

Report on:

Effect of Climate Change on Vegetable Seed Production in Some Selected Pockets of Nepal



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A report on:

**Effect of Climate Change on Vegetable seed Production in
Some Selected Pockets of Nepal**

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ACRONYMS

| | |
|-----------|--|
| AEC | Agro Enterprise Centre |
| AIC | Agriculture Input Corporation |
| ARPP | Agriculture Research and Production Project |
| ASC | Agriculture Supply Corporation |
| CARIAD/UK | Centre for Advanced Research in Agricultural Development/ United Kingdom |
| CBED | Community Based Economic Development Project |
| CBS | Central Bureau of Statistics |
| CBSP | Community Based Seed Production |
| CCNN | Climate Change Network Nepal |
| CDM | Clean Development Mechanism |
| CEAPRED | Center for Environment and Agricultural Policy Research, Extension and Development |
| CIDA | Canadian International Development Agency |
| DADO | District Agriculture Development Office |
| DAG | Disadvantage Group |
| DDC | District Development Committee |
| DFID | Department for International Development |
| DISSPRO | District Seed Self Sufficiency Program |
| DNA | Designated National Authority |
| DOA | Department of Agriculture |
| FGD | Focus Group Discussion |
| GHGs | Green House Gases |
| GLOF | Glacial Lake Outburst Flood |
| GTZ | German Technical Corporation |
| HMRP | Hill Maize Research Program |
| IPCC | Inter-governmental Panel on Climate Change |
| IPM | Integrated Pest Management |
| ISTA | International Seed Testing Agency |
| JICA | Japan International Cooperation Agency |
| KIS | Key Informant Survey |
| KOSEVEG | Koshi Hills Seed and Vegetable Project |
| LDCF | Least Developed Countries Fund |
| MARD | Market Access for Rural Development |
| MoAD | Ministry of Agriculture Development |
| MOPE | Ministry of Population and Environment |
| NAPA | National Adaptation Plans of Action |
| NARC | Nepal Agriculture Research Council |
| NMRP | National Maize Research Programme |
| SDC | Swiss Agency for Development and Cooperation |
| SEAN | Seed Entrepreneurs of Nepal |
| SPISP | Seed Production and Input Storage Project |
| SRR | Seed Replacement Rate |
| STIP | Seed Technology and Improvement Program |
| UNDP | United Nations Development Programme |

| | |
|--------|---|
| UNFCCC | United Nations Framework Convention on Climate Change |
| USAID | United States Agency for International Development |
| VDC | Village Development Committee |
| VFC | Vegetable, Fruits and Cash Crops Development Project |
| VSP | Vegetable Seed Project |
| WWF | World Wildlife Fund |

EXECUTIVE SUMMARY

Climate change has been one of the emerging global challenges in the recent years. In accordance with this, the Inter-governmental Negotiation Committee adopted the United Nations Framework Convention on Climate Change (UNFCCC) in May 1992. Nepal signed this Convention on 12 June 1992 and ratified it on 2nd May 1994. Nepal ranks among the fourth most vulnerable country to climate change impact due to (a) higher rate of temperature increase compared to global average (b) exposure to all type of climatic conditions (c) high dependence on nature based livelihood and economic activities (d) fragile geology (e) inadequate human resources and (f) poor economy.

The agro-climatic diversity of Nepal favors the commercial production of different kinds of vegetable seeds and has both the comparative and competitive advantage for the local markets as well as exports to International markets. Though the potentiality of the production of different kinds of seed in Nepal has been studied, however, the possible variability in seed production due to climate change hasn't been studied thoroughly. Scientific evaluations are yet to be carried out to understand the types and degrees of impacts of climate change on specific geographical region and on different varieties of seeds. This study was conducted to assess farmers' perception on climate change and its impact/effects on vegetable seed production in commercial vegetable seed production pockets of Dhankuta, Sarlahi, Ramechhap, Mustang, Rukum, Surkhet and Dadeldhura districts representing different agro-ecological zones of Nepal as well as indigenous technologies/knowledge for climate resilience followed by farmers and recommend suitable adaptation measures of climate change risk. Primary data were collected by face to face interview with the vegetable seed producing farmers of the study area by using structured questionnaire and check lists for FGD & KIS. Meteorological data of the study districts for the period of previous 10 years were collected from Department of Hydrology and Meteorology. Similarly, related data were collected from district profiles and other different publications from MoAD, MoEnv, CBS, DDC, DADO, VDC etc. The collected data were coded, entered and analyzed by using different data analysis software as SPSS and excel sheet.

The annual precipitation in the study area within a decade showed an erratic pattern of rainfall with an alternate increasing and decreasing pattern. The pattern of rainfall showed a slightly increasing trend in the mountainous areas receiving higher amount of annual precipitation. A sharp declining trend of monsoon, pre monsoon and winter rainfall was found in Terai. Regarding temperature, there was a slightly increasing trend in average annual temperature within the study area within a decade. The increasing trend of temperature was found higher in high hills and mid hills as compared to Terai. Furthermore, warming in the winter was higher as compared to other seasons. Study showed that, involvement of Janajati in vegetable seed production was highest followed by others (Brahmin, Chetri). Similarly the involvement of Dalit in vegetable seed production venture was least. Regarding sex of respondents, 60 % male farmers were engaged in vegetable seed production followed by 40 % female farmers. The level of education and food sufficiency, average land holdings, access to seeds and fertilizers were found highest in Sarlahi and lowest in Mustang. Most of the respondents in the study areas perceived the change in temperature and rainfall pattern as the most prominent and important indicators of climate change. Almost all the respondents responded that they felt increase in temperature as compared to previous years. Similarly, the increase in winter temperature was felt more than that of summer experiencing warmer than previous years. The high hills received higher amount of precipitation in the recent years in terms of intensity and

duration of monsoon. Almost all vegetable seed producers in high hill felt increased precipitation whereas trend of rainfall was in decreasing pattern in mid hills and Terai. Similarly, the decrease in snowfall was especially felt in the high hilly areas. Early flowering of forest plants i.e Rhododendron and temperate fruits i.e Apple, Pear, Peach, Plum etc. were felt in mid and high hilly areas. Similarly, the drying of natural water resources and increasing disease pest infestation were also experienced by the respondents. Most of the farmers of Sarlahi had experienced prolonged drought between the month of November to May thus hindering the production of summer crops especially Maize and other vegetables. Farmers of Dadeldhura had shifted from their practice of making wet seed beds of rice to dry seed beds. Similarly, the rice transplantation has shifted to July-August and lack of moisture in soil affected the sowing of wheat as well. Many farmers of Mustang reported some positive effects from climate change as well. Farmers of Mustang were able to grow Cauliflower, Cabbage, Brinjal, Chili, Tomato and Cucumber, which used to require greenhouses few years ago in order to protect from severe cold. Similarly, some farmers of Dadheldhura reported that, the shift in planting time of Lady's finger from June to August has prevented seed damage due to excessive rain. The flowering and ripening of Broad leaf mustard, Cabbage, Carrot, etc had shifted 10-15 days earlier in Mustang; however, higher proportion of respondent experienced negative impact of changed climate. Comparatively less and untimely rainfall had affected the sowing and harvesting time in rainfed areas. Increased temperature especially in Terai had affected the flowering, seed setting and ripening of cucurbits and Tomato. Hybrid seeds were more sensitive to humidity and temperature, therefore, their germination and development was directly affected by such weather conditions. Dry spell directly affects the quality of vegetable seed produced. There was higher pest incidence due to drought conditions. Decrease in quantity and quality of produced seed was another negative impact felt. In rain fed areas, where the seed production activities depend on rainfall, the lack of moisture in soil and increased temperature leads to forced maturity of seeds resulting distorted shape, size and luster. This hence deteriorated the seed quality making its sale difficult.

Most of the respondents felt that the planting time of most of the vegetables has shifted earlier at least by 15-20 days. The shift was found more in Mustang (25 days) and less in case of Sarlahi (13 days). Similarly, change in climate as perceived by the farmers of the study area has directly affected on flowering and ripening of vegetable crops. Majority of the respondents in mid-hills felt early flowering and ripening of vegetable crops especially the Cole crops and Radish. Similarly, flowering in Tomato, Brinjal was felt earlier in Terai region. Flowering of Broad leaf mustard, Cabbage, Chili and Carrot has shifted about 15-20 days earlier in Mustang. Even though early flowering and ripening of vegetables occurred but the farmers felt that, the seeds thus produced were of very low quality as they lack proper shape, size and luster.

Climate change parameters such as temperature, rainfall pattern and humidity have direct impact on diseases and insect pest infestations. Incidence of pest and diseases was found more severe in Terai as compared to hills. Respondents in Sarlahi felt excessive incidence of disease in some major vegetables such as Beans, Cucurbits, Tomato and Potato. The increased infestation of aphids, fruit fly and borer had directly affected the production and increased cost of production, whereas the Yellow Mosaic Virus in Lady's finger and Mosaic Virus in Tomato had decreased the quality of produced seeds. Cabbage butterfly and Diamond back moth infestation in Cabbage, Cauliflower and Radish, neck rot in Tukinashi variety of Radish was felt increased in Mustang due to increase temperature together with the higher infestation

of aphids and powdery mildew. Some pathogens of important crops from Terai zones has adapted best now in hills and mid-hills (e.g. rust and foliar blight) that adversely affect the quantity and quality of vegetable seeds. Increase in insect population leads to demand for higher pesticides application, which unknowingly causes lots of harm to ecosystem as well as human society and increases the cost of production. As compared to earlier years, the farmers of the study area were using many types of pesticides (insecticides and fungicides) to protect their crops. Among insecticides, Malathion, Endosulfan, Methyl Demeton, Dimethoate were common, whereas Carbendazim and Mancozeb were commonly used fungicides. Most of the farmers were applying 1-2 sprays of Malathion and Endosulfan insecticides during flowering time. Few of them were also using Rogor which is systemic and highly toxic to bees and other pollinators. But the effectiveness of IPM program in Dadeldhura had convinced farmers towards the use of safe pesticides like Nuvan. Increase use of organic pesticides and animal urine had decreased the use of chemical pesticides to some extent but the increasing infestation, relatively more effectiveness, less quantity requirement, less effort needed for preparation and easier in availability forced farmers to use these harmful chemical pesticides.

Majority of farmers felt that, vegetable seed production was decreasing due to climate change. In Ramechhap and Mustang, due to increase in road facilities, farmers were found attracted towards fresh vegetable production rather than seed production due to immediate return, higher demand and assured market of fresh vegetables. The farmers had opined various problems and constraints in vegetable seed production. The general notion of the farmers was that vegetable seed production was long duration and risky enterprise. The key informants in the study area had also opined that farmers produce seed of open pollinated crops only and the returns was less in comparison to cash crops, which were predominately grown by the farmers. They felt that, the income from hybrid seed is higher as compared to open pollinated varieties. Therefore, farmers should be encouraged for the production of hybrid seeds as well. At the study sites, there were some local coping and adaptation strategies adopted by farming communities in response to potential/observed risks and hazards related to climatic and non-climatic factors. Communities have been using traditional methods of adaptation for generations based on local knowledge and innovations. Searching and exchanging drought-resistant seeds and other abiotic stress-tolerant crop varieties and adopting and practicing specific soil and water management practices for marginal areas have long been core activities of the farming communities. Farmers were already adapting to changing conditions by using traditional seed exchange practices that are part of established seed systems. Farmers of Dadeldhura reported the shift in planting time of vegetables in accordance with the change in climate. The winter season crops has shifted some days before and the rainy season crops were found shifted some days after. The seed bank at Dadeldhura was another mechanism to ensure preservation, marketing and timely availability of seed thus decreasing risk in this enterprise. In Aadital V.D.C, construction of rain water harvesting tank and demand for drought tolerant varieties were increasing. Similarly, minimum tillage of soil to resume soil moisture and use of mulching materials were also found practiced by the farmers. Staking of the plants to prevent from winds and storms was also practiced by farmers. Practice of irrigating was a commonly adopted to prevent water stress to plants. Drip irrigation and sprinkler irrigation were practiced. Use of plastic bags for germination of cucurbits seeds was an effective method for producing seedlings. Similarly, the uses of plastic tunnels help in maintaining temperature and prevent crop from hailstones and heavy rainfall. In Terai areas, Farmers learned to grow Tomato, Bitter gourd, Watermelon, Sweet potato, Sponge gourd, Bottle gourd, and Pumpkin in sand of river banks as well.

But these coping strategies and adaptation mechanism were found limited and practiced by fewer numbers of farmers of the study sites. Local knowledge, practices and innovations are important elements for community-based coping and adaptation mechanisms. At the national level, there was lack of information, knowledge, and proper database regarding local and regional information, and government plans and strategies to deal with climate change impacts. The few existing initiatives of government are often scattered and isolated when mainstreaming development. However, Different policies including NAPA and Climate Change policy 2011 as well as different activities, agreements and commitments made by Government at National and International level shows increasing interest of Nepal Government towards the issue of climate change. However, these policies should focus on developing mechanism to assess the effects and likely impacts of climate change, identify the vulnerable sectors and enhance their adaptive capacity, develop a mechanism for reducing GHG emissions and focus on activities related to climate modeling and assessing the ongoing effects and likely impact of climate change in agriculture sector from the mountain and hill regions to the plains.

1. INTRODUCTION

1.1 Background

Climate change has been one of the emerging global challenges in the recent years. The United Nations General Assembly adopted a resolution to develop an international legal instrument to address this global problem. In accordance to the resolution, the Intergovernmental Negotiation Committee has been meeting several times. The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in May 1992. This Convention was opened for signature at the UN Conference on Environment and Development in Rio de Janeiro, Brazil in June 1992. Nepal signed this Convention on 12 June 1992 and has ratified it on 2nd May 1994, making it effective three months later on 31st July 1994.

Increasing green house gasses emissions has contributed to increased atmospheric temperature, resulting in location-specific impacts. Despite having only 0.4 percent of the total global population and being responsible for only 0.025 percent of total GHG emissions in the world, Nepal ranks among the forth most vulnerable country to climate change impact due to (a) higher rate of temperature increase compared to global average (b) exposure with all types of climatic conditions (c) high dependence on nature based livelihood and economic activities (d) fragile geology (e) inadequate human resource and (f) poor economy.

There has been change in rainfall patterns (high, low, and intensive rainfall) and seasons due to climate change with direct and indirect impacts on water resources, agriculture, forest and biodiversity, health, infrastructure development, tourism, and livelihood. Obviously, due to its higher dependence in weather, Nepalese agriculture has been vulnerable to climate change. Vegetable seed is a low-volume, high value agricultural commodity that is emerging as an important means for increasing income of poor farmers and reducing poverty in Nepal. APP has also prioritized this enterprise as potential in contributing to high agricultural growth and an important export commodity. In more remote and inaccessible areas, where poverty tends to be particularly severe, it is often the only feasible opportunity within farm sector for enhancing the livelihoods of the rural poor. The agro-climatic diversity of Nepal also favors different kinds of vegetable seeds hence have both the comparative and competitive advantage for the local markets as well exports to International markets.

Over the past decade, Nepal's vegetable seed industry has been growing considerably with respect to the number of farm families engaged in vegetable seed production. The quantity of seed produced and market in and outside country with support of various governmental and non-governmental organizations are also in the verge of tremendous growth. The Center for Environment and Agricultural Policy Research, Extension and Development (CEAPRED) has been implementing vegetable seed production program since January 2004. From the first phase titled "Promotion of Vegetable Seed for Poverty Reduction in Remote Areas of Nepal" to the running third phase "Vegetable Seed Project (VSP III)", the project has targeted small, poor and disadvantaged farmers in remote districts of the country and has been able to demonstrate that vegetable seed production can be a viable income raising opportunity for the poor in remote areas of Nepal.

Though the studies regarding the potentiality of this enterprise in Nepalese economy have been performed, the possible variability in this sector due to climate change hasn't been

performed yet. Scientific evaluations are yet to be carried out to understand the types and degrees of impacts on specific geographical regions on different varieties of seeds. Similarly, programmes for avoiding, minimizing or adapting to the changing climate by developing appropriate technologies for risk reduction and disaster preparedness are also yet to be implemented.

