Traditional Climate Change Adaptation Practices by farmers in Nepal

Final Report

GWP Nepal/Jalsrot Vikas Sanstha (JVS)

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Disclaimer

The findings, interpretations and conclusions expressed herein are those of the author(s) and do not necessarily reflect the views of the institutions.

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Jalsrot Vikas Sanstha

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Abbreviation

FAO	Food and Agriculture Organisation
VDC	Village Development Committee
UNESCO	United Nations Organization for Education, Science and Cultural Organisation
FGD	Focus Group Discussion
SRI	System Rice Intensification
NARC	Nepal Agriculture Research Council
IRRI	International Rice Research
SCF	Siddhartha Community Forest

CHAPTER I
INTRODUCTION

1.1 Background

Climate change is a natural process. However, anthropogenic activities have accelerated the process of change in the climate system, which causes extreme weather events, and disasters are having increasing impacts on rural poor population. It has been threatening lives, food security, agricultural production, forest, water resources on which people depend on their survival (FAO, 2009). Therefore, to minimize the impacts of Climate Change, people of different lifestyle have developed their capacity to cope with and adapt to climate change impacts from generations to generations in food production and disaster preparedness.

Nepal falls under high risk of climate related disaster because of its geography. Most of the people are poor which further accelerates the effect of climate change. Therefore, it is necessary to develop a suitable strategy to adapt with changing climate and it is proven that local knowledge are the key source of information and essential part of the solution (Raygorodetsky, 2011). Farmers are the people who works for soil, water, air and plants from generation to generation and hence they are the keen observer of the climate change and its uncertainty. With their long experience in farming, they have developed themselves and practiced the traditional knowledge to cope with the changing environment in their farming systems. This knowledge is generated through series of testing and hence is very significant for the policy makers while formulating the strategies for climate change adaptation at local and national level. Therefore, this study was carried out by GWP Nepal/ JVS to document the traditional practices of climate change adaptation by the farmers of Khokana as well as other parts of the country.

1.2 Methodology of the study

1) Field observation
2) Focus group discussion
3) Interaction with farmers of different age group
4) Literature review

1.3 Study Communities

For the present case study, various parts specially the communities of the country were studied. The study tried to incorporate all the various ecological regions of the country like from Mountainous region, Hilly region and the Terai. The basic concept of this documentation was to cover all the possible areas of the country ecologically and socially.

CHAPTER II
RESULTS

3.1 Khokana Village Development Committee (VDC), Lalitpur

Introduction

Khokana is a Village Development Committee (VDC) that is located in Lalitpur district of Kathmandu Valley. According to CBS, 2012, Khokana has 1,056 households and the population of total 4,927 with male 2,452 and female 2,475. It has an area of 3.47 km^2 and situated at an altitude 1260 m to 1335 m from mean sea level. The geographical location of Khokana VDC is 27^0 28' N to 27^0 38' 30" N latitude and 85^0 17' 20" E to 85^0 17' 60" E longitude.

Khokana is a traditional and tiny Newari village about eight kilometers south of Kathmandu (on the outskirts of Patan), which has its own history and has retained its tradition and culture. It is a living museum and recalls medieval times. The farming community of Newars who live here are mostly dependent on agriculture and much of their daily activities take place outside of their dwellings. There are women sitting outside spinning, men crushing seeds, and other daily activities. The village is famous for its unusual mustard-oil harvesting process in which a heavy wooden beam is used to crush the mustard seeds in order to extract the oil. This oil can be consumed if desired, but it can also be used for therapeutic massage. This was also the first village, indeed the first habitation, to be electrified, before Kathmandu. In the center is a three-storey temple, Shree Rudrayani, with a main street, especially for a village of such small size. Khokana has been nominated to be listed as a UNESCO World Heritage Site representing a vernacular village and its mustard-oil seed industrial heritage. Khokana is a unique village, which can be taken as a model of a medieval settlement pattern with a system of drainage and chowks. It houses chaityas and a Mother Goddess temple. The mustard-oil seed industry has become the living heritage of the village. In January, the Khokana festival is held to highlight the unique aspects of the village. Cultural Newari dances, such as the Thimi dance and Devi dance, Newar food, such as Newar pancake (woh), a sweet steamed dumpling filled with molasses and sesame (yomari) and strong Nepali wine (ayla), crafts, music and the towns mustard production are the major attractions of this place.

Although the study site - Khokana, comprises 9 wards, the study is the outcome of three standalone Focus Group Discussions (FGDs) in its two bucolic settlements consisting of Ward 9, ward 6 and ward 4. In the Khokana VDC, local people have practised and developed technologies to address and/or contribute to adapt to climate change impacts through traditional wisdom, knowledge and practices. Some of the relevant technologies and practices are given below:

Case 1: Waste water management

Sano Khokana of ward number 9 lies in Khokana VDC of Laitpur district. Around (15 – 20) years ago, there was adequacy of water in earthen canal (locally called *Rajkulo*), and there used to be a larger incidents of rainfall in those dry months. However, nowadays, there is water shortage period in Falgun, Chaitra, Baisakh and Jestha (Mid-February to Mid-June). This creates an acute water shortage for the irrigation. Therefore, Newari Community has started to collect wastewater in their drying pond.

Wastewater generated from kitchen, bathroom and laundry is collected in nearby drying natural pond and is used for irrigation purpose. Some farmers use bucket and jug to carry water from the pond to irrigate their nearby vegetable whereas some have constructed a canal to irrigate their vegetable farm directly. The wastewater-collection pond is also used in preparing seedbed for paddy. The various sources of wastewater collection are as follows:

1. **Washing and cleaning from natural wells:** In this natural well, around 15 years ago, the well was considered a holy place and people used to go bare foot into the well to carry water for the drinking and domestic purpose. They used to take out buckets of water from the well, carry it to the 10 – 15 meters distance and perform bathing, cleaning and washing clothes. At the present context because of climatic variability, and decreased number of rainy days, level of water has been reduced and water quality has been gradually degraded (impure). It is used for washing clothes, and rarely used for bathing purpose. This encouraged the local people to collect wastewater in the village pond and use for irrigation purpose.
2. **Domestic wastewater:** In one of the picture at the right, water of the bucket with fitted tap is used for cleaning pots and washing limbs. After the usage, the wastewater goes to the pond.

