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Bimal R. Regmi
LI-BIRD, Nepal
Lalita Thapa
LI-BIRD, Nepal
Rojee Suwal
LI-BIRD, Nepal
Sudha Khadka
LI-BIRD, Nepal
G.B. Sharma
LI-BIRD, Nepal
B.B. Tamang
LI-BIRD, Nepal

Satdobato, Lalitpur
PO Box: 12207, Kathmandu, Nepal
Contact number: +977 1 5552924; 5550631 **Fax:** +977 1 5535190
Email: forestaction@wlink.com.np; **URL:** www.forestaction.org

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Agro-biodiversity Management: An Opportunity for Mainstreaming Community-based Adaptation to Climate Change

Bimal R. Regmi*, Lalita Thapa*, Rojee Suwal*, Sudha Khadka*, G.B. Sharma* and B.B. Tamang*
*Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Nepal
Corresponding author: bregmi@libird.org

Abstract: Climate risks and hazards adversely impact the livelihoods of local communities. Based on a recent participatory study conducted in the western hills of Nepal, this article explores opportunities and strategies for integrating climate change adaptation in poverty reduction projects and programmes in ways that increase the capacity of individuals, households and communities to respond to climate variability and change. The findings of the study suggest that a wide array of agro-biodiversity management strategies offer options and opportunities for farmers to cope with the adverse impact of climate change. However, this is possible only if adaptation is incorporated into the existing development efforts with sufficient understanding of local livelihood context and strategies instead of separately planning climate change adaptation programmes.

Key words: Climate risks and hazards, community-based adaptation, vulnerability, poor, farmers, agriculture

INTRODUCTION

Ecological changes in the high Himalayas indicate that global warming have seriously impacted the lives and livelihoods of the local communities. These communities are experiencing unusual changes in the weather pattern (Regmi and Adhikari 2007). A section of them are content with some of these changes; for example, increased apple sizes in recent years. Others, however, face hardships, for example water leakage has increased in traditional houses, which people attribute to new precipitation patterns (Dahal 2006, Regmi and Adhikari 2007).

Poor, marginalized and disadvantaged people in rural areas of Nepal, whose livelihoods primarily depend on natural resources and climate-sensitive sectors such as agriculture, forestry and fisheries, are more vulnerable to climate change (Raut 2005, Dahal 2006, Regmi and Adhikari 2007). The majority of farmers depend on monsoon rain for crop cultivation. Changes in rainfall pattern can be devastating for their crops. Extreme rainfall can cause landslides and soil erosion, destroy property, and can also cause injuries and loss of life (Regmi and Adhikari 2007). Farmers in Nepal have used indigenous knowledge and innovations to adapt to climate change for generations (Dahal 2006, Regmi and Adhikari 2007). Local-level biodiversity management is regarded as an important adaptation strategy for farmers to deal with the adverse impact of climate change.

This research was carried out in four mid-hill villages in Nepal. These villages are project sites of LI-BIRD. LI-BIRD and its partner organizations working in the study areas, mostly in Kaski and Tanahun districts, have been instrumental in introducing biodiversity-based livelihood strategies in the communities. These interventions will also be a basis for understanding external inputs with regard to community-based adaptation practices.

The study was intended to understand the adaptive capacity of local people and to determine how it could be enhanced. People have resources both within themselves such as knowledge and culture and in their vicinity such as access to water, livestock fodder and education. In Nepal, poor and marginalized people, such as landless *Dalits*, have relatively little resources, and are, therefore, more vulnerable to climate change. This adds to their daily struggles to feed themselves and their families. Since the vulnerability context is constituted by an inexhaustible number of factors and conditions, the aim was to identify those factors that were most significant in the study areas. Finally, it was also necessary to gain an insight into the local capacities and strategies, including local knowledge with which people attempted to address challenges--both climatic and non-climatic stressors.

METHODOLOGY

Relevant literature available on climate change adaptation relevant to Nepal was reviewed to gather information for this report and to find gaps in this area of study. The researchers visited three villages in Kaski district and one in Tanahun district in mid-hill Nepal. The villages in Kaski were Kalabang (Pumdibhumdi VDC, Ward 6), Amalachaur (Arba Vijaya VDC, Ward 5) and Chaur (Lekhnath VDC, Ward 11), whereas the one in Tanahun was Serabensi (Thaprek VDC, Ward 1). Both Kaski and Tanahun districts have a wide range of altitude, and their climates range from sub-tropical, mild temperate to cool, temperate, and even tundra and alpine.

