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Climate Change: Perceptions, Reality and Agricultural Practice: Evidence from Nepal

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Abstract

The study investigates whether the farmers' perception of changes in climate have led to any changes in their farming practices over the last three decades. The study surveyed 496 farmers living near 10 meteorological stations in Nepal for their understanding of climate change between 1980 and 2014 and adaptation strategies in terms of farming practices in response to perceived change. The results show that nearly all farmers attributed changes in crops grown, in crop varieties, and other farming practices to technological, market, and other factors rather than climate change. A comparison of farmer perceptions and meteorological data showed that farmers' perceptions of changes in minimum temperature and rainfall over the period did not match actual trends in this period in the stations near where they lived. However, their perception of changes in maximum temperature did match the observed trends at the stations quite well, possibly because the trends in this variable were clearer than those for the minimum rates. The results of the study demonstrate that the climate change signal in Nepal during the 1980-2014 period has not been clear and strong enough to have a consistent impact on farmers' perceptions or, even more so, on their agricultural practices. The study found no evidence that adaptation to climate change has occurred. This suggests that for farmers to effectively adapt to future climate change, better communication of expected changes in climate from responsible state and non-state actors may be necessary.

Keywords

Farmer perceptions, Climate change, Aadaptation, Cropping pattern, Agro-ecology

Climate Change: Perceptions, Reality and Agricultural Practice: Evidence from Nepal

1. Introduction

Nepalese farmers are very vulnerable to the threats posed by climate change (Gentle and Maraseni, 2012). Nevertheless, despite its high dependency on agriculture, Nepal has recently turned into a net food importer, with hill and mountain regions reporting a food deficit of 14% and 19% respectively in 2008 (MOAC, 2009). In order to adapt effectively to the very real phenomenon of climate change, farmers need a clear understanding of the actual changes and trends in climatic conditions, associated risks and how to moderate the potential impacts (Esham and Garforth, 2013). Although farmers' understanding and perception of climate change are crucial for making adaptation decisions, for long this aspect has been overlooked only now gaining recognition in the policy making circles for climate change in some parts of the world (Gandure *et al*., 2013). In Nepal, much work still remains to be done in order to take into account farmers' perceptions of climate change for the purpose of designing and implementing modern adaptation and mitigation strategies.

A related but important question has to do with farmer perceptions: do farmers perceive climate change accurately? Accuracy in relation to the topic is not easy given that weather varies a lot while climate change occurs slowly. Furthermore, even if farmers perceive climate change accurately, how big a factor is this in their decision-making since, in the last few decades, other factors like technology and market access have changed enormously. Our study focuses on these questions. It specifically asks whether farmers' perceptions of climate change are consistent with actual trends in climatic variables over roughly the three decades of 1980-2014 and to what extent changes in farmers' agricultural practices are adaptations to changes in climate as opposed to those in technology and market opportunities.

Many studies (Devkota *et al*., 2011; Ogalleh *et al*., 2012; Wiid and Ziervogel, 2012; Baul *et al*., 2013; Varadan and Kumar, 2014) have examined whether farmers' perceptions of climate change match actual climate data for a period longer than three decades. They have also looked at whether farmers' responses were climate induced or not. The studies have found farmers' perceptions to be in line with actual long-term climatic trends. In coming to this conclusion, the studies however depended on semi-structured questionnaires that were not carefully designed and seemed rife with leading questions which would inevitably result in biased estimations. Moreover, the methodology adopted in the studies was found to be inadequate for the purpose of matching respondents' perceptions of long-term climatic parameters with actual climatic variables.

Other studies from around the world which focused on whether farmer perceptions matched reality and reported that their perceptions of climate change are validated by actual climatic data have worked with short-run actual data of two decades or less (Maddison, 2007; Gbetibouo, 2009; Chaudhary and Bawa, 2011; Kemausuor *et al*., 2011; Fosu-Mensah *et al*., 2012; Moyo *et al*., 2012; Piya *et al*., 2012; Roco *et al*., 2014; Hou *et al*., 2015). But short-run time series data do not provide actual and reliable trends due to the high variability as well as the noises in short-term time series climatic data. A very recent study by Kibue *et al*. (2016), conducted in two farming regions of China, too used climatological data of two decades to corroborate the accuracy of farmers' perceptions of climatic variability. It too found farmers' perceptions of climatic variability to be consistent with actual climatic data though the study was not careful in its selection of study sites, used short-term climatic data to show trends, and did not use a properly designed survey instrument.

Many studies conducted in Nepal on the subject also reveal similar inadequacies though Nepal is a good place to study if farmer perceptions match observed trends. This is because warming trends are strong at high altitudes whereas they are either weak or missing at low altitudes which lead to variations in climate change trends. These studies too have attempted to compare actual meteorological data with famers' perception of climate changes though they cover only a small geographical area, use a small sample size and apply qualitative methods using questionnaires that are not carefully designed (Chaudhary and Bawa, 2011; Devkota *et al*., 2011; Manandhar *et al*., 2011; Piya *et al*., 2012; Baul *et al*., 2013; Devkota, 2014; Paudel *et al*., 2014). These studies have mostly focused on comparing perceptions with actual meteorological data. In contrast, our study applies both qualitative and quantitative methods, covers ten districts drawn from different agro-ecological and development regions of Nepal, and examines the relationship between farmers' perceptions and actual climate data using farming household heads that are above 50 years old and actual data of climate change for a period that is slightly more than 30 years. Whereas previous studies reported that farmers' adaptation decisions were in response to climate variability, our study was interested in eliciting the major motives behind the changing cropping varieties and cropping patterns of farmers over the given 30-year period. Additionally, it examines the major determinants of farmers' choice of various adaptations strategies that are evident in the agricultural sector of Nepal.

We designed the household survey tools in such a way that they did not lead to possible biases with regard to responses on climate change during the survey. The questionnaires therefore started with agricultural practices in operation now as well as before, which were followed by questions on whether there had been any changes in agricultural practices over the given time-period under consideration in our study and the reasons for altering cropping patterns and varieties. The survey concluded with questions on farmers' perception of different climatic indicators. The primary household survey was conducted in villages close to the meteorological stations. We obtained farmer perceptions of day-time temperature, night-time temperature, precipitation and rainy days over the last three decades (1980-2014) and then compared them with actual met data on maximum temperature, minimum temperature, precipitation and rainy days over the three cropping seasons.

The results reveal that for nearly all the farmers any changes in crops grown, in crop varieties, and other farming practices were due to technological, market, and other changes rather than climate change. Although they perceived the fact of climate change, they did not report this as one of the top two reasons for adopting new crop varieties. Farmers' perceptions of changes in minimum temperature and rainfall over the period also did not match actual trends in this period in the stations near which they lived. Therefore, in the rest of the paper, we will first discuss methodology, variables, and empirical strategies; next describe and discuss regression results; and finally draw conclusions and relevant policy implications based on the results.

2. Data and Methods

2.1 Meteorological data

Although Nepal has more than 300 weather stations, only 54 stations have at least 30 years of weather data on temperature and precipitation. Of the 54, 10 weather stations and their respective districts were selected for the study. In Nepal, there has been more warming in high altitudes than in low altitudes (Shrestha *et al*., 1999). Since we were interested in seeing if perceptions matched reality with regard to climate change, we chose districts with a large altitudinal range, so that they would display different degrees of warming. We chose 10 districts in the Central Region of Nepal in order to minimize travel time. We obtained monthly data from the Department of Hydrology and Meteorology (DHM) on total precipitation, number of rainy days, monthly average of daily minimum temperature, and monthly average of daily maximum temperature for thirty years (1980-2014) for these 54 stations. Based on the cropping timings, we divided the whole year into three seasons, i.e., June to September as the monsoon season; October to January as the winter season; and February to May as the spring season.