3. **Community spout:** It is the only source of drinking water in Sano Khokana. Locals reported adequate domestic water only for eight months. During monsoon, wastewater from the tap is higher in volume and it is supplied to: (i) pond where the wastewater from above two sources is collected; and (ii) earthen canal.
4. **Kitchen waste:** Vertical polythene black pipe is for disposing kitchen waste. Generally, in Newari community of Khokana, kitchens are at the top story of the house.
5. **Rainwater harvesting and kitchen waste:** Somewhat white polythene vertical pipe in figure is for carrying rainwater and kitchen waste. Pipe for the kitchen waste is internally connected in the same pipe that collects rainwater.
6. **Wastewater collection (in Pond):** From above five sources of wastewater, water is finally collected in the pond from which water is used for the irrigation purpose.

Figure 1: Collection of wastewater in the pond

Along with collection of wastewater in the pond, outlets of individual household's wastewater are finally joined to earthen canal. In dry season, water shortage makes difficult to get canal water for irrigation and wastewater collection and reuse is considered a good practice, especially for the vegetable farming. The picture below shows two small outlets that carry wastewater from the cluster of households and final discharge of wastewater in irrigation canal.

Figure 1: Channelling of wastewater for irrigation purpose

Collection of wastewater in natural pond is governed by several factors such as soil type, soil moisture, its construction as well as maintenance provision. Regular impact monitoring of the wastewater provides opportunities to rectify the problem, if any. If wastewater storage is difficult, channelling of wastewater through a canal would be effective solution. Furthermore, stagnant water hosts mosquito's larvae and other insects also.

Message

Wastewater collection in the pond can be the best strategy to address irrigation in the water shortage months. In addition, the wastewater does not encompass chemical wastes. This case depicts collection of wastewater as a valuable source of irrigation for water scarcity period. Further, following precautionary measures would further enhance the efficiency as well as the capacity:

- Water collection in the pond in a pit before passing to the pond would help in collecting the sediment free water in the pond.
- Lay lining pond on the base and sides to control the seepage.

Case 2: Pipe water irrigation

In ward no. 6 of Khokana VDC, canal irrigation water does not reach lower part of land (tail reach). Reduced rainfall also limits monsoon rice to grow. Hence, tail reach farmers used to leave their field barren in winter and in spring season. It propels the farmers to construct well.

They use underground water for irrigation even in the months when head and mid-reach farmers use water from canal irrigation.

After constructing an artificial well in the farmland, farmers succeed in large-scale production of vegetables even in the dry months. The sequential pictures arranged below and brief write-ups show how farmers are using well water for irrigation:

1. **An artificial well:** For the tail reach farmers, natural well has become the only option for drinking and for irrigation purposes. Farmers have been using well water for the irrigation in vegetable. They use electric pump-set to irrigate their vegetable farm.
2. **On-farm polythene pipe:** After the well water is pumped through the pump sets, water is either distributed directly in farm or stored in the metal drum from the outlet, which is made in the hanging polythene pipe.
3. **On-farm metal drum:** Water from the metal drum has been used using jugs and small bucket to irrigate the farm. In the middle picture below, drum is kept for the irrigation of the chilli.
4. **Drip-irrigation using metal drum:** For the irrigation in tomato, cauliflower, chilli, pumpkin, bean and cabbage, farmers are using drip irrigation using the metal drum and separate low cost polythene pipe.
5. **Laying polythene pipe:** The pipe is directly connected to the well through pump sets. Farmers can use well water for the irrigation from laying the polythene pipe only at the time when pump is operated.

Figure 0: Adaptable innovations in irrigation

The pipe water irrigation is solely dependent on the groundwater system. The excessive withdrawal of water from the ground could deplete the groundwater resources in future. Groundwater recharge facilities would make this practice sustainable and input and output balance should be maintained.

Message

Use of underground source of water by constructing well can be economical for small-scale irrigation. Long polythene pipe can be used for water distribution purposes and metal drums can be replaced by inexpensive water storage facilities. Alternatively, metal drum is corroded due to continuous exposure in air and moisture and therefore, it needs to be protected from moisture. The following should be taken care during the process.

- The withdrawal of water should be such that it does not exceed replenish rate. Thus, groundwater recharge would be better option to resolve this issue.
- Red oxide paint of the metal drum would protect against corrosion.

Case 3: Plastic pond and poly-tank for irrigation

During water shortage period from mid-February to mid-June, farmers face extreme shortage of irrigating their farm in vegetables like tomato, cauliflower, cabbage, chilli etc. In this period along with lack of canal irrigation and reduced rainfall, farmers have to bear lowest water table in the natural well, therefore farmers are compelled to use well water for drinking and domestic but not for irrigation. In the remaining 8-month, because of increased water table in natural well, irrigation becomes comparatively easier. Local people have experienced maximum decrease in water table in both water sufficient and water shortage period. In this scenario, irrigation in vegetable in water shortage is the problem faced by famers living at ward number 6 of Khokana VDC.

Local people constructed plastic pond and purchase of poly-tank in addressing water shortage months. In these containers, water is stored during water sufficient months and applied for irrigation in dry periods. The water should be potable for irrigating mushroom. They grow mushroom in the industrial scale even in the water shortage period due to water storage in ponds and tanks.

Local people store water during the fourth quarter of the water surplus period in well and collect wholesome water from the well in poly-tank of 10,000 litre capacity for showering in mushroom in water shortage period. The water of poly-tank is only used for the showering in mushroom. For irrigation in vegetable farming, local people use diesel pump sets to collect water in the plastic pond from the nearby Bagmati River. The plastic pond is of

5: 12: 5 (5 feet depth, 12 feet length and 5 feet width) of size with the capacity of 35,000 litres. 120-gcm plastic is used for the lining purpose. Local people informed NRs. 9500 (USD 1 = NRs. 95 at early August, 2014) as total cost of plastic with additional 9-mandays to make an artificial pond of aforementioned size. Hence, the plastic pond has the total cost of around NRs. 13,100 to collect about 35,000litres of water.

Figure 4: Innovations in irrigation of mushroom and other vegetables

Cost of vegetable production is increasing due to water pumping from chemically polluted Bagmati River. This demands water treatment before irrigating the field from Bagmati River water.

Message

This case artfully demonstrates use of pure and impure water in mushroom farming and in other vegetables in water shortage period along with innovation in storage techniques. Poly-tank can be kept on farm for storing drinkable water for irrigating mushroom while water from plastic pond can be used for irrigating other vegetables.