In order to analyse the project activities and their potential to contribute to sustainable adaptation, the key linkages between poverty and climate change impact were mapped out in each geographical location of the project sites. Checklists were developed to guide systematic mapping of risks, vulnerability and adaptive

capacity, in addition to the influence of project activities on these factors. First, the climate risks experienced by the local population were mapped. The types of climatic conditions and weather patterns that were most problematic for local communities and why these are being perceived as problems were identified. Also, the social, economic and environmental factors that were likely to influence their vulnerability to climate risks were assessed. Since the vulnerability context is constituted by an inexhaustible number of factors and conditions, the aim was to identify those factors that were most significant in the study areas. Finally, insights were gained into the local-level capacities and strategies, including the indigenous knowledge with which the local people tried to address the challenges they faced, both climatic and non-climatic stressors.

Data collected for this study were based on household and community responses to climate change. Data collection was largely based on qualitative methods with a focus on the experiences of the local population and project staff. This helped to gain insights into the strategies that poor people used to secure their basic needs, how these strategies and their outcomes were influenced by climate variability and change in combination with other factors, and how the project activities touched upon relationships between climate change and poverty. Baseline information documented by LI-BIRD in the four villages was also used for reference and analysis.

CLIMATE CHANGE AND RISKS AT LOCAL LEVEL

Climate risks include changes in temperature and average precipitation. Meteorological data from five stations of the Narayani Basin indicate that temperature of the study area is increasing. The data for the area from 1965 to 2005 show that the mean average temperature is increasing by 1.16ºC. Average rainfall has also increased in most areas of the mid-hills and the Terai, whereas it has decreased in mountainous areas such as Mustang. Rainfall has increased in Lumle Hill Station in Kaski by 774 mm, whereas in Mustang it has decreased by 36 mm over the last forty years (DoHM 2007).

Information derived from focused group discussions and key informant interviews indicates that all four villages experienced such water stress in recent years. Farmers linked it to erratic monsoon and changes in rainfall intensity and patterns[1]. Many people living around Pokhara Valley had observed increasingly unusual fog in the valley the last few years. Negative impact was also observed on aquatic plants and fish species, with major implications for the fishing households' livelihoods. Excessive rainfall, longer drought periods, landslides, glacial outbursts and floods were becoming increasingly frequent and intense. Local communities also mentioned that intense rainfall exacerbated erosion of soil, riverbeds and banks, as well as sedimentation of fertile land.

Drying up of water sources had forced villagers to walk for longer distances to fetch water, for example in Pumdibhumdi VDC. So, some families had installed improved tube wells to get water[2]. At many places water pools for livestock had disappeared. Similar stories are shared across rural Nepal where water springs, natural ponds and rivers are slowly degrading (Regmi and Adhikari 2007, Dahal 2006). Meteorological data are to a large extent consistent with the farmers' experiences, as in the other two project sites. Severe impact of climate variability and change was experienced by the local people. Droughts had become more frequent in some areas; whereas hailstorms had become more intense in some areas, while they had decreased in some other areas. Intense rainfall had induced landslides and flooding, and had consequently caused loss of houses, farms, crops and infrastructure. Some villagers recalled that one such event a few years ago had taken five lives, mostly from poor households. Increased incidents of landslides and flooding, as well as frost and fog, were experienced in all the four villages, affecting farm work and yield.

Farmers stated that increased unpredictability and intensity of weather events and hazards had disrupted rain-fed agricultural system, even causing loss of local landraces of crops[3], which require specific timing and intensity of rainfall. Pear, plum, peach, citrus and coffee was flowering earlier than in the past, and the ripening and harvesting patterns of some crops had changed. Farmers also mentioned that the grazing resources for farm animals had declined due to decline in some local grass species and reduction in the size of some fodder trees. Therefore, the number of livestock had decreased in the area, thus negatively affecting people's food intake.

In all the study villages communities reported of increase in the number of mosquitoes and flies, which was resulting in frequent illnesses among children. Several new pests had also appeared and were attacking local landraces of crops, for example snail attacks on vegetables, and there were more cockroaches than before. These findings are similar to those of a study carried out by Dahal (2006) in Manang district, where farmers were experiencing unusual changes in climatic patterns and their impact.

