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Research Article

Climatic variability and livelihood of rural farmers in Chisapani, Ramechhap, Nepal

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Abstract
Agriculture is the mainstay of livelihood of the people in rural Nepal. Any perturbations in agriculture stemming from climatic and/or non-climatic factors can affect their livelihood. Farmers keep on exploring alternative practices in agriculture to adapt to increasing uncertainties and some of which can be scaled out to enhance resilience of the agricultural system. An exploratory study was done in one of the most vulnerable districts of Nepal, Ramechhap. The objective was to assess the effects of local livelihood owing to climatic variability. Ninety-one farm households were selected using purposive random sampling and information was collected through semi-structured questionnaire along with key informant interviews and focus group discussions. Historical weather data, particularly of rainfall, were analyzed to see the rainfall pattern and linked to agriculture production over time. Almost nine out of 10 farm families were marginal farmers and 60% of the household face food deficit half a year. Most of the respondents reported changes in climate and agriculture production practices. Historical rainfall data confirmed that the rainfall trend was declining by 13.77 mm per year. The average rainfall of the nearest station (Manthali) was 1008 mm, which is almost half of the national average. Since rain-fed farming predominates in the area, drought events have negatively affected agriculture and local livelihood. Due to drought 18% of the paddy land was converted to Bari land. Similarly, cold spells along with increasing foggy days aggravated the occurrence of pest and diseases affecting winter crops far more than what it used to be. Landraces of many crops had disappeared and new invasive species started appearing in the farmlands. Farmers had shifted from large animals to smaller ones as a coping strategy. Adoption of new crop varieties, crop rotation, rainwater harvesting and use of plastic tunnel in vegetable farming were the major new practices introduced in the area which have a greater potential for out- and up-scaling. However, strong institutional supports are required to build stakeholders (including farmers) capacity to experiment with adaptive strategies.

Key words: Adaptation, Agriculture, Climate change, Drought, Historical rainfall

Introduction
Climate is a key determinant of agricultural productivity, especially in the case of developing countries like Nepal where agriculture is primarily rainfed (Joshi et al., 2011). Although Nepal's contribution to global greenhouse gas emissions is only 0.025% (MoPE, 2004), it is amongst the most vulnerable countries to climate change impacts. Changing temperatures and erratic rainfall pattern are affecting crop production and livelihood of people in Nepal (Malla, 2008; Devkota et al., 2011). Recurrent droughts that prevail in many parts of the country affect agriculture negatively and exacerbate rural poverty (NDMC, 2005) as rainfed agriculture suffers the most due to the risks associated with climate. Key changes in agriculture, which are the resultant of both climatic and non-climatic drivers, are loss of local land races of crops and domestic animals, changes in cropping sequences, scarcity of water due to drying up of local water resources, and increasing incidences of disease and pest (Regmi et al., 2008).

IPCC (2007) has listed food and fiber, land degradation and biodiversity as the most vulnerable sectors to climate change in the South Asian region. The most vulnerable population to climate change and variability has been rural communities with few resources to cope with extreme weather events like landslides, floods, erosion, and droughts (IPCC, 2007). Climate change is expected to influence crop and livestock production, hydrological balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and

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uncertain (Apata et al., 2009). Climate change imposes constraints to development especially among smallholder farmers whose livelihoods mostly depend on rain-fed agriculture (IPCC, 2007).

Globally, Nepal ranks as fourth most vulnerable country to the impact of climate change (maplecroft.com). Ramechhap is ranked as the second most vulnerable district (vulnerability score 0.995 out of 1.000) to the impact of climate change in Nepal (MoE, 2010a). It is also highly vulnerable to drought lies between vulnerability index 0.515-0.759 (MoE, 2010b). Over half of the villages including research area of the Ramechhap are drought prone areas. Increasing drought events in the recent decades in have affected the rural farmers and women to a great extent. Different households adopt different strategies according to their particular asset profiles (Ellis, 2000). Similarly, asset profiles also affect adaptive capacity of the farmers. People in the rural set-up like in Ramechhap overwhelmingly depend on agriculture. Since a great majority of the farm households lack adequate resources to adapt to changing circumstances on the one hand and human capital to adapt to the changes on the other hand. There is a need to evaluate changing agricultural practices and recommend the best-bet adaptive strategies for a particular farming community. Agriculture is the mainstay of livelihood of the Nepali people and it largely depends on weather and climatic conditions. About 7% of Ramechhap district has irrigation facility (DDC, 2012). As the agriculture production is highly associated with rainfall, a small change in the climatic condition for a short period could largely affect the livelihood of the people. Variation in crop production because of these changes in climatic variables could worsen the food insecurity

There is a paucity of research that evaluates historic weather information linking this with current farming practices and adaptive measures. This study takes into account the local farmers' perception on climatic variability and aims at understanding the localized impact of the climate which is not directly visible but nevertheless is happening indirectly. Furthermore, it is important to see what farmers explore under changing circumstances including climate change and variability and what practices can be promoted to make farming communities resilient. This current study focuses on this part as well. The paper therefore addresses the following pertinent issues: 1) the pattern and trends of climate change based on recorded meteorological data and experiences of local people, 2) the status of livelihood in the study area and link livelihoods with climatic variability and, 3) the adaptation strategies practiced by local people to minimize the impact of climate change.

Materials and Methods

Study Area

This study has been carried out in Chisapani Village Development Committee (now a ward of Manthali Municipality) of Ramechhap district in central Nepal. Ramechhap is highly drought prone area and many of its villages face this challenge. Located between 27°24'-27°26' N to 86°01'- 86°5' E, Chisapani village is bordered to Tamakoshi, a perennial river (Fig. 1). The elevation of the village ranges between 500 to 1500 m above sea level. The climate of the area can be divided into two parts: below 1200 m and above 1200 m. The lower altitude presents subtropical climate, where the average summer temperature is about 30°C and that of winter is about 15°C. In the higher altitude (above 1200 masl), temperate climate is found with summer temperature ranging from 22 to 25°C and average winter temperature of 5°C (VDC, 2010). It has a total area of 14 sq.km of which 29% is under cultivation. The village receives very low rainfall and hence it is noted as a highly drought prone area. The major crops cultivated are maize, rice, wheat, millet and rice-bean. It encompasses a total of 686 households with a total population of 3187, out of which 56% female (CBS, 2012). The dominant ethnic group is Newar (40%) (VDC, 2010).

