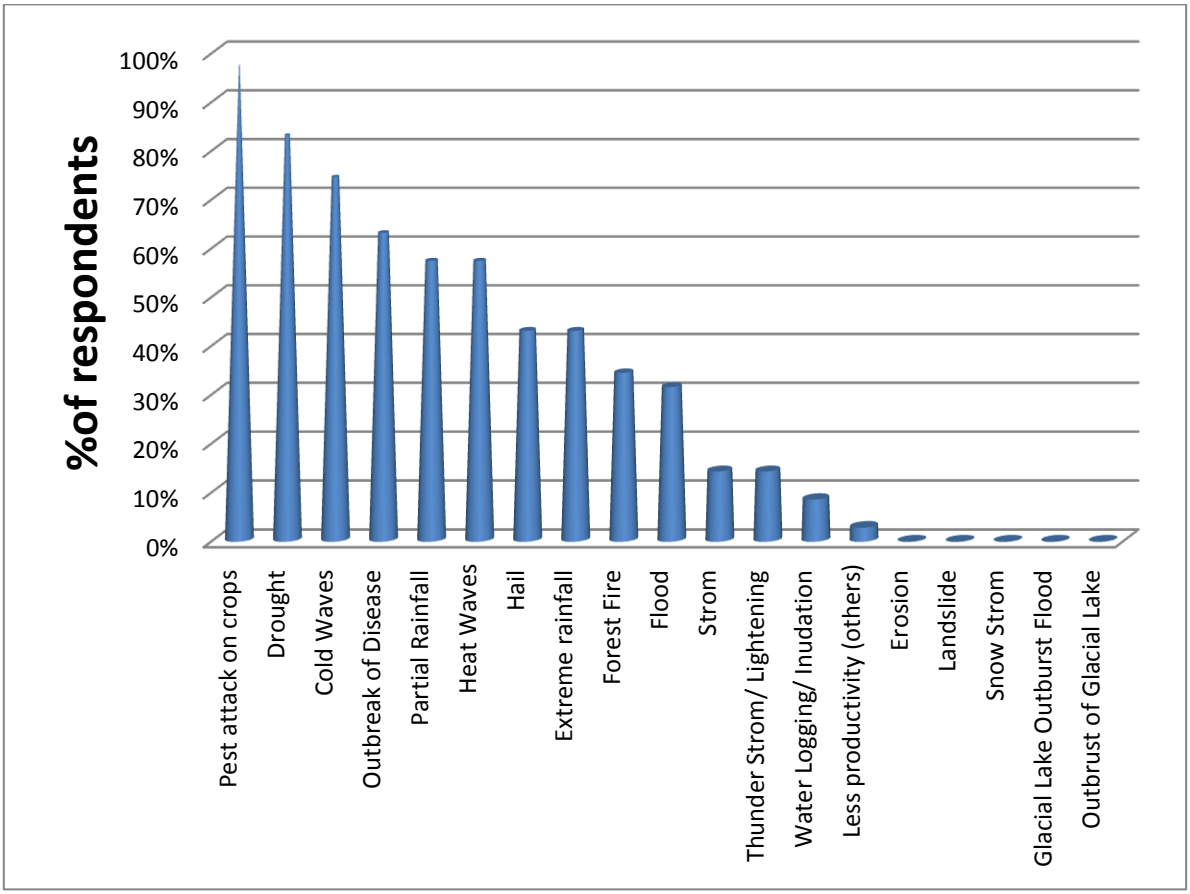


Table 2 : Hazards in order of their priority/ impacts

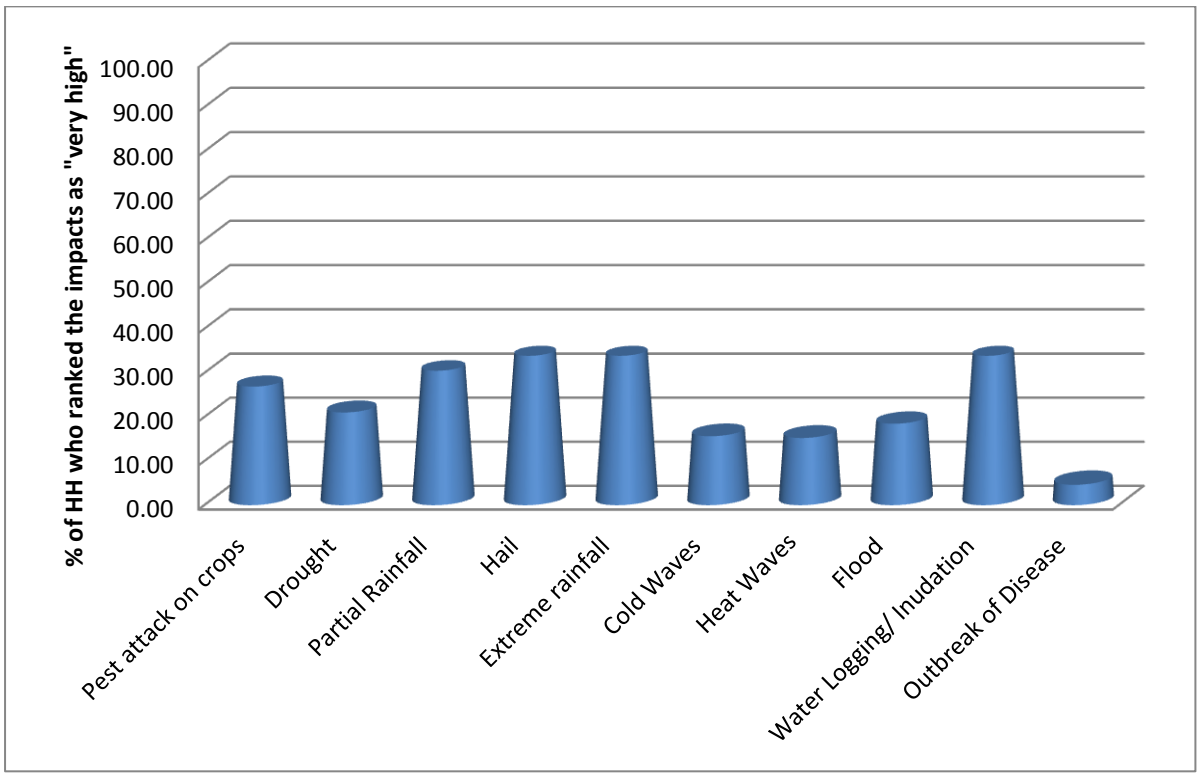
1.Pest attack on crops	8. Extreme rainfall
2.Drought	9. Forest Fire
3.Cold Waves	10. Flood
4.Outbreak of Disease	11. Storm
5.Partial Rainfall	12. Thunder Strom/ Lightening
6.Heat Waves	13. Water Logging/ Inundation
7.Hail	14. Less productivity

Out of these 13 climate stresses and hazards identified, firstly, increasing pest attacks on crops and drought emerged to be the topmost issue for the farmers. According to the farmers, there has been significant increase in pest attacks than 10 years before in the command area. Around 97.14% of the respondent farmers agreed that this was a major climatic impact that they were facing. 88.57% agreed that it was increasing and new pests are attacking their

crops and production more in these 10 years than before. 26.47% respondents shared that this increase in pest attacks had affected them very highly, while 44.12% of the respondents shared that they were impacted highly.

After pest attacks, drought emerged as second most climatic stress in the community. Around 82.86% of the respondent farmers agreed that this was a impacting them and 68.97% agreed that it the problem of drought was increasing in the past 10 years. 20.69% of the respondents shared that they were very highly impacted by the increase in drought while an equal percentage shared that they were highly impacted. Around 82.86% farmers shared that the cold waves occurrence in the areas was changing in the last 10 years. 57.69% farmers believe that it is decreasing than in previous years. Due to this decreasing trend, farmers have considered its severity to be mostly (37.46%) very low for their household. Similarly, 74.29% farmers shared that there had been change in occurrence/ outbreak of new diseases especially in livestock. Around 72% of the respondents shared that it is increasing than before. Partial rain was also reported to have been increased by a percentage of 75% of the respondents who agreed that it was changing. 33.33% respondents shared that the increasing occurrence of partial rain is impacting them very highly. Apart from these, Hail and Extreme rainfall events have also been prioritized by the respondents in terms of its degree of impact to their households. The top 10 prioritized climate hazards and stress on the basis of its degree to impact to their household is presented below:

Figure 8 : Hazards ranked as very high by the respondents



When asked if the respondent's family had been displaced or had to migrate to the climate extreme and hazards, 100% of the respondents shared that the climate hazards have not displaced or forced them to migrate yet. The impacts have not been severe.

However, some of the respondents of the respondents shared that they had to face certain loss of property due to climate induced hazards in past. As per the respondents, 36.36% had to lose property due to flood event. Similarly, 33.33% had to face loss due to water logging and inundation of their fields during flood related event. Another 26.67% had to bear loss due to hail event. Hence, the most of the respondents linked their loss of property and agriculture events to the following hazards/ stresses

i. Flood
ii. Water Logging/ Inundation
iii. Hail
iv. Extreme rainfall
v. Partial Rainfall
vi. Drought
vii. Pest attack on crops
viii. Heat Waves

ix. Cold Waves

From the survey, it was observed than majority of the respondents either strongly agreed or agreed that their households had perceived the impacts of climate stresses. Majority of the respondents have strongly (greater than 60%) perceived the following impacts:

- Fresh water sources are drying up over the years.
- Crop pest attacks have increased over the years.
- Livestock diseases have increased over the years.

Hence, it can be summarized that most of the farmers have perceived climate change stresses in agriculture and water availability. From the group discussions as well, climate induced hazards have been reported to have increased, new pest attacks are seen (new pests- *Fauji* pest, new diseases, *dadhuwa* (Blight) Disease in Potato etc).

Further, when asked about the responses and coping mechanisms, majority of the respondents neither agreed nor disagreed that the existing mechanisms were enough to deal with climate change extremes. This shows that majority of the farmers within the command area don't possess knowledge on the response and coping mechanisms for climate change. Around 20% strongly responded that the existing mechanisms were not at all enough; while 25.71% also agreed that it was not enough. This highlights the need of adequate response mechanisms within the system and more awareness on the need of these adequate response mechanisms to deal with climate change extremes.

4.2.4 Coping and adaptation strategies within the household levels

a. Agriculture

For short term coping, many of the farmers are using boring water pumps to fulfil their adaptation requirements. Some of the farmers have also shifted to less water/ drought resistant crops and are increasing using new improved breeds of crops that requires less water. Some farmers shared that due to increase in pests and diseases, they are using more pesticides than before. Regarding the long term adaptation strategies, many famers had little or no knowledge on adaptation options for agriculture. Only one farmer mentioned about the

need of improved farming system as an adaptation strategy. However, his household was yet to practice the improved farming system themselves.

b. Forestry

Respondents did not mention any coping or adaptation strategy at household level for stresses within forestry sector, as all the forest resources there were community forests and taken care by the community forestry user group (CFUG) themselves. Some suggested that CFUG should plant less water requiring crops and vegetation in the forests to reduce water use by the forestry sector as a long term adaptation option.

c. Water resources

Many of the respondents mentioned that boring of groundwater was the only coping mechanism that has been used at the household level. They don't know any other solutions or strategies to reduce stress in water resources at their level.

d. Health

Only one respondent mentioned that vaccination prevention could be the only coping response to the health impacts due to climate change. Most of the respondents felt less need or had little knowledge on coping or adaptation in health sector due to climate change.

e. Energy

Many of the households have been using solar, biogas and LPG as an alternative energy in the community. However, this is not a coping strategy but rather they have opted as these options are more preferable than burning firewood for cooking and kerosene lamps for lightening purpose. No adaptation strategy has been identified at household level for energy sector stress due to climate change.

4.3 Institutional structure, governance, actors and their interactions

4.3.1. Institutional Evolution and Arrangement

Previously Panchakanya irrigation system (PIS) was handled by an informal committee. According to the participants in the focus group discussions, the informal committee then, were mostly handpicked from different parts of the system and did not have a defined tenure, duties and responsibilities. The responsibilities were mostly limited to the water allocation schedule during monsoon as per the water availability in the system and the demand. Previous project Chitwan irrigation development project (CIDP) had recognized this informal body as Water User's organization representative. There had been very little resource mobilization from the users for the regular repair and maintenance of the system.

An election was conducted, where the functionaries and main committee members were elected from *parishads* (councils) and branch canal nominees. The constitution was drafted and enacted by the general assembly and the process for registration of the water user's association was initiated. Panchakanya Jal Upabhokta Samiti (Panchakanya water user's Committee) was registered in 2051-52 BS (1994 AD). The WUG made the decision to take the system and run it as a FMIS in 1997, through its General assembly. The Government of Nepal handed the Panchakanya irrigation system to the User's Committee as a Farmer Managed Irrigation System (FMIS) in December 1997. The water user's Committee is governed by its constitution that had been amended after the handover along with operational rules and regulations to match with the new handover and changes.