The evaporation loss in the pond during the hot sunny days accounts a measurable amount in quantity. Thus, the use of thin plastic sheet or microfilm layer on the top of the pond would be a better option.

Case 4: Developing the sustainable mechanism (Institutional improvement)

Farmers have been irrigating their farm from an earthen canal, locally called *Sukamuka Rajkulo*. Lack of canal irrigation in major crops like paddy, wheat, mustard, potato etc. push farmers in a yawning water shortage problem. Declining water level in earthen canal because of conveyance loss, seepage, leakage from earthen canal and diminishing sources is perceived as one of the major causes of climatic variability. Farmers took initiative for the lining of the earthen canal in 1999. However, continuous shortage in canal irrigation and increasing demand of water compromise the chances of irrigation.

Demand-based institutional arrangement has made possible to cope with problems from reduced water in Khokana. In 2010, local people in coordination with Khokana VDC formed a group called *Dafa* group for the management of irrigation system. At present, eight *Dafa* groups are active and there are around 40 to 50 members in each group. Each group have a working period of one year. The responsibilities of the Dafa group are, *inter alia*, to:

a) Inform each household for the canal cleaning and maintenance process;
b) Check unauthorized water use from the main canal and ensure water availability in it during the rice plantation, wheat, mustard and potato irrigation;
c) Ensure water availability in the '*Pancho*' (higher levelled farm land for the storage of the water);
d) Collect fines from the households who did not contribute in canal maintenance and collect water charge in terms of area;
e) Perform religious activities using their own musical instrument twice a year; and
f) Provide list of water users who have not participated in canal maintenance process and who have not collected water charge.

Dafa group in association with the concerned experts could launch the following program too for the sustainability of the system:

- Water management training to the farmers or the beneficiaries

- Maintenance training of the irrigation system.

Fines and water charges

Those water users who did not contributed in canal maintenance need to pay Rs. 500 as fine. In 1999 when there was earthen canal, there was higher discharge in the canal because of higher water availability in the source-river called *Nakhhu*. Now the discharge in the river has noticeably decreased. Farmers reported that they have lesser discharge even in the lining canal. Since they have to irrigate their land by reduced amount of water in the canal, its management became inevitable. Those who failed to contribute in canal maintenance; they were deprived from VDC related record keeping processes and other benefits. Even birth, marriage, death events of those farmers were not registered in the VDC office depriving them from many other services like connection of pipe water. Along with fines, farmers have to pay area based water charge of Rs 48 per ropani annually. As the *rajkulo* have to cross 2 VDCs before reaching to the Khokana VDC, the farmers from those 2 VDCs who irrigate from the khokana *rajkulo*, pay higher annual water charge of Rs 100 per ropani.

Distribution rules

In the mid reach of the command area, they have around 120 ropani of land that they called *Pancho* (higher levelled terraces). Before the distribution of water from the main canal, they collect the canal water in the *Pancho* of around 2 feet high water level of water and around 2-inch (3 to 4 inches) water in other terraces for rice plantation. After ensuring the 2 feet high water in the *Pancho*, water distribution to individual land starts from head reach. In case required amount of water is not provided, farmers also use kerosene pump sets for pumping water from Bagmati River that is used for planting and irrigating major crops.

Message

Customized governance rules water management and maintenance of infrastructure timely provide opportunities to keep the system functional in the acute water shortage period. Linking of water charge collection with VDC service facilities is instrumental in addressing perennial challenge of water shortage.

Case 5: Protecting potato farm from cold wave and weeds

Potato is planted in the second week of Magh (Last week of January). Farmers store selected good potatoes of past year for the planation in following year to their local bamboo-made container. The influence of the cold wave and abundant of weeds in potato field are the two major problem observed in the present context. Local people have safety nets of storing potato in cold store for its plantation. In past, cold wave (locally *tusaro*) used to be in the matured stage of the potato and did not adversely affect its productivity. Now-a-days, cold waves have been experienced in three leaves stage and it is usually 12-14 days after plantation of potato. In such delicacy, it is almost not possible to protect the seedling-staged potato. Likewise, as the farmers realized continuous degradation of soil fertility, they started application of farmyard manure in the potato field to properly manage the soil; however increment of weeds are seen in the farm.

A couple of day or a day before of cold wave, farmers could not predict the coming cold wave; they start irrigating the potato farm before being influenced by cold wave. Earlier, there used to be rain and need not to irrigate the field for the protection against cold wave. At present, irrigation is neither available nor sufficient. As cold wave damage and reduce potato production, local people cover the delicate potato by straw or other similar organic materials. A few of the farmers reported that they have shifted plantation period of potato. In order to protect potato from cold wave, local people;

1. Irrigate the potato farm predicting the cold wave's influence (rare in use)
2. Cover the seedling staged delicate potato by straw and other organic material (most practised method)
3. Either plant in first week of January or last week of the January instead of plantation in mid-January (practised by a few farmers)

Irrigating potato, covering the delicate plant by organic material, and shifting plantation period are rather an outcome of many years' experiences of farmers. Farmers perceived that increase incident of weeds are the cause of climatic variability along with application of farmyard manure. Farmers reported that density of weeds in the potato field has been soaring because of climatic variability. Most of the farmers informed that it was because of application of compost manure and/or farmyard manure that weeds in the potato

field have increased. In compost manure, aerobic bacteria fungi plays the major role and the green shoots and associated seeds remain alive and such manure's application gives rise to more weeds in potato. In one hand, there was a problem of degrading soil fertility because of application of chemical fertilizer and continuous farming practices and in the other, response of farmers to low fertility was the application of farmyard manure, which also have caused another problem of weeds dominancy.

In the past, farmers used to pick out those weeds from the potato field and collect in the corner of the field. The reason behind lower density of weeds in the potato field is application of chemical fertilizer. Although its invasion is going up at present context, they have invented a fresh management practise and flipped the weeds problem into benefit. They plug the weeds, make a tight bundle, put back in the field in a way that roots part lies upward, and shoot part lies into the soil resulting into fertilizer-rich soil. Some of the male use spade to flip the soil instead of plugging it by hands.