Sampling and Data Collection

The study blended both qualitative and quantitative techniques of data collection and analysis. Primary data were collected from household survey. Number of sample size required for the village was first determined by using the formula given by Arkin and Colton (1966). The village was divided into different strata and then into substrata to minimize heterogeneity. Purposive random sampling was done from each sub-stratum. The survey was carried out in September (2012) duly considering the engagement of respondents in farming using semi structured questionnaire. Among the 686 households, 91 (13%) households were selected for this study. Informal discussion with key informants such as district agriculture development officer, social worker and head of the mother's group to get more information and also substantiate the information obtained through household survey. Focus group interviews were conducted with farmers from a set of representative villages with the aim of triangulating the information obtained from the households and key informants. Five focus group interviews were conducted.

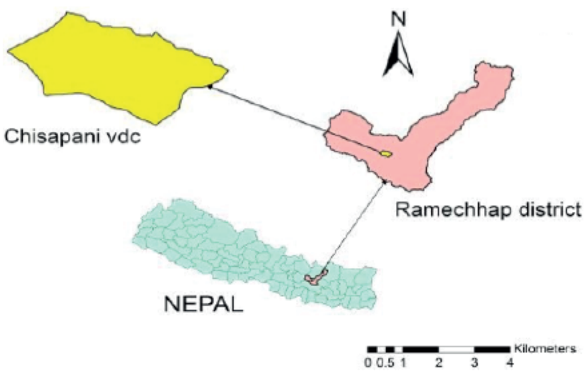

Figure 1 Map of Nepal showing the study area, Chisapani village in Ramechhap district, Nepal

One interview with group of females, one interview with group of male and three interviews with group of both female and male were made in order to ensure that views were as representative as possible of the population. Secondary data was reviewed and collected from secondary sources such as collection of historical rainfall data recorded at nearby Manthali station from 1992-2011 from the Department of Hydrology and Meteorology (DHM). Since only two years data on temperature was available, we deferred its analysis. Historical crop production data (whole Ramechhap district) were obtained from the District Agriculture Development Office, Ramechhap (DADO, 2012). Household level crop specific information was, however, collected through interviews and other from related published articles, books, journals.

Materials and Methods

Data obtained through different sources were processed, analyzed and interpreted. All data collected were entered and analyzed using SPSS software (Version16) and Excel 2007. Qualitative and quantitative techniques were applied. To determine the climatic trend, time series regression analysis of the meteorological data was done. As some of the data which were used for the trend analysis were missed, these missing data were replaced by averaging the data of the corresponding months of the previous and after year. Correlation and regression analysis were done whenever required. Coefficient of variation (CV) of rainfall was also calculated.

Results and Discussion

Socio-demographic information of the households

Table 1 Socio-demographic characteristics of the respondents in Chisapani, Rameshhap district, Nepal

Gender	No of respondents	% age
Male	65	71
Female	26	29
Profession		
Farmer	73	81
Government Services	9	10
Daily Wages	1	1
Private Services	3	3
Business	2	2
Others	3	3
Education Level		
No formal education	23	25
Literate	50	55
SLC	6	7
Intermediate	10	11
Bachelor	2	2
Economic status of population		
Economically active population		
Economically inactive population	58 %	42 %

Farming is a major occupation of the people in the area as responded by around 81 % of the farm households. Other occupations are government service, business, off-farm wage work and business, among others (Table 1). However, it should be understood that the people who are engaged in the job are also partially involved in agriculture. Almost all farm households operate in subsistence mode. A large number of respondents were male (71%). The percentage of male respondent was high simply because females are involved mostly in indoor activities and are either hesitant to respond to the interviewer or don't have time to participate in the interview or both. The average family size of the respondent was 7 (with a range from 3 to 23), which is higher than national average (4.88) (CBS, 2012). Around 58% of the total respondents were economically active. The major crops grown are paddy, maize, wheat, millet and rice-bean. The education level of the respondent shows that most of the people are literate (55%) followed by 25% who do not have any formal education.

Inhabitants of the study area include several ethnic groups. A dominant ethnic group is Newar with around 46% of the total population in the villages followed by Majhi (17%), Brahmins (14%), Dalits (11%) and Chhetri (8%) (Fig. 2). The other groups are Magars and Bhujels.

Yearly income and expenditure of the respondents

The major sources of income of the respondents' family were agriculture (35%), followed by government services (18%), jobs abroad (16%), private service (15%), daily wages (10%) and business (6%) (Fig. 3).

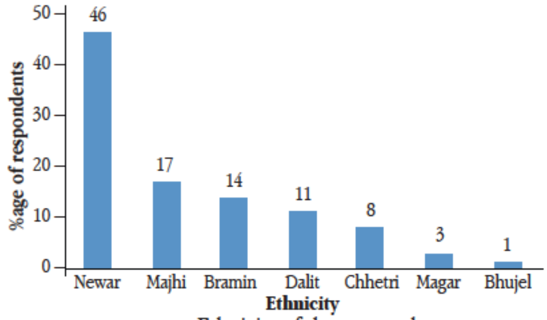

Figure 2 Ethnicity of the respondent

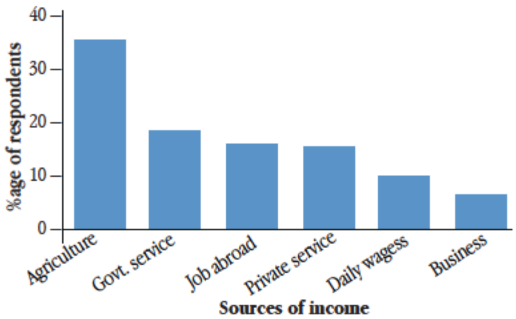

Figure 3 Major sources of income of the respondents

Most of the respondents reported that they did not have sufficient land of their own. Most of the respondents expressed that the paddy land was converted to Bari due to drought for 10 years, and food production was insufficient to feed their family throughout the year. About 18% of the paddy land was converted to Bari. Since agriculture production didn't suffice household food demands, farm households had to find alternative means to be food secure. These alternative sources of income included work in government or private sector, migration to foreign countries, on and off-farm wage work. Livestock was the important source of cash in the village and goat was owned by almost all households.