A two tiered structure of the WUG was conceived with a main committee at the main central level and two levels and lower canals- branch committee at the branch level and outlet committee at outlet level. Any other user/ farmer are eligible to obtain the membership upon payment of membership fee set by the WUG. As per the constitution, a 5 membered branch or outlet committee was proposed to be constituted including two functionaries- chairperson and secretary and three members. They are elected by the branch or outlet assembly of the users. General assembly members are again elected by the user assembly at each branch and outlet regions such that one member represents 15 *bighas* of irrigated land. Similarly, apart from elected members, ex officio from there branch and outlet canals can also be non-elected general members in the general assembly. Altogether there are 110 members in general assembly.

The main committee is provisioned to be 16 -membered committee. Currently, the 13-membered main committee includes 4 functionaries- Chairperson, Vice chairperson , secretary and treasurer along with 7 members who are the chairpersons of the branch committees, one woman elected/ nominated through General assembly and two ex officio member representatives from the outlet committees (1-5 and 6-10) . The General assembly members take part in the electoral process for the "main committee". The members of this main committee come mostly from *Parishads*. There are. The chairman of the *Mul* (main committee) *Samiti* is nominated through election process.

The irrigation system identifies land owners who have less than 5 *kattha* land as small holder farmers. The Irrigation system has 1800 HH as total beneficiaries in 7 wards (9,8,7,6,5,4 and 1). The WUG doesn't identify landless communities as members or users, even if they are dependent and living within the system.

4.3.2. Governance process

Within the WUG, general assembly and main committee have evolved as two important decision making arenas. The WUG constitution has stipulated all the constitutional authority to general assembly including authority of constitutional amendment, approval of rules and regulations developed by the branch and main committees and policy decision on outstanding issues. The constitution directs the WUG to organize general assembly every two times a year. All the general assembly members are to be notified 5 days earlier and attendance of 51% of total members is the required quorum for the general assembly. For urgent and special circumstance, the main committee can decide to call for the general Assembly. All the issues such as increase in price/ *Paanipot*, big repair activities have to be discussed and decided by majority in the general assembly.

During the Power, institution and Legitimacy (PIL) exercise, it was highlighted that the committee has been unable to include major stakeholders and users in decision making and there is a growing mistrust between the committee and its users. This is also because all the users are not included in general assembly, only their elected representatives from branch outlet canals are part of General Assembly. These branch canal representatives are the major links between the main committee of the water user group and its users in the General assembly platform. When the branch canal members are strong and communicate effectively, the users feel more aligned, sympathetic and responsive to the committee; whereas if the

branch canals representative were aloof or non-responsive towards the user's and their problems, the users were found to be more aggressive towards the committee. In most of the cases, branch canal members are mostly influential farmers, who have big landholdings and can spare time for voluntary committee work. Hence, they tend to fail to include the issues of poor and small landholding farmers.

With regards to General Assembly, there has been no GA since last five years. The main committee has been unable to conduct GA, and blames the users disinterest in GA and branch and outlet assemblies as the cause behind the inaction.

In regards to the *paanipot* (water cost), the main committee proposes the new cost along with reasons behind the increment to its general assembly members and the GA members based on the interests of the users from the branch and canals they represent will decide. It is interesting that over a period of 10 years the *paanipot* and the labour cost have doubled. For instance, the labour cost was Rs 10/*kattha* in 2054 BS while it became Rs 20/*kattha* in 2065 BS. However, this increase in cost has not taken into account the climatic impacts or costs such as less water availability into account. It has only considered difficulty in hiring labourers. When asked if there is any special consideration for poor marginalized farmers, there were none. Hence, both the head end users and tail end users have to pay the same amount irrespective of the fact that they don't get equal access to water. When asked with users during group discussions, they had mixed responses. Many of the users said they were not willing to pay more *paanipot* as they were not satisfied with the services, while some insisted that the committee may increase *paanipot* but have to give satisfactory results to the users with responsible and fair water management.

Table 3: Changes in Paanipot and labour Cost over the years

Particulars (per kattha)	Cost in (2054-2065 BS)	Cost at present	Trend
Labour cost per kattha	10	20	doubled
Labour (for Canal)cost per kattha	10	20	doubled
Cleanliness cost per kattha	10	NA	NA
water cost for paddy per kattha	5	10	doubled
Water cost for corn and other costs	2.5	5	doubled

per kattha			
Water cost during monsoon for paddy per kattha	NA	5	started

4.3.3. Actors and their interaction

Following are the major actors that have been identified within the Panchakanya irrigation system during the PIL Exercise.

Table 4 : Results from Power Influence and Legitimacy (PIL)Exercise

Stakeholder	P	I	L
Panchakanya Water users Group	High	H	H
Branch Committee	H	H	H
Outlet Committees	H	H	H
Sub branch Committee	Medium	H	H
Municipality	Low	M	H
District irrigation Division Office	M	M	H
Purbi rapti bhumigat Sinchai Ayojana	M	M	M
Irrigation Federation	L	L	L
Local groups	L	H	M
Political parties	H	M	M
Women's Groups	L	H	M
Non governmental organizations	L	M	L
Users	L	H	M

4.2.3.1. Users

Any farmer, who has irrigated land within the command area of Panchakanya Irrigation System and has paid the membership fees are identified as the users of the Panchakanya Irrigation System (PIS). The irrigation system identifies land owners who have less than 5 *kattha* land as small holder farmers. The Irrigation system has 1800 HH as total beneficiaries in 7 wards (9,8,7,6,5,4 and 1). These users pay the *paanipot* and also the labour cost as per the mandate of the PIS constitution and in return is entitled to receive water in a turn wise

schedule. All the users of a particular branch/outlet are members of their respective branch assembly.

Amongst the users, the communities who have their farms at the tail end of the system, receive less water than the head end users. They have to pay equal amount of *paanipot* though. These users are responsible to elect the branch committee and outlet committee members in their respective branch/outlet assemblies.

4.2.3.2. Branch level committee members

Branch committee members are elected by their respective branch users. Each branch representative is responsible for their branches which maybe a particular branch or a combination of sub branches accounting for 15 *bighas* of land under irrigation. In addition to elected general assembly representatives, provision was made for ex officio representation of chairperson and secretary from each branch level committee. They are eligible to cast votes at the general assembly for the main committee. There are 5 functionaries in each branch committee and in total there are 8 such branch committees (currently 7 branch committees)

4.2.3.3. Outlet committee members/ sub branch committes

Similar, to that of branch committee, the 5 functionaries of the outlet committees are elected by their respective users in the outlet level assembly. There are 10 outlet committees in total.

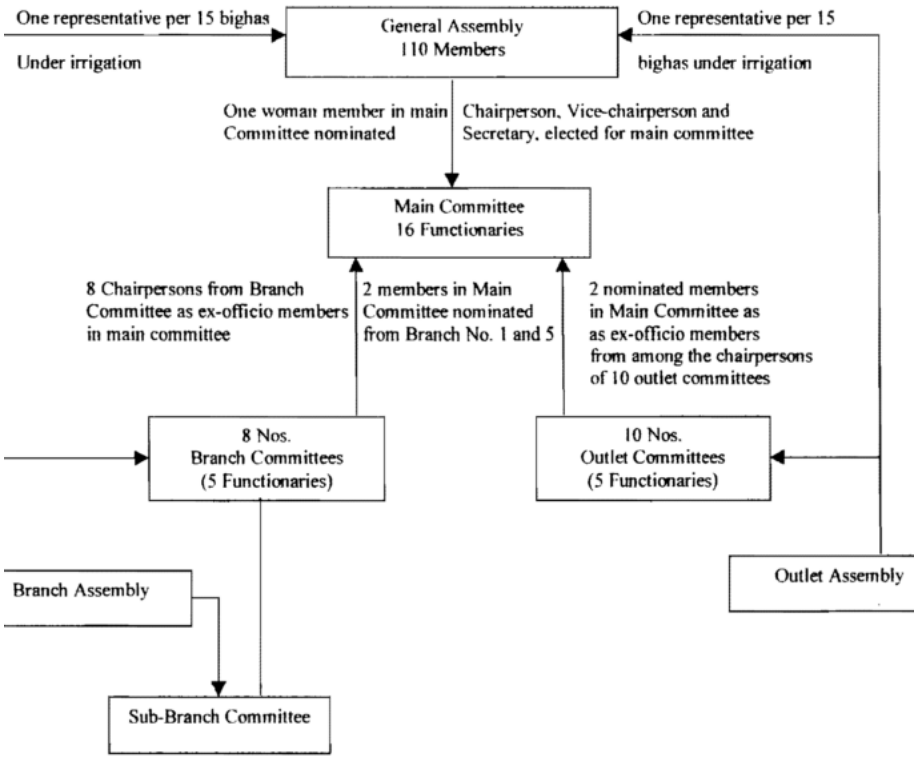
4.2.3.4. Main Committee members

The constitution stipulates the provision of 16-membered main committee. Out of them, 8 chairpersons, who have been elected from the 8 branch committees are eligible to be members ex-officially. Similarly, 2 members are nominated from Branch no 1 and 5 given its large area while 2 members are nominated from among the chairpersons of 10 outlet committees. Apart from these members, the 4 functionaries in the main committee- Chairperson, Vice chairperson, and secretary are elected from general assembly while one woman member is nominated from the general assembly.

Currently, the WUG has a 13 membered committee, where there are 4 functionaries elected and nominated from general assembly, 7 chairpersons from the 7 branch canals and 2

nominated members from the 10 outlet committees. This is due to the exit of Branch no 8 communities from the irrigation system and the cancellation of provision of nominated members from Branch no 1 and 5.

Figure 9 : Process of formation of different committees in WUG



4.2.3.5. Landless agricultural labourers

There is a separate community of about 40-50 households that live within the Panchakanya Irrigation system that don't possess any agricultural lands but have been working as agricultural labourers. These communities are not recognized by the irrigation WUG as they don't have any land are not considered to be members. Some of the families were displaced from the Chitwan National park while some had lost their land (due to various reasons such as drinking habit, gambling, etc) only some generations before. In both cases, they have been working in others farms since 2-3 generations and all they know is going to the field and working there till the sun sets. Agriculture labour is their daily livelihood.

4.2.3.6. *Padampur* settlement

Padampur, lies in *Kalika* Municipality, where ward no 9,10,11 and 12 were relocated from national park area. They lie outside of Panchakanya Irrigation system. There are 13-14 boring pumps installed in Padampur area, for drinking water purpose. These deep boring pumps have been installed with support from the government program- *Purbi rapti bhumigat Sinchai Aayojana*. As this settlement lies in the catchment area of Panchakanya spring sources, the communities have shared that the irrigation discharge has been directly impacted due to the deep boring activities there. They blame that after the community settled in the area and started boring, the discharge in the Panchakanya Irrigation system has decreased by 50%. However, there have been no study on this matter and hence no concrete evidences.

4.2.3.7. Government of Nepal- Department of Irrigation and District Irrigation Division Office, Chitwan

Previously, before the Panchakanya irrigation system was handed over to the farmers, Government of Nepal was managing the system with the help of local informal water users group. Majority of the constructions, canal linings and head gates have been installed during different projects at different times. After the handover in 1997, Government of Nepal doesn't have a direct role and authority in the day to day management and repair and maintenance of the system. However, since the WUG and the constitution has been registered with DoI , it has been identified a s a key stakeholder. During KII with Mr. Lohani, Department of irrigation, he agreed that there are no clear policies on the installation of deep tube wells near water sources and as Terai has huge recharge potential, the impact of deep tube wells on irrigation spring systems may not be pronounced.

4.2.3.8. Purbi Rapti Bhumigat Sinchai Aayojana

Purbi rapti bhumigat sinchai Aayojana started its operations in Chitwan in 2065BS (2008/2009) and is mandated to provide the farmers with technical and financial support for communities and farmers for shallow tube wells and deep tube wells installation. During a KII with Rajendra Neupane, Division head, Purba rapti Bhumigat Sinchai deep boring tube wells have a command area of 10-15 ha and a discharge of 12-25 ltrs/sec while shallow tube

wells have a command area of 2.5 ha and a discharge of 4-6 ltrs/sec; hence, shallow tube wells are not much a of a threat but there have been no studies or policy guidelines on the impact of deep tube wells in the spring source irrigation systems such as Panchakanya irrigation system. He also added that Terai has a huge recharge potential of 1700 ml/years hence deep tube wells should not have an alarming impact. This is in line with the opinion of DoI.