Figure 5: Weeds management in potato field

Message

Application of organic manure has increased weeds requiring more labor cost in the producing potato. Weeds could be used for covering the potato field to protect it from cold wave. Similarly, soil fertility should be enriched by applying compost and farmyard manure or similar organic materials rather than continuous application of chemical fertilizer.

Case 6: Innovation in seedbed preparation for the plantation of rice

Having majority of Newar community (98.41%) in 2010 and their consumption habit, Newari people of Khokana preferred producing Taichung paddy. This variety is very popular for the beaten rice, which has a life span of 4 month and 7 days. In Terai region of Nepal, farmers plough the field, apply the water and in the muddy bed; farmers sow paddy saplings. In hills like in Khokana farmers plough the field and sowed around 3.25 to 4 kg of dry paddy seeds in the dry soil. Lack of water to irrigate the seedbed, protection of delicate paddy seedlings from the intense sun are the climatic challenges faced by the farmers during the rice plantation.

First week of Jestha (Mid-May) is the popular date in Khokana for the seedbed preparation of rice. Farmers do not want to take risk of shifting date (Mid-May) for seedbed preparation. The respondent expressed that within in around 22 days they tolerate enduring hardship by fetching buckets of water most of the days and carrying organic mulch to cover the seedbed.

Around 20 years back, farmers did not experienced problem of intense sun and lack of irrigation but they are prominent now. Hot weather and untimely rainfall encouraged farmers to develop technologies and change practice to protect the seeds and seedling stage of rice from climatic variability. Farmers cover the sowed dry seeds by thin layer of soil to protect them from intense sun and from birds as well. Birds take rice seeds. Early seedling is very delicate and faces 'survival threat' from intense sun. To address it, farmers cover the seedlings by straw and other organic material and shower it to keep wet.

Farmers have to apply water frequently to protect the seedling stage and around 20-litre capacity of 5 bucket, full water is required to irrigate 1 ropani of land. Local people informed that it takes around one and half hours to fetch water from the nearby river or from home to apply in the seedling stage of rice and, therefore, it is not applicable. A few farmers experienced dying of seeds in some part of the seedbed and sometimes even in the whole seedbed. In that situation, they sow the dry paddy seeds having the lesser life span (about 4 months) than that of the Taichung rice variety. These newer rice varieties include Mansuli and Pokhreli.

Message

Although farmers have practised to protect seedbed from climatic variability, they are working in finding the exact shifted period to protect seedbed timely. Besides fetching of water and use of organic mulch, re-sowing of rice seeds would help to adapt to present conditions. Covering the rice seed with thin layers of mud, straw (organic mulch) helped a lot in coping the climate change variability.

The cope against the climate variability following measure also could assist in certain extent:

- Community based common nursery for the preparation of rice bed seed would reduce the difficulty water management for the purpose;
- Introduction of System Rice Intensification (SRI) which was first developed by Mr. Henride de Laurie in Madagascar to cope against the water scarcity:
    - 8 to 10 days older plant for sowing.
    - Anuthing longer than 3 days is avoided and intermittent flooding and drying instead encouraged.
    - Planting at distance of 25- 30 cm instead of 15 cm.
    - At most two allowed against bunch of seedlings
    - Organic matter's encouraged
    - Mechanical weeders used instead

Case 7: Use of organic mulch and plastic sheet

Location of farmland away from settlement area, lack of irrigation water, and decreased frequency of rainfall in dry season has limited dry season vegetable farming. It was further exacerbated by increasing ascendancy of weeds and insects in vegetable.

No rainfall and no irrigation brought about mulching the preferred adaptation practise for farmers. Garlic, ginger, onion, cauliflower are the crops on which farmers apply organic mulch for increasing soil moisture for longer duration. Straw and other similar organic material are used, generally in seedling stage of crop, and shower on those organic mulch maintain the soil moisture for a longer period. Along with increasing moisture, mulching check insects and weeds as well, and are perceived the causes of climatic change by the farmers.

Unlike greenhouse, which slightly increases the temperature inside it, the plastic enclosure as shown in the right part of the figure, is not for increasing the temperature inside it, but for protection of seedling-stage vegetables from the hot, wind, insects, pests, and for keeping the moisture inside it. Inside the plastic enclosure in the figure below, farmers are growing tomato, chilli, okra and cucumber.

Figure 6: Mulching and use of plastic sheet for plant protection

Message

The risk involved in the above practises is that even a mild wind can displace organic mulch and loosely fixed plastic sheet. Organic mulch could be the effective practise for checking insects, weeds, keeping the soil moisture, and protecting the delicate plants from the intense sun. Similarly, plastic sheet would help to adapt to climate change impacts. Introduction of Sprinkler and Drip irrigation for water such crop would in such cropping would be better option.

Case 8: Soil management

Continuous application of chemical fertilizer has gradually been reducing soil fertility besides fertility decrement due to prolonged dry period generally from mid-February to mid-June. It is inevitable to maintain the soil fertility and maintain productivity and cost for inputs.

In Ward number 9 of Sano Khokana, community have established Integrated Waste and Wastewater management plant, which helped in generation of organic manure from household waste including faeces and ashes. Many farmers have abandoned the merely use of chemical fertilizer in vegetable farming, as it has been perceived that continuous use of chemical fertilizer degrade the soil fertility. They have reduced the use of chemical fertilizer and prioritized the farmyard manure, compost manure etc. Although weeds density will increase in the farm, soil fertility will be ameliorated.

To overcome with low soil fertility without applying chemical fertilizer, farmers have practised addition of riverbank's soil in their farm field, use of manure from poultry farm for mostly potato and other vegetable, and farmyard manure and compost for cultivation of rice, potato and other vegetables. Along with these practices, use of river's bank soil in the field of cash crops, increased use of mulching, plugging of weeds and putting it back in the farm in such a way that shoots goes into the soil resulting fertilizer rich soil are some other popular practices for maintaining soil fertility in the soil. Use of waste from ecological sanitation and use of riverbed black soil in tomato has been shown in the picture below.

Figure 7: Innovations in soil management

Message

Addition of reasonable amount of riverbank soil would increase production, and unlimited extraction of such soil would increase riverbank erosion. Continuous use of chemical

fertilizer would slowly degrade the soil fertility and therefore farmyard manure, manure form poultry farm and compost could be practised without lessening productivity. Along with fertilizer application, mulching practices, weeds management and addition of riverbank soil could be other effective methods for maintaining soil fertility.
Time to time testing of soil in a lab to indentify the requirement of nutrient would be helpful in analysing the quantity and type of fertilizer needed in a particular field.