People were reluctant to declare their accurate income. Our estimation showed that the income range per household was NPR 15,500 to 800,000 ($ 194 to $ 10,000) with an average of NPR 108,750 ($ 1,359). The income of the respondent is shown in Fig. 4.

The main sources of expenditure of the respondents were food, education, clothes, health, agriculture and cultural activities. The high share of expenses was covered by food because most of the households were unable to produce sufficient food. The quantification of expenses showed that the expenses ranged from NPR 21,500 to 400,000 ($ 269 to 5,000) and on average NPR 92,026 ($1,150) per year for fulfilling their basic needs. The expenditure of the respondent is shown in Fig. 4.

The Lorenz curve shows that the inequality in income and expenditure of the respondents. A Gini coefficient of income and expenditure was 0.40 and 0.32, respectively (a value of 0 suggests total equality, a value of 1 extreme inequality) (Fig. 5). Lesser inequality was seen in expenditure than in income. This means that richer and poorer, more equally distributed expenditure, but high inequality in terms of income.

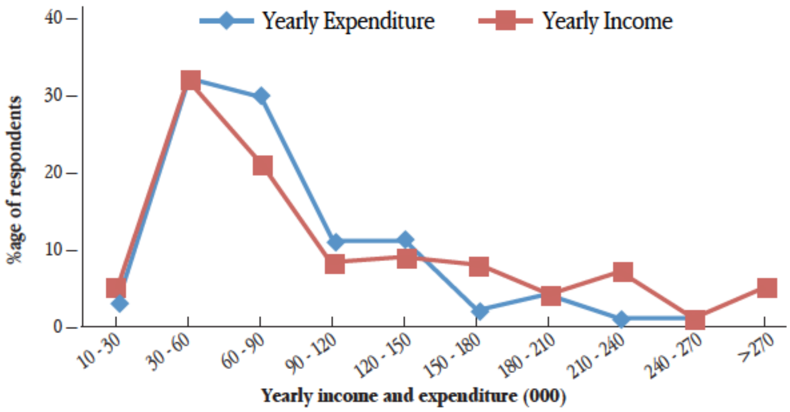

Figure 4 Yearly income and expenditure of the respondent families

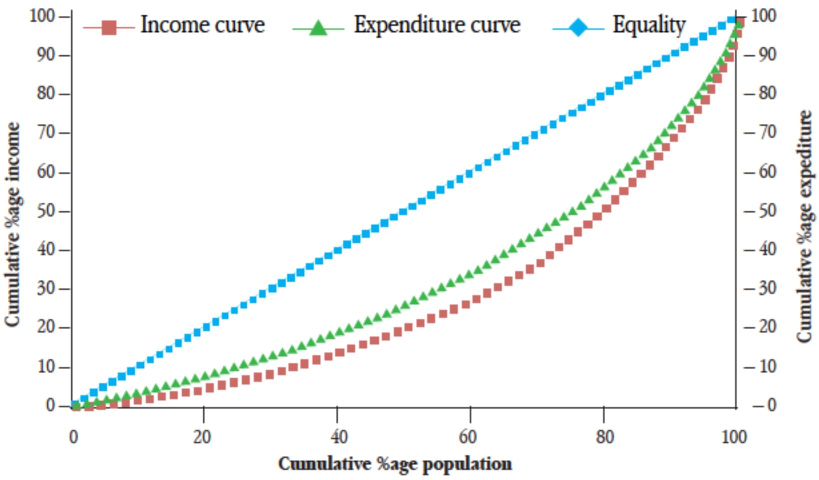

Figure 5 Lorenz curve showing income, expenditure distribution

Landholding Size

The study village was overwhelmingly dominated by unirrigated land (83%) called bari/pakho. The landholding size of the respondent ranged from 0.02 to 3.6 ha. The average landholding size of the respondent was 0.58 ha which is less than the national average landholding size (0.68 ha) (CBS, 2012). Almost nine out of 10 farm families were marginal farmers (<1 ha of farm), followed by 8% smallholder (1-2 ha) and the rest semi-medium holders (2-4 ha) (Table 2).

On-farm Food Availability

As stated above, farm families in Chisapani operate in subsistence mode and often on-farm production was not sufficient to meet the household food demands throughout the year. Therefore, they have to depend on external sources to fulfill household food requirements. About 10% of the respondent said that crop produced in their field was sufficient for less than 3 months, 48% said for 3-6 months, 18% said for 6-9 months and 24% said for 9-12 months (Fig. 6). The results also entail that almost 60% of the households are food deficit half a year (Fig. 6).

Analysis of Climatic Variables

The nearest Hydro-meteorological station is located at Manthali, the adjoining VDC of the study area, and hence 20 years rainfall data from 1992-2011 of Manthali hydro-meteorological station were collected and analyzed.

Annual Rainfall

Time series analysis of the 20 years (from 1992 to 2011) monthly rainfall reveal that July and August receive highest amount of rainfall (around 287mm and 203mm respectively) and November and December have minimum rainfall with respective rainfall of around 7 mm and 6 mm (Fig. 7). Normally the monsoon season starts from May and end at the first week of October. Monsoon season (June-September) contributes 77% of the total annual rainfall. Similarly, post monsoon (October-November), winter (December-February) and pre monsoon (March-May) seasons accounts 5%, 3% and 15%, respectively.