FACTORS INFLUENCING VULNERABILITY TO CLIMATE CHANGE

Poor countries, including Nepal, are disproportionately vulnerable to disasters and hence to the effects of climate change for a number of reasons. First, the ability

to adapt to and cope with weather hazards depends on economic resources, infrastructure, technology and social safety nets (IPCC 2001a). Many are already under the pressure of population growth, rapid urbanization and resource depletion, making them further vulnerable to challenges resulting from climate change (IPCC 2001b). The reason for uneven consequences is that individuals, households, communities or regions have different opportunities and capacity to respond to change and thus differential vulnerability. The dynamic context of a place means that vulnerability to climate change is more than the biophysical effects of a climate risk such as drought; it is also shaped by factors such as access to resources and other socio-environmental circumstances shaped by political and economic processes.

This section will present the main vulnerability factors identified in the selected study areas, and will highlight the dynamic context in which poor local people experience adverse weather events. There are several social, economic and environmental problems posing vulnerability to the climatic risks exemplified above.

Socio-economic Context

Baseline data from the study areas show that more than 80% of the population engage in agriculture and rely on natural resources, such as forests, lakes, grasslands and agricultural land, for their livelihoods, food, fodder, fibre, medicine, water and income (Sapkota *et al*. 2006). They have few livelihood options, and are, therefore, vulnerable to adverse weather conditions that affect their crops, animals, water sources and other natural surroundings. Furthermore, they have very few assets to recover and rebuild livelihoods, after hazards and climatic stresses. During discussions, it was observed that livelihoods varied among social groups (castes), and some groups owned more land than others. Brahmins were often farmers, while *Dalits* were mostly landless and relied on skilled or unskilled wage labour and remittances. High caste groups like Brahmins and Chhetris were also engaged in service jobs. Among *Dalits,* about 20% were landless, while others had very small landholdings. Sharecropping was common among *Dalits*. This group had little interest in farming because they didn't own much land. Landless families in Chaur village of Kaski district depended more on intensive wage labour for their livelihoods due to lack of options and opportunities. Employment pattern was changing in the study areas, and about 5% of the population had already migrated to foreign countries in search of jobs. They took loans to pay for their travel and search for work.

Baseline information on the study area documented by LI-BIRD shows that poverty is widespread in the area, and more than half of the population owns less than 1 *ropani* (0.051 ha) of land. In the study area it is found that average length of food self-sufficiency was only six months a year, and in one of the village food sufficiency was less than four months a year for more than 40% of the population (Sapkota *et al*. 2006). Local people were engaged in various on-farm and off-farm activities, including sale of agricultural and livestock products, for livelihood. Income was spent on food, medicines, clothes and children's education. Rich households invested in land and houses in nearby cities. Gender differences were noticed in the workload, and women worked more than men[4]. Women were involved in planting, sowing, processing and harvesting more than men, whereas men were involved in marketing and social services. Children from poor families were also engaged in heavy household and farm work, as well as wage labour.

The causes of vulnerability to impact of climate change or other shocks and stresses in the area included low education level, poor health conditions, conflict, and lack of infrastructure and public services. Studies show that education level is generally below secondary school and some are illiterate. In one of the villages, about 60% of the inhabitants were illiterate. *Dalits* and poor households from other groups have the lowest education (Sapkota *et al*. 2006). The study finds an increase in education rate in recent years, with almost all children going to school. However, *Dalit* children dropped out early because of poor financial condition of their families and to meet such needs by working as labour[5]. Owing to lack of clean water and sanitation, as well as poor health services, a number of health problems were common in the area. The study villages had no safe drinking water facility. Poor and *Dalit* households had no latrines in their homes and, therefore, used private and public land for defecation. Almost 90% of the *Dalit* children in the study villages used open land for defecation. Thus, poor personal hygiene and favourable conditions for insects affected water quality and health conditions in the region. Health problems are also related to lack of proper medication and health support, lack of nutrition and heavy workload. Smoke from burning firewood from the traditional household kitchens also affected health conditions.

Demographic Changes

Migration to cities and towns within the country and to other countries, particularly to the Gulf countries, is popular among the rural youth as they can get work there despite low education[6]. In many cases, such migration contributes positively to their household economy. At the same time, it leads to labour shortages, making it difficult for the migrants' families to adopt organic farming and other labour-intensive and less capital-intensive practices. A female respondent from Chaur village was forced to keep her land barren as most of her grown-up children who could work in the field were abroad. According to the farmers of Chaur

and Kalabang villages, 20-30% of their land was lying barren due to labour shortage. The respondents hoped for better education, health facilities, economic prosperity and lasting peace. However, overseas employment had reduced human capital in the study villages.

