USE-INSPIRED RESEARCH ON ADAPTATION STRATEGIES OF FARMER-MANAGED IRRIGATION SYSTEMS IN GANDAKI BASIN, NEPAL

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Executive Summary

Nepal has a long history of irrigation water management by farmers, also called as a farmer-managed irrigation system, where they take the sole responsibility of operating and maintaining the irrigation systems. While FMIS have survived decades of socioeconomic and hydroclimatic changes, these systems are also increasingly under stress due to local, regional and global level changes like climatic variability, labor out-migration, market pressures, and watershed degradation. Based on the feedback from my initial work on Nepal and research work of Netra Chhetri (Associate Professor, Arizona State University) in the region, I have chosen the two Water Users Group (WUA) of Nuwakot district of Central Nepal as the users and collaborative partners for this research. Based on the farmers' demand, I have two main objectives behind this research: 1) conduct a participatory vulnerability assessment of the irrigation systems under stress from climatic variability and natural disasters (earthquake); and 2) support the farmers with the development of appropriate adaptation strategies.

The study used the participatory vulnerability assessment methodology as proposed by Machhi (2014) that comprises of participatory based tools like focus-group discussion; transect walk and informal and semi-structured interviews to collect the necessary data in the field. Special attention was provided to ensure heuristic learning and continuous engagement with stakeholders at different stages of the research. Due to the earthquake in April 2015, farmers have different priorities during the period of my field visit. Understanding and respecting their other commitments, I focused my field research on selected components of social vulnerabilities (biophysical risks, earthquake risk, and market pressures) and adaptation. I have excluded other drivers of social vulnerabilities like equity and power relations.

The study has provided some key insights on climatic and social vulnerabilities affecting the farmers and adaptation responses of these farmers to changing climatic conditions. The farmers have addressed these climatic and socioeconomic challenges through different strategies. In order to supply additional water during shortages, they have installed community-managed water pumps to lift river water to up to 40 feet high and distribute through existing irrigation distribution system. In areas where augmenting additional water is not an option, farmers have switched to less water-demanding crops. Most of the farmers now use hybrid varieties that produce high yield for less water. They have new rules to manage the water-related conflict that is more common during the dry season.

Information gained through this research has been disseminated through interactions with the farmers during repeated field visits and conversation over the phone during my field stay in Nepal. In addition, since I have received external funding from ICIMOD to continue this research as my Ph.D. dissertation, I am working with the same group of farmers during my field visit of summer 2016 through an iterative process. Also, I am working on another deliverable i.e. the booklet on best practices on adaptation in irrigated agriculture. This booklet is expected to be released in December 2017 after I complete my third field visit in summer 2017.

1. Introduction

Small-scale irrigation systems, which are critical for food security, are under stress from climatic and non-climatic factors. Nearly 90% of farms in the world are less than 2 hectares, and a large proportion of these rely on irrigation that consumes an estimated 70% of global water supplies (Molle, 2004). The irrigation and agricultural systems are highly sensitive to climate change as it alters the seasonality and quantity of surface water flow, intensifies the variability in precipitation, and increases the frequency of droughts and flood risks (see Table 1) (Field et al., 2014). In addition to climatic changes, these systems are also challenged by socioeconomic and institutional changes, including high migration, market penetration, price volatility, and political turbulence (Janssen et al. 2007). Farmers and communities have been coping with and adapting to these changes for generations using indigenous and local knowledge (Chhetri, Subedi, & Ghimire, 2013). A rigorous understanding of the existing coping and adaptation practices can provide valuable insight into adaptation to future climate change in the region and globally. Further, a sound understanding of potential adaptation opportunities can shed light on pathways to climate-resilient irrigated agriculture.

Nepal has a long history of irrigation water management by farmers where they take the sole responsibility of operating and maintaining the irrigation systems. In the absence of strong government intervention in the past, farmers managed irrigation systems (FMIS) have slowly evolved through the collective effort of farmers to irrigate their agricultural land. According to the Department of Irrigation (DOI), FMIS irrigate about 645,716 hectare of command area which is about 67 percent of total surface water irrigation.[1]In Nepal, FMIS are characterized by the use of low-cost technology appropriate for heterogeneous local conditions, autonomous decision making suited to local contexts, and collective action by farmers for the operation and maintenance of the irrigation systems.