4.2.3.9. Ratnanagar Municipality

Since, this is a Farmer managed Irrigation System, no government or local government authority can affect or influence it directly. However, Ratnanagar Municipality has been supporting the Panchakanya Irrigation System with certain financial resources from the municipality time and again. For this, the main committee submit an application requesting funds and the municipality provides the support. However, the support is not very regular. Apart from this, the municipality have been using their land for their vegetable market and provides a certain amount for the lease fee. This is also an additional financial source for the Panchakanya irrigation system.

4.2.3.10. Local CBOs, other WUGs and Informal groups

There are many other formal/ informal CBOs and institutions that have been working in various themes and have a strong role and contribution to support the farmers and communities within the command area. These organizations are not directly affiliated with Panchakanya WUG. For instance, there is a group called "*Aadibasi tharu Utthanshil samuha*" that helps the *Tharu* famers access water for irrigation through other ground water sources by providing pump sets on hire. Similarly, there are many farmers' groups, women groups', cooperatives' that have been supporting the smallholder famers and marginalized farmers both technically and financially. To a certain extent these groups have been helping the farmers to respond (cope and adapt) to the changing climatic context, and filling in the gap left due to inaction of Panchakanya jal Upabhokta samiti.

4.2.3.11. Private lands where the ponds are situated

Since, Panchakanya irrigation system is dependent on Panchanadi spring sources, the private landowners where these springs are located are also quite an important actors for the system.

These private landowners have been cooperative so far and have supported the communities for the conservation of the springs. However, the irrigation system has no legal basis to take action if the private land owners don't cooperate.

4.2.3.12 Political parties

Political parties also influence the institution and governance. Due to the political parties, the issue of access and benefit sharing is highly affected, as people affiliated to certain political parties tend to give more access to his fellow comrades within the system.

By using the Stakeholder matrix method (Department for International Development , 1993), stakeholders can be plotted against two variables. These variables might be plotting the level of 'stake' in the outcomes of the project against 'resources' of the stakeholder. Another is the 'importance' of the stakeholder against the 'influence' of the stakeholder. The power, influence and legitimacy, as ranked by the users have also been used here

Table 5: stakeholder matrix method

<table>
<tr><td></td><td colspan="4">Importance of Stakeholder</td></tr>
<tr><td rowspan="5">Influence of stakeholder</td><td></td><td>unknown</td><td>Little/no importance</td><td>some importance</td><td>Significant importance</td></tr>
<tr><td>significant influence</td><td colspan="2" rowspan="3">• Padampur settlement
• Purbi rapti Bhumigat sinchai Aayojana</td><td colspan="2">• Main Committee members
• Branch level committee members
• Outlet level Committee Members/ sub Branch</td></tr>
<tr><td>Somewhat influential</td><td colspan="2">• Ratnanagar Municipality
• Political parties</td></tr>
<tr><td>Little/ no influence</td><td colspan="2" rowspan="2">• Landless agricultural labourers</td><td colspan="2" rowspan="2">• Users
• Government of Nepal- Department of Irrigation and Irrigation Division</td></tr>
<tr><td>unknown</td></tr>
</table>

			Office, Chitwan • Local CBOs, Informal organization, cooperatives

From the matrix we can see that, Main committee, Branch level committee, outlet level committee, and Ratnanagar municipality have significant importance and influence in the Panchakanya irrigation system. Similarly, stakeholders including users, Government of Nepal, local CBOs have significant importance but are less influential to the operations of Panchakanya Irrigation System. Out of these three stakeholders, users and local CBOs can play a significant role in increasing and supporting Panchakanya irrigation system, if given appropriate opportunity and conducive environment.

Purbi rapti Bhmugat sinchai Aayojana and Padampur settlement have a significant influence while their role is less important. Farmers within the system believe that Padampur settlement is responsible for the drying up the irrigation water source. *Purbi rapti Bhmigat sinchai Aayojana* on the other hand has been helping the farmers to cope with the deficit in the surface irrigation water by supporting with the boring and shallow tube wells.

Landless agricultural farmers who are the most vulnerable group are not recognized by the Panchakanya Irrigation system; hence they fall into the group with less importance and influence.

4.3.4. Outcomes

4.3.4.1. Institutional structure

In the Panchakanya irrigation system election process, the users are only involved at the branch/ outlet level elections. After that, it is the branch/outlet representatives who enter the general assembly and then move further to form the main committee. The main committee is mandated by the general assembly to run the irrigation system at central level, while the branch/outlet committee is responsible for the branch/outlet level. This institutional setup creates a lot of distance between the main committee and the users. During the FGDs, many users (especially females) had no idea what the terms of reference of the main committee were and who were the functionaries. This distance between the users and the main committee also makes the main committee less responsive and accountable towards the users. When asked if there are regular meetings and events to engage users and executive committee, majority (37.14%) strongly disagreed, 22.86% disagreed, 5.71% neither agreed nor disagreed, 25.71% agreed and 8.57% strongly agreed.

The branch/outlet committee is the main link between the main committee and the users. They are more responsible for effective communication and the focal point for all grievances. However, when the branch/outlet representatives fail to communicate the grievances, the users stop trusting the irrigation system. The users are also unaware of the challenges the main committee faces in terms of resources or technical capacities. Hence, for effective functioning of these tiers, either the communication mechanism has to be responsive and robust or the main committee should communicate directly with the users and solve their grievances.

4.3.4.2. Water management, Fee structure and benefit sharing

When it comes to water management, and conflict in water use, 42.87% responded that there are conflicts in irrigation water supply, which is mostly caused by leakage of canals, small size of sub canals, use of motor pumps during irrigation water supply and conflicts during turn wise distribution of water. Similarly, the tail end users receive very less amount of water. They blamed the decreasing water amount in the irrigation system as the major reason behind the conflicts.

During the FGDs and KII, it was discussed that the fee structure has remained very minimum and has been revised only once in 10 years. This has impacted the resource generation for the main committee and also impacted their ability for regular maintenance and repair of the system. The main committee members had shared that 40% of the users never pay any tax as mandated by the constitution. The revision of these water costs are also a big debated issue, which gets heavily politicized in the system. There are no fining mechanisms in place for the late payments as well. According to the main committee, amongst the famers, it is mostly the large holding big farmers who avoid paying the fees while the small holding farmers tend to pay. Some of the smallholder farmers shared that they always pay their dues to the branch canal representatives but are not sure if they reach the main committee. These kind of inconsistencies need to be addressed by a suitable fining mechanism.

4.3.4.3. Participation

With respect to participation, almost equal percentage (28.57%) of respondents agrees that participation of users in the meetings and organization activity is high and inclusive, while equal percentage disagrees with it. Generally large landholding farmers, who had more access and participation in committee, seemed more satisfied with its work than the small holder farmers. This also results in more alienation of the users from the committee.

4.3.4.4. Inclusion

Regarding inclusion of women, there have been provisions within the constitutions that promote women nomination for certain posts within the main committee as well as at the branch committee levels. Currently out of 13 members in the main committee, 2 posts ie vice chairman and treasurer are held by women. Some years ago, there were many capacity development programs led by CARE Nepal, where many women were trained. These women have been very active in leadership positions. However, most of these women come from large landholding backgrounds. Women who come from poor and small landholding backgrounds have not been included in such positions. The main committee believes that the reason behind this is that mostly women and men who hold these positions have to work voluntarily. They are not given any salary or ages for their contribution in the committee and have to attend the meetings and contribute considerable time and efforts. Hence, women from poor background seldom participate and are unwilling to work voluntarily as they have other

immediate priorities. On the other hand, the small holder and marginalized farmers on the other hand believe they lack the capacity but would be willing to contribute if provided with skills and capacities. Apart from this, the WUG has no special policy or program for the poor and marginalized farmers. In many cases, they pay equal amount of fee but receive less water. During the HH survey, majority of the respondents (34.29%) agree that the institution rules and policies are inclusive and community oriented while 22.86% respondents strongly disagree. Around 8.57% were ambiguous to the statement while 17.14% strongly agreed to the statement and equal percentage disagreed with the statement. In terms of benefit sharing as well, poor, women and marginalized households are not given foremost priority in representation, participation and benefits sharing as majority of the respondents (31.43%) strongly believe that institution is not inclusive for all. 25.71% also moderately believe that while 14.29% are ambiguous about the inclusion and prioritization issue. However, 20% agree and 8.57% strongly agree that the institution is inclusive and participatory.

4.3.4.5. Accountability and transparency issues

The Panchakanya Irrigation system has not been considered to be transparent by its users during the group discussions and HH interviews. Majority of the respondents (31.43%) disagree that access to and benefit sharing is fair and transparent, while 28.57% strongly disagree to the statement. 8.57% neither agree nor disagree while 28.57% agree and 2.86% strongly agree that it is fair and transparent. One of the main reasons behind the transparency is the communication gap between the users and the main committee. The General Assembly has also not been organized in last 5 years. It is the same committee that has been working without fresh elections. General assembly and the branch/outlet assemblies give users and the officiating members an opportunity to interact and share the financial reports, achievements and challenges, but when the main committee has failed to organize as per the constitution's mandate, users are more sceptic about the functioning.

Apart from this, the committee has failed to collect fees from all the users due to lack of fining/punishing mechanism. Thus, the farmers who pay their dues timely feel cheated as they are getting the same or in many case less benefit than the miscreants.

4.3.4.6. Interaction with other institutions within and outside the system

Since, the Irrigation system became farmer managed, the system has been operating mostly with its own resources. It has therefore been focusing less on interactions with other stakeholders. The main committee works closely with the municipality for additional funding and with Irrigation division for the technical support as and when needed. Apart from this, the main committee and the irrigation system hardly interact with other institutions or CBOs. When asked during the HH interviews, majority of the respondents (34.29%) disagreed that there is a strong network and no collaboration among agencies at local level, while 5.71% strongly disagreed and 20% neither agreed nor disagreed. On the other hand, 28.57% agreed that there is strong network and 11.47% respondents strongly agreed to it.

There are many organizations and CBOs that are emerging within the system. The WUG doesn't even acknowledge them, let alone collaborate with them. These CBOs and associations are gaining more trust of the users than the WUG as they helping the farmers/users deal with the emerging challenges and water deficit issues in an effective but limited manner. If the Panchakanya Main committee collaborates with these CBOs the impacts could be stronger and wider.

4.3.4.7. Resources and Technical capacity

After it became an FMIS, the water fees the users pay are its only sources of income. Apart from these, the committee gets some rent money by leasing its land to the municipality. The municipality also provides occasional support to the irrigation system financially. However, they have been using the surplus income effectively for the required repair and maintenance of the system. Majority of the respondents (34.29%) also agree that the institutions is managing resources properly, while 22.86% disagree and equal percentage neither agree nor disagree to the statement. Only 2.71% strongly agree with it while 14.29% strongly disagree.

In terms of technical capacity, during the FGD, the main committee representatives shared that they lack technical capacity in terms of improving system efficiency. They can hire labourers for regular repair and maintenance but don't have the required knowledge for bigger changes in system design. This is hindering the irrigation system to evolve and adapt to the new challenges.

In order to overcome this resource and technical constraint, the main committee should consider making a business plan that can include the technical and financial requirements

over a certain period of time and collaborate with supporting organizations which could be both government and other non-governmental organizations.

4.3.4.8 Gendered Vulnerability within the system

Within the system, most of the lands are owned by male farmers. Most women don't have sole or joint ownership over the land. This hinders them from interaction and capacity building opportunities at formal level. The committee also hasn't taken any strong role to include women, most women have no idea about the committee or who is the chairperson. In many households, men interact with the branch committee members and handle the formal work related with agriculture. If there are no men active in the house, the women and the household are almost cut off from the system. There are provisions for women participation at the main central committee and branch committee, but it is tokenistic and limited to elite farmers with big landholdings. These women officials at the committee level have been unable to propose or conduct any kind of women focused trainings that could help reduce their vulnerability. They fail to represent majority of poor and marginalized women within the system.

However, there are many women groups emerging within the system. These women groups have outreach to a specific ward or communities. However, they have been providing informal opportunities for many women to interact and build their capacities. These women groups and cooperatives provide their women members with trainings on improved agricultural system along with entrepreneurship trainings and loan money. Hence, even though these institutions have less power than the committee at formal grounds, they have more influence in reducing the gendered vulnerability within the system.

Apart from these women farmers within the system, there is a strong case of female agricultural labourers within the system. These labourers are landless and don't have their own land (physical capital) and have been working in other's lands s daily wage labourers for generations. As they don't own any land, the Panchakanya irrigation system doesn't recognize this community as its users. Similarly, they are not associated with other social networks such as farmer's groups, other boring water user's groups. Hence they have very less social and physical capital. Since, they have been working for generations, in other farms as daily wage labourers; they do not have any other skills and knowledge or the financial resources and institutions. If we look at the stakeholder analysis, this group of labourers fall

in the category of least influential and least important stakeholders but undoubtedly, from the sustainable livelihood approach framework (Department for International Development (DFID) , 1997)they are the most vulnerable groups within the system.