1.2 Objectives of the study

The main objective of the study was to assess farmers' perception regarding the climate change and its impacts on vegetable seed production in commercial vegetable seed production pockets in different agro-ecological zones. The study emphatically examined the following seven aspects:

- i. Farmers' perception on climate change in major vegetable seed production pockets (Dhankuta, Sarlahi, Ramechhap, Mustang, Rukum, Surkhet and Dadeldhura)
- ii. Effects on seed crop physiology/morphology and flowering habits
- iii. Effects on seed maturity and seed quality (boldness, size and look)
- iv. Effects on diseases and insects prevalence
- v. Other indicators including the coping strategy adopted by farmers to sustain the livelihood due to climate change impacts
- vi. Indigenous technologies/knowledge for climate resilience followed by farmers.
- vii. Analysis and recommendation of adaptation measures of climate change risk.

1.3 Geographical working area

The geographical working area for this study was selected so as to represent vegetable seed production pockets of Nepal as a whole. Dhankuta, a very potential vegetable seed production mid-hill district of Eastern Development Region represented the hilly region. Also, Sarlahi & Ramechhap from Central Development Region represented Terai & mid-hills respectively. Mustang was selected as a high-hill district from Western Development Region. Similarly, Rukum as a mid hill and Surkhet were selected from Mid Western Development region. Dadeldhura was another promising district for vegetable seed production representing Far Western Development Region.

1.4 Limitation of the study

This study was conducted to assess farmers' perception of climate change and its effects on vegetable seed production in commercial vegetable seed production pockets of Nepal. The study districts were selected so as to represent different agro-ecological zones within the country though districts from High hills and Terai were limited. The study was conducted with time and budgetary constraints as well. The meteorological data obtained were only of ten years and the information collected from the study site were entirely based on the farmers view. Hence, the problem of memory lapse and personnel biasness, though tried to be kept at minimal level, was inevitable.

2. REVIEW OF PAST INITIATIVES

2.1 Seed Sector History

Formal seed production and distribution in Nepal began in late fifties and sixties with the introduction of new varieties of Rice like Taichung Native 1 and IR 8; of Wheat Lerma 52 and, Lerma Roho 64, and Maize Amarilo de Blanco (MOAC, 2008). Seed production in those days was target oriented and mainly produced in government farms and stations, and seeds were distributed through extension services. With the establishment of Agriculture Supply Corporation (ASC) in 1974, it started to procure and market limited quantity of seeds to farmers. Organized seed production and distribution started in early seventies when FAO established a high capacity seed drying, processing and bagging plant at Hetauda for Agriculture Input Corporation (AIC). During eighties, GTZ and USAID further helped to establish seed processing and storage facilities at five AIC regional centres in Terai and 20 mini seed houses in the mid hills (Imtizaj, 1990). Until 1990, public sector continued to play a key role in production and supply of Agricultural seeds in Nepal. A time line on vegetable seed sector development in Nepal is presented in Table 2.1.

Table 2. 1: Time line of seed sector development in Nepal

| Year | Formal seed sector key events |
|---------|--|
| 1960-80 | Establishment of government farms at different agro ecological zones of Nepal initiated seed production activities |
| 1978 | Contract vegetable seed production at farmers level |
| 1979 | Fresh Vegetable and Vegetable Seed Production Project funded by FAO Swiss project started with Technical Cooperation Project |
| 1980 | Seed Production and Input Storage Project (SPISP) funded by USAID |
| 1981 | Vegetable Seed Production Project (FAO) financed by Switzerland government |
| 1982 | Seed Technology and Improvement Program (STIP) initiated |
| 1985 | Import of hybrid seed in vegetables and maize started by private sector |
| 1988 | Seed Act enacted |
| 1991 | Establishment of Seed Entrepreneurs of Nepal (SEAN) |
| 1997 | Seed regulations enacted |
| 1998 | Seed Sector Support Project (SSSP) funded by DFID |
| 1999 | National Seed Policy approved |
| 2002 | National Seed Company established |
| 2004 | Vegetable seed Project initiated with SDC funding |
| 2011 | Seed Vision 2025, A Seed Sector Development Strategy draft prepared |

Despite the past 30 years of vegetable seed development initiatives, unavailability of good quality seeds in sufficient amount at right time and at right place still hinders its production. Nepalese agriculture is yet to be modernized and made competitive for achieving national goal of food and nutritional security, poverty reduction and improved livelihood of farmers.

2.2 Vegetable Seed Development Projects

Koshi Hills Agriculture Project (Seed Component, 1987-1992): The project was aimed to develop cereal and vegetable seed production and supply system in Koshi hills. It was implemented at ASC level with full responsibility being with DADO and related line agencies

in the districts. The scheme could not continue due to poor financial and technical management by district based agricultural development line agencies and stakeholders.

Rural Development Projects (1988-1990): There were some rural development projects like Mechi Hills Program and Dhading Development Projects, which included seed activities and encouraged village level seed production of cereal and vegetable crops for income generation. It also helped to make availability of improved seeds of several crops. These projects were successful in raising seed use awareness but could not be regularised by the government due to lack of resources and other priorities.

Fresh Vegetable and Vegetable Seed Production Project: The FAO Swiss project started with Technical Cooperation Project in 1979 lasted till 1994 through its four phases. Working with Vegetable Development Division, this project introduced a systematic and integrated approach to vegetable seed production and marketing. It opened broad horizon for private sector to be involved in vegetable seed production and marketing.

Vegetable, Fruits and Cash Crops Development Project (VFC/Rapti- 1984): The seed production and marketing program of VFC in 1990s were successful to scale up the production by several times in Rapti zone, however due to its negligence in providing quality foundation seed and quality control services; as a result, it has minimized the supply of Nepalese Radish seed in Bangladeshi market.

Koshi Hills Seed and Vegetable Project (KOSEVEG, 1992-1997): This project was designed to develop an effective, sustainable and market oriented seed and vegetable programme and was primarily aimed to increase the food production and household income. The social mobilization process of the project was notably successful feature and creation of local farmers association was particularly important. It linked the seed growers with national and regional seed traders to give continuity to seed production after the project phased out.

Community Based Economic Development Project (CBED, 1997-2002): CIDA funded CBED also adopted the demand based vegetable seed production program linking seed growers with seed traders through regional seed contracting workshops. It became successful in bringing the seed production practices in the western hill districts of Nepal.

Market Access for Rural Development (MARD, 1997-2002): USAID funded MARD Project supported the farmers' group and cooperatives for vegetable seed production and marketing in Surkhet, Dailekh and Nuwakot districts.

Seed Sector Support Project (SSSP): The SSSP was a successor of the KOSEVEG project and adopted the same approach for seed production and marketing. The approach was based on contractual seed production agreed by seed producer groups and seed buyers during seed planning workshops. The model was later replicated in other districts (Dadeldhura and Achham). The SSSP contributed to enhance the seed industry in Nepal and was specially known for private seed sector growth.

Vegetable Seed Project (VSP): The VSP funded by Swiss Agency for Development and Cooperation, was initiated in 2004 in order to benefit poor farmers living in remote areas by diversifying their income opportunities through vegetable seed production and marketing. Thorough its first phase (2004-2006) and second phase (2007-2010), it contributed to improve

the food security situation significantly. The new phase (2011-2014) will address emerging issues in sustainable seed system and plans to contribute to the priorities set in the recent third year Plan (2010-2013). The future activities in this project will expand the program, integrate District Seed Self Sufficiency Program (DISSPRO) and Community Based Seed Production (CBSP), build capacity of groups and cooperatives and encourage public private partnership among others. The project has envisioned establishment of National Federation of Seed Cooperatives through their networking and collaboration for seed sector development in partnership with NARC and DOA.

Nepal has been an experimental ground for several approaches and models in improving seed production and distribution system. Some of the features of the successful seed production program described above are: a) Integrated approach to seed production and marketing, b) Private sector involvement in seed business, c) Institutionalization for involvement of Seed Groups and their association, d) linking seed producers with seed traders through contract agreement, e) Initiative for export market, f) community based seed production initiatives g) quality assurance and required legal provisions.

2.3 Present Situation of climate change in Nepal

Nepal has experienced an average maximum annual temperature increase of 0.06 degree Celsius. This rate of increase is higher in the mountains than in other regions. Despite having only 0.4 percent of the total global population and being responsible for only 0.025 percent of total GHG emissions in the world, Nepal will be affected disproportionately, especially from increasing atmospheric temperature. Changes in the annual rainfall pattern, intense rainfall and longer droughts have been observed. Similarly, both days and nights are presently warmer. The number of days (with 100 mm of heavy rainfall) is increasing. The timing and duration of rainfall is changing. As glaciers recede from rapid snow and ice melting, glacier lakes are expanding. The adverse impacts of climate change have been noticed in agriculture and food security, water resources, forests and biodiversity, health, tourism and infrastructures. Climate-induced disasters and other effects have caused damages and losses to life, property, and livelihoods.

Millions of Nepalese are estimated to be at risk to climate change. In the past 90 years, a glacier in the Sagarmatha region has receded 330 feet vertically. Because of glacier melting, new glacier lakes have formed. Although there will be an increase in river flows until 2030, this is projected to decrease significantly by the end of this century. The problems arising due to climate change are increasing over the years. Nepal has to implement adaptation programmes even if it is not being responsible for climate change. Hence, Nepal has considered climate adaptation as a national agenda and has taken initiatives for implementing different programmes for risk reduction in the recent years.

3. METHODOLOGY

The methodology for this study comprises the following activities

3.1 Collection of data

The first hand data were collected by conducting face to face interview with the vegetable seed producing farmers of the study area using a structured questionnaire. Similarly, Focus Group Discussion and Key Informant Survey were also conducted for the collection and triangulation of the data. Secondary data were collected from different sources. Meteorological data of the study districts for the period of last 10 years (2001-2010 A.D) were collected from Department of Hydrology and Meteorology. Similarly, district profiles and other different publications relevant to the study were collected from MoAD, CBS, DDC, DADO, VDC etc.



Plate 1: Focus Group Discussion with farmers at Ramechhap

3.2 Analysis of Data

The collected data were coded, entered and analyzed by using different data analysis software as SPSS & MS Excel sheet. The pattern of change in temperature and rainfall were based on the secondary data recorded at different meteorological stations of study areas. The perception of farmers regarding the change in climate and its impact in vegetable seed production were analyzed based on the data obtained by face to face interview with respondents using structured questionnaires and checklists. The analysis of farmers' perception was based under the following headings:

3.2.1 Socio demographic characteristics and access to resources

Different variables like education level, family size, organization involved, type of housing, level of food sufficiency, size of land holding, access to irrigation, fertilizers, seeds, training etc. were analyzed for socio demographic characteristics and access to resources.

3.2.2 Farmers perceived change in climate

Change in intensity, duration and pattern of rainfall, change in temperature, intensity, duration of snowfall, hailstone fog, storm and the natural calamities like landslides, floods, drought and impacts on crop production due to these factors as experienced by the respondents were analyzed.

3.2.3 Impact of Climate change in vegetable seed production

Farmers perceived change in planting time, quality and quantity of produced seeds were analyzed. Their production was analyzed on the basis of parameters such as shift in planting, flowering and ripening time of seeds, shape, size, luster of seed and number of pods and seed set, disease pest infestation, etc.

4. RESULT AND DISCUSSION

4.1 Study area

This study was carried out in seven districts of Nepal covering five development regions ranging from high hilly region Mustang to Sarlahi in terai region. Study includes the potential vegetable seed production districts of the country. The overview of the study area is presented hereunder.

Map of Nepal Showing Study Districts

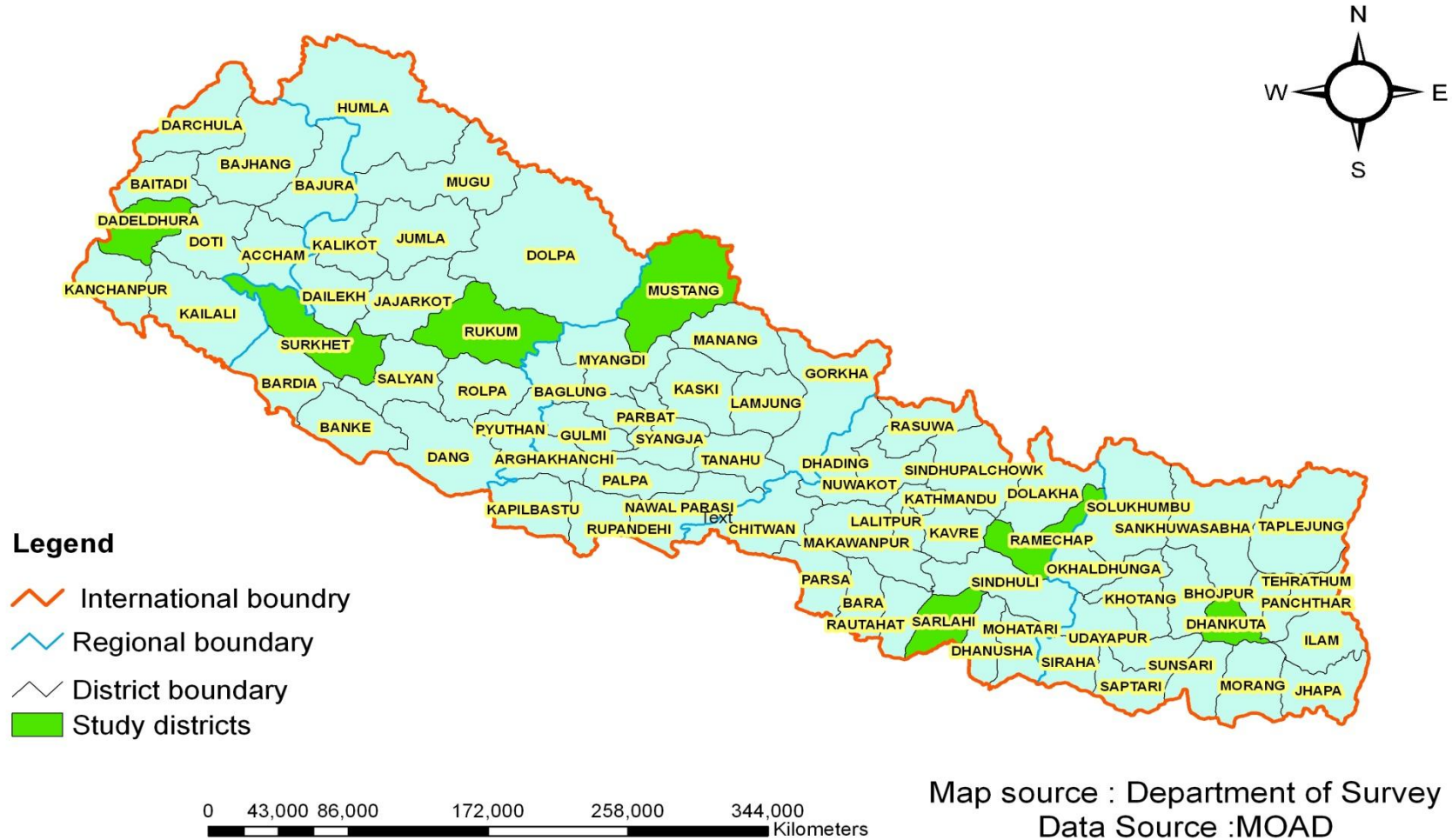


Table 4. 1: Brief Description of the Study Area

| District | Development region | Geographical location | Altitude Range (m) | Average Temperature range | Average annual Rainfall | Climatic variation |
|-----------------|---------------------------|--|---------------------------|----------------------------------|--------------------------------|--------------------------------|
| Dhankuta | Eastern | 26°53'N to 27°19'N Latitude, 87°19'E to 87°33'E Longitude | 120-2702 | Max:24.31°C Min:3.94°C | 1822 mm | Sub tropical to warm temperate |
| Ramechhap | Central | 27°28'N to 27°50'N Latitude, 85°50'E to 86°35'E Longitude | 439-6958 | max:31.3°C Min: 11.9°C | 2020 mm | Sub tropical to warm temperate |
| Sarlahi | Central | 26°27'N to 27°10'N Latitude, 85°24'E to 85°48'E Longitude | 60-659 | max:30.3°C Min: 19.5°C | 1500 mm | Sub tropical |
| Mustang | Western | 28°20'N to 29°05'N Latitude, 83°30'E to 84°15'E Longitude | 2000-8167 | max:22.5°C Min: -3.2° C | 280 mm | Temperate, Alpine, Tundra |
| Surkhet | Mid western | 28°20'N to 28°58'N Latitude, 80°59'E to 82°2'E Longitude | 198-2367 | max:29.4°C Min: 15.5° C | 1344 mm | Sub tropical and temperate |
| Rukum | Mid Western | 28°29'N to 29°00'N Latitude, 82°29'E to 82°53'E Longitude | 762-6072 | Max: 34.4°C Min: 0.42° C | 2200mm | sub tropical to warm temperate |
| Dadeldhura | Far western | 28°59'N to 29°36'N Latitude, 80°12'E to 80°40'E Longitude | 462-2639 | Max: 32.7°C Min: 3.6° C | 1343.6 mm | Temperate and warm temperate |