Political Context

The decade-long Maoist insurgency and embedded social conflicts have been disruptive for the communities, forcing closure of many development programmes. The political unrest had disrupted the distribution of resources in the communities, and strikes and blockades had hindered farmers from reaching the market, rotting their crops. Tourism was also negatively affected. A shopkeeper from Sundaridanda mentioned that her business had declined by 60% during the insurgency. Poor, *Dalit* and ethnic groups were encouraged to join the insurgency in order to combat the historical suppression and humiliation they had been subjected to face. There was still political turmoil and instability, continuing the suffering of the people in rural areas. Faced with such problems, the vulnerability to additional climatic shocks and stressors had obviously increased.

Institutional Context

There was little or no support from the government for these communities. According to the respondents of all four studied villages, the activities initiated by the government were fewer than those by NGOs working in the region. The social security system in the whole country was poor. Insurance was rare, and voluntary material support to disaster-affected groups was little. Physical infrastructure was generally poor and government services were far from the villages.

Over the last ten years, there has been a rapid shift from subsistence agriculture towards more intensive production. According to some local farmers, modern high-yielding varieties were introduced through markets and public policy. Extension service plays an important part in the introduction and distribution of new varieties. In the surveyed villages, 50% of the households used chemical fertilizers and pesticides and purchased modern and hybrid varieties of seeds. However, they were frustrated by the problems that occurred while growing these varieties[7].

The other key resource in the studied villages was social capital in the form of community groups. Around 50% of the households in the four villages were affiliated to one or more local farmer groups or community-based organizations, stimulated by support from donors and civil society. These groups operated savings and credit schemes for lending money to poor and needy households at low interest rates[8]. The numerous local, national and international organizations implementing development programmes in the villages probably benefited the adaptive capacity of the people. However, not all interventions were without problems, as exemplified by the agricultural transformation mentioned above, which increased vulnerability to climate variability and change.

In Nepal, disadvantaged groups, particularly women, orphans and the elderly without support, lack several of the adaptation options that exist for other groups. This may be true both for the resources people have within themselves, for example literacy, and for the resources they have access to, such as land, cattle, equipment or technology. It is difficult for poor people to explore new practices for adaptation to changing climatic conditions. Communities in all the study sites had knowledge of and skills in agricultural operations like planting, sowing, harvesting, processing, animal husbandry, food processing and storage, and fish farming, but transfer of this knowledge to the younger generation was becoming increasingly rare. A little traditional knowledge of maintaining local biodiversity still existed, but very little of this knowledge is being passed to younger generations.

The school curriculum also lacks focus on natural resources management and climate science; it is theoretical and often not applicable for poor households. Information on crops and biodiversity, wetland conservation and other issues that may be useful for farmers mainly comes from newspapers, magazines, radio and television, which only rich farmers have access to. Interviews with the District Development Committee (DDC) personnel indicated that the DDCs and the Village Development Committees (VDCs) also provided some conservation-related information.

Biophysical Context

Important livelihood assets in the area were agricultural land, agricultural biodiversity, farm animals, wells, rivers, ponds, lakes, forests, wild plants, roads, access to market and local varieties of seeds. However, many of these were being threatened by climatic and non-climatic factors.

Rapid shift in agriculture was one of the biggest challenges in the area. Modern crop varieties and hybrids demand excessive use of chemicals and pesticides, and they, therefore, have increased the economic and ecological burdens of marginal farmers. Many varieties released by the formal system were not performing well in the study areas. Farmers had rejected modern varieties, such as Khumal-4, due to their poor performance and yield. They were also of the opinion that agricultural services offered by the government didn't benefit poor people much since they lacked both land and financial resources for investing in inputs. At the same time, support and inputs from government agencies were inadequate. Farmers had

difficulty in purchasing seeds and costly chemical fertilizers and pesticides *(see Box 1)*. They were dependent on private companies, and were helpless if seeds were not available. Yields were lower than expected, and pressure on farmers was high. Farmers reported of the effects of the use of chemicals and pesticides on the ecosystem and soil and crop productivity[9]. Vulnerability to additional shocks and changes had therefore increased among many poor households. The respondents pointed out that the agricultural shift was contributing to loss of biodiversity