The annual rainfall in Ramechhap shows a highly variable trend over the years with maximum in 2002 (1546 mm) and minimum in 2010 (603 mm) (Fig. 8). Historical rainfall shows a declining trend with 13.77 mm per year (Fig. 8) but not significant at 5% level of significance. The rainfall was declining from the year 2003 to till 2011. Year 2002 recorded the highest rainfall so far followed

Table 2 Land size class of the respondents

Land size (Ha)	Households (No.)	Households (%)	Remarks
0-1	80	88	Marginal farmers
1-2	7	8	Small farmers
2-4	4	4	Semi-medium farmers

(APCAS, 2010)

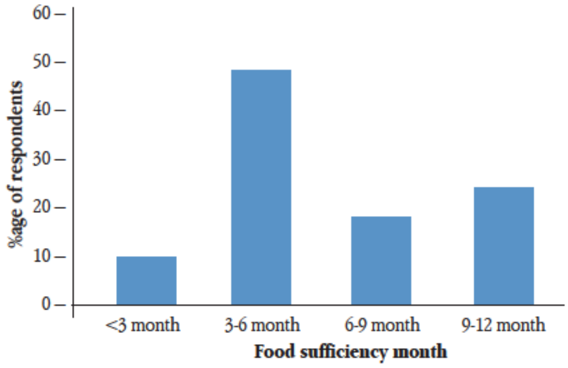

Figure 6 Farmland food availability

by 1998. Rainfall after 2004 started declining. The years 2008 and 2010 could be traced as severe drought years. Associated with this variability, it is assumed that farming operations got affected during extreme rainfall and extreme drought and the farmers suffered from food insufficiency. Because of lack of adequate farm level historical data, it was not possible to test this assumption.

Rainfall Variability

The rainfall variability shows that the variability from year to year. The Coefficient of Variation (CV) of yearly rainfall from 1992-2011 shows that all the year has highest CV which means that the rainfall trend was highly fluctuating in different months of the year. Highest CV was seen in the year 2002 and 2004 than that of other year (Fig. 9). The decadal data of rainfall shows the increasing trend of CV with significant increment over the period of time. The variability is increasing in current decade (2002-2011) than the previous decade (1992-2001).

Fig. 10 shows the rainfall variability during monsoon season in Ramechhap which highly variable except in some years. It goes as high as 125% to as low as 5%. One can easily find that farmers have been constantly struggling under such a precarious rainfall environment. In 2002 and 2004 the monsoon season had highest variability in rainfall and these were the very extreme years corresponding to very high and very low rainfall. The decadal rainfall of monsoon season shows the increasing trend of CV with significant increment over the period of time. The decadal data shows that the variability is increasing in current decade (2002-2011) than the previous decade (1992-2001).

The historical data on rainfall reveals that April to August had lower variability over the years, with lowest being in August (Fig. 11). With the onset of winter season, the rainfall variability started increasing over the years and this highly variable rainfall pattern in winter could have tremendous effects on production of winter season crops such as wheat, pulses and vegetables, among others.

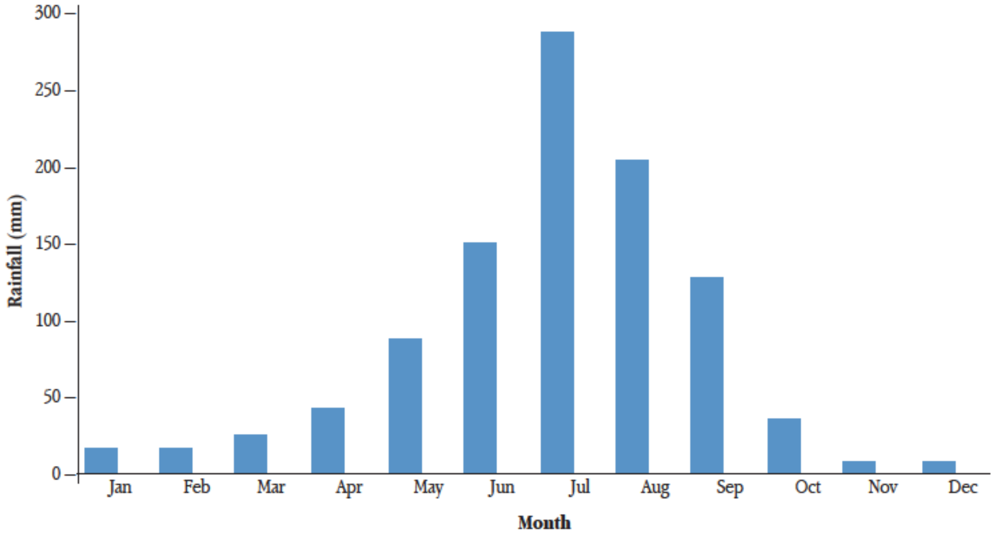

Figure 7 Mean monthly rainfall data of Ramechhap station

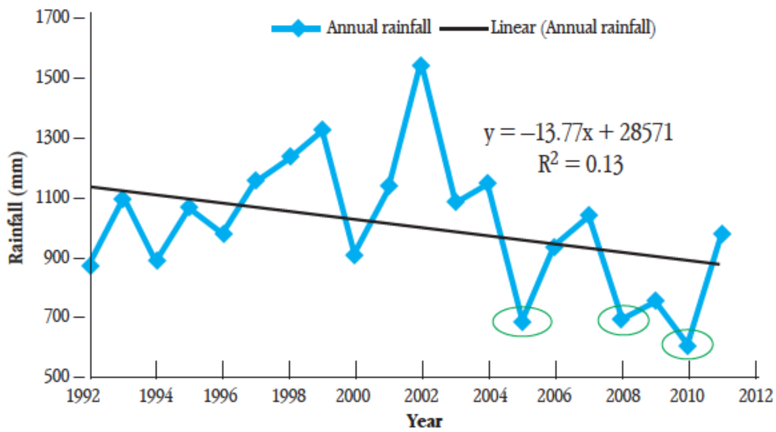

Figure 8 Annual rainfall with trend line and mean line of Ramechhap hydro-meteorological station