(Source: Annual Publication, DADOs)

4.2 Climate change

4.2.2 Change in Rainfall Pattern

4.2.1.1 Annual rainfall trend

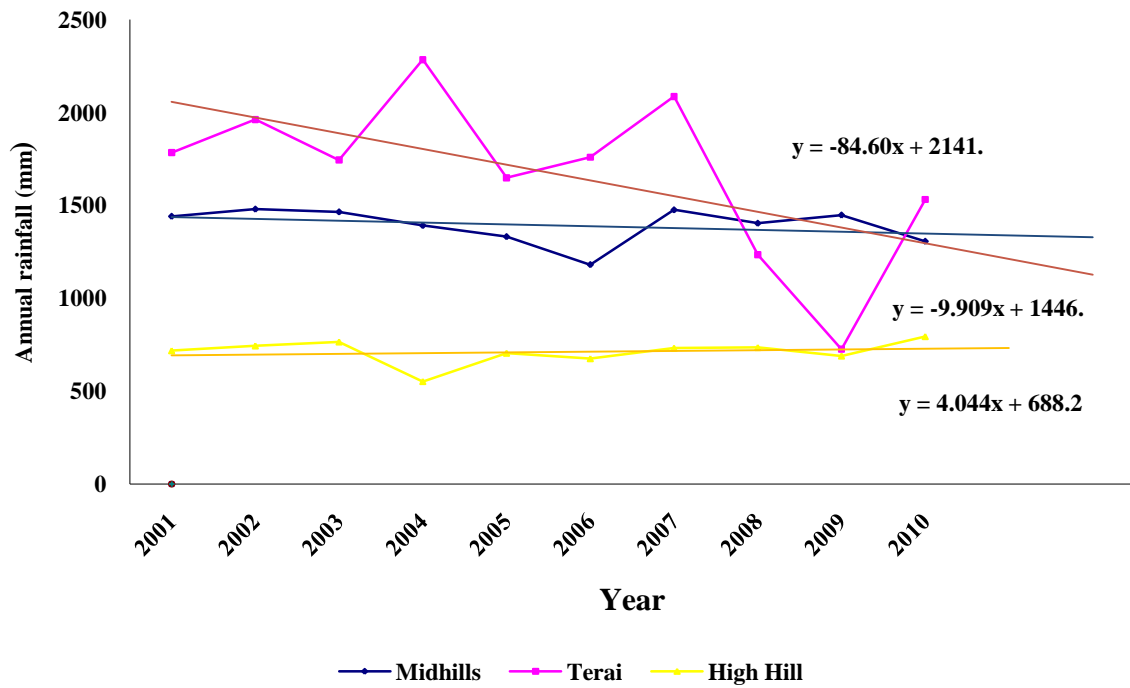


Figure 1: Trend of annual precipitation in the study area (2001-2010)

4.2.1.2 Trend of Monsoon Rainfall in the study area (2001-2010)

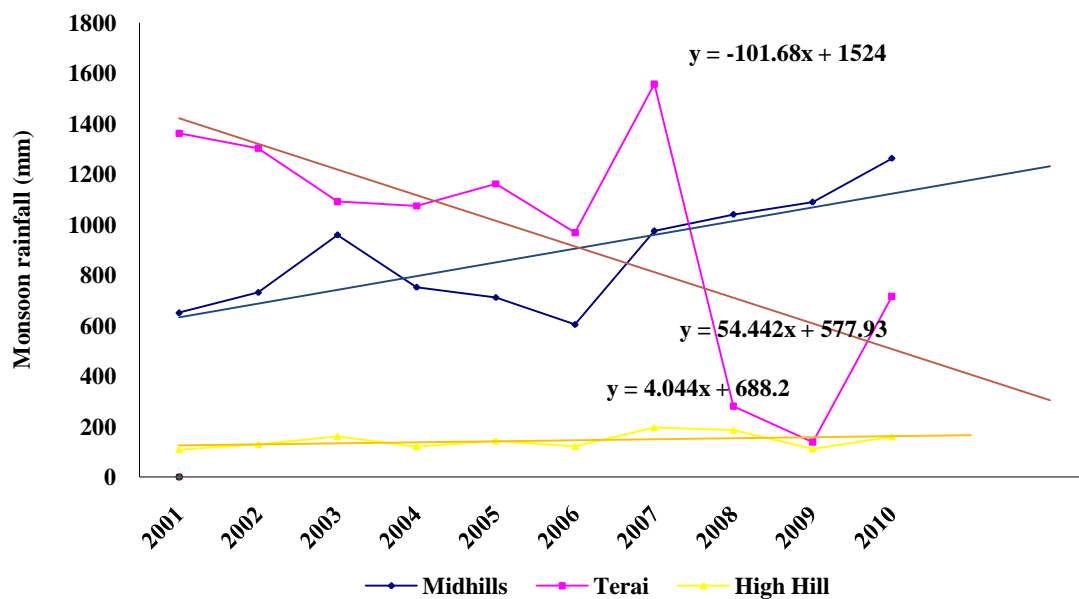


Figure 2: Trend of monsoon precipitation in the study area (2001-2010)

4.2.1.3 Trend of Pre Monsoon Rainfall in the study area (2001-2010)

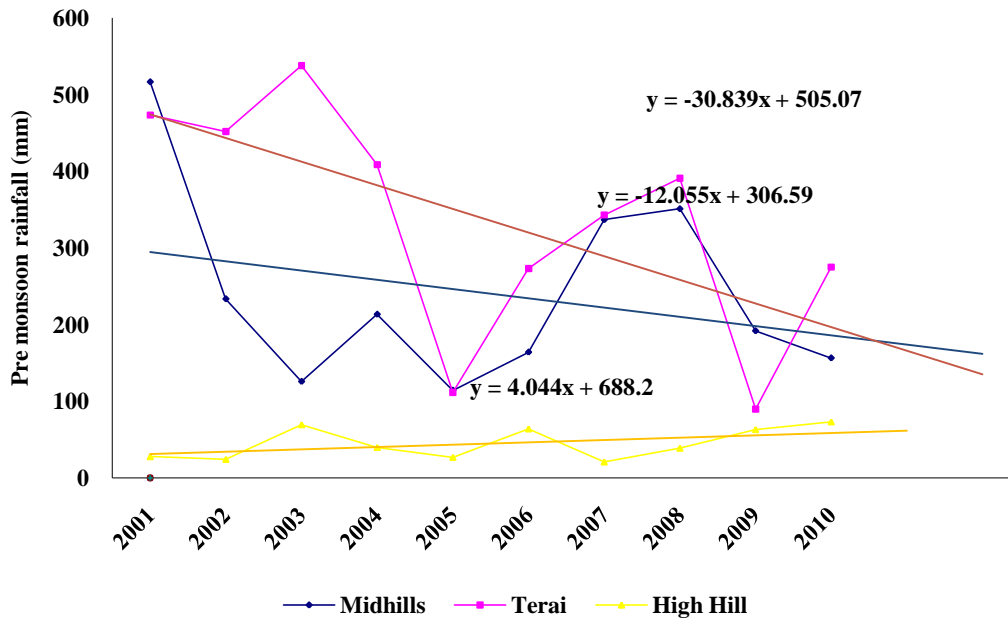


Figure 3: Trend of pre monsoon rainfall in the study area (2001-2010)

4.2.1.4 Trend of Winter Rainfall in the study area (2001-2010)

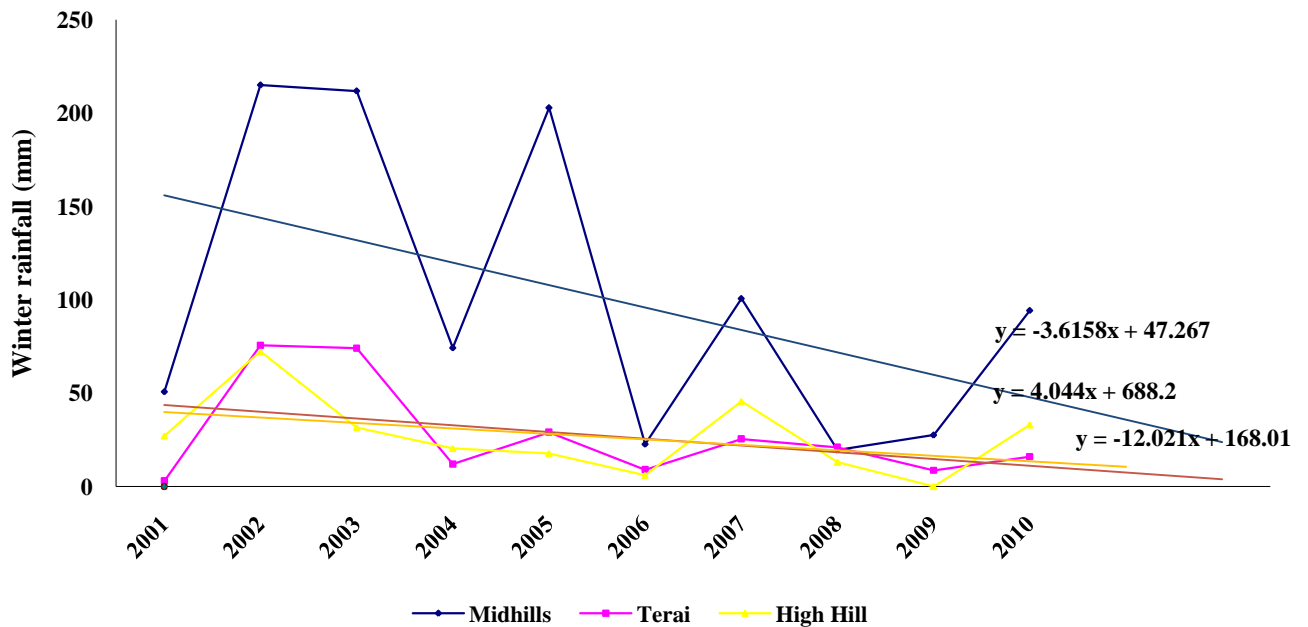


Figure 4: Trend of winter precipitation in the study area (2001-2010)

The annual precipitation in the study area within a decade showed an irregular pattern of rainfall (alternate increasing and/or decreasing). In Terai, maximum rainfall occurred in the year 2004 and 2007 and minimum in the year 2009. The pattern of rainfall shows a slightly

increasing trend in the mountainous areas receiving higher amount of annual precipitation. Amount of total precipitation in mid hills was found decreasing continuously with a slight increase in the year 2007. Interestingly, the year 2004 received highest rainfall in Terai whereas just opposite to that the mountainous areas received the lowest precipitation in that year. This erratic pattern of rainfall with an alternate increasing and decreasing pattern within the country thus creates rain deficit in some areas, moderate rainfall in other and alternate changing pattern of rainfall thus creating floods, landslides in one year and severe drought in other as well. The monsoon rainfall pattern shows sharp declining trend except for the year 2007 when there was excessive rain followed by floods creating heavy loss of life and properties in Terai followed by severe drought in the year 2009. The pre monsoon and winter rainfall was also in decreasing trend in Terai whereas rainfall pattern shows increasing trend in case of high hills, showing Terai areas as more vulnerable due to erratic rainfall pattern whereas high hills benefitng from the increasing rainfall pattern to some extent.

Over the past three years, the delay in monsoon season experienced in Nepal has changed the cropping pattern and crop maturity period. It has delayed the planting and harvesting season by a month, which has in turn affected rotation practices. The delay in monsoon season has also made thousands of hectares of farm land fallow and reduced production due to lack of water (Regmi and Adhikary, 2007). A drought in the Eastern region of Nepal decreased the rice production by 30% in 2006 and heavy flooding in the mid-Western and far-Western regions in 2006 and 2008 destroyed crops in many places (Paudel, et al, 2008).

4.3 Change in temperature

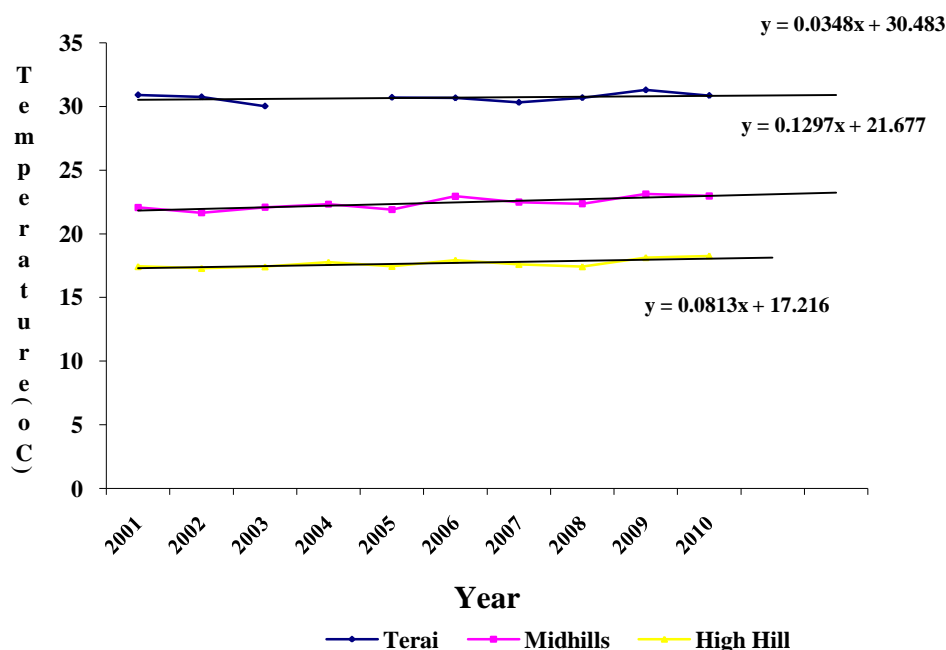


Figure 5: Trend of change in temperature over a decade (2001-2010)

4.3.1 Trend of winter temperature in the study district

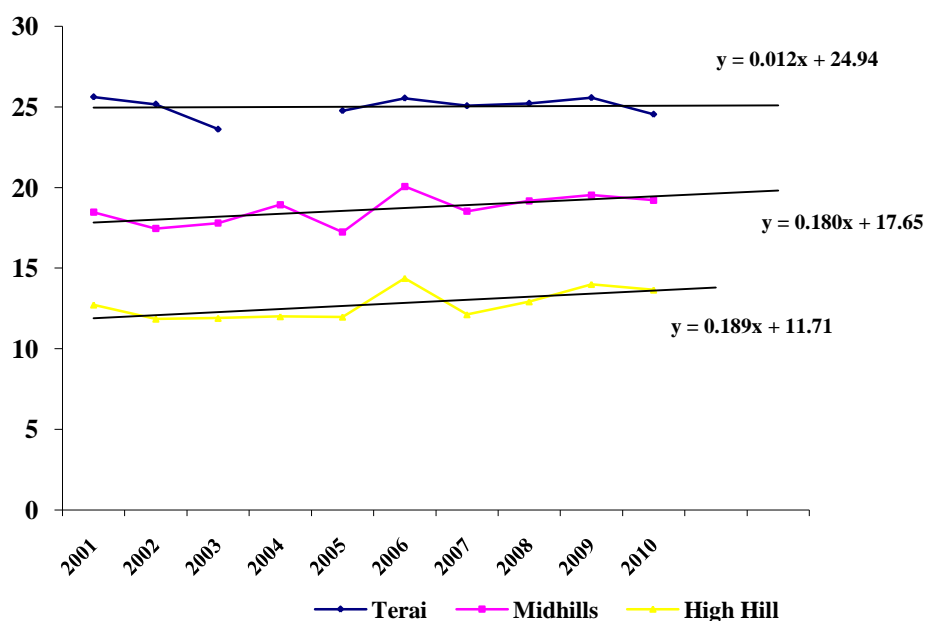


Figure 6: Trend of change in winter season temperature over a decade (2001-2010)