Case 9: Managing the drinking water

Every year in this decade from mid-February to mid-June, there has been a shortage of drinking water in Sano Khokana. Pipe drinking water is stored in concrete tank, fitted with tap and distributed to households. This supplied water is insufficient. It has a natural well for washing, cleaning and for other domestic water-require activities. This case demonstrates how community has managed and adapted shortage of water formulating some customary rules of governance.

In the months of drinking-water shortage, community has formulated some customary rules for 4 months (water shortage period). Each household strictly follows the following rules:

1. Each household get 2 bucket full water each of around 20 litre capacity and is available twice at 5:00 am and at 4:00 pm each day.
2. Each day operator is changed. Any member of household can be an operator of the storage tank.
3. The responsibilities of the operator are to lock the community spout except during 5:00 am and 4:00 pm. He or she also ensures that each households gets exactly two bucket of water each with around 20-litre capacity.
4. Only operator gets extra amount of water for domestic purpose.
5. Each year each household collect Rs. 20 for the maintenance purpose, including purchase of new locks.

As in other hilly villages, settlement in Khokana community lies in upper part of hills with farm fields in lower level. Few natural perennial wells exist in the lower part of the hills.

During water shortage period, famers go to these natural wells for washing, cleaning and bathing purposes. Fetching of a bucket of water from these well for drinking is inapplicable as the well is located farther from the settlement area.

Message

This case has demonstrated how well the people in Khokana united to cope with drinking water shortage problem. Enhanced community participation in resource use and would relax conflicts, promote peace and harmony in the community. Encouragement of rainwater harvesting would be helpful to resolve the problem to certain extent.

3.2 Arjundhara VDC, Jhapa district

Introduction

Arjundhara Village Development Committee (VDC) lies along a bank of the Birangee River in Jhapa District. Approximately 150 households reside along the bank. It is one of the VDCs worst affected by flooding.

During the devastating Koshi floods in 2008 that displaced more than 70,000 people in Sunsari district in the Terai, many houses near bamboo grooves were less damaged. These houses were some of the few standing structures after month of inundation, with most other buildings washed away.

Case 1: Building a biological wall

In 2044 (1987), a big flood hit the VDC. It damaged around 13 households leaving a devastated situation for life and property. Even after 10 years, the situation was unchanged. Every year floods cut (erode) lands, and displaces many homes and families. In the adjoining district in Madhumalla VDC, local have already started bioengineering work in their village. So, in 2058 (2001), the people of Arjundhara started bioengineering works with support from a few families. They prohibit cattle grazing in a zone extending 500 m along the riverbank and planted bamboo and grasses. Bamboo flourishes in sandy soil and grasses started growing. Next year they planted more grasses along riverbank. Grasses reduce the river current and protect the bank from erosion. The stability of the riverbank creates enthusiasm in the people. They even started planting more trees. The riverbank is no longer sandy and turned into greenery. It acts as a biological wall that protects from floods. There were many

additionally benefits as well. The river did not dried up. In summer, the area was cooler relative to other places. Grasses were readily available for all seasons (for fodder). However, uprooting of the grass was not allowed. Many birds nested in the areas. The VDC was completely changed since the bioengineering worked well for them.

Message

The use of bamboo and grass plantation along the riverbank helped to check and withstand the floods in the village. Hence, this case demonstrates the value of bioengineering and gives idea to adopt similarly in other such riverbank places in the country.

3.3 Kapilvastu District

Introduction

The Kapilvastu district is situated at the height of 93 to 1491 meters from sea level. Geographically, the district can be divided into plain low lands of Terai and low Chure Hills. The latitude is 27°32′N and longitude is 83°3′E.

Kapilvastu has a humid, subtropical climate. Its average annual temperatures range from 25°C - 19°C with a maximum of 43°C in the summer to a minimum of 4.5°C in the winter. Twenty-five years of temperature record in Kapilvastu shows that there is increasing trend of temperature with 0.0216°C/year. Its average annual rainfall is 1,850 mm, about 80% of which falls during the monsoon season, from mid-June to mid-September. Various lakes and ponds, including the Ramsar wetlands site Jagadishpur Reservoir, are located here and its major rivers include the Banganga, Arra, Aghiya and Surahi. Groundwater is the major source for drinking water in Kapilvastu.

The cases were conducted in Niglihawa, Hathausa, Barkalpur and Dhankauli Village development committee (VDC) of Kapilvastu district to know about the climate change impacts and adaptation measures of the area. Some of the pertinent issues shared by the people during study are presented below.

Case 1: Afforestation activities to combat with increasing temperature and river bank erosion

It is observed in Nigalihawa VDC of Kapilvastu District. Due to high temperature the trees of the community forests as Jharana community forest (JCF) and Sagarhawa community forest (SCF) of the VDC are drying. The unidentified diseases and thick fog also hamper the growth of forest resources. For e.g., *Dalbergia sissoo* (Sisau) and *Morus alba* (Kimbu) are badly affected by diseases. Many hectors of Sisau forest has now completely dried up. The growth rate of forest resources has declined. Due to less rain in the recent years, stem of Sal trees is found hollow. The local inhabitants have raised the trees like *Shorea robusta* (Sal) and *Dalbergia sissoo* (Sisau) in cooperation with District Forest Office. Some local clubs have planted trees near the riverbank of Banganga River to check riverbank erosion. Farmers believed that the afforestation was done to increase forest cover in community forests with a belief that forest also help to combat with increasing temperature.

Message

The tree plantation program will help to adapt with the increasing temperature in Terai region. The afforestation activities serve as many benefits to cope with the climatic variability issues in the regions.

Case 2: Change in agriculture practices and bedding farming

It is observed in Nigalihawa VDC of Kapilvastu District. The visible but surprising phenomenon like much flowering and poor fruiting in the fruits and vegetables was observed by local people in the recent years in the study areas. They have no idea about its root causes but they argued that the changing climatic condition is the main reason.