Box 1. Loss of local landraces

In Talbesi, near Chaur village, there used to be large swamps and wetland areas. Farmers of Chaur village used to cultivate a local rice landrace--*Gauriya*--which grew well in such areas. However, frequent flooding of the Talbesi River and its tributaries deposited massive amounts of mud and soil, thereby turning this swampy area into dry agricultural land. As a result, *Gauriya* rice is no longer grown here and has been replaced by modern varieties such as *Radha* and *Mansuli*. Now, farmers, on the one hand, cannot find seeds of the local landraces, and on the other hand, are facing difficulties with the production potential and expenses of growing modern varieties.

in both farm and wild species. Other causes of loss of biodiversity were reported as unpredictable rainfall pattern, deforestation, illegal trade, lack of awareness and lack of biodiversity conservation programmes. Furthermore, the growing squatter settlements had resulted in illegal harvesting of forest products.

Loss of local biodiversity on farms influences the poorest the most because they are too poor to buy seeds and other inputs. A critical issue for farmers is the lack of animal feed, thus reducing the number of livestock and manure, which is one of the reasons for high dependence on chemical fertilizers. Local livestock breeds were declining due to the introduction of hybrid and conventionally 'improved' livestock breeds. According to farmers, hybrid livestock are more vulnerable to diseases, which cause big losses. There were also fewer wild animals than before. Medicinal plants, local aquatic plants and local fish species were also disappearing due to infrastructure construction, agriculture, land encroachment and illegal poaching.

One of the key informant[10] reported that forests, lakes, grasslands, wetlands and agricultural ecosystems in the study area were in a critical condition, thus reducing the opportunities for fisheries, Non-timber Forest Products (NTFPs) and ecotourism. Grasslands had been converted to barren wasteland due to human interventions. These losses add to the vulnerability to climate variability and change because they weakened the livelihood resources that the poor had access to. Since the villages are in peri-urban areas of Pokhara Valley, they have roads and other infrastructure that allow farmers to transport their products to Pokhara and nearby market outlets. However, the quantity of products that they can sell is often too little, and during monsoon season the roads are too bad to take products to the market. These barriers to product marketing increase their vulnerability through limited opportunities for income-generating activities.

AGRO-BIODIVERSITY MANAGEMENT FOR PROMOTING COMMUNITY-BASED ADAPTATION

Some measures adopted by the local communities to combat the challenges mentioned above are necessary to produce crops. For example, when rice fields had dried up due to delayed rainfall, farmers in two of the project villages grew black gram and millet instead of rice. Many winter crops were not grown, and in one of the villages, maize was cultivated in late May instead of April. Sowing of millet was postponed for two months and that of wheat for one month due to decreased winter rain[11]. The local communities were testing and adopting various innovative mechanisms to combat the impact of climate change *(see Box 2)*. Some of these innovative mechanisms and good practices of community-based adaptation strategies are described below.

Box 2. Farmers' innovations

1. Watering for coffee flowering: Coffee needs water to flower. Krishna Neupane, a resident of Begnas VDC, Kaski District, introduced his own innovation and started to sprinkle water on coffee plants to induce flowering when the rains failed in the flowering season. He also sprinkled warm water in his nursery to maintain heat and sprayed ash to control ant attacks.
2. Hanging nurseries: Farmers of Serabeshi, Tanahun District, constructed hanging nurseries to control pests such as red ants. According to them, besides controlling pests, these nurseries also saved seedlings from frost, weeds and fungus (dampening).
3. Water shortage: Farmers collect waste water to cope with water shortage. Waste water is collected and used for irrigation. In one of the village, drip irrigation has been adopted for vegetable farming. This technique saves water, improves yield and reduces losses during droughts.

Organic Farming

Farmers of the study sites were widely practising organic farming for crop-growing and animal husbandry. The use of bio-pesticides and compost manure improves soil fertility, as well as reducing excessive and haphazard use of chemical fertilizers and pesticides.

These solutions also require little investment. *In-situ* manuring, i.e. keeping livestock in the field after harvest or during fodder-deficit periods, was practised. External support was focused on cowshed improvement for compost and slurry management. Plastic drums of 500 litres were used for making bio-pesticide and bio-manure. Landless farmers who did not own livestock used vermi-compost in their kitchen gardens. Use of green manuring and leguminous cash crops also improves soil fertility and income. Soil management using organic farming techniques increases soil resistance against wind and water erosion and other damage from climatic stresses.