Over the years, as the water availability for irrigation has been decreasing, many farmers/ landowners have opted to do personal or communal deep boring and had been using ground water for irrigation. Hence, the farmers / landowners had to pay additional cost for pump, electricity or diesel. They also reported that due to increasing occurrence of many new invasive species and new diseases in the crops, the famers/ landowners were also compelled to use additional pesticides and herbicides in huge amounts. This has led to increased cost of agricultural costs on one hand while the profits from agriculture remained the same.

Owning to this trend, within the command area, many famers/ landowners have already started leaving their land fallow. Some have sold their land for housing purposes. As you drive across the command area, one can already see plotted lands for housing purposes, instead of agricultural fields. This has directly impacted the livelihoods of the agricultural labourers.

Further, many farmers, who are still continuing agriculture within the command area, in spite of increased cost of irrigation, have started using contract services for the agricultural help. The labourers in the discussion shared that, many workers, who reportedly hail from Siraha and *Saptari* districts provide their agricultural labour services along with sue of modern agricultural technologies such as tractors, etc. Since, they complete work in fields in shorter and cheaper than as had been the case with traditional agricultural labourers, more and more farmers are opting these contract services over hiring the landless traditional agricultural labourers.

These consequential impacts have severely impacted the livelihood of the landless daily wage agricultural labourers in a trickle down manner. Firstly, the farmers were effected, but because they have resources and capital, they are less vulnerable and it then trickled down to the labourers. Many of the labourers have no another skills other than agricultural skills. They also lack the resources and technical knowledge to use sophisticated technologies unlike the contract group of labourers from other districts. Men, from these communities have started shifting to construction work as labourers there. Some were also working in the oil mills as labourers nearby. Women, without the skills and the capacity to work as agricultural labourers, are forced to stay at home these days. One of the participants shared,

that it was getting more difficult to feed her family of five twice a day, owning to the lack of employment. Single women and widows are most affected.

So far, there has been no technical and financial support to these female agricultural labourers. There is an unequivocal need to work with these communities, include them within the institutional setup and provide them with necessary skills and financial support to build their resilience.

4.3.5. Institutional governance and adaptive capacity

Panchakanya irrigation system has been handed over by the Government to a farmer- run water users committee and has been functioning in that manner since the last 20 years. Since, the last 20 years, the farmers themselves have been managing, repairing and maintaining the system with some financial support from outside stakeholders. Over the years, with the water availability decreasing in the system, the system has been facing numerous challenges. One of the main reasons behind this, is the fact that the system and the main committee has not been able to understand and incorporate the changing scenario. In terms of water resource management, majority (37.14%) of the respondents strongly believe that the executive committee is not playing a crucial role in water resource management, while 8.57% of the respondents strongly believe that executive committee is playing a crucial role. 5.71% neither agree nor disagree with the statement.

Most of the famers and the committee members themselves have perceived the impacts of climate change in terms of increasing temperature, prolonged drought, shift in rainfall pattern and amount etc. Users have been complaining about the declining water availability in the system and how they have to opt for boring to fulfil the demand. However, the committee has not been able to incorporate it and plan with these new variables into consideration. There are both financial and technical challenges that have constrained the committee to understand and incorporate the climate change issues. Majority of the respondents (48.57%) disagree that the institution's role in water resource management reduces climate risk/ hazard and addresses issue of climate change. 25.71% strongly disagree to this while 14.29% neither agree nor disagree. On the other hand, only 11.43% agree that issue of climate change is addressed. After becoming an FMIS, the committee has been managing the system themselves, however they don't lack the required technical knowledge on engineering, nor do they have financial sources.

Within the system, in order to cope with these challenges, many formal and informal institutions and CBOs have emerged and functioning well. These institutions have evolved in the vacuum that has been created by the WUG committee's inaction and have been useful to a larger extent. The committee however has failed to collaborate with these institutions for the greater impact and benefit of its users. Rather, during FGDs and KIIs it was felt that the committee prefers to work in isolation and concern itself only with distribution of available

water. There is an evidence of a certain branch exiting the system and opt for alternative sources of irrigation that shows that the Panchakanya system has been unable to diversify its sources and cope with the new sets of challenges.

If we compare the scenarios of exited branch no 8 with small holder famers of ward no 4, we can see that branch no 8 communities had alternative sources for irrigation water along with access to knowledge and institutions. These factors enabled them to exit the system. On the other hand, the communities from ward no 4, who are poor and marginalized farmers with no other alternative sources, we can see how access to resources, to alternative sources and technology, can play a key role in increasing the communities' adaptive capacity. The communities in ward no 4 have also been receiving very less water from the system and also have parallel institutions to fulfil the institutional vacuum left by the Panchakanya Users' group committee. However, they have been coping with the irrigation deficit by using expensive diesel electric water pumps on hire and are barely able to make the ends meet. On the other hand, due to alternative sources of irrigation and access to deep boring technology, the previous communities of ward no 8 are able to start other enterprises and more water intensive crops after leaving the system.

Additionally, the WUG has been unable to hold a general assembly for 5 years. Consequently, there have been no branch/ outlet assemblies either, hence the communication between the main committee, general assembly and the users have been halted. The users are getting more and more alienated from the committee and there is a growing mistrust in place. the users are hence coping with these responses on their own or through other small informal/formal committees. The effect can be seen in the collection of *paanipot* (water fee) as well. In one of the FGDs, the committee mentioned that 40% of the users don't pay their fees to the committee. This directly impacts the committee's revenue, fund generation, making it more difficult for the committee to do regular repair and maintenance and hence weakening the system.

From the household survey, around 43% of the respondents believed that ethnic minorities such as indigenous Tharu communities are mostly impacted by climate change because they have less money and are more vulnerable. Also, they have less knowledge and awareness and hence don't have access to various information and coping mechanisms. Some of the respondents also believed that due to changing climate, the water stress is more than before and many of the indigenous communities have less access to technology and hence their

drudgery has increased because of climate change. Similarly, women were identified as second most vulnerable to climate change impacts as they had less access to finance and resources than men in the community. The disadvantaged groups such as Dalits were identified as the third most vulnerable group followed by elderly, men and children respectively. However, there have been no special programs, packages and benefits for these vulnerable groups.

The adaptive capacity of the system is very weak. Neither the design of the system is climate adaptive, nor has it been able to adopt more efficient ways of water management. There is no investment or collaboration for climate adaptation. If the drought prolongs in the future or the water availability decreases significantly, the WUG will be unable to help its farmers unless it starts understanding and investing in adaptive water efficient measures. As the climate change impacts become more pronounced, there is a risk that farmers will shift altogether to the other institutions to cope with the changes and the Panchakanya Jal Upabhokta samiti may collapse. The users also believe that the system has to do a lot of investment for effective adaptation and it is very crucial that the system understands and internalize what their users feel for sustainable operations.

CHAPTER V: CONCLUSION AND RECOMMENDATIONS

5.1Conclusion

Various literatures have shown that local institutions can play a catalytic role in effective adaptation at local level and farmer managed irrigation system can play a key role in adaptation at agriculture sector. Farmer managed Irrigation System is a widely recognized and celebrated irrigation system management approach in Nepal and around the world. When farmers themselves own and manage the irrigation system, it becomes more effective, transparent and efficient as the beneficiaries themselves operate it in the best possible way. Panchakanya Farmer managed Irrigation system is a well-recognized, well studied site it Nepal that has been managed by farmer led water users committee for the past 20 years. However, there are numerous environmental, institutional and technical challenges that are evolving within the system that will be aggravated by climate change impacts.

The irrigation system doesn't possess the ownership of the land that constitutes of its sources- Panchanadi springs. The spring sources fall on private land. So far, the owners of the private land have been cooperating with the irrigation committee for the conservation of the springs, but there are many environmental challenges that are threatening the existence of these spring sources and the system. There are new settlements on the catchment area of the spring sources that use the deep boring pumps and pose a risk to the spring sources. Similarly, the annual sedimentation process that occurs naturally during monsoon also threatens the spring sources.

Within the system as well, there is a huge issue of water distribution and loss. Most of the canals towards the tail end of the system are earthen lines. The canals that have been lined are also in need of repair and maintenance. The system is losing a huge amount of water due to leakages. The tail end farmers don't receive irrigation water due to leakages and are only able to plant one crop per year, unlike the head end farmers. Hence, they are economically poorer than the head end farmers who have year round access to irrigation water. This results in inequity between the farmers within the system.

The governance of the system is very poor. There are issues of transparency and accountability within the main committee of the irrigation water users' group. Over the years, the conflict between the users and users' committee is increasing that has resulted in

polarization between the two parties. The committee has not been able to distribute water to the tail users nor has it been able to maintain and renovate the canals. So far, the committee has been unable to even collect the *Paanipot* (water tax) from all its users regularly. Resource constraint is crippling the committee in many ways and hindering them from day to day duties and responsibilities. There are many governance challenges within the committee as well. The committee is slowly losing the trust of its users. In terms of participation, the community has failed to be inclusive. Though there are special considerations for women, it has failed to include poor marginalized communities in its structure and processes. Mostly the elite and the big landholding farmers have access to its benefits while poor and marginalized farmers are unsatisfied and slowly moving away from the system. There are no special considerations for the poor and marginalized farmers and landless agricultural labourers as well.

Apart from these environmental and system challenges, the changing climate, ie increasing temperature, prolonged droughts and changes in rainfall pattern has been impacting the water availability of the system. From the secondary data we can see that the long-term rainfall data from Chitwan, Nepal doesn't show a clear trend. However, variation in the mean annual temperature, a upward trend for both minimum and maximum temperature in Chitwan, and the stagnation of crops yields in recent years has been observed. The highest maximum temperature (39.1 °C) was recorded in May 1995 and lowest minimum temperature (6.7 °C) was recorded in January 1970. Reportedly, the flow of the Panchakanya irrigation has decreased by around 50% in the past 10 years. This has impacted the system in many ways. Firstly, it has aggravated the issue of unequal distribution of water. Farmers, who are at the tail end of the system, receive even less water than they used to receive than before. The irrigation water they receive from the system is not enough for them hence they are now shifting towards deep boring pumps to extract the ground water for irrigation. The issue of new pests and crop diseases has also escalated over the years, forcing the farmers to use more pesticides. This has increased the overall cost of the agriculture, making it more expensive and less beneficial for the farmers and especially those who have small lands and are marginalized making them more vulnerable to climate change impacts and extreme events.

Further, the group of daily wage agricultural labourers that live within the system but don't own any land are losing their job as agricultural labourers, as people are either moving towards more mechanized help or leaving agriculture altogether. This has forced the community to move towards other livelihood options. While men are able to work as

construction labourers, the women, who have no other skills and resources, are left unemployed. As they are not recognized by the irrigation system and have no financial or technical skills and resources; they are more vulnerable than before. This trickle down impact of climate change is making women especially single women and widows more vulnerable as they don't have any means to feed their families.

Regarding climate change response, the committee has little or no knowledge about this issue and its impacts. This lack of capacity is making the committee aloof to the future climate change impacts. There have been no other coping mechanisms within the system apart from the increasing use of bore wells, which is again done by the farmers and not by the committee. New cooperatives and boring water users association are evolving within the system to fill the gaps left by the inaction of the committee. The committee however doesn't recognize their role and hasn't shown any willingness to collaborate for the welfare of its users. No research has been done, within the system, on the potential use of water efficient technologies and/ or water efficient crops.

Major findings of the study

•In recent years, Chitwan has experienced increasing extreme events and variability in temperature. The temperature has increased over the years. The rainfall has varied unpredictably resulting in prolonged droughts and increase in pest attacks and new diseases in crops.

•These climate change impacts have aggravated the complex hydrogeology and environmental factors around Panchakanya Irrigation System, resulting in around 50% decrease in water flow within the system. Decreasing water availability in the system and shrinking command area since past 20 years has been reported by the farmers.

•Increasing use of personal /communal shallow tube wells and boring within and around the system area (more than 40%) has been observed. These have emerged as the coping mechanism within the system.

•There is significant increase in mistrust between users and user groups, lack of equity, participation, inclusion and accountability are the major governance related challenges that are emerging strongly within the system.

•Increase in agricultural costs for the farmers due to climate change impacts have impacted in increased drudgery for the agricultural laborers (land less), which are the most vulnerable groups within the system, has been observed. As a result, these female agricultural laborers are unemployed.

•However the system is apathetic and unresponsive to the plight of female landless agricultural laborers.

The study has also identified the following keys drivers of vulnerability within the system:

•Unequitable access and benefit sharing, particularly access of water to tail users is very low and not prioritized.