People have been motivated to use pesticides and insecticides in the fruits and vegetables in order to resume the flowers. Use of pesticides and insecticides increases the number of flowers. Due to irregular rainfall and high temperature paddy has been substutited by vegetables as *Phaseolus vulgaris* (Green bean), *Trichosanthes cucumerina* (Gourd) and *Solanum melongena* (Brinjal). In addition, cereals like *Eleusine coracana* (Millet) and *Fagopyrum esculentum* (Buckwheat) are also grown. Crops like *Allium cepa* (Onion), *Allium sativas* (Garlic) and *Momordica charantia* (Tite karela) are also grown for higher yield. For the cultivation of *Allium sativas* (Garlic), farmers preferred Satrasaya local due to its

attractive quality but they did not prefer Bhote lasun though it produced higher yields. Burning of garlic leaves starting from the tip towards leaf base is serious problem that cause premature drying of leaves and reduced yields.

As the local varieties of paddy needs much water as irrigation, people are compelled to use hybrid varieties of paddy after 1981. Additionally, people are compelled to change seeds every year because second generation seed did not work properly. Changing rainfall patterns and higher temperatures have forced people to adopt short ripen varieties and switch to more expensive hybrid crops.

During the rainy season, there is a problem of water logging. Roots of the vegetables get decayed. So, in order to protect vegetable from excessive water due to intense rainfall, bedding farming has been adopted. Each bed is of 6 inches height and 50 cms width (in each bed). Excessive water in the field is drained out from the side of the bed.

a b

Figure 8.a. Shift from paddy to vegetable farm; b. Bedding farming practices

Message

Due to the untimely and irregular rainfall, the paddy needs more water and hence farmers substitute the paddy with vegetable farming to adapt to the water scarcity problem. Likewise in the heavy rainfall, the farmers practiced bedding farming which helped to cope with water logging problems in the field.

Case 3: Use of Bio-Pesticides to Control Pests

It is observed in Nigalihawa VDC of Kapilvastu District. People said that high moisture creates a favorable environment for the growth of fungal and bacterial diseases in the crops. People repeatedly expressed that the explosion of crop diseases is increasing due to excessive use of chemical fertilizer, pesticides and insecticides. Poor rain and longer droughts are other reasons as perceived by local people. Bean blights, caused by one or more species of bacteria increased in the VDC. Under favorable weather conditions, these bacteria can spread rapidly through a field causing defoliation and pod damage. For e.g., *Xanthomonas phaseoli* (Common Blight) also known as Piliya locally in Green beans in which beans get yellowish and ultimately die. On the other hand, people opined that the production of *Brassica juncea* (Mustard), *Solanum tuberosum L.* (Potato) are reduced due to excess use of pesticide and insecticide. *Phytophthora infestans* (Late blight) is the disease for potato.

Farmers use cow milk on those crops. Boiled juice of *Saccharum officinarum L.* (Sugarcane), leaves of *Azadirachta indica* (Neem), *Nicotiana tabacum* (Tobacco) and cow urine are mixed together and boiled. This boiled liquid is then sprayed in the affected plants to control pests. It is widely used in the locality.

Figure 9. a. Piliya disease in green beans; b. Pest causing Piliya

Message

The use of pesticide and fertilizers creates negative impacts, so farmers switch to the bio-pesticides. Bio-pesticides helped the pests to control naturally maintaining the ecology of the surrounding.

Case 4: Conservation of Jagdishpur Lake

It is observed in Nigalihawa VDC of Kapilvastu District. Due to climate change the farmers faced floods from farmers managed irrigation systems in the Jagadispur Reservoir. Due to low cost and based on the indigenous technology, people have been operating these systems since generation. Now, these systems are perceived to be at risks due to climate change. They get flood sometimes in rainy seasons from lakes whereas drought and low water level in the ponds in summer season.

Jagadispur reservoir lies in ward no. 1 of Nigalihawa VDC in an area of 157 ha. The concrete dam was constructed in 1978 with the support of the Department of Irrigation (DoI). The dam was constructed for irrigation purpose by rock-fill dike. It runs from north to south from the centre of the reservoir. The eastern part has shallow water body whereas the western part of the reservoir is deeper and completely covered by water. After the construction of dam, the water of this reservoir is used to irrigate agricultural land in 22 VDCs of Kapilvastu District. Water is allowed to enter inside the reservoir from the inlet at Laxman Ghat. Optimum amount of water is allowed to enter from inlet to avoid bursting of dam. The Kapilvastu District Irrigation Office manages the irrigation system. They have installed water gauge to measure level of water. The local people to store more water in the lake did conservation activities like afforestation. It is also used for irrigation in agricultural field. Maintenance of water level and utilization of pond water for irrigation is done by constructing an irrigation canal. Since it has been constructed predominantly for irrigation purpose, water level fluctuates according to the demand for irrigating cultivated land. To conserve water in the lake, local people have planted Sisso around the reservoir to recharge ground water. This afforestation practices increased the level of water in the reservoir. This reservoir is also used for fish farming and home for the migratory birds. Briefly, the Jagadish Reservoir is one of the Ramsar sites of Nepal, which has been extensively used to irrigate major cereals, and solve the problem of water scarcity in that area.

Message

The conservation of the water body (such as Jagadishpur Reservoir) helped to protect the aquatic environment of the specific place. The conservation also helps to get the benefits like irrigation to the agricultural land, protecting the habitats (land as well as water) of the animals, promoting tourism development, etc.

Case 5: Change in Rice Species

It is observed in Hathausa VDC of Kapilvastu District. Due to delayed monsoon and untimely rainfall, there are intensive downpours and reduction in yields. This results dryness in some areas and excessive rain in other areas. Due to reduction of monsoon season/period by 1.5 months, the cultivation of long period of monsoon crops is not feasible. As the rain starts late and stop early, people are unable to cultivate long variety of paddy like Masino Dhan with the genotypes Sawamansuli, Mansuli, Basmati and Kala nimak, Aanadi etc. Rainfall patterns have hindered the growing of long-season local indigenous varieties of crops.

To tackle this the farmers left growing Masino Dhan and have been growing Moto Dhan with the genotypes Radha-4 (IR 8423) and Osan which become ready within 125 days with potential grain yield of 6.0 t/ha and average yield of 3.0 t/ha. It has shown field resistant to blast and bacterial blight. The short duration *Raphanus sativus* (Radish) and *Daucus carota* (Carrot) are common in these days. High yielding off-season varieties includes Mino early, Japanese white, Tokinashi and 40 days. Among them 40 days is quite famous among farmers.