4.3.2 Trend of summer temperature in the study district

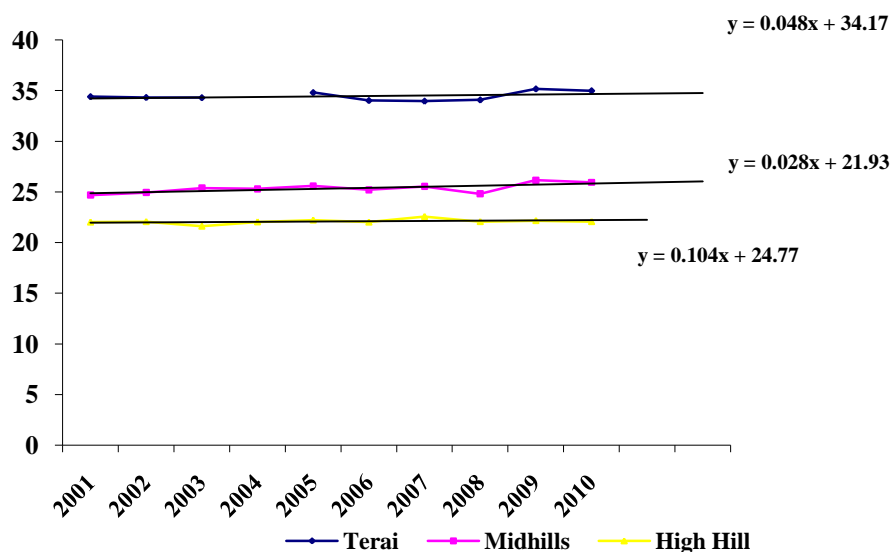


Figure 7: Trend of change in summer season temperature over a decade (2001-2010)

Figure shows a slightly increasing trend in average annual temperature within the study area within a decade. Nepal's temperature has increased by 1.8 degree Celsius during last 32 years. In Nepal average temperature increase was recorded as 0.06 degree Celsius per year and that in Terai and Himalayas was 0.04 degree Celsius and 0.08 degree Celsius /year respectively (Shrestha et al., 1999). The increasing trend of temperature was found higher in high hills and mid hills as compared to Terai. Furthermore, warming in the winter was higher as compared to other seasons.

4.4 Farmers Perception towards effects of Climate Change on Vegetable Seed Production

4.4.1 Socio Demographic Settings

Selection of crops and their varieties, crop planting, intercultural operations and harvesting practices in several instances are guided by the culture of the farmers. Social setting of a community including the caste/ethnic composition of people to a greater extent determines the type of farming system. The size of the holdings, food sufficiency level, type of residence, average family size and the availability and access to primary daily needs as safe drinking water, type of toilet and the type of energy source for cooking are some of the major indicators of the economic well off society.

4.4.1.1 Caste composition of the respondents

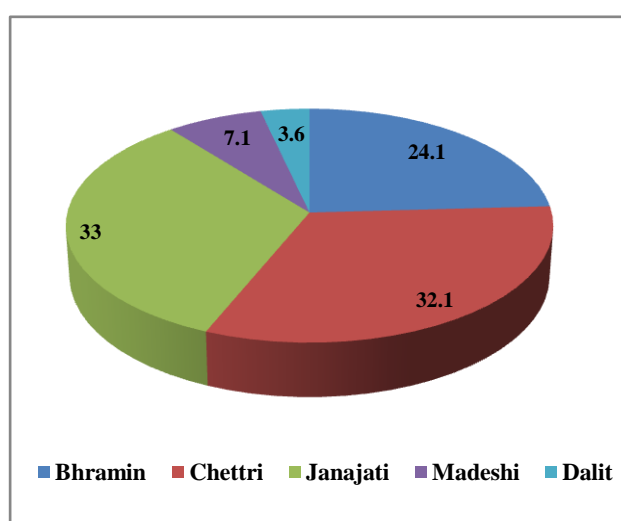


Figure 8: Caste composition of respondents (2012)

The ethnic/caste composition showed majority of the respondents (33%) were Janajatis followed by Chettri (32.1%) and Bhramin (24.1%) whereas 1.2% Dalits and 3.6% Madhesi involvement in vegetable seed production in the study area. However the proportion of Janajatis (86.7%) and Dalits (13.3%) in Mustang and Madhesi (53.3%) in Sarlahi were found dominating. Similarly, the vegetable seed producing farmers (92%) were found to be organized among themselves either in a group or a cooperative. However fewer proportions (53%) of the farmers of Mustang were organized in a group. A case study by Sagun program in different districts of

Nepal has reported that group dynamics play an important role in identifying options and opportunities for building resilience of communities.

4.4.1.2 Sex of the respondents

The gender of the respondent (generally the household head) plays a major role in household decision making. Majority of the respondents (61.6%) in the study area were male and 38.4% were female. In mid hills, nearly half (41.5%) of the respondents were female whereas the proportion was comparatively less in Sarlahi (26.7%) and Hills (33.3%).

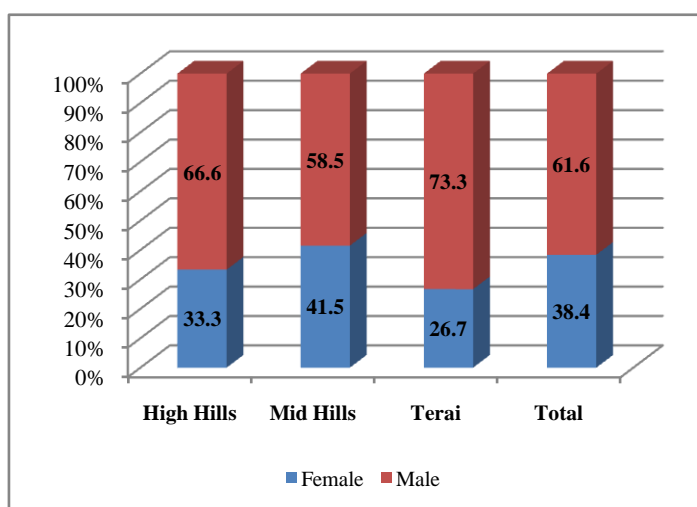


Figure 9: Sex of respondents (2012)

4.4.1.3 Average family size

Table 4.4.1.3 1: Family size of the study households

| Regions | Average Family Size | Minimum | Maximum | Modal size |
|--------------|---------------------|----------|-----------|------------|
| Mustang | 5.53 | 3 | 9 | 5 |
| Mid Hills | 6.76 | 3 | 14 | 7 |
| Sarlahi | 8 | 5 | 16 | 6 |
| Total | 6.76 | 3 | 16 | 6 |

4.4.1.4 Educational status of respondents

The small farmers, mostly illiterate or with low level of education depend heavily on their culture, habit and traditional practices to earn their livelihood without understanding the science behind their day to day decisions (Pant, 2011). The higher illiteracy rate (19.5%) of the respondents were found in mid hills followed by Mustang (13.3%) and none of the respondents in Sarlahi were found illiterate in contrary to the overall literacy status of the country where higher illiteracy prevails in high hills and terai.

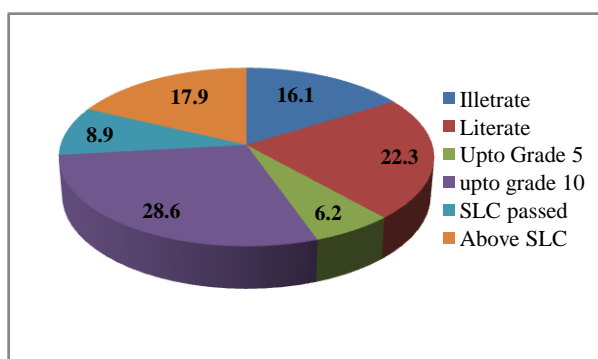


Figure 10: Educational Status of Respondents (2012)

4.4.1.5 Level of food sufficiency

The level of food sufficiency determines the level of status of the household and their ability to cope up with the adverse change in the climate. Obviously, the food insecure families are more vulnerable to climate change due to their weak coping capacity and hence are always in greater risk. Figure shows higher proportion of respondents in Mustang (33.3%) with food sufficiency less than 3 months. Similarly, more families (73.3%) in Sarlahi had food production sufficient for 12 or more months. Overall half of the respondents (50.9%) were at food sufficient level and the rest half were unable to meet their food demand from their own production for the

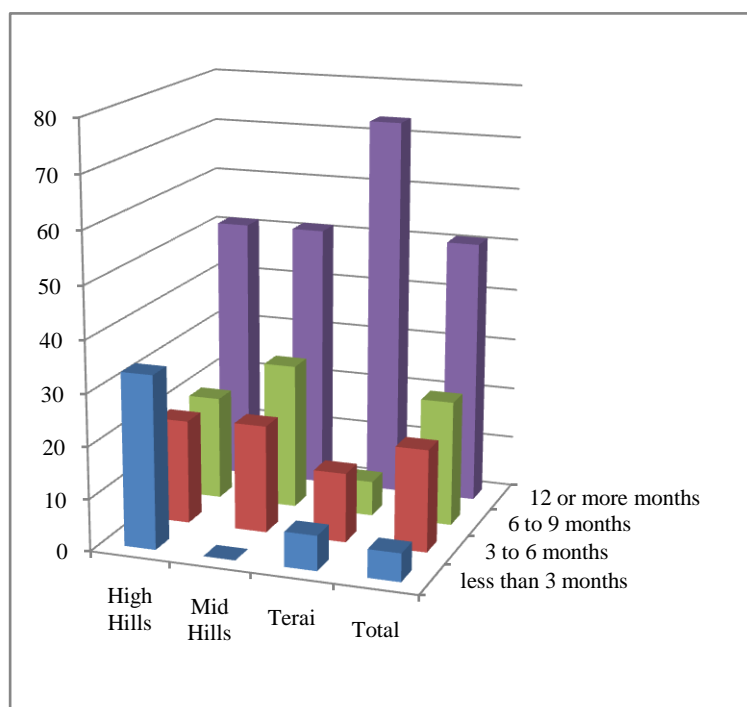


Figure 11: Level of food sufficiency of respondent households (2012)

whole year round. As the existing system of food production in Nepal is highly climate sensitive because of its low level of capital and technology thus any change in rainfall or temperature patterns leading to declining crop yields will further enhance the risks and exposure to food insecurity and malnutrition of those already in the food insecure level. Since agriculture constitutes a much larger fraction of GDP (33.5%), even a small percentage of loss in agricultural productivity could snowball into a larger proportionate income loss and general economic well being of the majority of Nepalese affecting the economy of the country.

4.5 Access to resources and agriculture inputs

4.5.1 Average Land Holdings of the surveyed household (2012)

The average land holdings of the surveyed household showed majority of the farmers in high hill own land size of less than 0.25 ha whereas most of the farmers in mid hills have land size between 0.25 to 0.5 ha. Comparatively, larger size (1 ha or more) of land holdings per household was found in case of Sarlahi. Thus, most of the vegetable seed producers in the study area are small to marginal farmers. Obviously the small holding with undulated terrains hinders production and hence higher proportions (33%) of the respondents in Mustang have food sufficiency for less than 3 months from their own production whereas more than 73% of the vegetable seed producing farmers in Sarlahi were at food sufficiency level for 12 months or more.

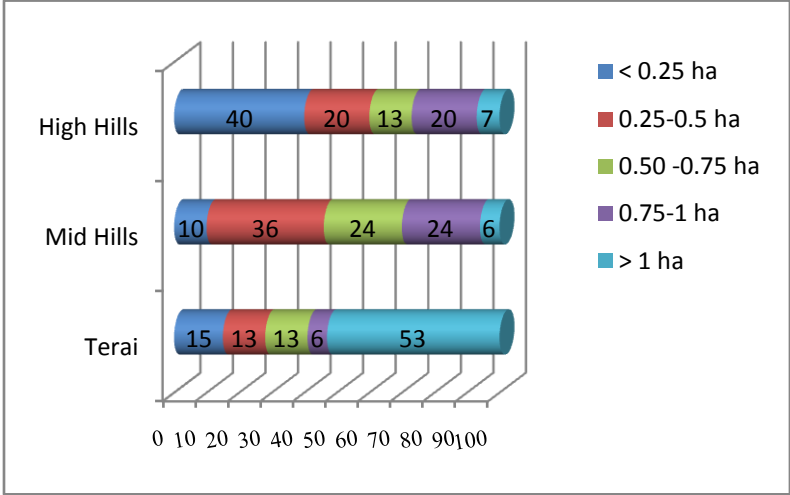


Figure 12: Average land holdings of households (2012)

4.5.2 Status of agriculture inputs in study area

One of the many adaptations to climate change involves the use of different varieties of seed, for example the use of early maturing varieties or drought resistant ones. The non-availability of seed might be an obstacle to the adaptation. Temperate horticulture development center, Marpha; a government farm; is the only source of foundation seed in case of Mustang. This may be due to

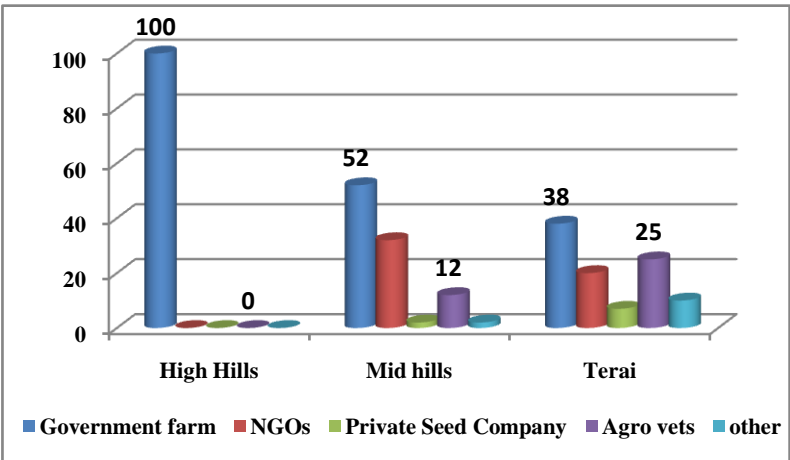


Figure 13: Status of Agri inputs in the study areas (2012)

more reliability over the government farm or lack of other sources in Mustang. Whereas abundance of agro vets, Seed Company, NGOs and other sources, especially the cooperatives involved in production and marketing of vegetable seeds in Sarlahi and mid hills increased farmers' access to foundation seeds in these areas.