•The participation and inclusion is very tokenistic and male dominated.

•The institutional governance is very weak and not transparent.

•Difficulty in resource management for efficient functioning of the system

•Lack of proper technical knowledge on climate change adaptation measures and mechanisms.

5.2 Recommendations

•It is very important to establish clear linkages between the rainfall variability, sedimentation at the spring sources and the decrease in water variability. For this, detailed hydrological and geological study needs to be conducted in a spring-shed study approach. It will be important to see to see if the deep boring practices in the catchment area of Panchakanya will have any impact over the drying up of the sources.

•Secondly, the sources of Panchakanya irrigation System lies in private lands. It is very crucial for the Panchakanya water user's Committee to conserve the catchment area and the land where springs are located for the sustainability of the system. The committee should therefore collaborate with the government to acquire the land where the spring sources are and adopt necessary conservation measures.

•The climate change impacts are already visible within the system and have been exacerbating the complex nature of the system. The secondary data and the communities' perception have also shown that the impacts are urgent and strong. Thirdly, the Water user's Committee should work with the Department of Irrigation and Ratnanagar Municipality to

maintain and upgrade the system's efficiency with hard level interventions such as lining of canals, maintaining the leakages and upgrading to an efficient system design with reduced losses and leakages.

•Also, the system should assess the adaptation needs of its users and take a systemic approach for adaptation. It could start with collaborating with CBOs and other water user/ farmers groups within the system and intensify the adaptation measures. These adaptation measures could range from improved agricultural technology, integrated pest management, use of drought resistant varieties, water efficient practices etc.

•Most importantly, the system has to improve its governance and performance. General assembly should be regular as mandated by the constitutions. The branch/outlet committee members and main committee members should be more accountable to its users and more empathetic to their problems.

•The resource management should be prioritized. The committee has to be fair and come up with punishment / fining mechanisms for users who fail to pay the water tax. The water tax should be revised and the cost of less water availability due to climate change should be considered while revising the costs. Similarly, the committee should focus on building relationships with government and non-governmental organizations for more resources to make the system more efficient.

•The issues of tail end users should be prioritized. The canals should be maintained and lined up so that they get enough water. For the communities who don't receive water, the committee should come up with subsidized rates and /or alternative mechanisms to fulfill their water demand.

•The poor, marginalized communities should be given more priority. Incentives should be provided to include them at decision making levels such that the committee is more inclusive and equitable. There should be special policies and packages to uplift the marginalized communities.

•Women should be given priority. There are very less opportunities and incentives to engage them at decision making levels. The women should be engaged at all levels. Effective orientation and capacity development program should be introduced.

•The female landless agricultural laborers should be given technical skills so that they can diversify their livelihood options. these trainings can range from entrepreneurship skills such as handicrafts, sewing, etc. They should be given trainings on governance and institution management such that they can generate resources through establishing saving cooperatives and uplift their economic statuses. For this, firstly and fore mostly, the system has to recognize them and include them formally in their structure. Then, necessary skill development trainings and opportunities can be provided.

5.2.1 Recommendations for Further Study

From the study findings, the following recommendations for further studies are made:

i. Study the hydrogeology of the *Panchanadi* and understand the impacts of the rainfall variability and the use of boring tube wells in the decline in spring flow.

ii. Study the impact of prolonged drought on the increasing occurrences of pests and diseases.

iii. Examine the impacts of the recommended interventions, their costs, the institutions and infrastructure required for its successful implementation.

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ANNEXES

ANNEX 1: LIST OF PHOTOGRAPHS

Photo 1 : Focus Group Discussion with female users of Panchakanya FMIS

Photo 2 : Grain exercise with ward no 7 participants (Canal no 1)

Photo 3 : One of the *Panchanadi* springs, which as the main sources of Panchakanya Irrigation System, lie in private lands.

Photo 4 : Key Informant Interview with Mr. Thakur Mainali, Operator of the Irrigation System

Photo 5 : Headwork of the Panchakanya Irrigation System

Photo 6 : Users and Branch Committee members discussing the problems and benefits for outlet no 1, 2 and 3

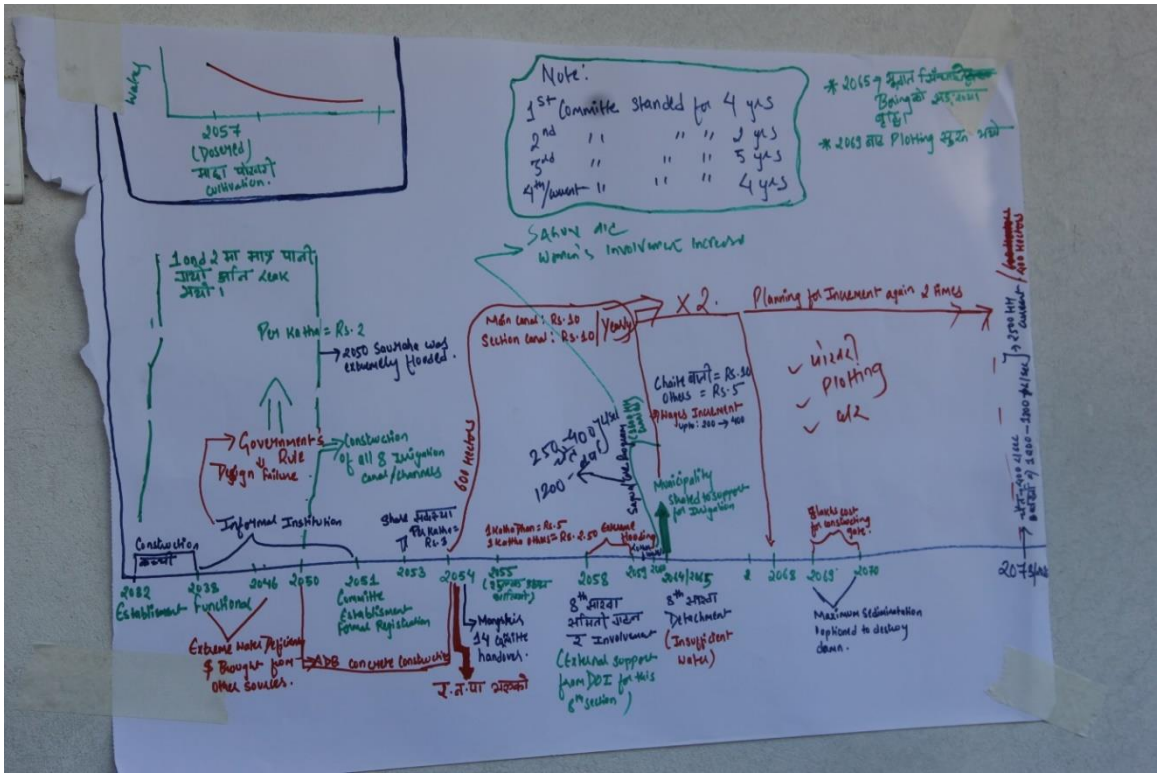


Photo 7 : Timeline exercise with 3 participants on Panchakanya irrigation system

Photo 8 : Female user of the irrigation system with her Potato crops.

Photo 9 : Users and Main committee members identifying key stakeholders during PIL exercise

Photo 10 : Power Interest and Legitimacy tools and Trust Mistrust Exercise

Photo 11 : During the Focus Group Discussion with landless female agricultural labourers.

Photo 12 : Communities are adopting deep boring as a coping mechanism to water deficiency in the irrigation system.

ANNEX 2: HOUSEHOLD SURVEY QUESTIONNAIRE

Household survey questionnaire for a quantitative study on

Community perception to alternative energy sources and

Effectiveness of local governance arrangements

Country…… Year……

ICIMOD

Household Survey (Tool: Questionnaire)

Objective:

- To assess how various local institutions and the action situation (provisioners and beneficiaries) manage (or fail to manage) the effects of climate change enabling and/or constraining coping and/or adaptive strategies undertaken by women and men within households, communities and VDCs.
- Understand the Renewable energy technology Impact on local livelihood of high mountain people.

Participants: 30 households randomly selected but representing both male and female.

Time: 30 minutes

Questionnaire code number:

Enumerator:

Section 1: Socio-economic Roster

1.	VDC	
Code for Village: hill-1; lowland-2		
2.	Name of the Village	
3.	Distance to closest market	
4.	Name of respondent	
5.	Sex	1. Male 2. female
6.	Age	
		Code: 1-<13; 2-13 to 25; 3-25-49 ;4-49 to 60 ; 5->60
7.	Education	
		Code: 1-Illiterate (can't read or write at all) 2-Literate 3-<5 std 4-SLC 5.+2 6.Graduate 7.Degree
8.	Ethnic group	
		Code: 1- Brahmin/chhetri; 2- Newar ;3-Thakali ;4-Kami ;5-Damai, 6-Sarki, 7-Other
9.	Religion	1. Hindu 2. Buddist 3.Muslim 4.Christian
10.	HH source of income (%)	Primary:
		Secondary:
		Code: 1-Farming; 2-Wedge labour ; 3-Local business ; 4-Service; 5- Remittence ;

11.	Migration		In past 2 years has any member of HH migrated? Ye-1, No-2					
			For what purpose? Study-1, Earnin-2, Permanent migration-3, Others-4					
			Where? (Golf-1, SE Asia-2, Korea-3, Europe-3, America-4, other					
12.	HH Monthly expenses	Total						
			Code (upto): 1-<5000 ; 2-1000 ; 3-15000 ; 4-20000 ; 5-25000; 6-25000+					
		Heading	Foodin g	Educatio n	Energ y	Transp ortatio n	Comm unicati on	Other
		Rank						
		Amount						

13.	Ownership of house (if rented skip next question)	
Code for ownership: Own-01, Rent-02		
14.	Owner of house	
Code for owner of house: Male-01, Female-02, Both-03		
15.	Type of House	
Code for type of House: Pakki (permanent)-01, Ardha Pakki (Semi-permanent)-02, Kachchi (temporary)-03 and others-04		
16.	Foundation of house	
Code for foundation of house: Mud/bonded-1, cement bonded-2, RCC with piller-3, wooden piller-4, other-5		
17.	Roof type	

Code for roof type of house: Thatch/straw-1, Galvanized iron-2, Tile/slate-3, RCC-4, Wood/plank-5, others-6		
18.	Wall type	
Code for wall type : Mud bonded-1, cement bonded-2, wood/planks-3, Bamboo-4, other-5		

19. Type of agricultural system. Rainfed-1, Irrigated-2

20. Landholding and ownership (Area will be recorded in local unit and will converted to standard unit for analysis)

Particulars	Area (Ropani/ Muri)	Location of agricultural land in reference to MHP, Above the canal-1 Below the canal- 2
a. Irrigated		
b. Un-irrigated		
Land ownership (Area)	Male:……..	
	Female:……	

21. Is there any conflict in water use? Yes-1, No-2

22. Could you please mention major two conflicts in water use?

-
-

23. Who do you turn to if there is any conflict?

a.) Mukhiya b.) VEC c.)Water user group d.) others

24. How often the conflicts are solved?

a.) Always b.) Sometime c.)Occasional d.)Never

Section 3: What is households' perception of weather variability and climate changes?

3A Temperature and rainfall

Q. No.	Question	Response (if Yes, respond to next column)	
1.	Have your household observed any change in temperature patterns in last 10 years?	Yes = 1 No = 0	Increased =1 Decreased=2
2.	Have your household observed any change in rainfall patterns in last 10 years?	Yes = 1 No = 0	Increased =1 Decreased=2
3.	Have your household observed any changes in summer temperature	Yes = 1 No = 0	Increased =1 Decreased=2
4	Have your household observed any changes in winter temperature	Yes = 1 No = 0	Increased =1 Decreased=2
5	Have your household observed any changes in timings of the monsoon season	Yes = 1 No = 0	Early =1 Delayed =2

3B. Water availability

		Spring	**River**	**Well**	**Tap**	**Canal**
Drinking	**10 years ago**					
	Now					
Irrigation	**10 years ago**					
	Now					
Other use (if any specify)	**10 years ago**					
	Now					

Section 4: Households' perception of extreme events, the impact and response mechanisms

4A what is the perception of households on Climate stresses and extreme events?