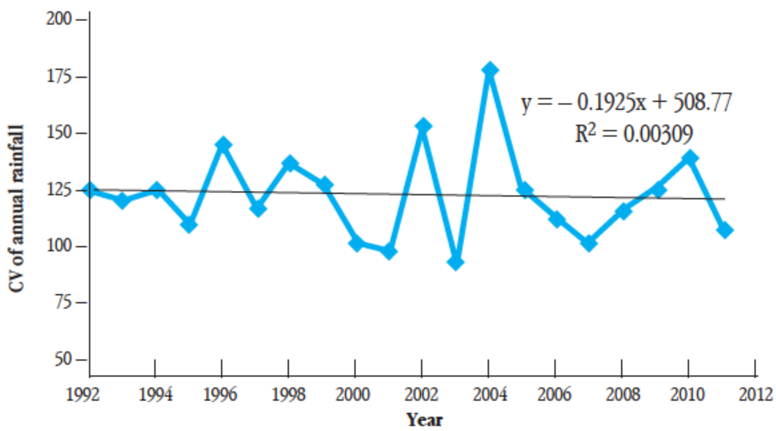

Figure 9 Yearly rainfall variability from 1992-2011

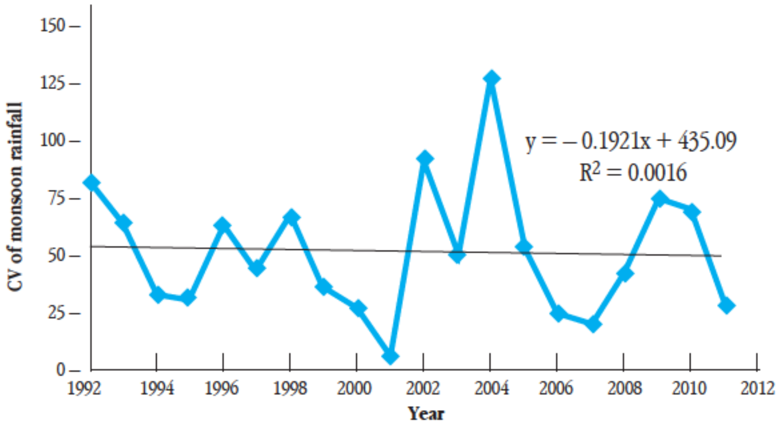

Figure 10 Monsoon rainfall variability from 1992-2011

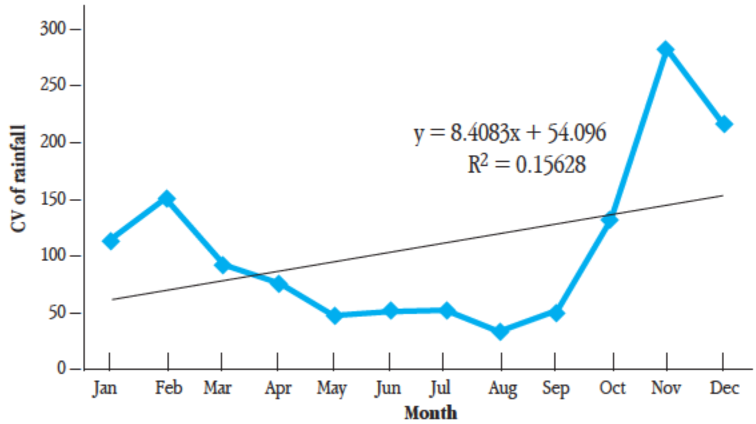

Figure 11 Monthly rainfall variability from 1992-2011

The analysis done by Practical Action (PAN, 2009) also shows that the 80% of rainfall was occurred during monsoon season in Nepal. The mean monthly rainfall for the month July (287mm) was found highest and the months November (7mm) and December (6 mm) receives the less rainfall with 20 years average of mean monthly rainfall 84 mm. Nepal receives the highest monthly rainfall in July and the lowest in November (PAN, 2009). In this study, trend analysis of the graph shows that the rainfall was erratic with no significant decreasing trend. There was also no significant change in annual and monsoon rainfall in Nepal (APN, 2007).

Unusual changes in climate such as rising temperatures, irregular monsoon and changes in intensity and pattern of rainfall have become increasingly noticeable in Nepal (Manandhar et al., 2011). The year 2002 was the wettest year with annual rainfall of 1546 mm and driest year was 2010 i.e. 603 mm. In the context of Nepal, the year 1998 was the wettest year and the year 2005 was the driest year (Baidya & Karmacharya, 2007 cited in Malla, 2008). The Ramechhap was announced as drought district in 2010 by DADO Ramechhap. In most of the year 1992, 1994, 1996, 2000, 2005, 2006, 2008, 2009, 2010 and 2011 the rainfall was below than that on average in the study area (Fig. 7). All year the rainfall is below average as compared to the national average. The average rainfall of this station was 1008 mm which was very low as compared to the national average (1858mm) (PAN, 2009). The national level data show that, except Mid-western development region (now Karnali and no. 5 Provinces) almost all regions of the country showed an increasing annual rainfall trend, but, some small pocket area showed decreasing trend i.e., areas around Dhankuta, Dolakha, Ramechhap and Tanahu districts (PAN, 2009).

Most of the farmers are unaware about climate change, they practice autonomous adaptation. The temperature of both the winter and summer season has been in increasing trend. The number of cold days and night has decreased and the number of warm days and night has increased on the global scale (IPCC, 2013). With respect to the droughts, almost all respondents observed increased drought events now than before. Higher temperature and decreased rainfall have contributed to increased drought (PAN, 2009). Our results from focus group discussion also confirm the statement. It was also noted that last four years observed higher intensity of droughts. Most of the drought events happen in the rainy season, a crucial period for food production point of view. Since a majority of the farmers are marginal and rain- fed subsistence based, increasing drought events marginalizes own farm food production.