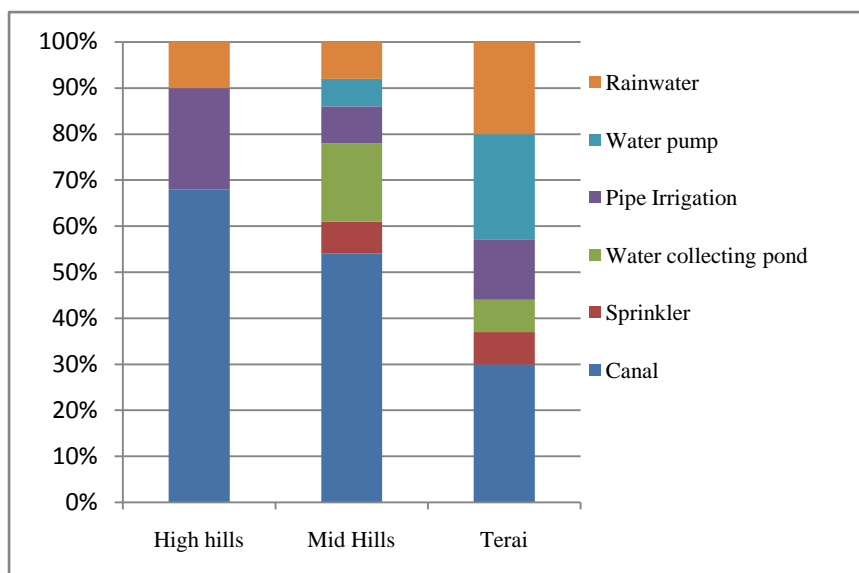


Figure 14: Sources of irrigation in the study areas (2012)

Mustang hills were found to be dependent upon rain water for cultivation and 68% farmers have facility of canal irrigation whereas only 30% vegetable seed growers in Sarlahi were facilitated with canal irrigation despite the topographical hindrance for canals in high hills to Terai. Deep and shallow tube wells in Terai and use of sprinklers, water collecting ponds, pipe irrigation were other sources common in mid and high hills. Similarly, more farmers in hills 84%, 80% in Mustang and 47% in Sarlahi were found trained in the vegetable seed production, processing and marketing.

Similar statements could be made regarding fertilizer availability and its use. The difficulty in transportation and livestock rearing being an important integrant of hill farming system, the use of organic fertilizers was found higher in these areas whereas the excessive use of chemical fertilizers (42%) was found in Sarlahi. Interestingly, only 10% of the farmers in

4.6 Farmer perceived change in climate within a decade

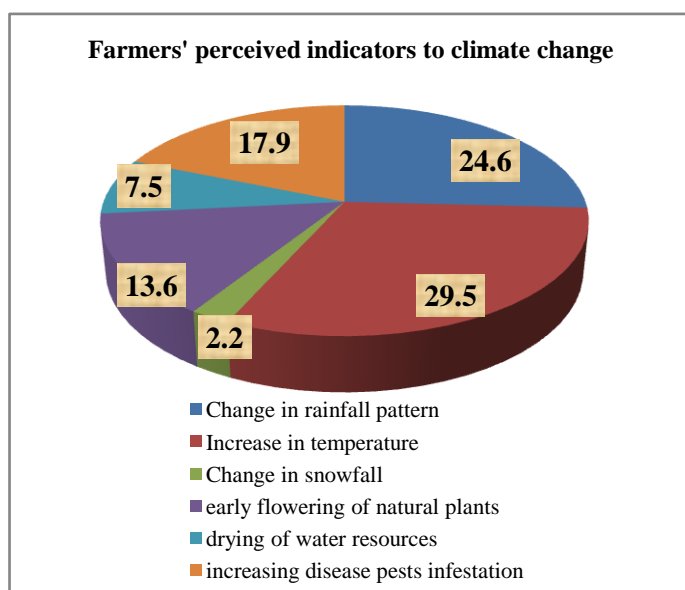


Figure 15: Farmers' Perceived Indicators to Climate Change in the Study Area (2012)

were felt in mid and high hilly areas. Similarly, the drying of natural water resources, more effort needed to take water from the wells due to decreasing water level, drying of ponds/lakes were felt in Terai regions. The increasing disease pest infestation however was felt by most of the respondents of the study area. Changing climate has also been realized by the farmers through unpredictable period of rains and increasing temperature. The weather has become unpredictable and crop failures have become common. During FGD, farmers discussion concluded that the change in climate led the settlement of Chisapani; one of the VDCs in Ramechhap district; in the verge of shifting due to continuous drying of water resources in that area.

The information collected on climate is based on the perception of individual farmers or key informants. Most of the respondents in the study areas perceived the change in temperature (29.5%) and change in rainfall pattern (24.6%) as the most prominent and important indicators of climate change.

Similarly, the decrease in snowfall is especially felt in the high hilly areas. During FGD, farmers reported that snowfall used to occur 8-9 times to 4-5 feet few years before but had decreased to 4-5 times to 4-5 inches these years. Similarly, thunderstorms felt sometimes were unusual in the previous years. Early flowering of forest plants like Rhododendron and temperate fruits such as Apple, Pear, Peach, Plum etc.

Box 1: Experience of farmers of Rukum

Farmers of Rukum district felt that snowfall used to occur in the lower areas also which was now restricted to the upper areas only. Interestingly, hailstone which was uncommon during nights have been felt during nights also. Similarly, the incidence of aphids used to decrease after rainfall but not felt these years. The grey leaf spot of Maize and late/early blight of Potato have shown devastating effects. Also, the stem of Onion used to be straight but now started curving the reason after which was unanswered.

4.6.1 Change in temperature & Rainfall within last decade

Change in temperature and rainfall pattern is the most prominent indicators of climate change as perceived by farmers. Almost all the respondents (86% in high hills, 72% in mid hills, 78% in terai) responded that they felt increase in temperature as compared to previous years. None of the respondents have reported the decrease in temperature concluding that days are getting hotter and felt more in high hills. Similarly, the increase in winter temperature was felt more than that of summer experiencing warmer winters than previous years. The high hills received higher amount of precipitation in the recent years in terms of intensity and duration of monsoon. Almost all vegetable seed producers in high hill felt increased precipitation whereas trend of rainfall was in decreasing pattern in Mid hills and Terai as experienced by 81% and 60% of the respondents respectively. Also, 34%, 94% and 60% of respondents in high hills, mid hills and terai respectively felt the initiation of monsoon has delayed thus enforcing delayed plantation of major crops. Similarly, the intensity, duration and season of snowfall in high hills was found to be changed within the past decade. People reported that heavy snowfall used to occur in the month of December but now it is occurs in the month of February and March. Moreover, less snowfall occurred as a whole in Mustang. Similarly, the problem of increased storm (59% in Mid Hills and 46% in Sarlahi) and drought (97% in mid hills and 93% in Sarlahi) were felt. Similarly, most of the farmers of Sarlahi had experienced prolonged drought between the month of November to May thus hindering the production of summer crops especially Maize and other vegetables. Farmers of Dadeldhura has shifted from their practice of making wet seed beds of Rice to dry seed beds. Similarly, the transplantation of Rice shifted to July-August and lack of moisture in soil affected the sowing of Wheat as well.

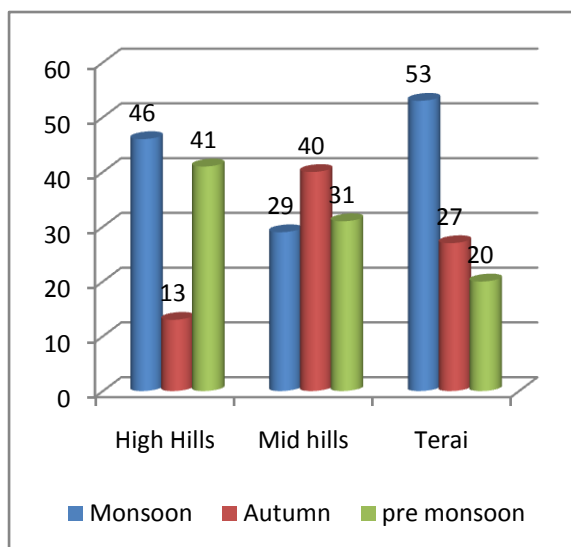


Figure 17: Farmer's Perceived Change in Rainfall Pattern in Study Area (2012)

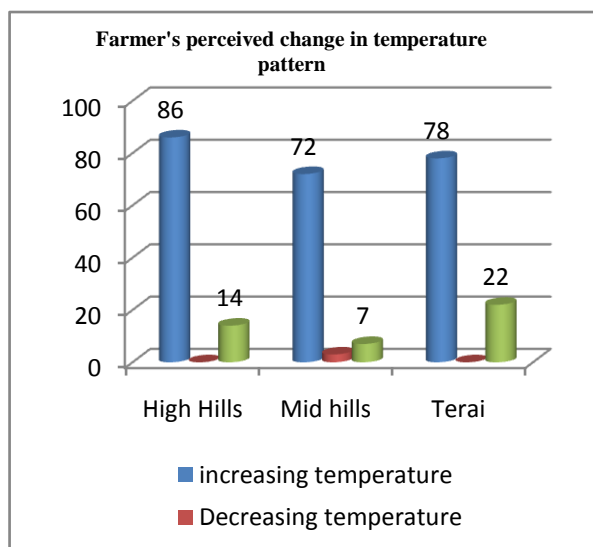


Figure 16: Farmer's perceived change in Temperature pattern in Study Area (2012)

Many farmers of Mustang reported some positive effects from climate change as well. Farmers of the Mustang district have noticed improved Apple sizes in recent years which might be due to favorable environment as well as due to improved cultivation practices. However, most of the respondents reported a number of negative effects of major concern. Over the past three years, the delay in monsoon season experienced in Nepal has changed the cropping pattern and crop maturity period. It has delayed the planting and harvesting season by a month, which has in turn affected rotation practices. The delay in monsoon season has also made thousands of hectares of farm land

fallow and reduced production due to lack of water (Regmi and Adhikary, 2007). In Madiphat of Pakkarbas V.D.C, Ramechhap, farmers were found replacing their traditional Rice cultivation with commercial Chilli cultivation basically due to irregular monsoon felt in the recent years. The increasing market of Chilli in nearby Jiri Bazaar has increased their income level as well. A drought in the Eastern region of Nepal decreased the Rice production by 30% in 2006 and heavy flooding in the mid-western and far-western regions in 2006 and 2008 destroyed crops in many places (Paudel, et al, 2008).

4.7 Effects of climate change in vegetable seed production

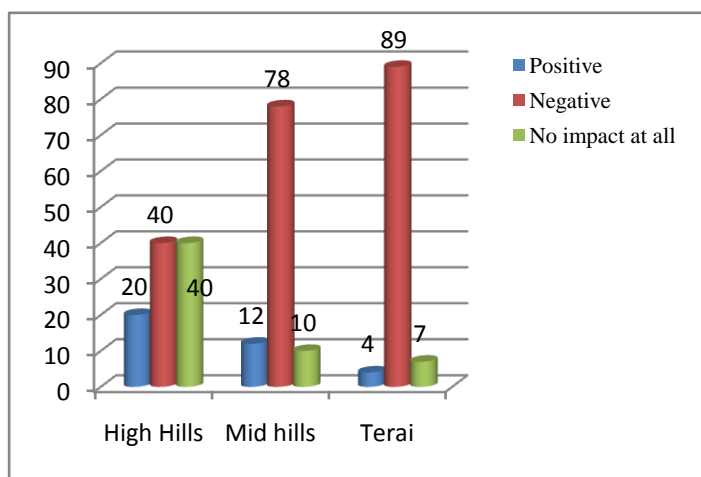


Figure 18: Farmer's Perceived Impact of Climate Change in Vegetable Seed Production (2012)

There was mixed response of the farmers when they were asked about the effect of climatic change on the vegetable seed production. Very few farmers (20% in Mustang, 12% in Mid Hills, 4% in Sarlahi) reported that they felt some positive impacts due to climate changes. Farmers of Mustang were able to grow Chili, Tomato and Cucumber, which used to require plastic houses in order to survive. Similarly, some farmers of Dadheldhura reported that the shift

in planting time of Lady's finger from June to August has prevented seed damage due to excessive rain.

41% of the respondents in Mustang expressed their view that cultivation of Brinjal, Chilli and cucurbits has been done successfully in Mustang these days due to favorable environment created due to changed climatic condition. The flowering and ripening of Broad leaf mustard, Cabbage, Carrot has shifted 10-15 days before. However, higher proportion of respondent experienced negative impact of changed climate. Most negative effects were felt in Sarlahi as responded by 89% of the farmers followed by mid hills (78%) and Mustang (40%) was found. Comparatively less and untimely rainfall had affected the sowing and harvesting time especially in rain fed areas. Increased temperature especially in Terai had affected the flowering, seed setting and ripening of specially the cucurbits and Tomato. Hybrid seeds are more sensitive to humidity and temperature. Therefore, their germination and development is directly affected by such weather conditions. Dry spell directly affects the quality of vegetable seed produced. There is higher pest incidence due to drought conditions. The increasing disease pest infestation, as indicated by 63% of respondents in Mustang, 21% in mid hills and 32% in Sarlahi was the major negative impact. Decreased quantity and quality of seeds produced (22%) was another negative impact felt. Tulman Tamang, an experienced farmer of Ramechhap stated that due to increased rainfall in late monsoon the harvesting and drying of Bean seed has adversely affected. In rain fed areas, where the seed production activities depends highly in rainfall, the lack of moisture in soil and increased temperature leads to forced maturity of seeds leading to distorted shape, size and luster hence difficulty in selling for seed purpose. Decreased number of bees however was reported mainly due to excessive use of pesticides rather than climate change.

4.7.1 Shift in planting time

The impact of climate change as perceived by the vegetable seed producing farmers was the shift in planting time. Most of the respondents (66% in Mustang, 72% in mid hills and 86% in Sarlahi) felt that the planting time has pre-pond by about 15-20 days. The shift was found greater in Mustang (25 days) and lower in case of Sarlahi (13 days). However, planting time in case of rainy season crop had shifted some days after (22% in mid-hills and 8% in Sarlahi) generally due to delayed monsoon.

4.7.2 Change in germination

The change in germination percentage of seed in the study areas was found somewhat affected by the change in climate. 33% of the respondents in Mustang and 47% in Sarlahi reported decrease in seed germination whereas the proportion in case of mid hills was a bit higher (79%). This change in germination was mainly due to the lack of proper soil moisture and/or soil temperature required rather than the change in inherent property of seed.

However, alternation in plant morphology was felt in some areas. Fourty six percent of the respondents in Mustang, 68% in mid hills and 86% in Sarlahi experienced the decreased canopy of the crop. Although, the luxurious vegetative growth of some crops especially the cucurbits and legumes were found but fruit setting or reproductive growth was found lower.

During FGD at Rukum, farmer reported that the stem of onion used to be straight previously have now found curled, the probable cause might be due to increased infestation of purple blotch and/or downy mildew of Onion. Similarly, some double rooted Carrots were also found in Horticulture Development Farm, Marpha and such forking and double roots usually occurs due to acidic soil in the root crops.



Plate 2: Upper part of onion stem seen bent found during field visit at Rukum

4.7.3 Change in flowering time

Change in climate as perceived by the farmers of the study area had direct affect on flowering and ripening of vegetable crops. Majority of the respondents in mid-hills (80%) felt early flowering of vegetable crops especially the Cole crops and Radish. Similarly, flowering in Tomato, Brinjal was felt earlier in Terai region. Flowering of Broad

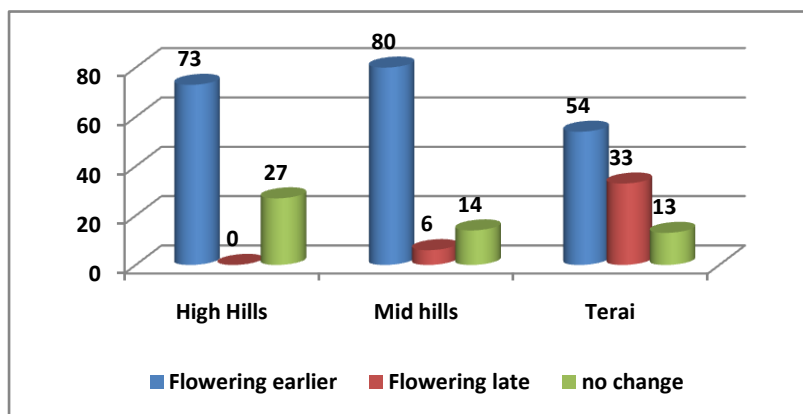


Figure 19: Farmer's Perceived Change in Flowering time of vegetable (2012)

leaf mustard, Cabbage, Chilli and Carrot have shifted some 15-20 days earlier in Mustang. Moreover, early flowering of Broad leaf mustard in Rukum is more prominent by 20-30days.