We calculated the trend for each meteorological variable i in each season s in {Spring, Monsoon, Winter} for the station in each district d by running the following regressions

$$y_{ids} = a_{ids} + \mathbf{b}_{ids} t \quad (1)$$

where t denotes the years ranging from 1980 to 2014. For each variable, season and station, the change in i between 2014 and 1980 was calculated by multiplying the estimated trend coefficient b by 34.

Table 1 reports summary versions of these regressions to indicate the changes in climatic variables over the period 1980-2014. The first row uses data from all 54 stations with station-specific intercepts and a common trend. The next two rows show all the stations from the hills and Terai respectively while the last three rows show only the 10 stations selected the data from which will be compared with farmers' perceptions from the primary survey.

Table 1: Estimated changes in climatic variables by cropping season, 1980-2014

Station Name	Spring max temp	Monsoon max temp	Winter max temp	Spring min temp	Monsoon min temp	Winter min temp	Spring rainfall (mm)	Monsoon rainfall (mm)	Winter rainfall (mm)
Nepal (54 stations)	2.33***	1.27***	1.05***	0.64***	0.31***	0.28***	3.2	-1.6	-10.7***
Terai (16 stations)	0.8***	0.65***	-0.4**	0.61***	0.15	0.41**	7.8**	-11	- 10.2**
Hills (38 stations)	1.88***	1.55***	1.73***	0.66***	0.38***	0.22***	1.2	2.6	-10.9*
Study area (10 stations)	1.48***	1.19***	0.78***	0.66***	0.42**	0.39*	16.3***	10.2	-11***
Study area Terai (5 stations)	0.59**	0.70***	-0.7***	0.76***	0.09	0.42*	21.3***	-19.3	-12.5**
Study area Hills (5 stations)	2.27***	1.6***	2.18***	0.56*	0.78***	0.37	11.6	38.4	- 9.64*

Note: Changes are calculated as the coefficient on year multiplied by 34. * indicates significance of trend coefficient at 10% level, ** significance at 5% level, *** significance at 1% level.

As seen in Table 1, though both the hills and the plains (Terai) got warmer with the increase in temperature, the increase in temperature is greater in the hills than in the plains. There is just one exception to this pattern: that is, the Terai which experienced the maximum increase in temperature in the winter. In contrast, in the case of precipitation, there was no discernible trend, whether in terms of increase or decrease in the rainfall in either the monsoon season (the monsoon season accounts for most of the precipitation in Nepal), or in the spring season with one exception: there was a decrease in the winter rainfall.

2.2 Farmer surveys

Initially, we conducted 10 key informant interviews or village level surveys with the leader of the farmers' group, NGO/INGO workers, or social activists, choosing one from each study area or locality. We also conducted ten Focus Group Discussions (FGDs), again conducting at least one each in each study district in the process of finalizing the primary household survey questionnaire. The FGDs were conducted in order to elicit general qualitative information on farmer perceptions on climate change, agricultural practices and existing adaptation strategies.

We conducted structured interviews with randomly selected household heads in the sampled villages. We selected eleven villages which were in close proximity to the weather stations with at least thirty years' data on temperature and precipitation from the ten districts. The selected villages were located at a distance of 2 to 32 km from the weather stations with an average distance of 13 km. They were located at altitudes ranging from 69 m to 2048 m from sea level. When conducting the household surveys, villages with a long history of residence were selected over newly established villages which were excluded from the survey given that we were soliciting farmers' perceptions of long-term climate change trends in the villages in which they were resident.

We interviewed approximately 500 household heads from the study villages. From each village, we randomly selected at least 45 household heads from a list of elderly farming household heads who were at least 50 years old and who had been domiciled in the same village for the past 30 years for the purpose of tapping their long-term memory of climate events and farming experience. We prepared the list with the help of village leaders of the respective study areas based on the following criteria: they had to be (a) at least 50 years of age during the period of the survey, and (b) continuously engaged in the agricultural sector or working as farmers from 1980. Though we found that it was not easy getting the required information on past climatic events from elderly persons due to inevitable memory lapses, we tried to elicit information from them on a recall basis by offering a reference point via a landmark political event that had occurred during 1980. For example, a referendum on the Nepalese governmental system was held on May 2, 1980 where voters were offered the choice between a non-partisan Panchayat system and a multi-party system. The Panchayat system received a slim majority of approximately 55% of the vote. It was felt that ease of recollection would be facilitated therefore via reference to the 1980 Referendum.

We designed the household-level structured and semi-structured focus group discussion questionnaires in such a way as to minimize if not eliminate biased responses. Hence, respondents were not asked any questions relating to climate change until the last two sections of the questionnaire starting instead with questions on socio-economic characteristics followed by changes in agricultural practices such as changes in cropping patterns, cropping varieties, and planting and harvesting times of different crops across the various seasons since 1980. If the respondents stated that changes had been made, they were further asked about possible reasons for the change of practice.

In the second part of the last section of the questionnaire, farming household heads were asked about their perceptions of various indicators of climate change. Respondents were asked if they had observed any changes in rainfall and temperature across the three agricultural seasons since the Referendum, which covers the period over the last three decades. In the last section of the questionnaire, those respondents who had perceived changes in climatic parameters were asked about household level agricultural adaptation strategies that they had made in response to the perceived changes in rainfall and temperature across the cropping seasons. But no hints on climate change were communicated to the respondents at this stage of the survey in order to avoid possible biases in the study as pointed out by Mertz *et al*. (2010). This was because, if a discussion on their perceptions of climate change was initiated, they may have felt obliged to say that they had perceived some changes when in fact they had not (Maddison *et al*., 2007). At the same time, we also gathered data on various crop varieties grown by farmers from other secondary sources.

Figure 1 shows the farmers' perceptions of various indicators of climate change. On the whole, most farmers tend to believe that rainfall has declined in all seasons. A majority of farmers also believe that spring and monsoon temperatures have increased since 1980. However, farmers were more divided about changes in winter temperatures. During the survey, farmers reported that rainfall variability was one of the essential determinants of adaptation decisions in farming. They felt that rainfall and temperature have changed during this period and that rainfall variability has had a higher impact on agricultural production than a change in temperature. Most of the

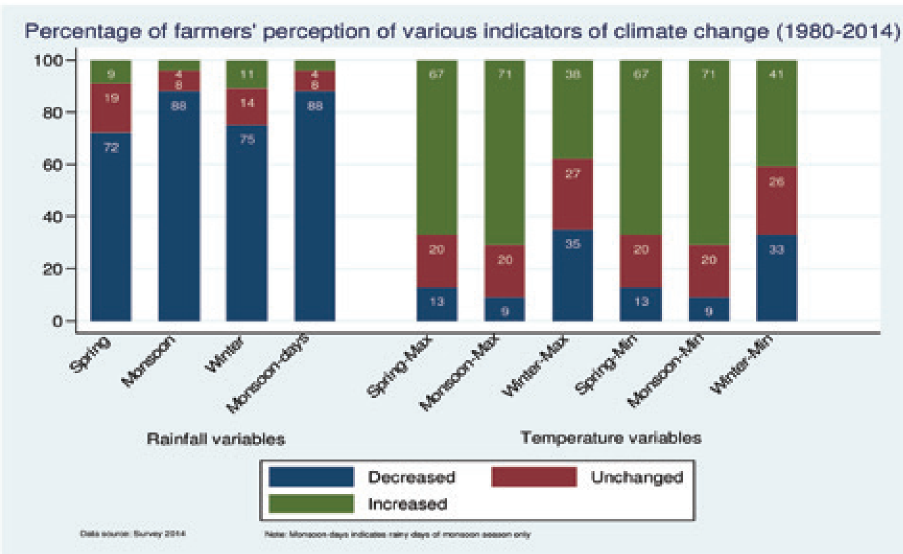

Figure 1: Farmers' perceptions of different indicators of climate change (%)

respondents did not consider a slight rise in temperature to have a serious impact on crop production although research indicates that a rise in temperature would lead to soil moisture loss and desiccation in addition to affecting crop production in the long run (Esham and Garforth, 2013).