The Water User Association (WUA) in Nuwakot districts, which comprises of the group of farmers that manages the FMIS, in Nepal have voiced their need for assistance in the identification of climate change impacts on the local irrigation system and device response strategies. In response to these concerns, the project has three objectives:

i) Conduct participatory assessment on some elements of biophysical and social vulnerabilities of the FMIS to climatic stresses;
ii) Conduct preliminary assessment of the impacts of Gorkha Earthquake of April 24, 2015 on FMIS system; and
iii) Provide support to the WUA with the development of appropriate adaptation strategies.

[1]DOI. (2007). *Development of Database for Irrigation Development in Nepal* (p. 180). Department of Irrigation, Kathmandu, Nepal.

The first part of the study focuses on participatory vulnerability assessment against climatic variability and change. The study adopted some of the methods and tools as proposed by community-based climate vulnerability and capacity assessment to assess the climatic and natural disasters risks and their impacts (Machhi 2014). The adaptation strategies were primarily developed through interactions with farmers and related stakeholders, mainly personnel from related government and non-government agencies like Department of Irrigation, Ministry of Agricultural Development, and FMIS Trust. The earthquake impacts assessment was evaluated through field visit and interactions with farmers in the affected area.

Table 1: Climatic vulnerabilities and adaptation strategies in irrigation sector

Climate variables	**Vulnerabilities to irrigation**	**Adaptation strategies**
Reduced and variable precipitation	-Less water available for irrigation - Increase in irrigation requirements from evapotranspiration	- Structural development & improvement of irrigation reservoir capacity and drainage systems - Increase in water efficiency using water saving technologies & water efficient cropping systems - Organizational strengthening for effective and efficient water management - Reducing mal-adaptation via equitable water allocation & conflict resolution mechanisms; reducing trade-off - Extension Services for capacity building& anticipatory adaptation
Intensification of precipitation	- Structural damage to reservoir, intakes and canals	
Intense/prolong/ the increase in drought	- Water shortage for irrigation - Increase in irrigation requirements	
Increase in temperature	- Water shortage in spring run-off dependent irrigation system - Near-term increase in glacier-fed irrigation system - Increase water requirements due to evapotranspiration	

(Source: Adapted from JICA, 2014)

2. Study area

The study focuses on the detail case study of two FMIS located in Nuwakot district of Central Nepal (see Table 2). Nuwakot district is chosen because it is located in Trishuli-Narayani sub-basin of Gandaki River Basin (GRB) in the Central and Western Nepal, and there were existing contacts and interest of international institute called International Center for Integrated Mountain Development (ICIMOD) in the region with whom I worked closely during the field research.

The screening visit of FMIS was conducted on four FMIS in the same district with the main objectives to understand the impacts of the earthquake on changing the climate. The two FMIS are selected for detail case study to understand the impacts and response of FMIS to changing climate.

Table 2: Irrigation project visited

FMIS / Irrigation Project (I.P)	Village Development Committee (VDC)/Ward	Command area & beneficiary household	Study conducted
Pokharephat I.P.	Khadga Bhanjyang-5	75 acre ; 55 household	Case study
Kamalakuti Pipale I.P,	Belkot	17 acre ; 25 household	Case study
Labdu Dhikure I.P.	Khanigaun-5, Bidur Municipality	360 ha; 1000 household	Screening visit
Kabilas-Simari I.P.	Chaugada-1	463 ha, 1330 household	Screening visit
Simutar Indriyani I.P.	Derkhu-3, Bidur Municipality		Screening visit
Sundaradevi I.P.	Sundaradevi-4	600 rop; 55 household	Screening visit