4.7.4 Change in ripening time

Change in ripening time was found in line with that of flowering time of vegetable crops. The early flowering crops had early ripening as well. Eighty nine percent of farmers in mid hills, 73% in Mustang and 67% in Sarlahi experienced crops reaching early maturity. Farmers had their opinion that the increase in temperature leads to forced maturity of the seeds. During cold waves in Terai the ripening time of vegetable

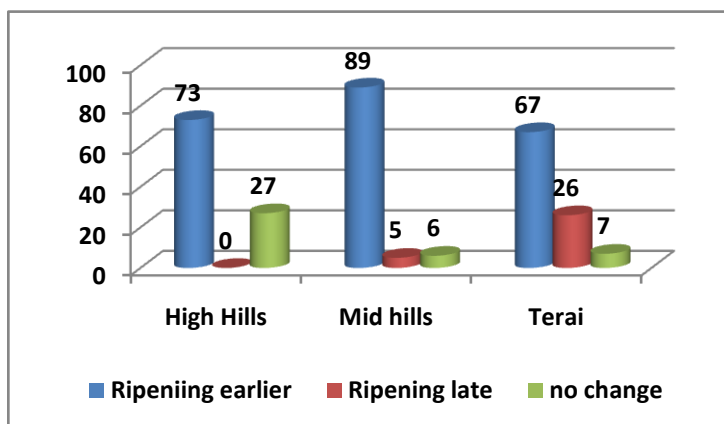


Figure 20: Farmer's Perceived Change in Ripening time of vegetable seeds (2012)

seeds were found delayed. Both the early and late ripening had adverse affect in seed quality. Problem in seed shape, size and luster was experienced due to early maturity. Kumar et.al, 2009 in one of the study found rapid rise of temperature at the time of the pollination lead to pollen abortion in Cabbage hence no viable seed was produced. Though no cases of complete failure to seed set in any of the vegetable seed produced in the study area, the increased temperature decreased the setting of seeds especially in beans in mid hills (71%) and Tomato and Cabbage in Sarlahi (54%). The production per unit area of seeds was found decreasing as responded by 74.1% of the respondents.

4.7.5 Effect of changed climate in Quality of seed produced

Much of the variation in seed quality among seed lots is the direct or indirect result of variation in weather before or at harvest, hot dry periods generally providing good quality seed (Austin, 1972). Majority of the respondents (94% in mid hills, 93% in Sarlahi and 66% in Mustang) felt decreased seed size as compared to previous year. Similarly, the shape of the seed was also found to be changed. The wrinkled seeds were found by 71% and 59% of the respondents in mid-hills and Sarlahi respectively.

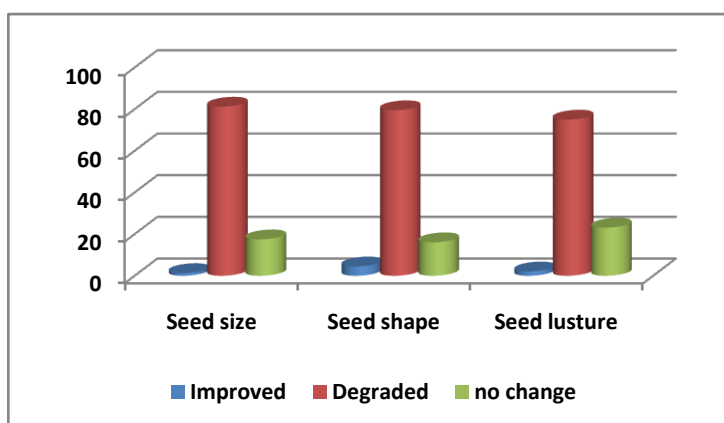


Figure 21: Farmer's Perceived Effect of Changed Climate in Quality of Seed Produced (2012)

The proportion was relatively less (7%) in case of Mustang. Farmers also found decrease in luster of the seed they produced. Almost 80% of the farmers accepted that seeds were dull looking and less attractive than previous. Sher Bahadur Roka of Surkhet worried that the quality of seed has decreased so rapidly that farmers/buyers might not accept for seed purpose. Some farmers in Ramechhap reported late harvesting and

drying of Bean seeds due to continuous rainfall at the harvesting season thus degrading the seed quality. Agam Sher Rai of Dhankuta stated that the increased foggy period in higher altitude (1600-2100m) has hindered quality seed production in these areas. Siddique and Goodwin, 1980 found reduced seed quality in Bean (*Phaseolus vulgaris* L.) due to high temperatures after anthesis.

4.7.6 Intensity of disease pest

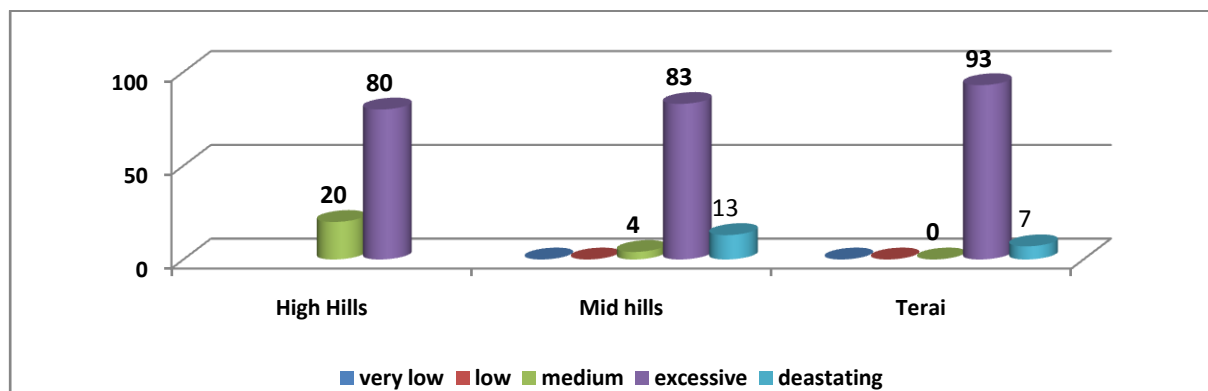


Figure 22: Farmer's Perceived Intensity of Disease and Pest in Vegetable Seed Production (2012)

Climate change parameters: temperature, rainfall pattern and humidity have an impact on the development and distribution of pests and diseases. Increase in temperature and CO₂ increases the rate of reproductive cycle of insect and pest and hence increased incidence. Results indicate that climate change could alter stages and rates of development of the pathogen, modify host resistance, and result in changes in the physiology of host-pathogen interactions. The most likely consequences are shifts in the geographical distribution of host and pathogen and altered crop losses, caused in part by changes in the efficacy of control strategies. Incidence of pest and diseases was found more severe in Terai. The incidence and damage caused range from medium in some crops to devastating loss in other. 93% of respondents in Sarlahi felt excessive incidence of disease in some major vegetables as Beans, cucurbits, Tomato and Potato.

The increased infestation of aphids, fruit fly and borer had directly affected the production and increased cost of production whereas the yellow mosaic virus in lady's finger and mosaic virus in Tomato has decreased the quality of the



Plate 3: Onion plant heavily infested with *purple blotch* found during field visit at Rukum



Plate 4: Radish heavily infested with *Aphids* found during field visit at Surkhet

produced seed. Cabbage butterfly and Diamond back moth infestation in Cabbage, Cauliflower and Radish, neck rot in Tukinashi variety of Radish was felt increased in Mustang. Gradual shift of pest and diseases of Sarlahi have felt in hills and mountains. The infestation of aphids and powdery mildew were found increased in Mustang. Some pathogens of important crops from Terai zones has adapted in hills and mid-hills (eg. rust and foliar blight) that adversely affects the quantity and quality of vegetable seeds. However, during group discussion in Dadeldhura, some positive impact of changed climate in disease pest infestation was also discussed. The decreased infestation of beetle in Beans due to late plantation (third week of August) in comparison to the early plantation in July was felt. This was due to the completion of the life cycle of the insect before planting time. Radish when planted in third week of August showed less or no infestation of aphids compared to late plantation in September.

The increase in insect population leads to demand for more use of pesticide, which unknowingly causes lots of harm to ecosystem as well as human society and increases the cost of production.

The farmers of the study area are using many pesticides (insecticides and fungicides) in the process of seed production. Among insecticides, Malathion, Endosulfan, Methyl Demeton, Dimethoate are commonly applied whereas Carbendazim and Mancozeb are commonly used fungicides. They had the view that pesticide spray was necessary, especially against diseases. According to their experience, if the crop is not sprayed before the disease incidence, it is not possible to



Plate 5: Women farmer spraying pesticides at vegetable seed production field Rukum

control it later on. Interestingly, the number of sprays has increased in recent years. The least number of sprays (1-2) are required in onion seed production. Most of the farmers are applying 1-2 sprays of Malathion and Endosulfan insecticides during flowering. Few of them are also using Rogor which is systemic and highly toxic to bees and other pollinators. But the effectiveness of IPM program in Dadeldhura has convinced farmers towards the use of safe pesticides like Nuvan. Increase use of organic pesticides, animal urine has decreased the use of chemical pesticides to some extent though the increasing infestation, relatively more effectiveness, less quantity requirement, less effort needed for preparation and easier in availability forced farmers to use these harmful pesticides.

4.8 Other indicators and coping strategy adopted by the farmers to sustain livelihood

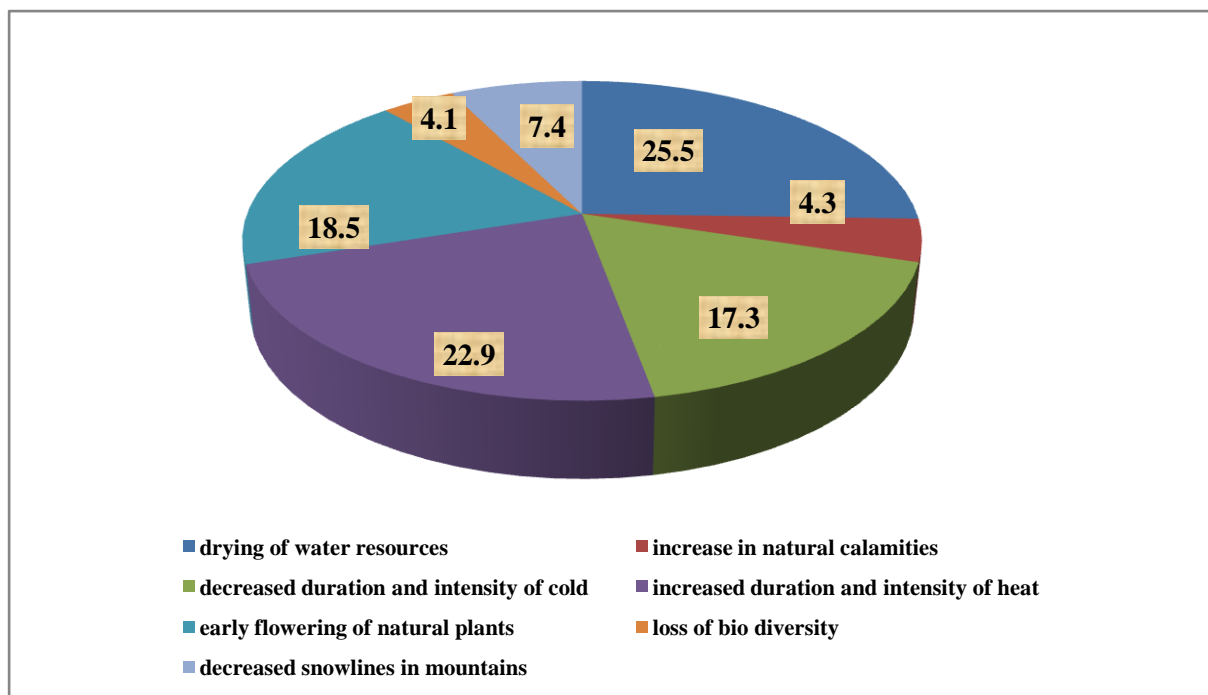


Figure 23: Other indicators to Climate Change as Perceived by Farmers of the Study Areas (2012)

Most of the farmers (25.5%) perceived drying of natural water resources as the most prominent indicator of climate change felt in the community. The drying off and decreased flow of rivers, complete drying of ponds, natural stone taps, decreased water table leading to increased depth of wells and tube wells were reported. Similarly, the increased duration and intensity of heat during summer and less duration and intensity of cold during winter were other indicators of the increase in temperature. The erratic rainfall pattern with increased intensity leading to flood, landslides in some years and long drought in other were also felt mostly in Terai and mid-hills. The early flowering, especially of the forest species such as Rhododendron (*Rhododendron sps.*), Palash (*Butea monosperma*), Simal (*Bombax mori*) etc, were also experienced by the farmers in their areas. Similarly farmers of Mustang experienced the decreased in snowlines of mountains as well. Some farmers have related the loss of local landraces due to climate change. According to them, local landraces require a longer rainy season and that in the past 10 years the duration of rainfall has decreased. These local landraces have been replaced by short duration modern varieties. Tika

Box 2: Is climate really changing??

A case of Mustang district

According to respondents, thunderstorm in Mustang was not felt in previous years but they have experienced thunderstorms these days though no record of lightening in the district till date. Similarly, the drying up of natural water resources was also felt basically in upper Mustang. People of Dhey, ward no. 9 of Surkhang VDC have already migrated due to lack of water resources. Excessive infestation of Woolly Aphids experienced in **Bainsh** (*Salix alba*) forced farmers to completely remove these trees from Tukunche area.

Interestingly, the agro vets reported that they were selling hybrid seeds of almost all vegetables (especially cole crops) except coriander indicating more vulnerability towards the changed climate felt.

Malla, a progressive farmer of Rukum worried that Mustard and local varieties of cucurbits, Tomato, Radish, Soybean were in the verge of extinction.

Farmers have also described effects on beekeeping and an increase in insect and pest numbers. The number of jungle bees (*Apis dorsata*) has decreased to greater extent. Regmi, et al., 2009 had reported that increased unpredictability and intensity of weather events and hazards have been described by farmers as causing significant disruption to rain-fed agriculture, contributing to the loss of local landraces of crops change in timing of fruit tree and forest trees flowering.



Plate 6: Drought area of Mustang District

4.9 Different Coping Strategy adopted by farmers

4.9.1 Adaptation and coping strategy



Plate 8: Community Seed Bank: An Initiative of CEAPRED



Plate 9: Farmers of Ramechhap practicing local method for maintaining moisture in soil

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (UNFCC, 2009). However, at the study sites, there are some local coping and adaptation strategies adopted by farming communities in response to potential/observed risks and hazards related to climatic and non-climatic factors. From the perspective of poverty reduction, adaptation is already necessary as people's lives and livelihoods face an increasing burden of broader shocks and stresses. Communities have been using traditional methods of adaptation for generations based on local knowledge and innovations. There is a need of investigation regarding the existence of local knowledge and livelihood assessments enabling the villages to cope with climate change. It further examines how local knowledge and innovations are important in designing research and for development interventions targeted among the vulnerable communities.



Plate 7: Vegetable seed production practiced under plastic tunnel

Nepalese farmers have tradition of worshipping the nature as god and loving the land as mother. They play with nature and try to adjust with it rather than going against it. Farmers are innovators as well. Traditional farming system management practices and farmers'

innovations are clearly a key element in local adaptation to climate change. According to Reid and Swiderska, 2008, while scientists and policymakers worked to find out solutions, local farmers have already amassed considerable experience of coping, based on their observation and experimentation in the field. Searching and exchanging drought-resistant seeds and other abiotic stress-tolerant crop varieties and adopting and practicing specific soil and water management practices for marginal areas have long been core activities of the farming communities. Farmers are already adapting to changing conditions by using traditional seed exchange practices that are part of established seed systems. Farmers can also use their knowledge of abiotic stress tolerance and adaptability in their materials and work with plant breeders to develop varieties that are adapted to changing local conditions and possess improved yields and quality (Jarvis et al, 2007).