2.3 Determinants of farmers' perception of climate change

Each respondent was asked whether they have observed any changes in the rainfall, and day-time and night-time temperatures during the three cropping seasons, i.e., monsoon, winter and spring seasons, over the years since the Referendum. They were given the option of choosing among the following three scenarios: increased (coded as 1), unchanged (coded as 0), and decreased (coded as -1). The scatterplot diagrams given in Figure 2 below show whether farmers' perceptions have any relationship with actual changes in climatic variables. Horizontal axes of first and second scatterplots of Figure 2 indicate the total changes in actual minimum and maximum temperatures over the 30-year period under consideration while the vertical axes show the percentage of farmers who perceived changes in minimum and maximum temperatures, where 1 indicates the proportions of sample households who believed that there was an increase in temperature and -1 referring to the proportion of those who believed that a decline in temperature had occurred since 1980. Thus, the vertical axis measures the difference between the proportion of farmers who believes the temperature has increased and the proportion of farmers who believes the temperature has decreased. Similarly, the horizontal axis of the third scatterplot of Figure 2 demonstrates actual changes in rainfall in millimetres since 1980. Each dot of the three scatterplots of Figure 2 refers to one station. The first scatterplot in particular compares farmers' perception of minimum temperatures with actual minimum temperature across the three seasons. The second scatterplot likewise compares actual and observed changes in maximum temperatures over the three seasons. Lastly, the third scatterplot compares actual and observed changes in rainfall across the three seasons. A filled symbol indicates that actual changes in climatic parameters are significant at the 5% level while a hollow symbol indicates that an actual change was not significant at the 5% level.

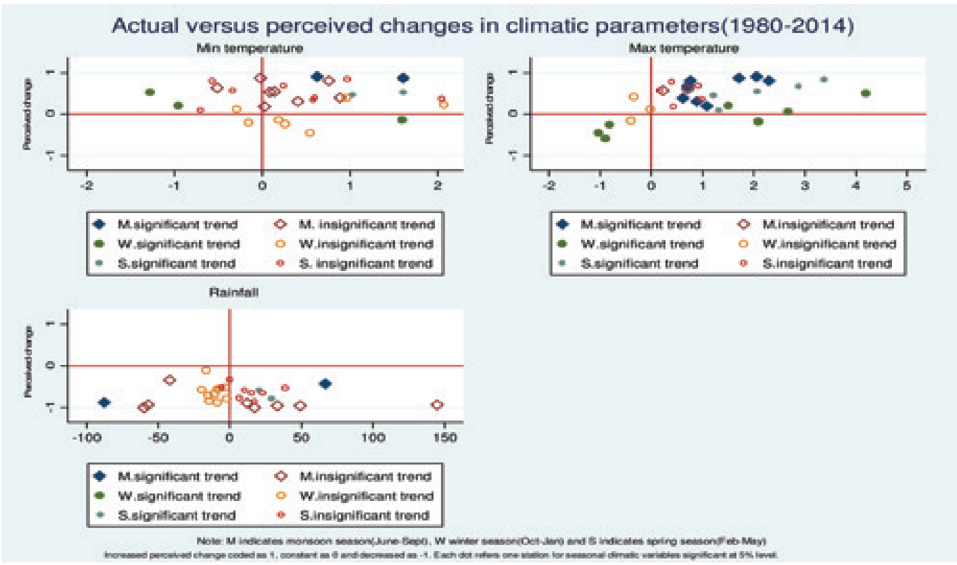

Figure 2: Actual versus observed changes

In addition to this figure, we conducted a more formal statistical analysis of the relation between reality and perception using ordered logit models for estimation. Separate ordered logit models were run for each climatic variable. The ordered logit model is given by

$$y^*_{hd} = x_d \beta + e_{hd}, \quad e/x \sim normal(0,1) \qquad (2)$$

where y^*_{hd} represents latent and continuous measures of climate change perception by a household h near the meteorological station in district d, x_d is the change in a climate variable at the station in district d, β is the coefficient to be estimated, and e denotes a random error term, which follows a normal distribution. The changes in climate variables used are the predicted changes in x_d over the period 1980-2014 with the linear trends in each variable in each season described in Section 2.1.

3. Results and Discussion

3.1 Perceptions vs reality with regard to climate change

The scatter diagrams illustrate the relationship between actual climatic parameters' trends and farmers' observations on climatic indicators in the10 study areas of Nepal (Figure 2). A comparison of farmers' perceptions with actual trends in maximum temperature for different stations during different cropping seasons finds that farmers' understanding of day-time temperatures is in line with actual temperature. However, farmers' perception of minimum temperature did not match actual trends for most of the stations as evident from the uncoloured dots in the first quadrant, which clearly indicates that farmers have overstated the rise in minimum temperature in the study areas. On the other hand, farmers' perception of rainfall amounts across cropping seasons in the 10 different areas of Nepal under consideration in the study showed no clear trend (see Figure 2). The third scatterplot in Figure 2 clearly shows that actual rainfall patterns do not provide corroboration for the farmers' perception that rainfall has declined during the different cropping seasons.

To further substantiate the findings in Figure 2, we run separate regressions. Table 2 reports the results of the ordered logit models of farmers' perception of actual season-wise mean changes in maximum temperature for the last 30 years. It shows the actual changes in the mean maximum temperature of the monsoon, winter and spring seasons to be positively and significantly related with farmers' perceptions of season-wise maximum temperature.

Table 2: Ordered logit models of perceived changes in seasonal maximum temperature

Explanatory variables	**Dependent variables: Farmers' perception of max temperature (-1: Decreased, 0: Unchanged and 1: Increased)**		
	(1)	(3)	(5)
Actual parameters	Monsoon max	Winter max	Spring max
Monsoon max	0.66***(0.15)		
Winter max		0.32***(0.05)	
Spring max			0.39*** (0.10)
Constant cut1	-1.65***	-0.33***	-1.64***
	(0.24)	(0.11)	(0.20)
Constant cut2	-0.13	0.86***	-0.45***
	(0.20)	(0.13)	(0.17)
Observations	496	496	496

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3, which presents a logit regression model, illustrates how the actual mean change in various seasonal minimum temperatures will have an impact on farmers' perception of a change in minimum temperatures across the three cropping seasons. The negative and significant relationship found between farmers' perception of winter minimum temperature and the actual change in winter minimum temperature over the three decades could arise from the fact that people are less likely to perceive an actual rise in minimum temperature during winter night-time because people tend to overstate the increase in cold during winter time, particularly at night. This is consistent with the finding of Goebbert *et al.* (2012).

Since no relationship is found between actual changes in seasonal rainfall and farmers' perceptions of seasonal rainfall, it is reasonable to conclude that farmers do not form their perceptions based on actual changes in rainfall patterns over time (see Table 4). It is possible that farmers' perceptions may be shaped more by risk events that they face than by actual temperature trends. It is also the case that though farmers appear to perceive changes in climate, their concern for climate variability seems ambiguous because some of their responses were more directly related to the desire to secure a higher income and only indirectly related with climate change (Mertz *et al.*, 2009). Several scholars concur with this opinion. Simelton *et al.* (2013) have argued that farmers' perceptions were more shaped by recent rather than long-term climatic phenomena while Rao *et al*. (2011) have pointed out that such inconsistency in the actual and observed parameters could be due to overestimation of poor seasons or negativity bias, which suggests a tendency on the part of farmers to perceive a higher risk than what actually prevails in the environment.