Diversification of Kitchen Gardens

Diversification of gardens and crops can provide additional income and improve nutrition, in addition to reducing the risk of crop failure as a consequence of climate variability and change. Beekeeping, goat-rearing and bag-weaving were some of the income-generating activities implemented with external support in the sites. Many of these activities are relatively robust to climatic stresses. The project proponents and external support agencies in the areas encouraged agricultural innovations through technical and material support in order to increase farmers' capacity to apply innovative practices. These activities are clearly relevant to climate change adaptation through reduced risk of climate impact and increased capacity to respond to changes. Among the innovative solutions in the support is vegetable farming in tunnel houses (simple greenhouses made of local materials and plastic covers), which enables production of off-season vegetables while also protecting plants against adverse weather. Diversification of kitchen gardens with special focus on nutrition, diversity and income had proved to be effective in the areas. Households were now growing a large variety of vegetables and fruits. Increased diversity also reduced the risk of total crop failure, and the system was able to tolerate climatic stresses like drought and flooding. Fodder trees were planted to cope with invasion of new grass species, and rainwater harvesting was practised by building water conservation ponds to collect water during monsoons.

Soil Conservation

In the study sites, farmers' had constructed support walls and planted vegetation fences to avoid soil loss (such as planting broom grass, mulberry and Napier grass on sloping lands and roads). Drainage canals are dug to check soil loss from intense rainfall. Check dams, trail improvement and vegetation fences were used to control gully erosion. Alternative energy sources such as biogas were used to save firewood. *Harro (Terminalia* species*), barro (Terminalia* species*)* and *amala (Implica officinalis)* are also useful for sanitation. Growing techniques that require less water have been developed, and a 'diversity kit'[12] containing a variety of fruit and vegetable seeds are given to poor farmers.

Crop Improvement

Biodiversity on farms is threatened by various factors. Some farmers of Begnas village had requested LI-BIRD for assistance in reintroducing local varieties and landraces of rice. They were motivated as a result of gradual decrease in yield and disease and pest outbreaks in modern varieties released by the government. They needed high-yielding varieties that were healthy, less dependent on fertilizer and pesticides, and adapted to local climatic conditions. Participatory plant breeding was initiated to improve local varieties through conservation and use of local biodiversity of farm plants. Use of local biodiversity in the breeding process, as well as participatory plant breeding in the farmers' fields, facilitated development of seeds that were locally adapted.

As part of the participatory plant breeding activities, a community seed bank was established and sixty-nine varieties of rice were collected. Farmers analysed their characteristics and selected eight varieties based on their preference and knowledge for further improvement. One of the varieties, *Mansara*, had good drought tolerance, early ripening, low fertilizer input and suitability for delayed monsoons, but had some negative characteristics like low productivity and poor taste. It was, therefore, crossed with a modern variety and a new variety was developed. In conventional plant breeding, breeding is carried out in research institutions, creating a few high-yielding varieties for broad dissemination. Some of them were bred to provide drought-resistant seeds, but they were still not adapted to diverse local climate conditions and ongoing changes. Moreover, such conventional high-yielding seeds often demand high fertilizer, water and pesticide inputs. Local participatory plant breeding has the advantages of plant breeding without these disadvantages of many conventional high-yielding varieties. In addition to giving increased yields, locally-bred varieties are well-adapted to local conditions, including the climatic ones[13].

Farmers in the study area perceived that local participatory plant breeding was crucial to maintaining local agro-biodiversity. This is important to allow flexibility in the choice and composition of crops, as well as maintaining genetic diversity, so that it is possible to breed plants with desired characteristics. Furthermore, diversity of crop species and varieties in the field is an insurance against losing the whole crop under adverse weather conditions, since some of them are likely to withstand these conditions better than others. Participatory plant breeding can reduce farmers' vulnerability to climate variability and change. According to some respondents, its practise had reduced their dependence on commercial seeds and

other inputs, which had earlier put them in a vulnerable position. It also reduced the risk of losing crops in adverse weather events, which was crucial in view of the increasingly extreme weather events and the expected and continuing climate change. Owing to these advantages of participatory plant breeding, losses can be reduced and income increased. Furthermore, the capacity to undertake other responses to climate change can thus increase, especially if awareness and knowledge of different options are available.