Similarly, drought events appearing during winter further adds to woe. Any drought events coupled with high temperature accelerates catabolic activity in the plants, lowering net assimilation and eventually yields reduction. In 2010 due to drought up to 14 pods of maize are seen in one plant but without any seed. Higher temperatures and droughts will reduce agricultural production (Dixit et al., 2013) and also intensify pest and disease problem (Fischer et al., 2002). Due to drought some of the people are migrated outside the village or district. Farmers have been observing droughts every year; wells and springs are drying out; a huge chunk of time was required to fetch drinking water than before.

Respondents reported lesser cloudy days in a year compared to a decade before, but the severity of cloudiness, whenever it happens, was higher, affecting winter crops like potatoes, mustard, tomatoes, etc. Since potato is a major crop in the hills, this variability in cloudiness impact food security. Cloudy days with a minimum temperature greater than 10°C, relative humidity greater than 70% and frost in the night aggravates fungus attack in potato causing late blight on it (APN, 2012). The occurrence of morning fog was found to be a critical factor in disease initiation like late blight on potato (APN, 2012). Cloudiness also affects disease out breaking potatoes and other crops. Furthermore, if there was an intense cloud in a particular day, the amount of net assimilation in the sink leading to yield reduction per se. Severe winter cold wave in Nepal in 1998 showed a high % age of yield reduction for potato (28%) (NARC, 1987-1998).

Climatic Variability Observed and Impact on Local Livelihoods

Table 3 presents respondents' perception on climate change. Only 45% of the respondents have given affirmative answer. Sources of knowledge about climate change did vary. Out of the 45% of respondents, said they have heard of climate change, a large proportion (around three-fourth) have heard from radio and 12% by television, 7% by NGOs/GOs and 5% through self-study. Most of the respond ents observed that temperature has been increasing in recent decades. Similarly, in terms of changing seasonal (summer and winter) temperatures, 96% of the respondents said that the summer temperature has been in increasing order and only 4% said that there was no change in summer temperature. Similarly, 9/10th of the respondents said that the winter temperature was increasing, 3% said that decreasing and 7% said that there was no change. Further discussion in focus group discussion also substantiates that the temperature is in increasing trend. Diseases and pests are increasing due to which local variety of crops such as rice bean, horse gram and local species of cucumber are extinct. Nowadays, local species are less resistant to diseases and pest. Various diseases are recently observed on food crops, fruits and vegetables. New species of weeds are seen which affect the crop production.

Respondents observed changes in rainfall pattern in the area over the period of time and it has been gradually declining (Table 3). Further discussion with respondents and analysis of meteorological data also confirm that the rainfall pattern was decreasing; the last four years have been drought leading to drying of the local sources of drinking water. Due to scarcity of water, livestock rearing was decreased and workload in fetching drinking water increased.

Regarding the number of cloudy days, almost half of the respondent said that such days are decreasing, 28% said no change and 23% said increasing (Table 3). While during focus group discussion most of the respondent said that the cloudy days are decreasing. They opinion is that there used to be high cloudy days in past from August to January, but nowadays this pattern has shifted to November to February. It is the season of winter crops such as potato, tomato, mustard, wheat, barley. Potato is the most affected by the cloud, yield declined and impact on food security.

With respect to the droughts, almost all respondents observed increased drought events now than before (Table 3). Further discussions also confirmed that the drought was increasing for last 10 years and last four years witnessed severe drought, during which most of the wells dried out. This is also substantiating by historical rainfall trend. As hailstorm and windstorm are the rare events, the responses of these events are reported mixed. About 57% respondents said that the events are decreasing, 33% said that same as before and 10% said that the events are increasing. The focus group discussion concluded that the event of hailstorm is decreasing, but windstorm is occurring in few time intervals.

Table 3 Climatic variability observed by the farmers currently compared to a decade before

Parameters		Respondents (%)		
		Increase	Decrease	No Change
Rainfall		0	90	10
Temperature	Annual Temperature	88	12	0
	Summer temperature	96	0	4
	Winter Temperature	90	3	7
Cloudy days		23	49	28
Drought		95	0	5
Wind storm/Hailstorm		10	57	33

Impact on Farming and Adaptation Strategies

Due to changing climatic variables, farmers have noticed a reduction in agricultural production. About 8% of the respondent said that agricultural production is increasing, 60% respondent said that decreasing and 32% respondent said that there is no significant change (Table 4). As compared to the 10 years before the yield is increased due to change in crop species but in between 10 years the yield is declining. The overall productivity data of the Ramechhap district also showed that the yield is in decreasing trend. Further discussion in focus group discussion concluded that the productivity of crop was decreasing. Drought happens to be a major factor in declining crop productivity.

Precarious weather has made appearance of new diseases, pest and weeds leading to more crop damage than ever before. For instance, new weed recently observed is Acmella spp. locally called Bikase Jhar, which has rapidly spread in the farmland and suppressed the growth of crop. Previously found weeds have also been replaced by the new ones. The respondents said that this weed absorbs the huge amount of nutrient and make land less productive. Most of the rainfed paddy land has now converted to Bari due to lack of assured rainfall and/or more variable rainfall pattern. Scientific communities believe that changes in temperature and rainfall are creating a favorable environment for pests, diseases and invasive species to emerge, spread and encroach on agriculture and forest lands (SAGUN, 2009).

According to the focus group discussion conducted in the study area, paddy, maize, wheat, millet and rice -bean were the major crops. The planting and harvesting times over the period of 10 years was discussed in the focused group and the results (Table 5). It was noted that planting and harvesting times have been shifted forward by almost one month in all major crops. For instance, rice used to be planted around 3rd week of June and harvested around 2nd week of November in the past (10 years before). Now these times have been shifted to 4th week of July and 4th week of November, respectively. The key rationale behind changing planting time as discussed by farmers is the lack of timely rainfall, mainly the late onset of rainy season. Since rice demands assured rain for its nursery to grow and facilitate transplanting, farmers noticed the late onset of rainy season and hence they have adjusted to it. Similar explanation holds true for other crops.