Table 3: Ordered logit models of perceived changes in seasonal minimum temperature

Explanatory variables	Dependent variables: Farmers' perceptions of minimum temperature (-1: Decreased, 0: Unchanged and 1: Increased)		
	(2) Monsoon min	(4) Winter min	(6) Spring min
Monsoon min	0.23(0.16)		
Winter min		-0.22***(0.06)	
Spring min			-0.07(0.09)
Constant cut1	-2.27***	-0.74***	-1.96***
	(0.18)	(0.10)	(0.14)
Constant cut2	-0.82***	0.35***	-0.73***
	(0.12)	(0.09)	(0.10)
Observations	496	496	496

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Ordered logit models of perceived changes in seasonal rainfall

	Dependent variables: Perception of seasonal rainfall and rainy days (Decreased: -1, Constant: 0 and Increased: 1)			
	(1) Monsoon	(2) Winter	(3) Spring	(4) Rainy day
Monsoon rain	0.00(0.00)			
Winter rain		-0.01(0.02)		
Spring rain			-0.02**(0.02)	
Monsoon day				-0.07***(0.03)
Constant cut1	1.97***	1.21***	0.59***	2.06***
	(0.14)	(0.24)	(0.16)	(0.15)
Constant cut2	3.13***	2.17***	1.96***	3.23***
	(0.23)	(0.24)	(0.17)	(0.23)
Observations	496	496	496	496

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Vedwan and Rhoades (2001) have reported that farmers formed their perceptions based on crop-climate interaction. More specifically, farmers are more likely to notice and perceive climatic events based on crop performance in the past. For instance, if they got a better harvest this year, they would generally infer that rainfall and other climatic parameters were more favourable during this year as compared to other years when there was poor crop yield. It is also predicted that farmers' perceptions of climate change depend on recent actual climatic parameters. In order to test this, we examined the impact of recent climate change trends on farmer perception by calculating the mean actual precipitation and temperature trends for the first 15 years and the previous 15 years coming under our 30-year study period starting from 1980. We did not find any difference in farmers' perception when we compared them with the previous results as shown in the above tables.

3.2 Existing agricultural practices

In the study area, farmers' most preferred crop combination consisted of paddy, maize and wheat, a combination that has remained unchanged since 1980. Nearly all the farming HHs were following the same cropping pattern in the monsoon season. A similar situation with regard to cropping patterns was discernible in the winter season: the primary crop choice combination during winter for approximately 92% of farming households in the survey areas was wheat, oilseed and potatoes. However, one fourth of households who used to keep their lands fallow during winter are currently growing wheat. Similarly, maize ranks first in terms of crop preference among farmers in the mountain and hilly areas in the spring season. Farmers now grow vegetables in some plots, which previously used to lie fallow and uncultivated (see Figure 3).

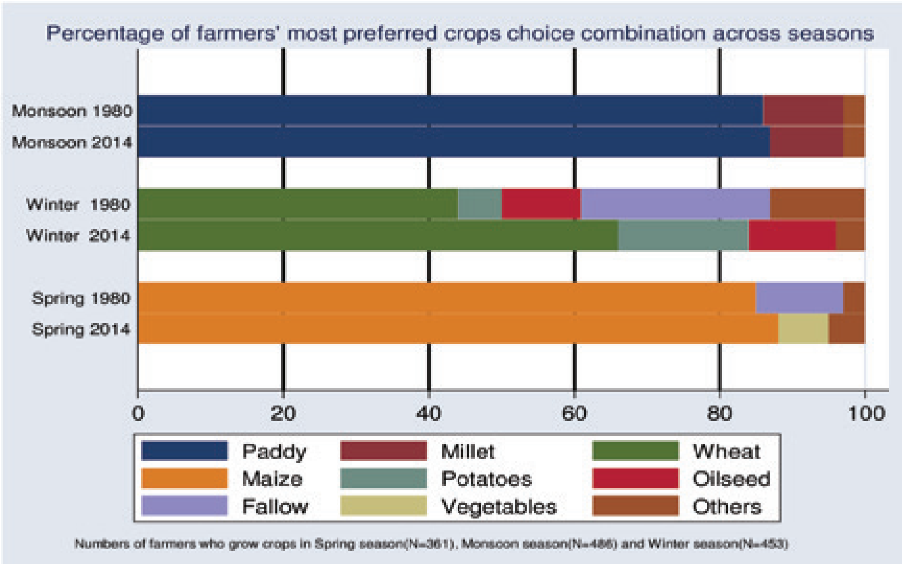

Figure 3: Changes in farmers' most preferred crop choice combinations across seasons

Likewise, there was not much of a change in the second most preferred crop choice combinations of farmers for the spring and monsoon seasons during the last three decades as shown in Figure 4. It shows that while winter fallows have decreased, the cultivation of potatoes in winter has increased.

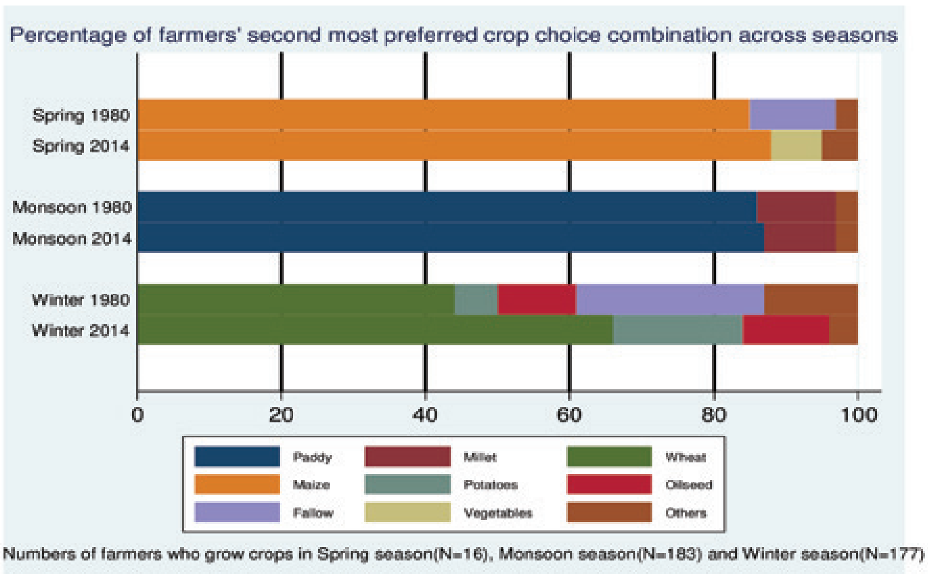

Figure 4: Changes in farmers' second most preferred crop choice combinations

The qualitative survey found that although farmers perceived rising temperature and falling precipitation, they did not take proper adaptation measures to deal with it. While farmers, particularly from the lowland region, resorted to water management and adoption of hybrid crop varieties as the major adaptation strategies to deal with changing climate phenomena, farmers from the upland regions did not do anything except wait for rainfall due to the unavailability of permanent water sources nearby.