A comparative study (Bhandari, 2009) of hill and Terai agro ecosystems found that more households (40%) in Sarlahi rather than in the hills (11.6%) reported production decreases (of 5-25%) due to abnormal rainfall. It has been suggested that the continuing richness of traditional varieties in the hills places an important part in explaining this difference. A higher risk of food insecurity during abnormal rainfall years in the Terai has also been noted due, perhaps, to vulnerability of modern varieties. Through farming practices farmers are able to keep traditional varieties adapted to changing growing conditions and social preferences. Farmers of Dadeldhura reported the shift in planting time of vegetables in accordance with the change in climate. The winter season crops has shifted some days before and the rainy season crops were found shifted some days after. The seed bank at Dadeldhura was another mechanism to ensure preservation, marketing and timely availability of seed thus decreasing risk in this enterprise. In Aadital V.D.C, construction of rain water harvesting tank and demand for drought tolerant varieties were increasing. Similarly, minimum tillage of soil to resume soil moisture and use of mulching materials were also found practiced by the farmers. Staking of the plants to prevent from winds and storms was also practiced by farmers. Provide irrigation was a common practice adopted to prevent from water stress to plants. Drip irrigation and sprinkler irrigation were practiced. Use of plastic bags for germination of cucurbits seeds was an effective method for producing seedlings. Similarly, the uses of plastic tunnels help in maintaining temperature and prevent crop from hailstones and heavy rainfall. In Terai areas, farmers started to use riverbanks for vegetable cultivation. This riverbank used to be cultivated land before. Due to riverbank erosion and change in river routes, the land was converted into sand fields. Farmers learned to cultivate this type of land to grow tomato, bitter gourd, watermelon, sweet potato, sponge gourd, bottle gourd, and pumpkin.

4.10 Status of vegetable seed production – Problems and constraint

Majority (74.1%) of farmers felt that vegetable seed production is decreasing. Eighteen percent of the vegetable seed producers were having no idea about the status of vegetable seed production. However, 8% revealed that the vegetable seed production was increasing.

In Ramechhap, due to increase d road facilities, farmers were found attracted towards fresh vegetable production rather than seed production due to immediate return, higher demand and assured market of fresh vegetables. Similar cases in Mustang were reported. The increasing access to transportation in Mustang providing easier access for them to market has increased farmers attraction towards temperate fruits production (Apple, Walnut) replacing vegetable seed producing area with Apple orchards. The farmers have opined various problems and constraints in vegetable seed production. The general notion of the farmers was that vegetable

seed production is long duration and risky enterprise.

The unavailability of technical knowhow through private or public sector organization is also a kind of bottleneck in the smooth running of this venture. The other main production constraints are: timely unavailability of seed, lack of irrigation facilities, and high cost of pesticides along with increased pesticidal sprays.

Natural calamities like untimely rains, prolonged drought conditions and hailstorms are also affecting the efficient seed production. A large proportion of farmers also complained about the financial constraint. The majority of farmers reported that the cost of inputs have increased manifolds since last decade in comparison to increase in the rate of the fresh seed produced. The farmers also highlighted the marketing problems. The low price of the produced seeds, lack of processing facilities, lack of storage, proper grading and packaging facilities and the degrading quality of seed due to change in climate were main hindrance for effective marketing of seeds. The use of hybrid seeds by the farmers on large quantities to fetch more productivity per unit area of land has also decreased the affection of the farmers towards seed production in open fields. Chances of production of hybrid seed in farmer's fields is very less and hence is being imported or being provided by private companies. *The policy of hybrid seed production in farmer's field is not yet materialized. As a consequence, huge amount of seed has been imported from abroad by paying significant amount of money in dollar.* The key informants in the study area have also opined that the farmers produce seed of open pollinated crops only and the returns are less in comparison to cash crops, which are predominately grown by the farmers. They felt that the income from hybrid seed production is higher, so should be encouraged for the production of hybrid seeds as well.

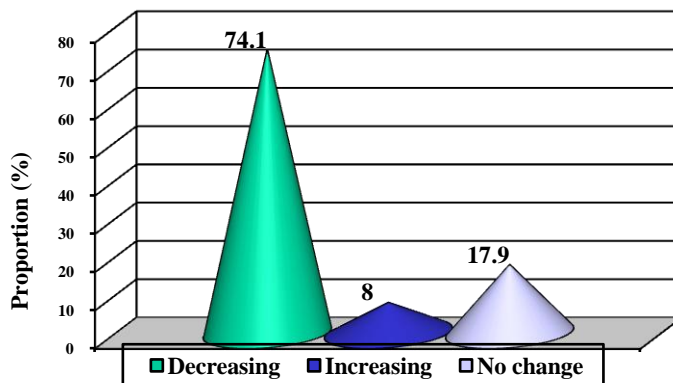


Figure 24: Farmers view about Status of Vegetable Seed Production in the Study Areas (2012)

4.11 Analysis of Existing Policies Related to Climate Change in Nepal

The effectiveness of policies and measures for climate change adaptation are strongly dependent upon the ability to identify extent of impact, and therefore of the vulnerability to climate change, of economic and social systems, both in space and time. Various constraints regarding vulnerability and adaptation measures have been identified, most important of which is the lack of technical capability to apply the results of Global Climate Models to local areas and making projections on their impact in different sectors and areas (Regmi et al., 2009). At national and international levels, the government has made several commitments and agreed for policy formulation related to climate change issues. Analysis of existing situation of policies on climate change shows some gaps that require urgent addressing in order to devise an all-inclusive policy that delivers strategic plan of action to adapt and mitigate climate change impacts.

The Government of Nepal showed its commitment to address climate change by becoming party to the Framework Convention on Climate Change in 1994. Since then, some initiatives

were conducted by Climate Change Network Nepal (CCNN), an informal network of international and bilateral agencies/organizations to help the government ratify the Kyoto Protocol and prepare the 1st Initial Communication Report. Kyoto was ratified in 2005 and the government appointed MoEST as Designated National Authority (DNA) for looking at Clean Development Mechanism (CDM) projects. There were already some initiatives on CDM and adaptation carried out by I/NGOs in Nepal. On 14 November, 2008 an agreement was signed between UNDP and MoEST for NAPA. All these initiatives are aimed at promoting climate resilience and low carbon development. The progress of these initiatives is very slow and time demanding. Government of Nepal, with support from UNDP, has initiated NAPA with funding from the Least Developed Countries Fund (LDCF). Preparation of NAPA is the 1st official initiative for mainstreaming adaptation to national policies and actions for addressing adverse impacts of climate change and reducing vulnerability to climate stimuli including extreme events. Nepal has prepared the project document to initiate NAPA with participation from a multi-disciplinary team coordinated by MOPE (Alam and Regmi, 2004). In November 2008, the government signed a contract with UNDP to officially start formulation of NAPA. MoEST drafted a climate change policy with support from WWF Nepal. This policy aimed at addressing impacts of climate change through mitigation and adaptation. It has given emphasis to clean energy and technologies, knowledge center, need for research and development, disaster and risk reduction, information flow and empowerment.

5. SUMMARY AND CONCLUSION

Climate change is evident in the study areas. Communities have started to experience unusual changes in temperature and rainfall patterns, which were supported by a number of indicators such as decreased rainfall over the last few years, increased rainfall intensity within short duration, increasing temperature, invasion of weeds and species, and outbreak of pests and diseases. These outcomes were linked to increased risks and hazards, increased magnitude of impacts and their severity and vulnerability posed by such factors in vegetable seed production and hence to the livelihoods of farmers residing in all the three ecological zones.

Current and future scenarios of climate change indicate that many of the study areas will face risks that include higher aridity, more variable water supply, melting of glaciers, erratic rainfall, and periods of water scarcity and drought. Drought may cause outbreak of pests and diseases. Melting of snow and glaciers will result in formation of glacier lakes and consequently outburst events, less water in rivers and streams and thus water scarcity. On the other hand, intense rainfall may trigger flooding and landslides in some areas. Climatic stresses have made sectors such as agriculture, biodiversity more vulnerable and fragile. The shift in planting, flowering and ripening time of vegetable seeds, decrease in quantity and quality of seed produced, poor germination of seed, poor pod and seed setting along with the change in crop canopy were also experienced by the farmers of the study area. Impacts were observed contributing to loss of species and local landraces, declining productivity and yield, outbreak of diseases and pests. One of the villages in Ramechhap was evacuated and resettled at another location basically due to continuous drought persistent for longer period of time. Other hazards, such as fire and hailstorm, also resulted in the loss of biological resources and community assets.

Poor, marginalized; women and Dalit households were more vulnerable to the impacts of climate change. Besides climate related disasters, the vulnerability was also aggravated by low income, lack of access to technology and knowledge, low education, limited assets and weak infrastructure. People with higher income, education, knowledge, and adaptation options are less vulnerable than those who are deprived from them.

Similarly, coping mechanisms, external interventions, traditional knowledge and innovations all play an important role in shaping vulnerability. Coping strategies and adaptation mechanism were limited at all study sites. Local knowledge, practices and innovations are important elements for community-based coping and adaptation mechanisms. There were few examples of adaptation strategies mostly in agriculture such as change in cropping patterns, choice of crops, and improvement in the system. There was limited awareness, knowledge and capacity at local and district levels to understand climate change scenarios, address issues, and conduct long-term planning. However, some observations were made regarding changing climate and its indicators, and skepticism was expressed in terms of climate change impacts and magnitude. At the national level, there was lack of information, knowledge, and proper database regarding local and regional information, and government plans and strategies to deal with climate change impacts. The few existing initiatives are often scattered and isolated when mainstreaming development.

6. RECOMMENDATION

Nepal has always been considered close to nature because of its unique location and huge bio diversity. More than 65% of total population is actively engaged in agriculture and agriculture depends on situation of weather to a greater extent. A slight change in climatic condition might have higher impact in production and hence to economic condition of the country as a whole.

Impact of climate change on vegetable seed production is a burning issue which affects seed security, employment and livelihoods in the developing countries like Nepal. The condition of Nepal is even more vulnerable with problems like: insufficient investment, weak infrastructure, inefficient irrigation, low productivity, fragile geology, lack of trained manpower weak policy etc. Thus, to minimize such vulnerabilities in vegetable seed production; water, seed and soil management should be implemented with focus on seed production and livelihood by applying following recommendations and climate smart vegetable production practices.

- Develop mechanism to assess the effects of climate change on vegetable seed production to identify the vulnerable pocket in Nepal.
- Enhance adaptive capacity of climate change to increase a mechanism for seed production pockets.
- Enhance climate smart vegetable crops to reduce GHG emissions for mitigating climate change.
- Initiate activities related to climate modelling on the vegetable crops in all eco-zone assessing climate effects.
- Develop cooperation and coordination with neighboring country to cope with vulnerabilities.
- Develop climate-forecasting system and aware farmers well in advance for reducing climate hazards.
- Develop irrigation infrastructure for reducing drought hazards and promote rainwater harvest and micro irrigation systems in hill and mountain districts.
- Enhance locality specific research activities so as to develop crop varieties suitable to heat resistant, drought resistant, insect pest resistant, submerged varieties.
- Identify safe agrochemicals like organic or bio-pesticides to reduce human/ animal health hazards.
- Increase mechanism of IPM (Integrated Pest Management) to minimize pest and disease damage in the vegetable crop.
- Develop quality seeds and planting materials in all agro-ecological regions to improve the productivity of vegetable crops.
- Communicate with farmers' intensively in all eco- regions regarding impact of climate change on vegetable seed production and its importance on improving people livelihoods.
- Encourage farmers to adopt climate resilient practices like water smart practice, nutrient smart practice etc. to improve soil health.
- Develop crop insurance schemes in vegetable seed production in all eco zones to enhance farmers' interest on the vegetable seed production.
- Initiate plans for medium-term adaptation measures like policy development also the long-term adaptation measures like strengthening of research institutions.

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8. APPENDIX

Annex 1: Questionnaire designed for Household Survey

Study on the effect of climate change in Vegetable Seed Production

(A) Basic Information about farmer:

1. Name of head of household:

.....

2. Address: District..... VDC..... Ward..... Tole

3. Name of the informant:

.....

4. Involvement in Group Cooperative
5. Family members Male Female
Total
6. Education Level Illiterate 5-10 class
 Literate S.L.C.
 1-5 class Above S.L.C
7. Type of house Ordinary/thatch Concrete building
8. Toilet Open Private
Public
9. Drinking water source Private Public
10. Fuel Used for cooking Gas Biogas
 Fire wood Cow dung
Others
11. Land holding (Ropani) 0-5 5-10 10-15
 15-20 > 20
12. Food sufficiency from own production
 < 3 months 3-6 months
 6-9 months > 9 months
13. Irrigation facility Canal irrigation Sprinkler
 Ponds Pipe Irrigation others

14. Soil type

Texture Loam Clay Sandy
 Color Red Black Ash color

15. Fertilizer Use Chemical fertilizer Organic fertilizer
 Mixed fertilizer Low use of manure and fertilizer

16. Type of support from government and other organizations

Subsidy on seed Subsidy for plastic tunnel
 Subsidy for agricultural tools Subsidy on fertilizer
 Subsidy for organic fertilizer Support for irrigation
 Support for marketing Others

17. Have you received training on seed production, processing and marketing ?

Yes No

B. Information on seed production

1. When did you start seed production?

..... BS

2. What kind of seed you are producing?

| Crop | Variety | Area (Ropani) | Average yield kg/Ropani |
|--------------------|---------|---------------|-------------------------|
| Radish | | | |
| Cauliflower | | | |
| Beans | | | |
| Broad Leaf Mustard | | | |
| Okra/Ladies finger | | | |
| Others | | | |

3. Where from do you buy the foundation seed ?

Government farm Non-government organization
 Private company Agro vet
 Others

4. Have you experienced any change in climate in the last 10 years? If yes what kind of change?

a. Temperature Decreased Increased No change

b. Rainfall Decreased Increased No change

Rainfall during monsoon Decreased Increased
No change

Rainfall during winter Decreased Increased
No change

Start of Monsoon Early Delayed
No change

c. Hailstone

| Details | In the past | Recent days |
|---|-------------|-------------|
| No of hailstone | | |
| Hailstone times (Months) | | |
| Size of hailstone (Large/medium/small) | | |

d. Snowfall Increased Decreased No change Early
Late

e. Fog Increased Decreased No change

f. Smog Increased Decreased No change

g. Hurricane Increased Decreased No change

h. Erosion Increased Decreased No change

i. Dry spell Increased Decreased No change

| Details of dry spell | In the past | Recent days |
|----------------------------------|-------------|-------------|
| When (Mosnoon/Winter/Premonsoon) | | |
| Duration of dry spell | | |

5. Have you experienced any effect of climate change in seed production? Tick mark in the box below.

Positive Negative No change n't know

6. If climate change has brought positive change, describe the change in detail and crop type as given below?

| Details | Crop type |
|--|-----------|
| Early flowering and maturity | |
| Increase in bee activity and increase in production | |
| Success of any crop which was not successful in the past | |
| Others | |

7. If climate change has brought any negative effect of seed production describe the change in detail and crop type as given below.

| Details | Crop type |
|---|-----------|
| Decrease in bee activity and crop yield | |
| Drying of water spring | |
| Increase in insect pest damage | |
| Decrease in seed germination | |
| Failure of seed production of any crop which was successful in the past | |
| Others | |

8. Have you changed the site for seed production?

No

Yes. If yes what is the reason ?

Climate change

Infrastructure

Others

9. Is there any change in cropping pattern during last 10 years ? if yes mention the cropping pattern before and at present ?

Upland

Low land

.....-.....-.....

.....-.....-.....

.....

.....-.....-.....

.....-.....-.....

.....

10. Is there any change in planting time of vegetable seed during last 10 years? If yes mention the detail.

Early planting (....days)

Late planting (....days)

No change

11. Is there any change in germination of vegetable seed during last 10 years? If yes mention the change as below.

Increased
 Decreased
 Required special treatment for seed germination
 No change

12. Have you experienced any effect of climate change in the growth and development of vegetable crop? If yes tick mark the change as below.