As an adaptation, people shift from traditional farming practice to vegetable farming, waged labor, and employment outside country and off-farm businesses due to insecurity in agriculture and less availability of pasture land (Gurung & Bhandari, 2009). Weather and climate are the key determinant of the productivity of crops grown (Joshi et al., 2011) in that region where agriculture depends on rainfall. The cultivation season in Khaniyapani and Rampur area of Ramechhap district is also two months later due to drought for 12 years (Shrestha et al., 2010) However, the time of raising nurseries of rice and millets has not been affected. The reason why seedling raising time was not affected is that it requires less water to raise the seedlings and farmers would not like to take risks raising nurseries in the later dates. However, as it requires copious volume of water for transplanting, it takes place as and when the first monsoon shower takes place.

Livestock was an important source of income of the people in the study site Chisapani. Farmers in risk prone areas have taken livestock as an alternative means of generating income under the situation of climatic risks such as droughts and floods. Growing of water scarcity and appearance of unknown diseases, livestock population in the area was declining. Farmers have shifted from large animals to smaller ones (buffalo to goat and cow rearing). Some farmers have reduced their livestock due to scarcity of water. Goats are increasingly being preferred because they are more drought tolerant and suited for the browse, the species that survive in extended dry conditions and drought (Musimba et al., 2004). Climate change will directly impact animals through heat stress, changes in water availability (with droughts affecting livestock in particular) and a greater range of livestock diseases and disease carriers (Thornton et al., 2009). Droughts and extreme rainfall variability can trigger periods of severe feed scarcity, especially in dry land areas, with devastating effects on livestock populations (CCAFS, 2012). The present study found

Table 4 Perception towards farming

Agricultural Production	Respondents (%)
Increase	8
Decrease	60
No Change	32

Table 5 Change in crop calendar of the Chisapani, Ramechhap in Nepal

Crop		Planting time	Harvesting time
Paddy	10 years before	Jun. 3rd week	Nov. 2nd week
	Now	Jul. 4th week	Nov. 4th week
Maize	Before	Mar. 4th week	Aug. 3rd week
	Now	Apr. 4th week	Aug. 4th week
Millet	Before	July 3rd week	Oct. 4th week
	Now	Aug. 3rd week	Nov. 3rd week
Wheat	Before	Nov. 4th week	Mar. 4th week
	Now	Dec. 3rd week	Apr. 3rd week
Rice bean	Before	Jun. 3rd week	Nov. 1st week
(Masyang)	Now	Jul. 1st week	Nov. 1st week

Note: Before indicates 10 years ago

Table 6 Showing the correlation of agricultural production and rainfall

Crops	Paddy	Maize	Millet	Wheat
r-value	-0.26	0.24	0.01	0.47

that the changing climatic condition was affecting the livestock like deteriorating health because of i) Decrease in rainfall harms the forage production and hence grazers don't get enough grass and ii) Introduction of invasive species results in decline of grass variety. Moreover, the farmers also reported some 'new diseases' infecting livestock.

Correlation of Agricultural Production with Rainfall

Seventeen years rainfall data for the growing season and annual productivity of paddy, wheat, maize and millet was correlated by using Karl Pearson's Correlation. There was a positive correlation between rainfall and overall yield of maize, millet and wheat. Wheat has a strong correlation. The rainfall variability from June to November shows that there was high variability in rainfall pattern except 2000 and 2001. In the year 2002 and 2004 there was high variation on rainfall. This means CV shows increasing trend but not a significant increment. The mean yield of paddy for 17 year was 3.19 ton/ha. The yield of paddy was below average except in the year 2002-2009 (Fig. 12). The yield of paddy showed an increasing trend over the years (Fig. 12). The local farmers conceded that they were adopting high yielding varieties, agro-inputs and or adjusting planting time to get a higher return per se. The increasing production may also be due to an expansion of the area under rice and expansion of irrigation facility. This can infer that climatic variability has less to do with production of rice paddy.

The CV of rainfall from April to September also showed that there was variability from year to year. The year 2002 and 2004 presented high CV, but 2000, 2001 and 2006 presented the lowest CV. The maize season rainfall variability was almost constant over the decades but yield showed polynomial relation. The mean yield of maize for 17 year was 2.58 ton/ha. The yield of maize was below average in the year 1994, 1995, 1996, 1997, 2001, 2009 and 2010 (Fig. 13). The yield was in increasing trend with significant increment over the years. The yield of maize was increasing from 1994 to 1999 and peak during 1998 to 2000 and decreasing till two years, again increasing from 2002 to 2008 and decrease sharply in 2009 and 2010 (Fig. 13). The farmers reported that they were using drought resistant and high yielding varieties. Thus, its production increased even under low rainfall condition. Like rice yield and rainfall variability, maize production also exhibits the similar trend.

The CV of rainfall from December to April also showed that there was high variability from year to year, almost all year have high CV. Year 1996 and 2000 had high CV and in 1999 there was no rainfall (Fig., 14). The trend line showed that the rainfall was in increasing trend though not significantly. The mean yield of wheat for 17 year was 2.15 ton/ha. The yield of wheat was below average in the year 1994, 1995, 1996, 2000, 2006, 2007, 2008, 2009 and 2010 (Fig. 14). The yield of wheat was fluctuating from year to year. Year 2003 and 2004 had highest yield and 2009 had lowest yield (Fig. 14). The trend line of wheat yield showed decreasing trend with significant value.

In a study in Salyantar, central Nepal by Paudydal et al. (2015), about 15.3% of the respondent felt that there was an increased productivity, while 69.4% of respondent agreed on decreased agricultural productivity in the agriculture sector due to climate change. In a study of agricultural growth impact of climate change in Nepal, Acharya and Bhatta (2012) calculated that one additional milliliter of rainfall adds NPR 9.6 million values into the agricultural output, that is, one-unit rainfall causes agricultural output to increase by 9.6. On the other hand, the rise in temperature seems to have negative impact on the agricultural value addition with one degree rise in temperature having a loss by NPR 542 million (Acharya & Bhatta, 2012). In the present study, paddy and maize production were in increasing trend despite an unfavorable climate. This provides an avenue for the researchers to have an in-depth assessment focusing on increasing crop yields despite increasing climatic variability.