#	Natural hazards or extreme events attributed to environmental/ climate change (first identify the main hazards/events of the locality)	Have you ever experienced the change in the following events in this area since last 10 years?	If yes, how has it been changed since last 10 years	During past 10 years to what extent has these events impacted/ affected you or your family?	Have you and your family being displaced or have to migrate due to attributed event and hazard to climate change?	Did you have to lose any property or loss of life due to climate induced hazards?
		Yes=1 No=2 Not applicable =3	Increased =1 Decreased =2	Very low=1 Low=2 Moderate= 3 High=4 Very high=5	Yes=1 No=2 Not applicable=3	Yes=1 No=2 Not applicable=3
a.	Drought					
b.	Forest fire					
c.	Flood					
d.	Water logging/ inundation					
e.	Storm					

f.	Thunder storm/lightening					
g.	Hail					
h.	Extreme rainfall					
i.	Partial rainfall					
j.	Erosion					
k.	Landslide					
l.	Snow storm					
m	Glacial landslide					
n.	Outburst of glacial lake					
o.	Heat waves					
p.	Cold waves					
q.	Outbreak of diseases					
r.	Pest attacks on crops					
s.	Others (specify)					
t.						

4B: How household perceived the Impact of Climatic Stresses?

Extent to which households agree to environmental and climate changes

Q. No.	Questions and filters	Coding categories
404	I have with me some statements by people giving their opinion about different aspects of	

	climate change. As I read out each statement, please tell me the extent to which you agree or disagree with that statement.					
		Strongly disagree	disagree	Neither agree nor disagree	Agree	Strongly Agree
a.	Climate change is impacting agriculture sector mostly leading to declining productivity	1	2	3	4	5
b.	Food insecurity is increased due to extreme variability and hazards					
c.	Invasive species is spreading and impacting the agriculture and forest areas	1	2	3	4	5
d.	New type of diseases are observed in the livestock due to climate change	1	2	3	4	5
e.	Change in weather and climate is causing people to suffer more sickness	1	2	3	4	5
f.	Farmers now use less water for crops and animals than they used to 10 years ago	1	2	3	4	5
g.	Crop growing seasons are changing over the years	1	2	3	4	5
h.	Fresh water sources are being dried up over the years	1	2	3	4	5
i.	Crop productivity has declined over the years	1	2	3	4	5
j.	Crop pest attacks have increased over the years	1	2	3	4	5
k.	Livestock diseases have increased over the years	1	2	3	4	5

l.	There are increased in occurrence and impact of natural hazards	1	2	3	4	5
m.	The loss and damage from the impact of climate change is increasing in recent years (losses at household level)	1	2	3	4	5
n.	Mostly women, children, poor and marginalized groups are impacted more by climate change	1	2	3	4	5
o.	The existing coping and responses is not sufficient to deal with climate change extremes	1	2	3	4	5
p.	The migration trend has increased due to water stresses and impact on agriculture productivity	1	2	3	4	5
q.	Water availability has decreased	1	2	3	4	5

Who is mostly impacted by Climate Change and why?

Women	
Men	
Children	
Elderly	
Disadvantaged	
Ethnic minority	
Poor	

4C: What are the existing Coping and Adaptation Strategies at the household level to deal with climatic stresses?

Sectors and stresses within sectors (e.g. heat and water	Coping (short term or autonomous adaptation)	Long term (planned adaptation)

stresses)		
Agriculture		
Forestry		
Water resources		
Health		
Energy		

Section 5: How household benefited from the Water resource management/arrangements?

Q. No.	Questions and filters	Coding categories				
404	I have with me some statements by people giving their opinion about different aspects of effectiveness of governance arrangements. As I read out each statement, please tell me the extent to which you agree or disagree with that statement.					
		Strongly disagree	disagree	Neither agree nor disagree	Agree	Strongly Agree
a.	The institutions rules and policies are inclusive and community oriented	1	2	3	4	5
b.	The decision making process is fair and transparent					
c.	The participation of users in the meetings and organization activity is high and inclusive	1	2	3	4	5
d.	The executive committee is playing a crucial role in water resource management	1	2	3	4	5
e.	There is regular meeting and	1	2	3	4	5

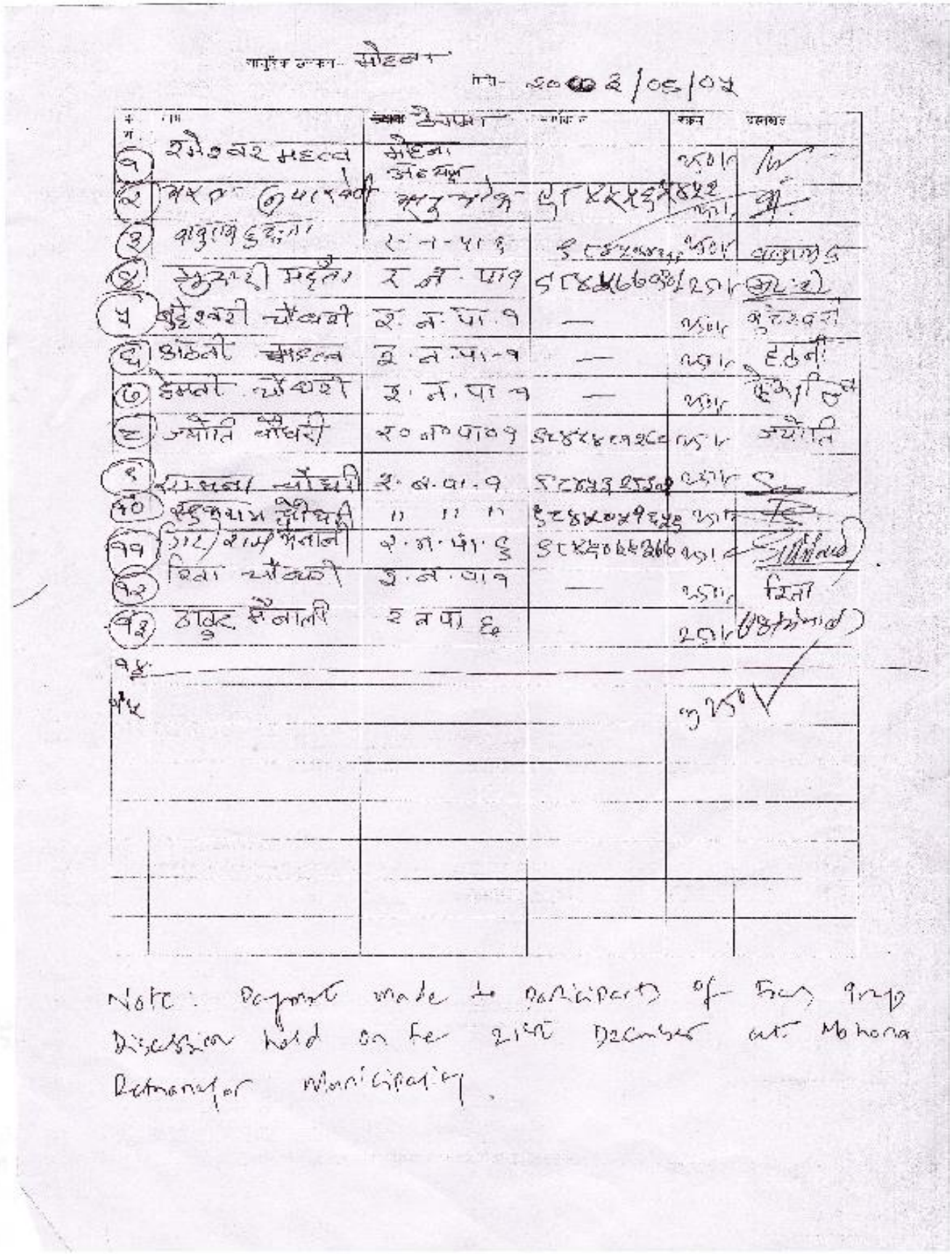
	events to engage users and executive committee					
f.	There is strong network and collaboration among agencies at the local level	1	2	3	4	5
g.	The institution is functioning well in terms of resource management	1	2	3	4	5
h.	Poor, women and marginalized households are given foremost priority in the representation, participation and benefit sharing	1	2	3	4	5
i.	Access to and benefit sharing is fair and transparent	1	2	3	4	5
j.	Due to water resource management the issue of climate change is addressed (reduction in risk/hazard)	1	2	3	4	5
k.	Households are getting multiple benefits from the water management	1	2	3	4	5
l.	Every households in the village is very satisfied with the benefits they have received from water resource management	1	2	3	4	5
m.	You are satisfied with your role and participation in the organization	1	2	3	4	5

Thank you very much for your kind cooperation

ANNEX 3: FOCUS GROUP DISCUSSION SCHEDULE

S. No	*Date*	*Focus Group Discussion Details*
1	16/12/2016	Users of *Panchakanya jal Upabhokta samiti* ward no 4 (female only)
2	16/12/2016	Users from Ward no 7
3	17/12/2016	Participants and users from the branch canals 1,2 and 3
4	18/12/2016	Canal no 8 community members
5	18/12/2016	Timeline exercise
6	20/12/2016	*Panchakanya Jal Upabhokta samiti* (executive committee and its users)
7	21/12/2016	Landless female agricultural labourers

ANNEX 4: FOCUS GROUP DISCUSSION PARTICIPANTS DETAILS



Note: Payment made to participants of this group Discussion held on the 21st December at Mahona Rathmanpur Municipality.

Memo No. _____
Date: २०७९ ०६ १०७

FGD with Users

क्र.स	नाम	ठेगाना	सम्पर्क नं	हस्ताक्षर
१	[illegible]	2.4.41..6	9745065866	२५०
२	[illegible]	"	9745207866	२५०
३	[illegible]	"	9745206522	२५०
४	[illegible]	"	9865105159	२५०
५	[illegible]		9745420264	२५०
६	[illegible]	"	9745496366	२५०
७	[illegible]	"	9809272424	२५०
८	[illegible]	"	9745	२५०
९	[illegible]	"		२५०
१०	[illegible]	"		२५०
११	[illegible]	"		२५०
१२	[illegible]	"		२५०
१३	[illegible]	"		२५०
१४	[illegible]	"	9845617855	२५०
१५	[illegible]	"	9845616266	२५०
१६	[illegible]			२५०
१७	[illegible]			२५०
१८	[illegible]	"		२५०
१९	[illegible]			२५०
२०	[illegible]	"	9845139451	२५०
२१	[illegible]	"	9845271724	२५०

Note: Name not in community forest

Date: [illegible]

Panchayan
Irrigation

Su Mo Tu We Th Fr Sa

FGD with Users

Memo No. _____
Date : 2009 08 / 09

क्रमसंख्या	नाम	टिप्पणी	सम्पर्क नं	रकम	हस्ताक्षर
(१)	नाटो चौधरी	देवीलाल-४ सदस्य-४	—	२५०/-	नाटो
(२)	गुलमी चौधरी	"	9845218869	२५०/-	गुलमी
(३)	मैया चौधरी	"	9845342893	२५०/-	मैया
(४)	शत्रुघ्न चौधरी	"	—	२५०/-	शत्रुघ्न
(५)	लखनै चौधरी	"	9845222040	२५०/-	लखनै
(६)	रानी चौधरी	"	9845057480	२५०/-	रानी
(७)	राजकुमारी चौधरी	"	—	२५०/-	राज
(८)	पुष्पराम्या चौधरी	"	9845318223	२५०/-	पुष्पराम्या
(९)	बौंती महत्व	"	—	२५०/-	बौंती
(१०)	रविता चौधरी	"	—	२५०/-	रविता
(११)	लक्ष्मी चौधरी	"	9८४५०४२४३२	२५०/-	लक्ष्मी
(१२)	चहावो चौधरी	"	9८०४६१०९४०	२५०/-	चहावो
(१३)	रामनुराम चौधरी	"	9८४५०४३६३६	२५०/-	रामनुराम
(१४)	डाकुर मौनाली	देवा-८	9८४५२७१७४५	२५०/-	डाकुर
(१५)	सितारा महतो	देवा-८	9८४१४२६९६	२५०/-	सितारा
(१६)	गिरी राम मैनाली	देवा-८	9८४२०६५३६०	२५०/-	गिरी राम
(१७)	प्रमोदा	"	—	२५०/-	प्रमोदा
(१८)	विक्रमचौधरी	डाँगीपुर	9८४२३४८९८८	२५०/-	विक्रम
				४५१/	

Note: Request made to Community for their time for FGD.

नगरपालिका [illegible] वार्ड नं. [illegible]

दिनांक 2062/05/02

क्र. सं.	नाम	पेशा	कार्ड नं.	रकम	दस्तखत
(1)	नारायणदत्त पौडेल	[illegible]	[illegible]	[illegible]	[illegible]
(2)	तिलक राज पौडेल	[illegible]	[illegible]	[illegible]	[illegible]
(3)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(4)	गिरे [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(5)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(6)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(7)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(8)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(9)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(10)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(11)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(12)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(13)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(14)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(15)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(16)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(17)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(18)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(19)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(20)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(21)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(22)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(23)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(24)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(25)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: payment Made to participants of Focus Group Discussion held at ward No. 6 of Rethanagar Municipality

मितेसारे, गाईटोले, रत्नपा-४.