3.3 Factors affecting farmers' decisions to change cropping varieties

About 87% of sample households have been growing paddy during the last three decades. Of that percentage, 76% of households grow high yielding paddy varieties[1]. In contrast, during the 1980s, farmers used to grow only traditional paddy varieties[2]. Similarly, around 72% of the sample households, particularly from the mountain and hill areas that fall within the purview of the study, grow maize. While all the maize growers used to cultivate traditional maize varieties during the 1980s, currently, nearly 50% of the maize growers cultivate improved maize varieties[3] although the rest still grow traditional varieties[4]. Likewise, nearly three fourths of the wheat growers changed their wheat varieties from traditional[5] to modern[6]. In the case of growers of wheat, though they cultivated traditional wheat varieties during the 1980s, currently they grow improved wheat varieties across all geographical regions of Nepal, from the lowlands and the hill and mountain areas. But no such changes over the years have taken place in relation to mill *et al.* though it is one of the predominant crops grown in the rain-fed plots of the hill and mountain regions of Nepal. This is due to the unavailability of improved millet varieties (see Figure 5). In sum, the study finds a significant increment in modern varieties of cereal crops over the time-period under consideration except for millet.

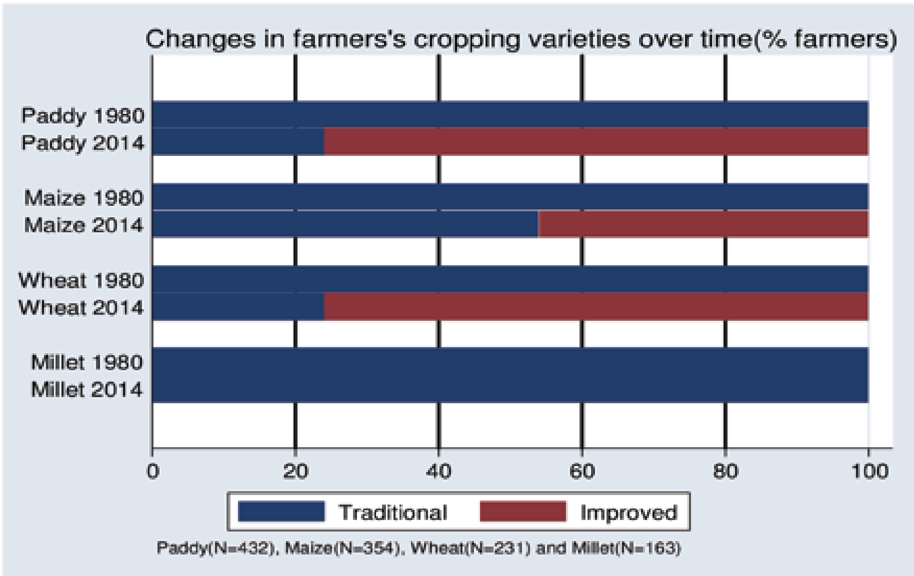

Figure 5: Changes in farmers' cropping varieties

3.4 Reasons for changes in agricultural practices

Surprisingly, nobody appears to change their cropping patterns in response to climate-related changes. As Figure 6 shows, maximization of profits and technological changes are the prime reasons for changing the cropping patterns. Figure 6 shows that around 10% of households have changed their monsoon season's cropping pattern, particularly

[1] High yielding varieties: Gorakhnath, Taichin, Radha 4, Mansuli, etc.

[2] Traditional rice varieties: Rambhoj, Thapachiniya, Marsi, Didai, Mansara

[3] Traditional maize varieties: Rato, Seto, pahalo, etc.

[4] Improved maize varieties: Mankamana, Aruna, Kumaltar-4

[5] Traditional wheat varieties: R21, Rato, Seto, etc.

[6] Modern wheat varieties: NL, Bhaskar, Khumaltar, etc.

in the mountain and hilly regions, from millet to potatoes and other cash crops such as oranges. Among them, the majority of farmers have changed their cropping patterns with the primary objective of earning profits. Similarly, 42% of households in the survey areas have changed their cropping pattern in the winter season. Most of the plots, which used to lie fallow in the winter season during the 1980s, now grow potatoes and wheat primarily due to market-related and technological changes. The survey highlighted the fact that expectation of higher yields/profits and changes in irrigation facilities are the main causes of changes in cropping patterns during the winter season. An additional reason for cultivating wheat and potatoes in the fallow plots was food shortage. Similarly, 10% of sampled households changed their spring season's cropping pattern to grow vegetables and potatoes in the uncultivated plots mainly due to market-related causes such as the prospect of increased profits and new sources of income. Another reason was technology, which in the main meant improved irrigation facilities and new crop varieties.

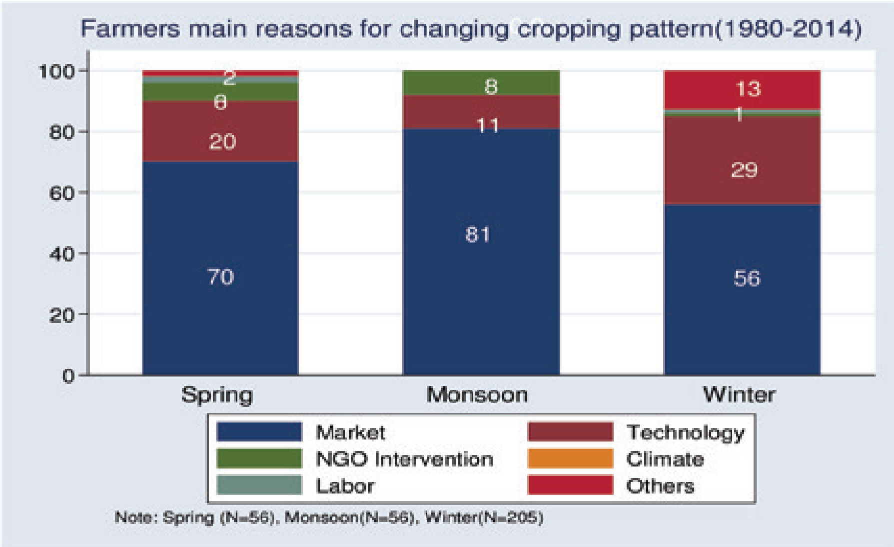

Figure 6: Main reason for changing cropping pattern

Figure 7 shows that 67% of households have changed their crop varieties during the time period under consideration (1980-2014). Among them, 63%, 20% and 15%, respectively, have changed their crop varieties due to market-driven forces (such as more production, more profits and new sources of earning, etc.), technological changes[7], and other reasons among which are NGO interventions and unavailability of seeds for local varieties of crops respectively.

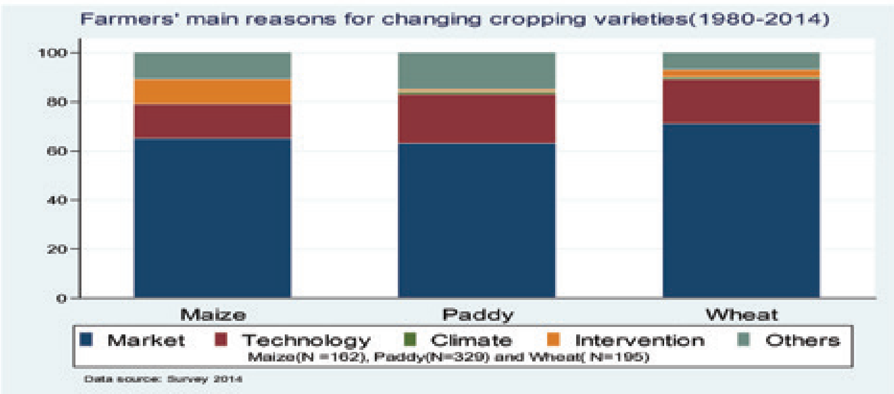

Figure 7: First main reason for changing crop varieties

In a similar vein, technological and market-related changes were the two main reasons for changing the crop varieties of wheat and maize during the time-period under consideration (see Graph 8). A few respondents reported that they had adopted improved varieties due to unavailability of traditional varieties. The findings of our study thus

[7] Old crops but new varieties with high productivity, improved irrigation, early are maturing varieties, etc.

contradict previous findings (Manandhar *et al*., 2011; Ogalleh *et al*., 2012; Tambo and Abdoulaye, 2013; Paudel *et al*., 2014), which assert that farmers change their agricultural practices in response to changes in climatic parameters. Our study finds that farmers frequently made changes in their agricultural practices motivated by market-related drivers rather than by climatic stressors.