Message

Farmers are modifying their cropping patterns and choice of planting the rice variety according to the changing climatic variability. This will allow the farmers to adjust with the climatic extremities unaffecting in their income and lifestyle. As NARC has developed different varieties of rice in technical collaboration with IRRI of Philippines such as flood resistant as well as drought resistant seeds, introduction such crop in consultation with concerned experts would be beneficial.

Case 6: Shift from Agriculture to Livestock Farming

It is also observed in Hathausa VDC of Kapilvastu District. The yield has become unpredictable due to climate change effects. Grazing lands are also disappearing. With the changing pattern of climate, people prefer to raise improved variety of livestock instead of local. Murrah buffaloes indigenous to India, which are well adapted from Terai to High Hills have been producing at higher level than the Indigenous breeds. They have been widely used

in improving the productivity of indigenous breeds in terms of milk production. Farmers preferably feed lacting animals and grazing calves on posilo and obhano fodders. *Bos primigenius* (Cow) and *Bubalus bubalis* (Buffalo) varieties of improved livestock are common. More milk giving livestock are popular because selling milk is very easier because of dairy development. With the few numbers of livestock, there is no need of grazing land. Stall feeding practice is largely practiced. They provide local grasses to livestock to get more milk. There is increasing trend of replacing unproductive or indigenous livestock with improved varieties of livestock. Similarly, cultivating new varieties of grass and fodder in private land is also popular.

Message

The farmers preferred to raise improved variety of livestock's like cow and buffaloes. This allows having better diary production. Since grazing lands are declining, stall-feeding is highly practiced. The farmers can plant varieties of grass and fodder and raise the livestock side by side as an extra income-generating source. This will help the farmers to uplift their living standards.

Case 7: Bagar farming or River-bed Farming

It is observed in Barakulpur VDC and Dhankauli VDC of Kapilvastu District. Due to climate change, the activities like floods are occurring every year in the rivers of Terai. The banks of the Banganga River in the Kapilvastu district were degraded due to frequent floods and subsequent land degradation. Farmers reported that the river has been changing its course since the past 15-20 years, posing a risk to monsoon season crops. In the recent past, more than 100 Bigha (1337 m^2) of land are being affected by sedimentation along the riverbank in the Dhankauli village. Flood-induced river cutting and deposition of sand and gravel in agricultural field have become severe problem in the field near riverbank in Kapilvastu. Belgurduwa River (previously called Gurung Khola) has created the same in the Barakulpur VDC.

The farmers have left to grow cereals like paddy and have started cultivating *Arachis hypogaea* (groundnut/peanut) in Barakulpur VDC. Jyoti and B-4 are the highest yielding varieties that become ready for harvesting in 140 days. Sandy loam soil, which is near river-eroded area, is suitable for peanuts. Farmers located along the river banks in the Terai region

cultivate *Citrullus lanatus* (Watermelon) and *Ipomoea batatas* (Sweet potato) in the river banks during winter (January-February), also known as **Bagar farming** (Baluwa kheti). Therefore, farmers have adopted Bagar farming of *Arachis hypogaea* (groundnut/peanut) as an alternative to cereals. *Cercospora arachidicola Hori* (Early leaf spot) and *Phaeoisario psis personata Berk. Curt* (late leaf spot) are the common disease.

Figure 10: Left and Right. Bagar farming of Groundnut

Message

The introduction of *Arachis hypogaea* (groundnut/peanut), *Citrullus lanatus* (Watermelon) and *Ipomoea batatas* (Sweet potato) along the riverbanks, also known as Bagar farming, protects the land from excessive degradation.

Case 8: Conservation of Marhatte Pond by the Community

It is observed in Barakulpur VDC of Kapilvastu District. Community of Barkalpur VDC is suffering from erratic rainfall. Similarly, inadequate water at the time of fruiting of maize has lead to decrease in crop yield substantially. In order to address water scarcity problem, Siddhartha Community Forest (SCF) constructed dam in Marhatte pond through its own effort in 2008 to conserve water and use for irrigation purposes. Rainwater is collected in this pond and is used to irrigate 150-200 Bigha of land in different villages of Barkalpur VDC. People use the same pond for fishing purpose in order to uplift their economic status. Farmers believe that conservation of forests is essential to recharge ground water, control erosion and consequently, reduce siltation in rivers and to protect fisheries as well. For the conservation

of pond, the community conducts cleanup campaign once in a year and removes weeds from the pond.

Message

The conservation of the existed village pond could help in the irrigation purpose. The irrigation from the pond benefits in the cultivation as well as in fishing activities. Likewise, its conservation also helps to reduce the siltation problem in the pond as well as in groundwater recharging phenomenon.

Case 9: Raise Foundation of House

It is observed in Dhankauli VDC of Kapilvastu District. Every year during monsoon, Dhankauli VDC is inundated with rainwater due to flash flood in a Bel river. Floodwater enters inside the house and cause loss of lives and property. Higher intensity and frequency of rainfall cause huge damage every year and hundreds of family members are affected.

To resolve this people have raised a plinth level of house with mud and has constructed at a greater height so that the house is not submerged with flood. However, this practice is not feasible during heavy rainfall as the house gets inundated. In such case, the people leave the place with their family members and moves to a safer place, or stay at relatives and landlord's house.

Message

The building of the shelter house in the village helps the villager to escape from the flood in the village. However, if the house is made from the mud then it will be not sustainable. Hence, the concrete type of houses should be constructed and in many places. In such a situation, shifting of houses in a higher elevation would be a better solution.

3.4 Mahadevsthan VDC, Dhading District

Case 1: Supporting farmers with lift irrigation

The lift irrigation system is operated in Kalanga-1, Mahadevsthan of Dhading District. Since March 2013, the twenty-three households of Mahadevsthan including the Magars, have been able to grow a significant amount of vegetables through lift irrigation. UNDP- supported Renewable Energy for Rural Livelihood (RERL), along with the District Energy and Environment Section (DEES), provided support to install a Micro Hydro Operated Lift Irrigation (MHOLI) system. The system provides water to irrigate 103 ropanis (around 5 hectares) of land. It also provides water for household consumption to the 23 households of Chepang, Magar and Dalit communities.
This system was installed through the 26 kilowatt Malekhu Khola 1 Micro Hydropower Plant that was built in 2009. Since then, besides lighting their houses, the people of Mahadevsthan have been using the electricity to operate a grinder a huller, a tailoring shop, refrigerator, a computer institute and an internet cafe.