समूह अगुवा तुलसी माया तामाङ

अध्यक्ष साक्षी अनुमोदन नं:- २०७३/०५/०२

क्र.सं.	नाम	हस्ताक्षर / औंठाछाप	दस्तखत	रकम	कैफियत
१	लक्ष्मी साम्की			३०१/-	लक्ष्मी
२	लक्ष्मी साम्की			३०१/-	लक्ष्मी
३	सरस्वती "			३०१/-	सरस्वती
४	चाहिन सुनुवार			३०१/-	
५	दिल खरारी थामी			३०१/-	दिलखुमारी
६	विरमाया साम्की			३०१/-	विरमाया
७	बसु साम्की			३०१/-	
८	सरस्वती साम्की			३०१/-	सरस्वती
९	सीता साम्की			३०१/-	सीता साम्की
१०	माया साम्की			३०१/-	माया
११	तुलसी साम्की			३०१/-	तुलसी
				३०००/-	

Note: Payment made to participants of focus group discussion at Mitresari, Kathmati ward No. 5 of Ratnanagar Municipality, Chitwan

पंचकन्या
[illegible] मिति २०६८/०५/०६

क्र.सं.	नाम	पद/ठेगाना	सम्पर्क	रकम	दस्तखत
१	सीताराम घिमिरे	इ.न.पा. ५ आरोग्य जीवन	९८४४०९३४०८	२५०	[illegible]
२	कुन्दन महतो	इ.न.पा. ६ आरोग्य सरोवर	९८४२९२३६२१	२५०/	[illegible]
३	संजु लामा	इ.न.पा. ६ [illegible]		२५०/	[illegible]
४	[illegible]	[illegible]	९८४२५४०८०	२५०/	[illegible]
५	[illegible] प्रसाद अधिकारी	इ.न.पा. ७ [illegible]	९८४२४५४२३३	२५०/	[illegible]
६	सुरेन्द्र [illegible]	इ.न.पा. ६ [illegible]	९८४२०१८४२३	२५०/	[illegible]
७	नीलबहादुर मैनाली	"		२५०/	नीलबहादुर
८	[illegible] राम परियार	"		२५०/	[illegible]
९	[illegible] शर्मा	इ.न.पा. ८		२५०/	[illegible]
१०	[illegible] बहादुर लम्साल	इ.न.पा. ४		२५०/	
११	[illegible] कुमार शर्मा	इ.न.पा. ६ [illegible]	९८४६७५४	२५०/	[illegible]
१२	[illegible]	इ.न.पा. ८ [illegible]	९८४२४२३४६९६	२५०/	[illegible]
१३	लक्ष्मी चौधरी	इ.न.पा. ७ [illegible]	९८४२०२४२५७२	२५०/	[illegible]
१४	राम हरि मैनाली	" [illegible]	९८४२०४४२४९	२५०/	[illegible]
१५	रामेश्वर महतो	इ.न.पा. ४ [illegible]	९८४२०४२६१८	२५०/	[illegible]
१६	[illegible] राज मैनाली	इ.न.पा. ६ [illegible]	९८४२०६४२६६	२५०/	[illegible] मैनाली
१७	देवी ला. कार्की	इ.न.पा. ८ [illegible]	"	२५०/	[illegible]
१८	टंकनाथ पौडेल	इ.न.पा. [illegible]	९८०४२४२४०६	२५०/	[illegible]
१९	चन्द्रिका लम्साल	इ.न.पा.		२५०/	[illegible]
२०	सरस्वति घिमिरे			२५०/	सरस्वति
२१	चेतकुमारी मैनाली	इ.न.पा. ३		२५०/	चेतकुमारी
२२	अनिता [illegible]	"	9811227948	२५०/	अनिता
२३	[illegible] मैनाली	"	561786	२५०/	[illegible]
२४	दिपा [illegible]	"	561359	२५०/	दिपा
२५	चन्द्रप्रसाद पाठक	"		२५०/	[illegible]
				६२५०/	

Note: Payment made to the participants of Focus group discussion with Panchakanya Users Committee at Itahari [illegible]

-णुक उपकरण- FGD

उपभो. मा: 2063/05/02

क्र. सं.	नाम	* हैसियत	सम्पर्क न.	रकम	दस्तखत
१	प्रेम बहादुर	I. न. पा. ट	९८४९२३५४६	५०/-	प्रेम
२	सरिता महतो	२. न. पा. ट	९८४४०६५९५०	५००/-	सरिता
३	सागता चौधरी	२ न पा ट	९८४२८४९९६०	२५/-	सागता
४	मनु चौधरी	२. न. पा. ट	९८४४२९६२६०	५००/-	मनु चौधरी
५	बिन चौधरी	२. न पा ट	९८४५६४६१८	२५०/-	बिन
६	सीता न्यौपाने	२. न. पा. ट	९८४९२१८९	१५५०/-	
७	हिरी लाल चौधरी	" "	९८४५३२	८०५/-	
८	मंगल लाल चौधरी	" "	९८४५३४०९५४	२५०/-	
९	जुरेराम दंगे	" "	९८४५१४२०३६	८०/-	जुरेराम दंगे
१०	सिता देवकोटा	" "		२५०/-	सिता
११	कुल आथा			२५०/-	कुल
१२	विष्णु देवकोटा	२ डब्लु-५		२५०/-	विष्णु
१३	शम्भु [illegible]	[illegible] ट	[illegible]	२५०/-	[illegible]
१४	सरस्वती [illegible]	२ नं पा ९	९८४९०१६१	२५०/-	[illegible]
१५	[illegible]	=	९८४९३१०१६	२५०/-	[illegible]
१६	[illegible]	२. न पा. ८	८४९२३२०६०	२५०/-	[illegible]
१७	अनु कोईराला	२-न पा-९	९८६-५	२५०/-	

Note: Payment made to the Participants of this group discussion of Irrigation Users Group 1, 2, 3 of Bethanchok Municipality.

बुटवल उपमहानगरपालिका नगरपालिका कार्यालय
मिति- 2073/03/05

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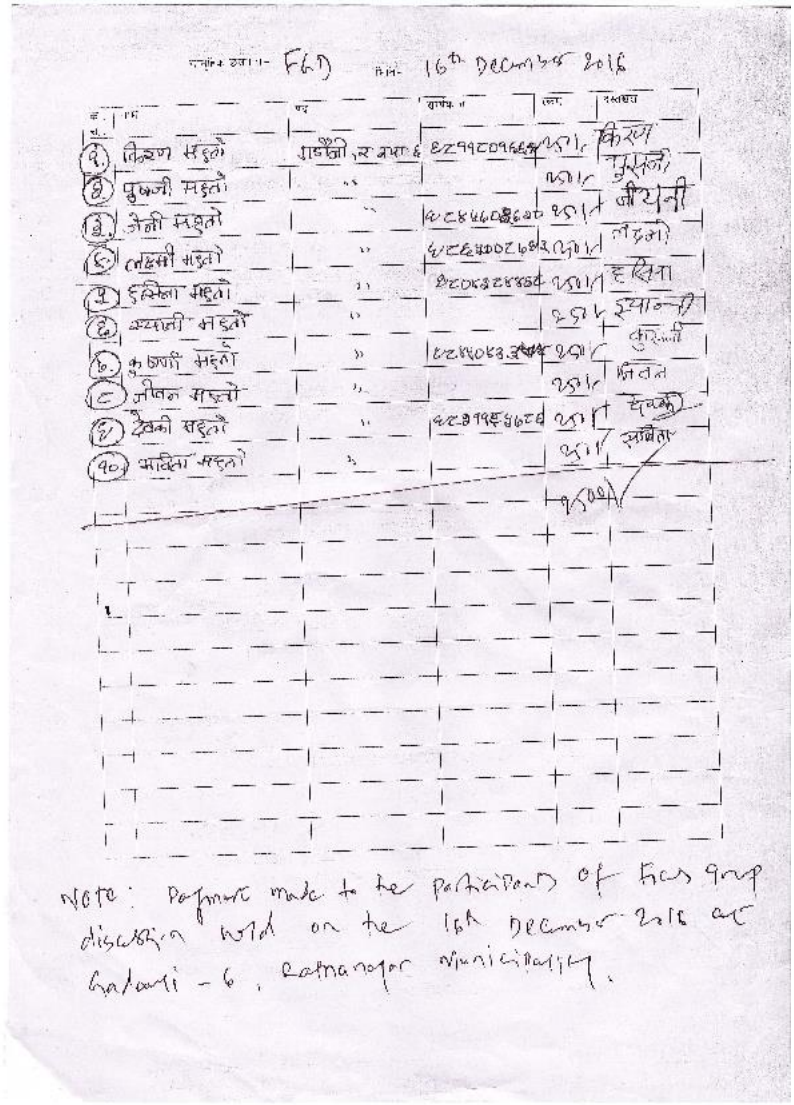
Note: Payment made to the Participants of
Focus group discussion held on the 28th December
at Jyoti Kashiram, Butwal.



Note: Payment made to the participants of focus group discussion held on the 16th December 2018 at Kalanki - 6, Ratnanagar Municipality.

ANNEX 5: FOCUS GROUP DISCUSSION NOTES

1. Day 1, FGD 1- Panchakanya jal Upabhokta samiti ward no 4 (female only)

In the first focus group discussion, the female participants belonged to Main canal 6 and sub canal 2 (which irrigates about 4-5 *bigha* land). Majority of the participants were *tharu* women with few Brahmin women. Most of the respondents were small holder farmers and shared that they received very less water in the command area compared to head end users. They received water for only 2 days in a week. Since, they lack other ground water sources and alternatives; they have to pay Rs 100 for 1 hour to pump groundwater from others' farm well. The electricity comes for only 15 Mins and the rest they have to use diesel generator for which they have to pay double the rate.

As a result the communities belonging to this sub canal can only plant one crop a year and *Musuro* (legumes) during winter. The rest of the time, they have to do daily wage labour in construction or nearby factory (mills , wood mill, flour mill). Male migration is not a big issue here, as most of the male prefer working in the flour mill.

In response to climate change , the participants shared that they have experienced increase in hotness/ temperature along with shift in rainfall, change in duration, change in amount: intense rainfall in short duration. Rainfall, now, starts *Asaar* end now, before it used to be *Asaar* 15. The calendar for nursery (*Byad*) preparation was from *Jestha* 5-6 now it has shifted to end of *Jestha*. Climate induced hazards have increased, new pest attacks are seen (new pests- *Fauji* pest, new diseases, *dadhuwa* Disease in Potato etc)

Water availability has decreased from the irrigation source in last 20-25 years due to shrinking of *Panchanadi* and the increase in groundwater extraction by *Padampur* settlement near the source and sedimentation.

Regarding the *Panchakanya Jal Upabhokta samiti,* many women had very less/ no idea on the committee or its members. Their only contact point was the representative in the committee from their branch canal. They don't have much idea on the rules and regulations of the committee either. The participants rated the participation in the committee as weak while the women inclusiveness was mediocre and the inclusion of poor and marginalized was rated as weak. In regards to access of resources, they shared that women are at the forefront while working but aren't included in decision making as men are involved there. Since,

giving time for community/ committee work is always voluntary, poor and marginalized are not very active there. There have been many improvements when it comes to conflict management. Previously, the landlord had access to water firstly, while even ordinary people (who are nearer to the irrigation source and canal) also can access irrespective of their economic and social background. So, the upstream communities have more access to water, and they can have two crops per year. Still, the ward that was further from the head source had less access. This is also because of damages in the canals, and hence there are huge losses of water and the tail end communities suffer from these losses. Also, previously there used to be huge theft of water, which has improved considerably now and hence this committee is more effective than the others.

However, they also shared that there have been no AGM and there hasn't been any transparent sharing of accounts last year at all.

Alternatively, there have been other cooperatives in their ward (such as Aadibasi tahru Kisaan samuha) that have been providing the farmers with the service of hiring pumps for groundwater, training on integrated Pest Management and improved farming skills. In a way, these cooperatives are providing the farmers with alternative coping strategies that the Panchakanya Water users committee has failed to provide.

2. Day 1, FGD 2- Users from Ward no 7

The second focus group discussion was conducted with ward no 7 communities, which belong to canal no 7. There were 115 HH, who were mostly Chaudhary. The participants shared that during monsoon, they planted paddy cultivation, while in winter they plant vegetables. Pre Monsoon is the driest season. The community have an hourly system where all the farmers in the ward get water for one hour in a turn wise manner. However, lots of conflict arises when households act slightly irresponsible and try to take advantage of other's turn. The main issue for them is the lack of maintenance of canals as there are huge holes in the mud lined canals.