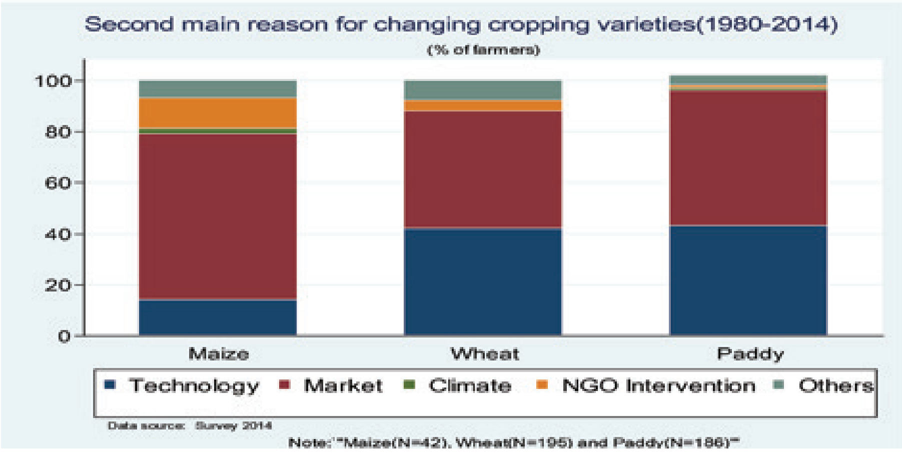

Figure 8: Second main reason for changing cropping varieties (%)

4. Conclusions and Policy Implications

The study assessed to what extent Nepali farmers' perceptions of climate change have led to adaptation decisions in relation to their farming practices. For this purpose, we conducted a survey of 496 farmers living near 10 meteorological stations in 10 select districts of Nepal on their perceptions of climate change during a given time-period. The study revealed that despite farmers' perceptions of climate change, it was not among their top two reasons for adopting new crop varieties. Almost all farmers said that any changes in crops grown, in crop varieties, and other farming practices were due to technological, market, and other factors.

The study further found that farmers' perception of maximum temperature matched seasonal changes in actual maximum temperature data for the last three decades while econometrics estimations showed that actual maximum temperature trends had a significant influence on farmers' perception of rising season-wise maximum temperature since 1980. But farmers' perceptions of changes in minimum temperature and rainfall over the period did not match very well the actual trends during this period in the stations near where they lived. Farmers tended to report a decline in rainfall regardless of whether the station near where they lived recorded a declining trend or not. Similarly, they tended to report an increase in minimum temperature regardless of whether the station near where they lived indicated an increasing trend or not. However, their perception of changes in maximum temperature did match quite well the observed trends, possibly because the trends in this variable were clearer with many of climatic trends statistically significant at the 5% level.

On the basis of these results, we conclude that the climate change signal in Nepal over the 30-year period between 1980 and 2014 has not been strong and clear enough to have a consistent impact on farmers' perceptions of such change and, even more so, on their agricultural practices. We find no evidence that adaptation to climate change has occurred among farmers in the sample. This suggests that if farmers are to effectively adapt to future climate change, better communication of expected changes in climate and the need for adaptation in terms of farming practices may be necessary by the government of Nepal, policy makers, and those concerned with climate change and human survival. The study makes it very clear that the farming community accepted the phenomenon of climate change but that they did not quite grasp either its actual trends or its impacts. Moreover, the level of understanding of climate change varied across farmers. These factors would get in the way of much-needed attempts by farmers to adopt suitable farming practices and to adapt existing practices to ensure sustainable livelihoods in a scenario of climate change. Understanding farmers' perception of climatic attributes would help policy makers and planners to take appropriate adaptation and mitigation measures to cope with recent changes in climate or climate trends.

It would also help them to formulate suitable policies on climatic variability in order to lessen the impact of climate change on people in their locality. The Government of Nepal could disseminate clear and concise information on climatic parameters among farmers in a timely manner in order to help the farming community to decide on the appropriate crops to grow and the right time to plant the crops in order to avoid either excessive dryness or excessive rainfall. Such climatic predictions would help farmers to cope with and adapt to climatic uncertainty for the purpose of saving their crops and enhancing crop productivity.

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Appendix

Household Survey Questionnaires **on** **Change in Agricultural Practices Over Time** **Funded by SANDEE**
[Respondent should be a member of the HH old enough to talk about the last three decades of agricultural practices. Also, he/she should be the decision maker in the HH's current agricultural practices and should have been involved in those practices since the Referendum (1980)] Introduction and agreement Namaste! My name is …………I have come from Nepal Economic Association to conduct this survey at your village. If you are interested in participating in this survey, I would be extremely thankful to you. If you do not feel like answering a particular question, you may do so. But if you share your valuable suggestions and inputs on these questions, it would be extremely helpful for the policy makers to make appropriate policy reforms and strengthen the ongoing project on "Nepalese Farmers' Adaptation Strategies to Climate Change." This interview will last for 30 minutes. Your personal information and identity will be kept confidential and your answers will not be used on an individual basis. Are you willing to participate in this survey? 1. Yes……………… (Start interview) 2. No………………. (Stop interview)

A. Household profile: [for HHs staying in that village and practicing agriculture for more than three decades]

101. District Name: __________102. VDC Name: __________103. Ward No. __________

104. Village/Tole Name__________________________

105. GPS Coordinate of the house: A. Longitude: _________ B. Latitude_____________ C. Altitude (Metre) ________

106. Name of the HH Head: _________________________________

(contact no., if any) ____________________________

107. Age of the HH Head (completed years) _____________

108. Sex (√)   1. *Male* 2. *Female*

109. Highest educational qualification of the Head of the Household (Use Edu Code)[8] :__________

110. Educational qualification of the person who was the Head of the Household around the time of referendum (if not the same person as of now) (Use Edu Code): ________

111. Caste (self-assessment) (√):

1. Dalit 2. Ethnic groups (Gurung, Rai, Limbu, Newaretc) 3. Bramin/Chhetri 4. Madhesi 5. Other (specify):

[8] **Edu Code for Highest Educational Qualification**: 0 = no schooling; else number of last class passed (till 12th); else G= graduate; PG= post graduate and above

112. Household's present member composition:

	A. Children under 5	B. Between 5-14 years		C. Between 15-60 years		C. Between 15-60 years	
		Male	Female	Male	Female	Male	Female
No. of members							

113. The number of years the respondent is engaged in agriculture: _____________ (Years)

114. Select all the assets presently possessed by the household:

1. Radio	2. Cell phone	3. Computer	4. Motorcycle	5. TV
6. Bicycle	7. Tractor	8. Four wheeler	9. Other (specify)	

B. Changes in Agriculture Practices since the Referendum [2036 BS/1980 AD]:

[Respondent should be a member of the HH old enough to talk about the last three decades. Also, he/she should be the decision maker in the HH's current agricultural practices and should have been involved in those practices since the Referendum]