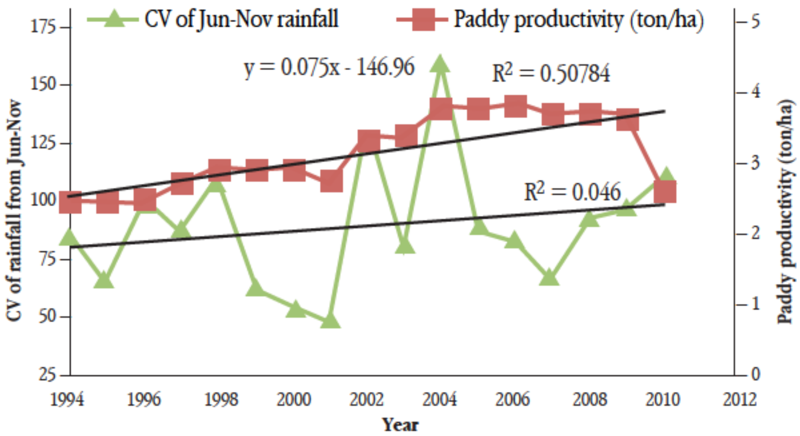

Figure 12 Rainfall variability of Jun-Nov and paddy production (1994-2010)

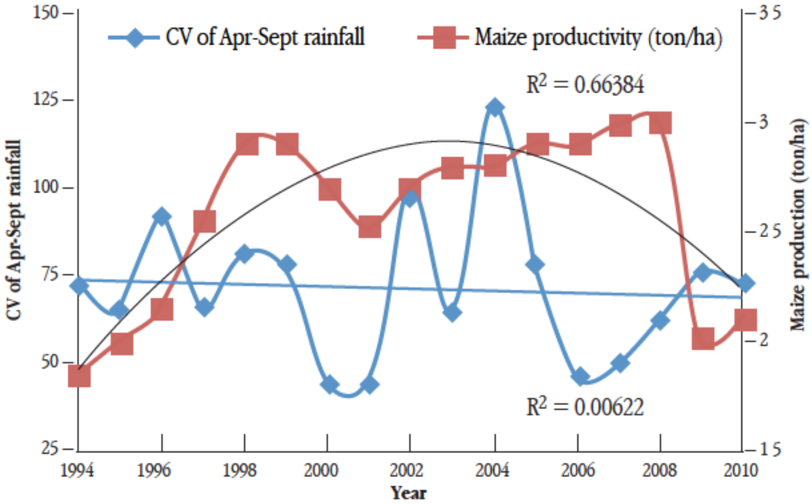

Figure 13 Rainfall variability of Apr-Sept and maize production (ton/ha) (1994-2010)

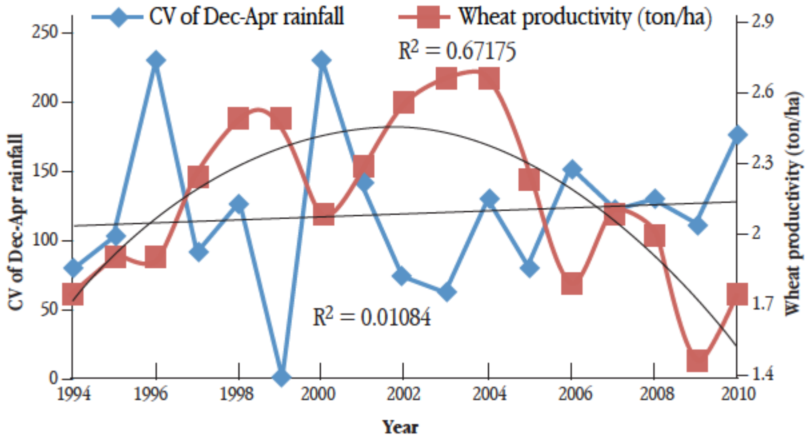

Figure 14 Rainfall variability of Dec-Apr and wheat production (ton/ha) (1994-2010)

Conclusion

Agriculture is the backbone of livelihood of the people in rural Nepal. The paper analyzed the effect of climate variability on agricultural production in the Ramechhap district, central Nepal. It identified a number of hydro-climatic stresses and local adaptation strategies adopted by rural households. The research also examined how farmers personal experiences and scientific seasonal weather forecasts guided the choices made during farming operations. It also identified the types of alternative practices in agriculture to adapt to increasing uncertainties and some of which can be scaled out to enhance resilience of the agricultural system. This study revealed that almost nine out of 10 farm families were marginal farmers and 60% of the household face food deficit half a year, where the climate variability and other associated factors had adverse impacts on agricultural productivity. Since rain-fed farming predominates in the area, drought events have negatively affected agriculture and local livelihood and the coping strategies adopted by households included early planting of crops, shifting one type of cropping pattern to others and so on. Findings in this paper indicated that due to drought 18% of the paddy land was converted to Bari land in the area. In addition, the results are revealed that many crops had disappeared and new invasive species started appearing in the farmlands in the study area. The results also showed that cold spells along with increasing foggy days aggravated the occurrence of pest and diseases affecting winter crops far more than what it used to be but the local farmers mostly relied on the traditional practices of pest control and they used the information, which they well understood.

More importantly, using their indigenous knowledge, farmers had shifted from large animals to smaller ones as a coping strategy. Adoption of new crop varieties, crop rotation, rainwater harvesting and use of plastic tunnel in vegetable farming were the major new practices introduced in the area which have a greater potential for out- and up-scaling. If such information is documented and integrated into scientific adaptational practices including weather forecasts, then local farmers will have better livelihoods and resilient communities could be developed. The assessment of climate variability on crops provides the basis for effective policy formulation and implementation in addressing the problem agro-practices under the context of climate change including the capacity building of institutions to enhance resilience of the agricultural system in Himalayan climatic regimes.

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