Saving Seeds and Materials for Future

Seed banks promote conservation and use of local genetic resources, while providing access to seeds among poor and marginal farmers after crop failure and during seed shortages, thus reducing vulnerability to crop loss. Farmers of Lekhnath village were managing more than sixty local landraces of important crops and medicinal plants for their livelihood. One farmer, Ms Lal Kumari Thapa, managed as many as 120 species of NTFPs and made *ayurvedic* medicines. She was providing medicinal support to villagers and spreading the knowledge of the use of medicinal plants[14]. Farmers believed that these activities could reduce climate risk and increase resilience of local livelihoods to climatic stressors because of the increased ability to benefit from the unique characteristics of a range of plant varieties thriving in local climates.

Value Addition and Marketing

Some local crops and species are conserved through value addition, product diversification (e.g. producing cookies, biscuits, flour and bread from finger millet) and marketing. A study carried out by LI-BIRD shows that value addition and marketing have had positive impact on biodiversity conservation[15]. There are several neglected and underutilized local agricultural plant species, and awareness of their nutritional and economic value is lacking. Buckwheat is now used in new ways, for example young tender shoots are used and sold as green vegetables. In these activities, there is sharing and exchange of information about how to manage newly introduced crops.

External support included promotion of local products by creating demands for new types of crops and locally processed products amongst consumers. This increases the diversity of local farm produce while increasing food security and income generation in resilient ways. Income-generating activities such as production of local crops, crop seeds, including vegetables, cereal crops and mushroom, are beneficial for the farmers involved in the project and are adapted to local climatic conditions.

Different types of quality bean seeds were sold at premium prices. In two villages, most of the farmers increased the production and sale of crops such as ginger, black gram, perilla, buckwheat, soyabean, taro, lentils and other vegetables. Some poor farmers, including women farmers had, found employment in collecting products from the sites and transporting and selling them in the market. It has been difficult for farmers to obtain reasonable prices for their products due to market complexities, lack of infrastructure and services, and low volume of production. According to some respondents, organic products had higher market value than conventionally grown products.

Capacity Building

One of the important elements of external support is capacity-building of individual farmers and private entrepreneurs to improve their efficiency and skills in conducting biodiversity-based economic activities. Training and exposure visits help farmers try new farming and value addition methods and reduce crop failure and loss. Increased awareness of the value of biodiversity is made possible via the radio, food fairs and educational programmes, including information on the nutritional value of local species such as finger-millet and buckwheat. A total of 226 members (women: 51%) in the study sites received training. Farmers of the study areas were of the opinion that these activities exemplified the ways of reducing climate risks and increasing capacity to adapt to climate variability and change by increasing the flexibility and robustness of income-generating activities and improving food security in the context of climate stress.

Strengthening Institutional Mechanisms

Agro-information and collection centres had been established in three villages for providing knowledge, technology and guidance to farmers. Farmers visited the centres and got information. There was also a room where farmers' produce was collected for sale. External organizations provided support for community-based organizations to initiate revolving funds and carry out their activities. These organizations were still influenced by the local power relations as the decision-making positions were held by male and high caste Brahmin and Chhetri people. Poor and *Dalit* households participated only to a limited extent. In one of the groups, entry fee for the latter was lowered after pressure from the project.

Community groups initiated a number of livelihood-based activities. Some farmer groups invested in activities that supported *Dalit* and landless groups by leasing land to them. External agencies supported them with seeds, and they produced crops for their own consumption and for sale. These groups also received donor funds. The project formed new groups in places where no community groups existed before and strengthened the existing groups in other places. These community groups ensured group cohesion, provide community-level support and acted as a kind of insurance system to help poor and marginalized communities to cope with climatic stresses, shocks and

losses. In some villages, *Dalits* were not affiliated at all and had low participation. Female respondents from *Dalit* families were not much aware of external interventions due to lack of time for social events. The groups had made provision for lending money to poor and needy households at low interest rates. The poor people's capacity to adapt to climate variability and change can be enhanced through these activities, although some of the most marginalized people may not benefit at all in some places.

CONCLUSION AND WAY FORWARD

Climate risks and hazards are already increasing and evident in the study areas. The communities are already experiencing unusual changes in weather patterns, which are corroborated by a number of indicators. Climatic stresses have made sectors such as biodiversity, water, tourism and agriculture sectors more vulnerable and fragile. This has caused big losses of livelihood assets of communities, particularly of the poor and marginalized. The stresses and shocks are aggravating the problems and vulnerability of communities. The climatic impact has become more severe due to the worsening economic conditions of the people and labour shortage due to migration. Low income households, women and *Dalits* are more vulnerable to such impact compared to other categories of farmers. All these events added to the socio-economic burden of the poor and marginal farmers in the study sites.