201. Landholding over the last three decades: (write the sizes along with units as the respondent reports)

Irrigation Status	A. Around the time of referendum Code: 1= Ropani 2= Bigga				B. At present Code: 1=Ropani, 2= Bigga				C. Brief description of primary cause for change in landholding (if any)
	Unit	B/R	K/A	D/P	Unit	B/R	K/A	D/P	
1. Irrigated									
2. Not irrigated									
3. Total									

202. Changes in Cropping Pattern over the period since referendum (put Crop Codes for major crops only)[9]: RAINY Season (Ashar –Asoj)

SN	A. At present (major crops)	B. Around the time of Referendum (major crops)	C. Brief description of the reasons for change in cropping pattern (if any)	D. Main two causes (reason code Main[10])	
1				1st Reason	2nd Reason
2					
3				Sub-code	Sub-code

[9] **Crop Codes**: 1. Paddy 2. Wheat 3. Maize 4. Peppermint 5. Millet 6. Upland paddy 7. Oil seed (Mustard) 8. Kagno (Buckwheat) 9. Sweet potato (sakharkhanda) 10.Vegetables 11. Dry season paddy (chaitedhan) 12. Any other (specify)

[10] Reason Code Main: Reasons for changing cropping codes

1. Market related: Sub-Codes: (a) New markets (b) New sources of earnings (c) More production (d) More relative profit (e) Any Other (specify)

2. Technological changes: Sub-Codes: (a) availability of new crop (b) old crops but new variety with more productivity (c) old crops but new variety with short maturing period (d) improved irrigation infrastructure (e) deterioration of old irrigation facilities (f) Any other (specify)

3. **Labor Market Changes: Sub-Codes:** (a) Less availability of hired labor (b) Less availability of family labor (c) Labor wage rate increased (d) Any other (specify)

4. Climate related changes: Sub-Codes: (a) Increased number of wet days (b) More intensity of rain per day (c) Decreased number of wet days (d) Decrease in intensity of rain per day (e) Erratic rainfall (f) Increase in number of hot days (g) Decrease in number of hot days (h) Increase in number of foggy days/cold spell (j) Decrease in number of foggy days/cold spell (k) Any other (specify)

5. Intervention related: Sub-Codes: (a) Training received from Government/NGO (b) Subsidies/provisions (seed/fertilizer) from Government/NGO (c) Any other (specify)

6. Other (Specify)

203. Changes in Cropping Pattern over the period since referendum (put Crop Codes for major crops only): WINTER Season (Kartik – Magh)

SN	A. At present (major crops)	B. Around the time of Referendum (major crops)	C. Brief description of the reasons for change in cropping pattern (if any)	D. Main two causes (reason code Main)	
1				1st Reason	2nd Reason
2					
3				Sub-code	Sub-code
4					

204. Changes in cropping pattern over the period since the Referendum (put Crop Codes for major crops only)[11] : DRY Season (Fagun – Jesth)

SN	A. At present (major crops)	B. Around the time of referendum (major crops)	C. Brief description of the reasons for change in cropping pattern (if any)	D. Main two causes (reason code Main[12])	
1				1st Reason	2nd Reason
2					
3				Sub-code	Sub-code
4					

[11] **Crop Codes:** 1. Paddy 2. Wheat 3.Maize 4. Peppermint 5. Millet 6. Upland paddy 7. Oil seed (Mustard) 8. Kagno (Buckwheat) 9. Sweet potato (sakharkhanda) 10.Vegetables 11. Dry season paddy (chaitedhan) 12. Any other (specify)

[12] Reason Code Main :

1. Market related Sub-Codes: (a) New markets (b) New sources of earnings (c) More production (d) More relative profit (e) Any Other (specify)

2. Technological changes: Sub-Codes: (a) Availability of new crop (b) old crops but new variety with more productivity (c) old crops but new variety with short maturing period (d) Improved irrigation infrastructure (e) deterioration of old irrigation facilities (f) Any other (specify)

3. Labor Market Changes: Sub-Codes: (a) Less availability of hired labor (b) Less availability of family labor (c) Labor wage rate increased (d) Any other (specify)

4. Climate related changes: Sub-Codes: (a) Increased number of wet days (b) More intensity of rain per day (c) Decreased number of wet days (d) Decrease in intensity of rain per day (e) Erratic rainfall (f) Increase in number of hot days (g) Decrease in number of hot days (h) Increase in number of foggy days/cold spell (j) Decrease in number of foggy days/cold spell (k) Any other (specify)

5. Intervention related: Sub-Codes: (a) Training received from Government/NGO (b) Subsidies/ provisions (seed/fertilizer) from Government/NGO) (c) Any other (specify)

6. Other (Specify)

C. Changes in Crop Varieties since Referendum:

Crop Name	301. Variety				302. Brief description of the cause of change	303. Main two causes (reason code main and sub-codes[13]) [e.g. 1 (a); 3(d) etc.]	
	At present		Around the time of the Referendum				
	1. Variety Name	2. Type 1. Traditional 2. HYV	1. Variety Name	2. Type 1. Traditional 2. HYV			
1. Paddy							
2. Maize							
3. Wheat							
4. Millet							
5. Other (Specify)							

304. How confident are you about your responses relating to recall information described in the above section? (√)
(i) *Very confident* (ii) *Confident* (iii) *Less confident*

D. Changes in Crop Planting and Harvesting Times since Referendum:

Crop Name	401. Change in Plantation Time				402. Brief description of the cause of change if there is chan	403. Main two causes (reason code : main and sub-codes) [e.g. 1 (a); 3(d) etc.]	404. Change in Harvesting Time				405. Brief description of the cause of change	406. Main two causes (reason code main and sub-codes[14]) [e.g. 1 (a); 3(d) etc.]
	At present		Around the time of referendum				At present		Around the time of referendum			
	Month (1 to 12)	Week (1 to 4)	Month (1 to 12)	Week (1 to 4)			Month (1 to 12)	Week (1 to 4)	Month (1 to 12)	Week (1 to 4)		

407. How confident are you about your responses relating recall information described in the above section? (√)
(i) *Very confident* (ii) *Confident* (iii) *Less confident*

[13] Reason Code Main :

1. **Market related: Sub-Codes:** (a) New markets (b) New sources of earnings (c) More production (d) More relative profit (e) Any other (specify)
2. Technological changes: Sub-Codes: (a) Availability of new crop (b) Old crops but new variety with more productivity (c) Old crops but new variety with short maturing period (d) Improved irrigation infrastructure (e) Deterioration of old irrigation facilities (f) Any other (specify)
3. Climate related changes: Sub-Codes: (a) Increased number of wet days (b) More intensity of rain per day (c) Decreased number of wet days (d) Decrease in intensity of rain per day (e) Erratic rainfall (f) Increase in number of hot days (g) Decrease in number of hot days (h) Increase in number of foggy days/cold spell (j) Decrease in number of foggy days/cold spell (k) Any other (specify)
4. Intervention related: Sub-Codes: (a) Training received from Government/NGO (b) Subsidies/ provisions (seed/fertilizer) from Government/NGO (c) Any other (specify)
5. Other (Specify)

[14] Reason Code Main :

1. Technological changes: Sub-Codes: (a) Availability of new crop (b) old crops but new variety with more productivity (c) old crops but new variety with short maturing period (d) Improved irrigation infrastructure (e) deterioration of old irrigation facilities (f) Any other (specify)
2. Climate related changes: Sub-Codes:(a) Increased number of wet days (b) More intensity of rain per day (c) Decreased number of wet days (d) Decrease in intensity of rain per day (e) Erratic rainfall (f) Increase in number of hot days (g) Decrease in number of hot days (h) Increase in number of foggy days/cold spell (j) Decrease in number of foggy days/cold spell (k) Any other (specify)
3. Other (Specify)