3. Research Method

The emphasis of the project is on the use-inspired collaborative research that focused on: i) usability, ii) heuristic learning, iii) stakeholders engagement, and (iv) deliberation and processes (Ferguson, Rice, & Woodhouse, 2014; Jacobs et al., 2010). The research entailed following methods incorporating the elements of collaborative research:

i) *Participatory vulnerability assessment:* The study followed the methods and tools proposed in the manual called "Community framework for community-based climate vulnerability and capacity assessment in mountain area" by Macchi (2014). Within the participatory vulnerability assessment, some of the methods that were used include participatory rapid appraisal tools like transect walk, focus group discussion, and semi-structured interviews with relevant stakeholders and farmers.
ii) *Assessment of adaptation assessment:* Using focused group discussion and field survey; the study has generated a list of structural and non-structural strategies that the community has implemented in response to climatic stresses. A semi-structured interview was also conducted with related stakeholders, mainly Department of Irrigation, Department of Agricultural Development, and ICIMOD personnel, understand the strategies that FMIS have implemented.

4. Findings

The preliminary assessment gave us the sense of the Gorkha earthquake impacts on the FMIS.

i) The study showed that all the six FMIS were severely affected by the earthquake. Since the sites were in hilly areas, the landslides and dry erosion damaged the canal structure and intake points for most of the systems;

ii) The farmers in every system show more than 50% reduction in water availability at the intake point after the quake, except one system;
iii) After the earthquake, farmers responded promptly to temporarily fix the system and bring water in their irrigation field. Since the May-June is a critical period where agricultural water demand is very high, farmers have strong motivations to maintain the system. But the capacity to maintenance also dependent upon the severity of damage. Farmers that required a large sum of the budget were unable to secure funding and hence were not able to conduct required maintenance. Hence, the ability to secure funding from government or external agencies after the natural disaster is crucial for the sustainable and efficient performance of FMIS.

Some of the key findings from two systems with detail case study are presented in Annex 1. The main findings are summarized below.

i) Both the systems are built and operated by farmers. They are being properly operated with very minimal conflicts except during the dry season. During the water shortage period, farmers often quarrel (non-violent). In these systems, labor mobilization is still being done to some degree;
ii) In terms of hydroclimatic variability, both the systems perceived decrease in river flow during the dry season (November-March) due to reduced non-monsoon rainfall. Other drivers that affected the system performance are mainly the lack of concrete irrigation infrastructure, increased cost of labor after the quake, and lack of housing and other priorities affecting their daily life;
iii) Farmers are applying both the structural and non-structural measures to address the climatic variability. In structural measures, farmers are using lift irrigation where the water from the Trishuli River, a perennial river of Nuwakot district, is being lifted to up to 50 meters and distributed through local canals. There are more than 40 lift irrigation systems in Nuwakot district. Though farmers are also keen on improving the canal structure from earthern lining to concrete lining, they are not able to do so due to lack of sufficient fund. They need government support to upgrade their infrastructure.
iv) During the period of water stress, farmer shares the available water through water rotation mechanism. The non-structural interventions include rules for water supply rotation among the agricultural land.
v) At the farmers' level, farmers area also increasing their individual adaptive capacity by expanding the livelihood strategies like livestock and poultry because there is an increase in meat demand due to higher remittance and increase in living standard.
vi) Since farmers are very knowledgeable on local systems, they may not be well aware of the regional climate dynamics like monsoon forecast. Hence, FMIS should be well connected with forecasting knowledge and regional patterns through extensions and other communication strategies.

5. Reflections on the research process

The use-inspired and collaborative model of research requires a considerable investment of time and effort. Following are some of the reflections on the research process, the challenges faced, and the solutions applied to them where applicable.

i) The co-production model requires the audiences who value knowledge creation. Since the research was done immediately after the earthquake and during the busy time of crop harvesting, it was difficult to find farmers who are willing to provide their time to engagement in collaborative research. To address this issue, we explicitly informed the farmers about the nature of research and got their consent. In order to minimize the time of the interview, I prioritized the questions to be asked and followed up over the phone for additional information.
ii) Since I visited immediately after the quake, many farmers have expectations for us to contribute to reconstruction and relief support. In order to address this, I explicitly informed about the purpose of my project and its knowledge contribution to the community.
iii) Since I have to work collaboratively with farmers, it is a very time-consuming process. During my field work, I visited the system a couple of times and interacted over the phone to pursue this iterative mechanism.