Although it is not possible to address many vulnerability factors and climate risks in Nepal, these innovative biodiversity-based livelihood activities adopted by the farmers and promoted by NGOs can increase the number of options that poor people can exercise to respond to both climatic and non-climatic challenges. Knowledge, awareness, sustainable management of local biodiversity, equipment, value addition, financial support and organic agricultural techniques reduce the risk of climate-related losses from farms in addition increasing the capacity and flexibility to adapt income-generating activities to variable weather conditions. An important success factor for adaptation is community participation. The study shows that it is possible to capitalize on the existing knowledge and resource base by promoting local knowledge and farmers' innovations. External interventions have helped livelihood diversification, which has enabled farmers, particularly poor farmers, to cope with a wide range of shocks and stresses. However, there is a significant need to create more income generating opportunities for the poor. Moreover, the external support is not able to meet and address the health and sanitation, basic infrastructure like schools, roads, irrigation and other needs.

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[1] The main problem of the farmers of Kalabang village in Pumdibhumdi VDC, Kaski district was the irregularity and great variation in climate, which made it difficult for them to decide what crops to plant, when to harvest, and to determine the quality and quantity of produce.

[2] Most of the female respondents in Pumdibhumdi VDC, Kaski district had to travel at least an hour to the nearest water source to fetch water.

[3] Farmers of Begnas village, Kaski district reported loss of local landraces as one of the major causes of the change in the monsoon pattern. According to them, local landraces needed a little rain during the harvest, i.e. till mid-October, but nowadays the monsoon ends in late September.

[4] A female respondent from Chaur village, Kaski district said that women had to wake up as early as 4 AM and could not go to bed before 10 PM.

[5] Lal Kumar Biswokarma from Begnas VDC, Kaski district couldn't send his children to school because he didn't have money for admitting them in school and for buying their books. He wouldn't be able to feed his family if his children didn't supplement his income by working as wage labour.

[6] In Kalabang, almost every household had a member who was either in a Gulf or a European country.

[7] Ram Bahadur Thapa, a resident of Chaur village, Kaski district complained that farmers were becoming poorer due to their increasing dependence on external inputs, which they had to buy in the market.

[8] Ujeli Gurung, a resident of Jamankuna village, Kaski district earned around NRs 3,000 per month by mobilizing the fund she received from savings and credit schemes. Many other farmers also shared similar stories on the benefits of savings and credit schemes.

[9] Farmers of Chaur village, Kaski District were dissatisfied with some NGOs' promotion of high-value crops, including vegetables. Due to the expansion of hybrid crops they had to depend more on chemical fertilizers and pesticides. This dependency was adding to their economic burden.

[10] Lekh Nath Dhakal, chairperson of Rupa Cooperative, said that Rupa Lake in Kaski district was deteriorating due to massive flooding and landslides during the monsoon season. He said that heavy rain within a short period was one of the causes of massive floods in the river.

[11] Kalpana Baral, a resident of Pumdibhumdi VDC, Kaski district believed that farmers were producing less millet than in the past because of unpredictable rainfall during the crop's flowering season. She had also almost stopped planting millet.

[12] Diversity kit is one of the important ways of enhancing biodiversity. The respondents from Begnas VDC of Kaski district shared good outcomes of the distribution of diversity kits. The diversity kit had helped in locating their lost varieties. *Basaune ghiraula (*aromatic sponge gourd), once rare in the area, is now widely available in the village after the use of diversity kit and maintenance in diversity blocks.

[13] Farmers of Begnas VDC, Kaski District mentioned that a local landrace, named *EKLE*, was performing very well in the area in terms of yield, taste and adoption to environmental stresses like water-logging and drought. According to one farmer, *EKLE* alone covered almost 60% of the area of Begnas VDC.

[14] Lal Kumari Thapa was awarded as an innovative female farmer by LI-BIRD in 2007 for her outstanding contribution to biodiversity conservation and management.

[15] The evaluation report of LI-BIRD's project (2007) shows that the areas under cultivation of taro, buck-wheat, perilla and finger-millet have drastically increased due to value addition and marketing initiatives.