408. Changes in input use for agriculture over the period since referendum:

	A. At present	B. Around the time of Referendum	C. Brief description of the reasons for such change (if any)	D. Main two causes (reason code Main)	
				1st Reason	2nd Reason
1. Use[15] of chemical fertiliser (Put √)	1. YES 2. NO	1. YES 2. NO 3. Don't Know			
2. Use of Bio fertiliser (Put √)	1. YES 2. NO	1. YES 2. NO 3. Don't Know		Sub-code	Sub-code
3. Use of Pesticide (Put √)	1. YES 2. NO	1. YES 2. NO 3. Don't Know			
4. Number of Cow/ Buffalo		________ / or Uncertain			
5. Number of earning members (other than agricultural earning)		________ / or Uncertain			
6. Main irrigation source (Put Code [16])					
7. Productivity[17] of Rice (write units)				1st Reason	2nd Reason
8. Productivity of Maize (write units)					
9. Productivity of Wheat (write units)				Sub-code	Sub-code
10. Productivity of any other major crop (specify name) (write units)					

409. How confident are you about your responses relating to recall information described in the above section? (√)
i) Very confident (ii) Confident (iii) Less confident

[15] Reasons Code main for using fertilizer and pesticides
(a) previously not available but available now in the market (b) previously available also available now in the market (c) more prevalence of diseases and insecticides

[16] CODES for IRRIGATION SOURCES:
1. Rain-fed (no irrigation) 2. Hand pump 3. Shallow tubewell 4.Boring/deep tubewell 5.Major Canal irrigation (Nahar) 6.Local canal irrigation canal (kulo) 7. Any other (specify)

[17] Reason Code Main for changing productivity of major crops :
1. Technological changes: Sub-Codes: (a) old crops but new variety with more productivity (b) more use of modern equipment for agricultural practices (c) more use of pesticides, insecticides and fertilizer in the agriculture (d) Improved irrigation infrastructure (e) deterioration of old irrigation facilities
2. Climate related changes: Sub-Codes: (a) Increased number of wet days (b) More intensity of rain per day (c) Decreased number of wet days (d) Decrease in intensity of rain per day (e) Erratic rainfall (f) Increase in number of hot days (g) Decrease in number of hot days (h) Increase in number of foggy days/cold spell (j) Decrease in number of foggy days/cold spell (k) Any other (specify)
3. Disease and insecticides sub-codes: (a) more prevalence of diseases and insecticides
4. Others (specify)

E. Perception of Household Head relating to following issues:

In your opinion, what are the natures of changes in the following labor market issues since the days of Referendum?

	Issues	Response (put √ on the appropriate option)		
501	Farm-labor availability in the village	1. Increased	2. Decreased	3. Unchanged
502	Local job opportunities for non-skilled labor	1. Increased	2. Decreased	3. Unchanged
503	Average number of crops per plot per year in the village	1. Increased	2. Decreased	3. Unchanged

504. How confident are you about your responses relating to recall information described in the above section? (√)

(i) Very confident (ii) Confident (iii) Less confident

What is your perception regarding the nature of changes in the following climate related issues since the Referendum?

	Issues	**Response** **(put √ on the appropriate option)**		
505	Number of rainy days in rainy season	1. Increased	2. Decreased	3. Unchanged
505	Amount of rainfall in rainy season	1. Increased	2. Decreased	3. Unchanged
506	Day temperature in rainy season	1. Increased	2. Decreased	3. Unchanged
507	Night temperature in rainy season	1. Increased	2. Decreased	3. Unchanged
508	Winter temperature in night time	1. Increased	2. Decreased	3. Unchanged
509	Winter day temperature	1. Increased	2. Decreased	3. Unchanged
510	Amount of rainfall in winter season	1. Increased	2. Decreased	3. Unchanged
511	Dry season day time temperature	1. Increased	2. Decreased	3. Unchanged
512	Dry season night time temperature	1. Increased	2. Decreased	3. Unchanged
513	Amount of rainfall in dry season	1. Increased	2. Decreased	3. Unchanged
514	Cold spells or foggy days	1. Increased	2. Decreased	3. Unchanged
515	Onset of monsoon in rainy season	1. Early start	2. Delayed	Unchanged
516	Cessation of monsoon in rainy season	1. Early start	2. Delayed	Unchanged

517. How confident are you about your responses relating to recall information described in the above section? (√)

(i) Very confident (ii) Confident (iii) Less confident

F. Adaptation Strategy: [These questions should be asked from those households who have already shown that they perceive changes in climatic parameters. If the answer to ALL questions in Section E is unchanged, then no need to ask section F]

What types of agricultural coping strategies do you mostly follow as a result of climatic change as experienced by you and informed in section E?

(Brief description of the spontaneous response has to be noted below the question (white space) and then at most three appropriate strategies need to be ticked by the enumerator]

601	During less rainfall/less number of rainy days/ erratic rainfall pattern	Cropping pattern change Short duration crops Better water management practices Hybrid crops (with less water) Use of pesticides Use of chemical fertilizer Seedlings protection strategies. Changing/planting strategies Other (specify)....
602	During more hot days (rising temperature)	Cropping pattern change Short duration crops Better water management practices Hybrid crops (with less water) Use of pesticides Use of chemical fertilizer Seedlings protection strategies. Changing-sowing/planting strategies Other (specify)....
603	During more foggy days/more cold spells	Cropping pattern change Short duration crops Better water management practices Hybrid crops (with less water) Use of pesticides Use of chemical fertilizer Seedlings protection strategies. Changing sowing/planting strategies Other (specify)....
604	Have you faced a climate related crisis (e.g. flood, drought, frost) in the last three decades?	1. Yes 2. No ——————Skip to 506
605	If yes, when did it occur? What happened? (brief description)	
606	Is there anything you would like to add to what you have shared with us today in relation to the topic we discussed?	

For enumerator:

Please note what, if anything went differently from the plan in this particular interview (concerns, observations). Please note any points that you want to highlight as important for this interview – include also specific household characteristics that seem worth mentioning.

Village Questionnaire: With Village Head/Former Village Head

[Changes over the period since the Referendum]

Name of the respondent:

Age (Years): __Position in the village (Brief)......................

Sl.No.	Information	At present			Around the time of Referendum		
1	Ward size (number of households)						
2	Average number of household members						
3	Number of cropping season						
4	Cropping pattern:(put codes of main crops grown in the village) CODES: 1. Paddy 2. Wheat 3. Maize 4. Peppermint 5. Millet 6. Upland paddy 7. Oil seed (Mustard) 8. Kagno (buckwheat) 9. Sweet potato (sakharkhanda) 10. Vegetables 11. Dry season paddy (chaitedhan) 12. Any other (specify)	Rainy:			Rainy:		
		Winter:			Winter:		
		Dry:			Dry:		
5	Time of onset and cessation of rainy season: (Put codes for month and week Month = 1 to 12 Week = 1 to 4)	Onset:	Month	Week	Onset:	Month	Week
		Cessation:	Month	Week	Cessation:	Month	Week
6	Nature of seeds mostly used (Put tick)	1. Traditional 2.Modern			1. Traditional 2.Modern		
7	Use of chemical fertiliser(Put tick)	1. YES 2. NO 3. Partial			1. YES 2. NO 3. Partial		
8	Means of land preparation other than labor (Put tick)	1. Animal 2. Machine 3 Both			1. Animal 2. Machine 3 Both		
9	Distance travelled to procure fertiliser/HYV seeds (km)	____________/ Or Not Applicable			____________/ Or Not Applicable		
10	Distance to the nearest wholesale market (km)						
11	Nearest road links from your villages (km)						
12	Distance to nearest bank branch (km)						
13	Distance to nearest agricultural development office (km)						

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