6. The next step

Within two months after I received the CLIMAS Fellowship, I received a prestigious fellowship from ICMOD HI-AWARE program. The fellowship covered the stipend and field travel support till May 2018. The proposed work for CLIMAS has now become my dissertation research. Also, I am compiling the main findings from the CLIMAS Fellowship and the dissertation research to produce a booklet on best practices in irrigation water management particularly targeting the farmers and other stakeholders. I am planning to compile it after I complete my last round of field visit in summer 2017.

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Annex 1

Case study of FMIS

FMIS	**Kamalkutti Pipale I.P., Belkot-1**
Description	This system is 17 hectare in command area with 25 households. The water source is Belkot River. It is very nearby to Kakani road that goes to Kathmandu.
System governance	It is governed by farmers in an informal way. They have a loosely official organizational structure. The system is cleaned three times by the farmers of the command area.
Drivers of changes	The system has seen a decrease in dry season flow and variability in rainfall. During an earthquake, the canals got shallow cracks on the earth surface. Since the intake is not cemented, after the quake, farmers quickly got back to fix it with the local materials like forest fodder. Migration is another big problem in the region. More than 50% of the farmers are either old people or ladies. There is also a problem of invasive species (see picture below).
Adaptation actions	The water source is decreasing every year. During water scarce period, there is water rotation. The farmers at the intake or head use the water first, then the farmer below the first user use it. Each farmer needs to wait for maximum of 7-8 days for his next turn. During severe water shortage, the turn is prolonged. Severe water shortage requires more water labor to manage the scarce resource. Expanding the infrastructure source is another form of adaptation action. They have plans to operate lift irrigation from Tadi River. The lift system pumps water up to 60 m with 20 horsepower. There is a subsidy for electricity for agricultural lift pumps. This pump provides water during the dry season. During barding season for rice, if the water is very cold, it will get rotten. So the farmers change the water in every few days. They cover the water with plastic so that the water is warm during the seeding time. This is a local approach to managing water resources. Livelihood is a good income diversification strategy.
Agricultural practices and adaptation	Three cropping pattern – spring paddy, monsoon rice, and potato during winter. Rice farming is hardly profitable because of difficulty to find the labor. After the potato is taken out from the soil, it has to be preserved from too much cold.
Other risks	There is an increase in invasive species in the agricultural plot. Rainfall affects the pesticide attacks. Without adequate rainfall, the farmers need to use more pesticides in order to kill the pests.

FMIS	**Pokharephat I.P., Khadga Bhanjyang-4,5,7**
Description	It is about 30 hectare of command area in Khadga Bhanjyang 4,5,7 covering the 220 households. The source of the river is Jodi River which is a spring-fed system. The river has very minimal flow during the dry season from February to May.
System governance	It has formal committee members with a president. During the time of water stress, there is another farmer-run cooperative that pumps water from Trishuli River through lift irrigation. The cooperative is owned by farmers.
Drivers of changes	There is a significant reduction in water flow during dry season period. The water at the intake is decreasing due to drinking water diversion upstream, as well as a diversion by other irrigation systems.
Adaptation actions	The farmers have installed a lift irrigation to supply water during water shortages. It was constructed with support from NGO and Nepal government. This is a good and reliable water source to manage the scarce period. The farmers rotate the limited water supply by providing the water first to water upstream land. The land immediately downstream receives the water. Since the market base is stronger, the farmers have slowly switched to vegetable farming and dairy production. There is a dairy collection center at a very closer distance. These are an alternate source of income to reduce the risk on livelihood during water stress period.
Agricultural practices	They also have three cropping system – maize, paddy, and potato/vegetables. Nonetheless, there is an increase in pesticide attack on vegetables and paddy. The system is less accessible to the road. As a result, there is difficulty in transporting the farming product. The village has only the trail distance.
Other risks	Maintenance of the lift irrigation is one of the main challenges. The lift irrigation has limited pumping capacity, so it is not able to irrigate the larger command area.

Annex 2: Pictures

Festival for monsoon rice plantation, Tupche V.D.C.

Earthquake damage on Kabilas-Simarai I.P, Chaugada V.D.C.

Invasive species on the water, Belkot VDC

Poor infrastructure condition

Household interview, Belkot

Transect walk, Khadga Bhanjyang V.D.C.