Almost 40% of the houses in this ward have boring facilities and use it in irrigation as well. Some people have installed boring with their own resources while others have installed with government support through *Bhumigat Jal Sinchai Aayojana*. (cost: Rs 70000 per HH)

The participants shared that water availability has decreased over the years, changes in climate, many human induced changes as well such as population pressure, plotting etc. They

have observed 15-20 days delay in monsoon with no/ less winter rain. Increase in pest attacks (*laai kira)* due to variability in rainfall and temperature which has increased cost of insecticides has also been observed. Similarly, there have been changes in cropping pattern and decrease in soil fertility due to extensive single cropping.

Grain Exercise was conducted where men and women were given grains/ lentils and asked them to be dividing in two groups and rank the identified issues within the irrigation system. Following issues were prioritized:

Men priorities	*Women priorities*
1.Distribution of Water	1.Water related conflicts
2.User's participation in committee	2.Unequal distribution (head end users access more water)
3.Carelesness of Users	3.Less water availability
4.Reduction in water availability	4.mismanagemnt of irrigation canal/ lack of maintenance
5.Infrastructure challenges	5.Lack of concrete canals

This exercise showed that communities were more concerned about the governance and distribution of water than the decreasing water availability due to climate change. It also showed that men and women priorities were slightly different as men shared that the water distribution was the main problem while women shared that the conflicts due to water was a major one.

Also, the need for more participatory approaches were highlighted as they shared that there is an information gap between users and committee. Internal governance should be strengthened. More capacity building esp. for women is needed. Trust should be developed between users and user groups. Investment in infrastructure is also needed.

3. Day 2, FGD 1- Participants and users from the branch canals 1,2 and 3

The third focus group discussion included participants who were mostly from outlet 1, 2 and 3; including both the users and branch canal representatives. Some of the branch canals were also members of the executive committee as well. Firstly, resource mapping exercise was conducted with the participants. The participants drew a map of the *Panchanadi* area and

highlighted that since the ponds lie in private lands, it is very difficult for the committee to take necessary conservation initiatives. So far, the owners of the land have been cooperative and the lakes are conserved but the future is uncertain. Similarly, there has been excessive decline in water flow (almost less than 50% in 10 years time) which is exacerbated by the annual sedimentation problem during monsoon. Population growth and the cultivation of more water demanding crops have also attributed to the scarcity of water within the system.

Outlet no 1, 2 and 3 have more access to water than other outlets . In regards to climate change, communities have perceived less rainfall. Shifting of season was also reported. Water scarcity was more prominent during pre-monsoon period (*Jestha*- early *Asaar*). Due to less water availability, farmers near the head box are also unable to have two crops a year.

The participants also identified that the implementation of the committee was very weak. Even though the committee was in authoritative position, it was unable to exercise its authority or punish the wrong doers effectively. The reason for committee's weakening position is its failure to provide adequate water to its users, lacking transparency and its inability to repair and maintain the canals and the system as per the necessity. Hence, 40% of the users never pay their water tax (*paanipot)* and the committee stays aloof.

Similarly, the participants also exercised hazard mapping exercise. From the exercise, the participants shared that the nature of hazard was slowly changing. Previously it was the flood that occurred frequently and caused huge economic loss. However, in the recent years flood has receded and there is a growing impact of prolonged drought. After the exercise the participants listed the major challenges and benefits to and from the committee for different outlets which are as follows:

Outlet	*Problems*	*Benefits*
1	Water availability decreases and causes distress in agriculture	12 months water access
	Canal cleanliness and maintenance	less time for water to travel due to proximity
	wildlife intrusion??	more cropping- rice cultivation
	leakage in canals	
2	Maintenance of the canals and system	
	Transparency of committee	

	Challenge of generating water fee from users	
	Cleanliness of branch canals	
3	Participation of women	
	Water fee collection	
	Cleanliness	
	Maintenance	

From the exercise, it was observed that the decreasing water availability in the system was the major challenge that could be attributed to climate change. Apart from this, other issues identified were largely related to water management and governance issues. Similarly, in terms of benefits, it was exclusively for the outlet 1 communities, who were closer to the source, while the other outlets were unable to access the water easily.

Apart from this, it was also observed that branch canal representatives were the major links between the executive committee of the water user group and its users. When the branch canal members are strong and communicate effectively, the users feel more aligned sympathetic and responsive to the committee; whereas if the branch canals representative were aloof or non-responsive towards the user's and their problems, the users were found to be more aggressive towards the committee. In most of the cases, branch canal members are mostly influential farmers, who have big landholdings and can spare time for voluntary committee work. Hence, they tend to fail to include the issues of poor and small landholding farmers. This also shows the failure of the committee to be more inclusive for the female and marginalized users within the system.

4. Day 3, FGD 1- Canal no 8 community members

A focus group discussion was organized with the previous communities of Canal no 8. the community had exited from the water users' committee in 2006/2007 and opted for deep boring systems for ground water extraction. The community lies at the tail end of the system and hence receive the least amount of water. The community are mostly Brahmin. They shared that they had been raising their dissatisfaction with the committee and their need for more irrigation water but the committee did not address their demand. Hence, after 7 years ,

when *the Purbi rapti Bhumigat jal sinchai Aayojana* started operating in Chitwan they shifted to alternative sources of irrigation and exited the Panchakanya irrigation system. They also have a small rivulet nearby from where they can access water for irrigation as well. Many of the farmers are now planting various new cash crops, and some have even shifted to fish farming enterprises as well.

This community had alternative sources for irrigation water along with access to knowledge and institutions. These factors enabled them to exit the system. If we compare this group with the participants from ward no 4, who were poor and marginalized farmers with no other alternative sources, we can see how access to resources, to alternative sources and technology, can play a key role in increasing the communities' adaptive capacity. The communities in ward no 4 have also been receiving very less water from the system and also have parallel institutions to fulfil the institutional vacuum left by the Panchakanya Users' group committee. However, they have been coping with the irrigation deficit by using expensive diesel electric water pumps on hire and are barely able to make the ends meet. On the other hand, due to alternative sources of irrigation and access to deep boring technology, the previous communities of ward no 8 are able to start other enterprises and more water intensive crops after leaving the system.

5. Day 3 FGD 2: Timeline Exercise

A timeline exercise was conducted with 3 participants during a FGD, which has been presented below:

Year(BS)	*Event*
2031-32	Establishment and construction
2038	Run under government through an informal committee
2050	Big flood in sauraha
2051-52	Registration (075- Registered no)
2050-54	ADB Project
2053	Here, when the government was managed the Irrigation system, they had announced shares which was Rs 3 per *Kattha.* Local communities used to provide labor support.
2054	Handover to farmer management committee
2057	Use of bulldozers to remove sedimentation at the spring source, the ponds for

	fish farming in private lands also started: helpful for irrigation system as it discouraged plotting and helped in water conservation at the source
2058	Canal no 8 was unhappy due to less water
2058/59	Big flood
2065	Canal no 8 separated due to less water access and opted boring
	Govt/ municipality provided support which was not a big support but was often for small maintenance.
	Start of *Purbi rapti Bhumigat Sinchai karyalaya*- more boring/ Ground water use intensified
2069	Rs 600000+30%= Rs 800000. They used the money to build the gate to replace the dam structure and make the irrigation system more efficient.

During the timeline exercise, the participants shared that the system was handed over to the farmer committee in 2054 BS (around 20 years ago). Since then various elected committee members have been handling the users group. The issue of sedimentation has been addressed occasionally since 2057 by using bulldozers. There have been some inflow of external supports from time to time but they have been small in amount and insufficient to continue the repair and maintenance. The committee has been unable to save significantly and has always been in financial deficit.

In 2058 BS, around 4 years after the system was handed over to the farmers, canal no 8 expressed their dissatisfaction with the water distribution within the command area, as they were tail end users and received very less amount of water. Consequently in 2065 BS, they separated from the system and started extracting the ground water for irrigation. This was the same year, when *Purbi rapti Bhumighat Sinchai Aayojana*(East *rapti* Ground water irrigation project) started its operations in Chitwan.

Similarly, the participants also shared about the changes in the crop cost (*paani pot*) and maintenance cost over the years, which has been summarized below:

Year	*Rate/ Charge*
2054-65	Labour cost per *kattha*=Rs 10
	Labour (for Canal)cost per *kattha*: Rs 10
	Cleanliness cost: rs 20 yearly

	water cost: Rs 5 / *kattha*: paddy
	water cost: Rs 2.5 / *kattha* for corn and other crops
Now	Labour cost per *kattha*=Rs 20
	Labour (for Canal) cost per *kattha*: Rs 20
	Paddy during monsoon: Rs5/*kattha*
	Paddy cost during pre-monsoon: Rs 10 / *kattha*: paddy
	water cost: Rs 5 / *kattha* for corn and other crops

It is interesting that over a period of 10 years the *paanipot* and the labour cost have doubled. For instance, the labour cost was Rs 10/*kattha* in 2054 BS while it became Rs 20/*kattha* in 2065 BS. However, this increase in cost has not taken into account the climatic impacts or costs such as less water availability into account. It has only considered difficulty in hiring labourers. When asked if there is any special consideration for poor marginalized farmers, there were none. Hence, both the head end users and tail end users have to pay the same amount irrespective of the fact that they don't get equal access to water. `

6. Day 5 FGD 1- executive committee members and users

Another FGD was carried out with the executive committee members of the Panchakanya Water users Committee and its users. During the discussion, the participants shared that increase in temperature and decreasing severity of winter are the key perceived indicators of climatic change. Similarly, the relocation of *Padampur basti*, changes in land-use and deforestation were identified as the key environmental stresses.

The participants also shared that in recent years, due to extensive farming and use of fertilizers and pesticides, the fertility of the soil has been decreasing. Hence, the farmers need agricultural training and improved agricultural training. Similarly, the participants identified the need of technical study to improve the efficiency of the irrigation system. For this, the committee members should be properly trained. They also highlighted that the resource constraint has been grappling the committee for years and due to the lack of technical knowledge on system efficiency and maintenance, the FMIS has been weakening over the years. Similarly, there is a need to provide commercial farming training to farmers, such that the farmers can get more benefits and the irrigation system can also generate more revenue.

When asked about the increasing use of ground water extraction by farmers to compensation the irrigation deficit , they admitted to the fact but said the committee has not done anything in that direction and it has been an autonomous coping strategy.

During the Power, institution and Legitimacy (PIL) exercise, it was highlighted that the committee has been unable to include major stakeholders and users in decision making and there is a growing mistrust between the committee and its users. Similarly, as per the mandate of the committee, the committee was supposed to conduct annual general Assembly annually. However, there has been no AGM since last five years. The trust mistrust exercise showed that the users did not trust the committee (66.67%).

7. Day 7 FGD 1- Female landless agricultural labourers

In another focus group discussion, we discussed with the female landless agricultural labourers within the system. They shared that they had a separate community, of around 40-50 households, within the command area of the Irrigation System, who were all landless Tharu community members and worked in agriculture labour on a daily wage basis. Some of the families were displaced from the Chitwan National park while some had lost their land (due to various reasons such as drinking habit, gambling, etc) only some generations before. In both cases, they have been working in others farms since 2-3 generations and all they know is going to the field and working there till the sun sets. Agriculture labourer is their daily livelihood.

In the recent decade, as the water availability for irrigation has been decreasing, many farmers/ landowners have opted to do personal or communal deep boring and had been using ground water for irrigation. Hence, the farmers / landowners had to pay additional cost for pump, electricity or diesel. They also reported that due to increasing occurrence of many new invasive species and new diseases in the crops, the famers/ landowners were also compelled to use additional pesticides and herbicides in huge amounts. This has led to increased cost of agricultural costs on one hand while the profits from agriculture remained the same.

Owning to this trend, within the command area, many famers/ landowners have already started leaving their land fallow. Some have sold to their land for housing purposes. As you drive across the command area, one can already see plotted lands for housing purposes, instead of agricultural fields. This has directly impacted the livelihoods of the agricultural labourers.

Further, many farmers, who are still continuing agriculture within the command area, in spite of increased cost of irrigation, have started using contract services for the agricultural help. The labourers in the discussion shared that, many workers, who reportedly hail from Siraha and *Saptari* districts provide their agricultural labour services along with sue of modern agricultural technologies such as tractors, etc. Since, they complete work in fields in shorter and cheaper than as had been the case with traditional agricultural labourers, more and more farmers are opting these contract services over hiring the landless traditional agricultural labourers.

This has severely impacted the livelihood of the landless daily wage agricultural labourers. Many of the labourers have no another skills other than agricultural skills. They also lack the resources and technical knowledge to use sophisticated technologies unlike the contract group of labourers from other districts. Men, from these communities have started shifting to construction work as labourers there. Some were also working in the oil mills as labourers nearby. Women, without the skills and the capacity to work as agricultural labourers, are forced to stay at home these days. One of the participants shared, that it was getting more difficult to feed her family of five twice a day, owning to the lack of employment. Single women and widows are most affected.