Increased growth of crop
 Decreased growth of crop.
 No change

13. During last 10 year have you experienced any change in flowering time of vegetable crop?

| Details | Crop | Change in days |
|-----------------|------|----------------|
| Early flowering | | |
| Late flowering | | |
| No change | | |

14. During last 10 year have you experienced any change in maturity time of vegetable crop?

| Details | Crop | Change in days |
|----------------|------|----------------|
| Early maturity | | |
| Late maturity | | |
| No change | | |

15. During last 10 year have you experienced any change in seed formation of vegetable crop?

| Details | Due to rise in temp (Crop and variety) | Due to decrease in temp (Crop and variety) |
|-------------------|--|--|
| More seed/pod | | |
| Less seed/pod | | |
| No seed formation | | |
| No change | | |

16. During last 10 year have you experienced any change in seed production of vegetable crop?

Increased
 Decreased
 No change

17. During last 10 year have you experienced any change in seed size of vegetable crop compared to its size in the past?

- Larger in size
- Smaller in size
- No change

18. What is your experience about the seed vigour of vegetable crop compared to its past?

- Healthy, vigour and plumpy
- Reduced in size and vigour
- Very poor in vigour and shrivelled
- No change

19. What is your experience about seed quality and luster compared with past?

- Good looking and shiny
- Dull and fading
- No change

20. Have you tried extra effort to improve yield and quality of vegetable seed as a measure for climate change resilience?

- To save from high temperature.....
- To save from low temperature and chilling.....
- To save from hailstone.....
- To save from heavy wind.....
- Others if any.....

21. Have you experienced any specific effect as an indicator of climate change?

- Drying of well, ponds and water spring erosion
- Increase in land slide and
- Increase in winter cold during summer
- Increase in heat intensity
- Early flowering and maturity of crops
- Others

22. Have you experienced any change in the depth of well due to change in climate in the past 10 years?

- Increase in depth of water well / decrease in water table
- Decrease in depth of water well / increase in water table
- No change

23. Describe the infestation of major insect pest of different vegetable seed crop in the past and present.

| Crops | Major diseases | | Major insects | |
|-------|----------------|------------|---------------|------------|
| | In the past | At present | In the past | At present |
| | | | | |
| | | | | |

24. What was the degree of damage of vegetable seed crop by insect pest in the past and at present?

| Degree of damage | In the past | At present |
|------------------|-------------|------------|
| Very low | | |
| low | | |
| medium | | |
| high | | |
| Very high | | |

25. What was the degree of damage of vegetable seed crop by diseases in the past and at present?

| Degree of damage | In the past | At present |
|------------------|-------------|------------|
| Very low | | |
| low | | |
| medium | | |
| high | | |
| Very high | | |

26. What is the trend of insecticide use in the last 10 years period?

Decreasing

Reason for decreasing Unavailability Decreasing pest Use of other alternative

Increasing

Reason for increasing Availability Increase in pest Increase in use of pesticide

No change

No use of pesticide

27. Have you used any botanicals/organics for pest control?

Yes (name the botanicals) No

28. Have you used any bio fertilizer in seed production?

Yes (name the fertilizer) No

29. What is the level of loss from insect pest incidence?

34. Do you feel need of any change/amendment in the existing government policy, act, regulation to address the issue of climate change?

Yes

No

Do not know

35. How do you sell your seed?

To seed company through group/cooperatives

To local seed seller Self (directly to farmers)

Outside seed merchant Others

36. What are the main problems in seed business (mention major four issues)?

Low seed price Processing

Poor seed quality Collection centres

Packaging and labeling group/Cooperatives

Transportation Market information

Others

37. What is the trend of seed entrepreneurs continuing seed business in the area?

Increasing Decreasing No
change

38. What is your impression about effect of climate change in seed production?

38. What is your impression about effect of climate change in seed production?

.....
.....
.....
.....

Thank You for your kind cooperation

Name of the data enumerator: **Phone No:**

Signature.....

Name of the consultant: **Signature**

Annex 2: Annual Precipitation (mm) Recorded at Different Meteorological Stations of the Study Districts

| Year | Study districts and meteorological stations | | | | | | | | | | | |
|------|---|-----------|----------|-----------|------------|--------|--------|------------|---------------|--------------|---------|------------|
| | Dhankuta | Sarlahi | | Ramechhap | Mustang | | | Surkhet | | Rukum | | Dadeldhura |
| | Pakhribas | Mansumara | Karmaiya | Manthali | Thakmarpha | Lete | Jomsom | Pusma Camp | Birendranagar | Chaur jahari | Musikot | |
| 2001 | 1507.9 | 2090 | 1478 | 1140.3 | 382.2 | 1530.3 | 239.9 | 1259.9 | 1722.1 | 1237.3 | 2373.4 | 1322 |
| 2002 | 1347.8 | 1936 | 1988.2 | 1545.5 | 390.2 | 1532.2 | 308.2 | 1629 | 1537.7 | 1153.5 | 2235.2 | 1293 |
| 2003 | 1516.9 | 1907.7 | 1580.9 | 1089.1 | 474.7 | 1501.7 | 318.8 | 1633.3 | 1849.1 | 1399.6 | 1746.8 | 1391 |
| 2004 | 1678.7 | NA | NA | 1151 | 315.6 | 1107.8 | 229.6 | 1363.4 | 1425.3 | 1057.3 | 2304.6 | 1194.2 |
| 2005 | 1377.7 | 1653.1 | 2915.5 | 689 | 430 | 1373 | 309.3 | 1363.2 | 1809.8 | 894.7 | 2256.1 | 1102.3 |
| 2006 | 1326.3 | 1471 | 1826 | 936.7 | 359.7 | 1362.4 | 301.5 | 1411.7 | 1484.9 | 990.3 | 1494.5 | 940.8 |
| 2007 | 1561.2 | 1422 | 2096 | 1047 | 458 | 1424 | 312.0 | 1650 | 1864.2 | 1098.7 | 1945.6 | 1668.5 |
| 2008 | 1746.1 | 2028 | 2144 | 695.7 | 422.2 | 1493.7 | 288.2 | 1461.3 | 1507.6 | 1254.9 | 2389.1 | 1478.6 |
| 2009 | 1604.4 | 731.3 | 1737.5 | 754 | 347.3 | 1397.7 | 321.5 | 1659 | 1726.4 | 1123.9 | 2030 | 1745.8 |
| 2010 | 1490.7 | 263.9 | 1187 | 602.7 | 435.9 | 1660.5 | 286.2 | 1449.5 | 974.5 | 825.2 | 2709.1 | 1526.5 |

Annex 3: Average Annual Maximum & Minimum Temperature (Degree Celsius) of the Study Areas

| Year | Study districts and meteorological stations | | | | | | | | | | | |
|------|---|-------|-----------|-------|---------|------|---------------|-------|--------------|-------|------------|-------|
| | Dhankuta | | Sarlahi | | Mustang | | Surkhet | | Rukum | | Dadeldhura | |
| | Pakhribas | | Mansumara | | Jomsom | | Birendranagar | | Chaur jahari | | | |
| | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| 2001 | 21.33 | 12.63 | 30.9 | 19.1 | 17.43 | 6.34 | 28.47 | 15.26 | 29.28 | 14.87 | 22.1 | 11.23 |
| 2002 | 21.54 | 12.24 | 30.74 | 19.39 | 17.27 | 6.35 | 28.26 | 15.48 | 28.45 | 15.01 | 21.65 | 10.99 |
| 2003 | 20.8 | 12.36 | 30.0 | 19.78 | 17.30 | 5.93 | 28.3 | 15.1 | 28.45 | 14.98 | 22.08 | 11.1 |
| 2004 | 20.69 | 12.31 | NA | NA | 17.59 | 6.59 | 28.59 | 15.38 | 29.0 | 15.28 | 22.32 | 11.26 |
| 2005 | 20.96 | 12.37 | 30.7 | 19.61 | 17.57 | 6.01 | 28.53 | 15.42 | 28.71 | 15.01 | 21.89 | 11.1 |
| 2006 | 21.29 | 12.94 | 30.65 | 19.29 | 18.1 | 6.4 | 28.81 | 15.92 | 28.5 | 15.6 | 22.94 | 11.85 |
| 2007 | 20.53 | 12.29 | 30.3 | 19.13 | 17.7 | 6.01 | 27.6 | 15.89 | 27.3 | 15.23 | 22.48 | 11.41 |
| 2008 | 20.84 | 12.11 | 30.67 | 17.62 | 17.63 | 5.44 | 28.15 | 16.9 | 27.23 | 14.89 | 22.35 | 11.16 |
| 2009 | 21.47 | 12.6 | 31.29 | 18.9 | 18.19 | 5.37 | 28.96 | 15.72 | 28.13 | 15.10 | 23.12 | 11.61 |
| 2010 | 21.67 | 12.89 | 30.85 | 18.97 | 18.44 | 5.71 | 29.09 | 15.9 | 28.28 | 15.17 | 22.97 | 12.03 |

Annex 4: Average Relative Humidity (RH %) of the Study Areas

| Year | Study districts and meteorological stations | | | | | | | | | |
|------|---|-------|-----------|-------|---------|-------|---------------|-------|--------------|-------|
| | Dhankuta | | Sarlahi | | Mustang | | Surkhet | | Rukum | |
| | Pakhribas | | Mansumara | | Jomsom | | Birendranagar | | Chaur jahari | |
| | Mor | Evn | Mor | Evn | Mor | Evn | Mor | Evn | Mor | Evn |
| 2001 | 82.85 | 88.15 | 90.47 | 90.45 | 56.73 | 60.97 | 84.35 | 62.1 | 86.1 | 64.02 |
| 2002 | 83.9 | 88.39 | 90.52 | 90.61 | 60.41 | 68.43 | 84.08 | 65.88 | 88.39 | 66.32 |
| 2003 | 83.09 | 90.44 | 90.4 | 92.36 | 58.3 | 75.99 | 83.48 | 67.52 | 87.4 | 66.32 |
| 2004 | 83.63 | 89.95 | NA | NA | 66.3 | 81.17 | 85.85 | 71.99 | 85.73 | 60.52 |
| 2005 | 82.37 | 87.85 | 91.93 | 94.57 | 73.66 | 85.86 | 80.51 | 59.9 | 82.22 | 61.65 |
| 2006 | 81.48 | 87.0 | 89.53 | 93.8 | 76.5 | 88.52 | 84.29 | 67.7 | 82.15 | 64.32 |
| 2007 | 82.73 | 89.01 | 91.4 | 93.78 | 73.95 | 83.9 | 83.29 | 65.27 | 88.34 | 72.05 |
| 2008 | 79.24 | 86.62 | 91.33 | 93.3 | 75.59 | 84.99 | 83.79 | 68.48 | 86.73 | 67.6 |
| 2009 | 75.81 | 83.77 | 91.59 | 89.9 | 78.08 | 88.53 | 82.83 | 71.33 | 82.29 | 61.56 |
| 2010 | 76.28 | 83.27 | 90.25 | 81.97 | 71.66 | 78.78 | 82.67 | 65.44 | 83.33 | 66.20 |

Mor: Morning (8:45 a.m), Evn: Evening (17:45p.m)

Annex 5: Ecological Zones Suitable for Vegetable Seed Production in Nepal

| S.N | Production Areas | Elevation Range (Meter) | Major Seed Production |
|-----|--|-------------------------|---|
| 1 | <u>Rapti area</u> Rukum, Dang, Salyan, Rolpa, Pyuthan | 725-1860 | Radish, Onion, Rayo, Okra, Cauli flower, Squash, Carrot, Cabbage |
| 2 | <u>West(Lumle) Area</u> Kaski, Parbat, Myagdi, Baglung | 800-2000 | Tomato, Radish, Rayo, Peas, Beans, Cress, Cucumber, Squash |
| 3 | <u>Koshi Hill Area</u> Dhankuta, Terathum, Bhojpur, Sankhuwasabha | 800-2000 | Radish, Rayo, Peas, Beans, Broccoli, Cauliflower, Turnip |
| 4 | <u>Kathmandu Area</u> | 1000 | Radish, Bean, Cauliflower |
| 5 | <u>Sarlahi Area</u> Sarlahi, Mahotrai, Rautahat, Bara | 90-110 | Okra, Chilli, Tomato, Brinjal, Gourds, Peas, Cauliflower, Beans |
| 6 | <u>Mid West Areas</u> Other than Rapti, Surkhet | 100-2500 | Carrot, Radish, Rayo |
| 7 | <u>Other Areas</u> Mustang, Dolpa, Kavre, Dolakha, Gorkha, Sindhupalchok | 1000-2300 | Radish(Mino Early), Cauliflower (Kathmandu Local), Cabbage(Copenhagen Market), Carrot(New Kuroda), Onion, Beans, Rayo, Tomato, Cucumber |
| 8 | <u>Far Western Areas</u> Dadeldhura, Baitadi, Accham, Doti | 800-1500 | Radish, Rayo, Peas, Beans, Carrot |

Annex 6: List of Vegetable Seeds Produced By Farmers of the Study Areas

| S.N | District | Seed produced |
|-----|------------|--|
| 1 | Dhankuta | Bean, Radish, Broad Leaf Mustard, Broccoli, Cress, Onion, Lettuce, lady's Finger, Cauliflower |
| 2 | Sarlahi | Radish, Cowpea, bean, Pea, Lady's Finger, Bitter Gourd, Sponge Gourd, Brinjal, Capsicum, Pumpkin, Tomato, Bottle Gourd, Broad Leaf Mustard |
| 3 | Ramechhap | Radish, Cauliflower, Bean, Pea, Lady's Finger, Cucumber, Pumpkin, Onion, Broad Leaf Mustard, Cress |
| 4 | Mustang | Radish, bean, Pea, Broad Leaf Mustard, Carrot, Cabbage, Cress, Local Coriander |
| 5 | Surkhet | Radish, Snake Gourd, Bean, Pea, Lady's Finger, Bitter Gourd, Broad Leaf Mustard, Onion, Broad bean |
| 6 | Rukum | Radish, Cowpea, bean, Pea, Lady's Finger, Pumpkin, Turnip, Broad Leaf Mustard, Onion, Broad Bean |
| 7 | Dadeldhura | Radish, Cowpea, Bean, Pea, Lady's Finger, Onion, Coriander, French Bean, Cress |

Annex 7: Vulnerability Mapping of Different Districts based on Climate change Impact

| | Dhankuta | Sarlahi | Ramechhap | Mustang | Rukum | Surkhet | Dadeldhura |
|-------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Temperature and Rainfall Risk | High (0.442-0.579) | Low (0.110-0.269) | Very high (0.58-1.00) | Very Low (0.000-0.109) | Low (0.110-0.269) | Moderate (0.270-0.441) | High (0.442-0.579) |
| Ecological Risk | Low (0.082-0.137) | Moderate (0.138-0.257) | Moderate (0.138-0.257) | Very Low (0.000-0.081) | Moderate (0.138-0.257) | Low (0.082-0.137) | Low (0.082-0.137) |
| Landslide exposure | Low (0.073-0.212) | Very Low (0.000-0.072) | High (0.358-0.556) | Very Low (0.000-0.072) | Very Low (0.000-0.072) | Moderate (0.213-0.357) | Very Low (0.000-0.072) |
| Flood exposure | Very Low (0.00-0.023) | Low (0.024-0.351) | Very Low (0.00-0.023) | Very Low (0.00-0.023) | Very Low (0.00-0.023) | Very Low (0.00-0.023) | Very Low (0.00-0.023) |
| Drought Exposure | Very Low (0.000-0.105) | High (0.348-0.562) | Very High (0.563-1.00) | Moderate (0.24-0.347) | Moderate (0.24-0.347) | Low (0.106-0.223) | Very High (0.563-1.00) |
| GLOF Risk | High (0.501-0.75) | No/Very low (0.00) | High (0.501-0.75) | Very High (0.751-1.0) | No/Very low (0.00) | No/Very low (0.00) | No/Very low (0.00) |
| Combined Risk/Exposure | Moderate (0.321-0.499) | Low (0.165-0.32) | Very High (0.682-1.00) | Moderate (0.321-0.499) | Very Low (0.00-0.164) | Low (0.165-0.32) | Moderate (0.321-0.499) |

(Source: Climate Change Vulnerability mapping for Nepal, GoN, MoEnv)

Annex 8: Monthly Rainfall Trend as Recorded in Different Meteorological Stations of the Study Areas