Local people reported that earlier the vegetables did not grow well due to lack of water. With the lift irrigation system, the vegetable yield has been very good and from it, the locals are making money. With the lift irrigation system, the farmers now can think of diversifying their crops. They planned to grow tomatoes, beans and bitter gourd in the field in large scale. A relatively small initiative has brought about a huge transformation in the village. Women no longer have to go back and forth to get water from a spring located downhill; since the water is now in their own homes. Some families have replaced their thatched roofs with the tin sheets because of the increased earnings.

Message

The climatic hardship occurred in the Mahadevsthan of Dhading district earlier. The farmers could not cultivate the plant/vegetables due to lack of water. They have to depend solely on the rainfall. Now the lift irrigation system had changed the lifestyle and agriculture pattern in the village. With the flourishing vegetable farming in the village, the farmers started to earn wholesome income, which helped to uplift their living standards.

- Irrigation facility could benefit or uplift the people (farmers) i n a measuring status;

- Community if required could manage the lift irrigation system, which could be a good message for whenever there is a barren land in higher elevation.

3.5 Chayanam VDC, Okhaldhunga District

Case 1: The Tande (table) Nursery

The Tande (table) nursery was developed by lead farmers in Chayanam Village Development Committee in Okhaldhunga District and was first seen by HELVATA Swiss Intercooperation staff in 2012. It is a single or double level structure, usually made of bamboo and waste wood, in which the lowest level or levels are used to produce vegetable seedlings, above the wet ground. It is protected from the rain by a second story or roofing material. This innovative step was taken by the farmers to combat the disease problem commonly associated with raising seedlings in a standard nursery bed for off-season vegetable production during the monsoon. Initially, farmers used just a single table, but individual farmers developed their own innovative variations.

The structure can be semi-permanent or permanent, cheap and easy to construct from local resources (with the exception of the plastic roofing sheet) and the only element that needs regular changing is the soil and compost for the nursery bed. It can be used in the winter, with extra polythene side sheets to create the effects of a protected greenhouse.

Project staff and partners have helped extend this practice from lead farmer to lead farmer, farmer's group to famer's group and from village to village. It has become a popular practice in Okhaldhunga district as its impact has been observed by farmers, both regarding the quality of seedling as well as labour saving. The practice is now beginning to establish itself in other neighbouring districts such as Khotang. Lead farmers and staff have also suggested improvement, such as better sitting to make best use of the sun and to best control damage from the wind.

Message

In the mountainous region, to protect the seedlings from the wind, farmers have initiated this Tande nursery. The covering of the nursery with plastic sheets also acts as a greenhouse,

which help the seedlings to grow faster and maintain the seedling temperature. This method helps to combat from the cold temperature and wind in mountainous place.

3.6 Rosera VDC, Baitadi District

Case 1: Construction of water harvesting concrete pond

Water management is not a wide spread practice but increasingly people are starting to harvest rainwater and reuse water. Simple practice such as building small ponds or installing rainwater tanks to collect rainwater for consumption and to irrigate kitchen gardens. In Rosera VDC of Baitadi district people have constructed water harvesting pond to irrigate vegetables. The water scarcity problem could be somewhat sort out by the construction of the pond in the village.

Figure 11: Water harvesting concrete pond

Message

The collection of water as a pond is used to irrigate the vegetables. The concrete construction of pond helps to prevent from excessive seeping problem and, the ponds can also used for other purpose like fish farming.

CHAPTER III
DISCUSSION

The traditional knowledge is the wisdom, knowledge and practices of local people gained over time through experience and passed over to their younger ones from generation to generation. This knowledge has played a significant part in solving problem including the problem of climate change and its variability also. Adaptation to climate change includes all adjustments in behaviour or economic structure that reduces the vulnerability of \society to changes in the climate system (Smith *et. al.*, 1996)

The study revealed the variety of coping strategies applied with mixed success, which suggests that the local traditional knowledge could provide the basis for development of more effective strategies (Gyampoh *et al.*, 2011). The study revolves with the traditional knowledge the people of the Khokana used for management in drinking water and in agricultural system. Khokana people harmoniously and cleverly sorted out the climatic variability (reduced rainfall, higher temperature, water shortage, groundwater depletion etc). Likewise, the study found that the farmers of Kapilvastu with modern agricultural methodology along with bio pesticides manage the agriculture production. They also conserve their water ponds, reservoirs. The Bagar (Riverbed) farming also helps a lot to alleviate food production esp. vegetable and fruits. The people in the mountainous region also utilise their knowledge in protecting the seed by developing seed nursery like in Okhaldhunga district, which protect it from the harsh climatic conditions in the area.

Not only the traditional agricultural practices the farmers are using to cope the climatic variability but, people also uses the modern technologies like lift irrigation system in Mahadevsthan, Dhading to increase food production in the higher elevated lands where there is water shortage. The dry barren land becomes green due to the modern technologies like lift irrigation. Likewise, the bioengineering practices along river bank helps to minimise the flood hazards and protect its river bank people. The people constructed the water storage pond in the village to sort out the water scarcity problem and the water is used for producing vegetables like in Rosera VDC, Baitadi district.

CHAPTER IV
CONCLUSION AND RECOMMENDATION

Jalsrot Vikas Sansthan (JVS)/Global Water Partnership (GWP) Nepal under the Water and Climate Resilience Programme South Asia (WACREP) has undertaken the activity to document climate change adaption practices Nepali farmers have developed and are using to adapt, and build resilience to climate change impacts. This study documents example of appropriate techniques, technologies or practices farmers have developed, used and disseminated to adapt to and/or build climate resilience. The examples were from the Khokana VDC, Arjundhara VDC, Kapilvastu District, Baitadi district, Dhading District and Okhaldhunga District.

The study helps to understand that the climate change variability though a natural process and unavoidable phenomenon could be somewhat sorted out by traditional knowledge of the farmers in that area. The traditional knowledge could be modified as per the demand and help to cope with the climatic extremes.

The study though could not address the entire traditional climate change adaptation practise done by locals and farmers in the country, but it is certain that people are coping with such and others possible adaptation measures that help them to combat climate change issues. Hence, the government should initiate to document all the traditional practices by the farmers. Moreover, it should help to regulate, monitor and develop the exiting practices for betterment of them. This could help to increase the food security, disaster risk reduction and water management.

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