Effect of climate variables on yield of major food-crops in Nepal -A time-series analysis-

Niraj Prakash Joshi and Keshav Lall Maharjan and Luni Piya

Graduate School for International Development and Cooperation, Hiroshima University

March 2011

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Joshi, Niraj Prakash (IDEC*, Hiroshima University)
Maharjan, Keshav Lall (IDEC, Hiroshima University)
Piya Luni (IDEC, Hiroshima University)

Climate change influences crop yield vis-à-vis crop production to a greater extent in countries like Nepal where agriculture depends largely on natural circumstances. Plausible scenarios of climate change like higher temperatures and changes in precipitation will directly affect crop yields. Therefore, this study assesses the effect of observed climate variables on yield of major food-crops in Nepal, namely rice, wheat, maize, millet, barley and potato based on regression model for historical (1978-2008) climatic data and yield data for the food-crops. The yield growth rate of all the food-crops is positive. However, the growth rate for all crops, except potato and wheat, is below population growth rate during the period. Climate variables like temperature and precipitation are the important determinants of crop yields. Trend of precipitation is neither increasing nor decreasing significantly during this period. However, temperature is increasing by 0.7 ^{0}C during the period. Climate variables show some influences on the yield of these major food-crops in Nepal. Increase in summer rain and maximum temperature has contributed positively to rice yield. Also, increase in summer rain and minimum temperature has positive impact on potato yield. However, increase in summer rain and maximum temperature adversely affected the yield of maize and millet. Increase in wheat and barley yield is contributed by current trend of winter rain and temperature. Consideration of spatial variation in similar type of study in Nepal that will be helpful in identifying the region more vulnerable to climate change in terms of crop yield is highly recommended.

Keywords: Climate variables, temperature, rainfall, food-crops, Nepal

Introduction

Nepal is a developing country with majority (63.7%) of its population living under poverty (Joshi, Maharjan, & Piya, 2010; Alkire & Santos, 2010). Huge proportions of its population derive their livelihoods from farm and forest, which are highly dependent on natural phenomena. Besides, disaster prone nature of the country due to its rugged terrain, steep topography, and fragile geological conditions place Nepal among the countries having high degree of vulnerability to climate change. Such high degree of vulnerability poses threats on water resources, agriculture, forestry and biodiversity, and human (Maharjan, Joshi, & Piya, 2009). Agriculture has been a major concern in the discussions on climate change as food production is essential for sustaining and enhancing human welfare (McCarl, Adams, & Hurd, 2001; Schmidhuber & Tubiello, 2007).

Climate is a primary determinant of agricultural productivity, especially in the case of developing countries like Nepal where agriculture is basically dependent on natural circumstances against the controlled environmental condition in developed countries. Therefore, climate change would influence crop yield vis-à-vis crop production to a greater extent in developing countries. Plausible scenarios in climate change i.e., increasing temperature, changes in precipitation, climate extremes like drought, flood and landslides, and higher CO_2 concentrations will directly affect crop yields. In general, temperature

* Graduate School for International Development and Cooperation

increase will reduce yields and quality of food-crops thereby exacerbating vulnerability in food supply. Similarly, changes in precipitation patterns i.e., intensive rain concentrated in a particular month has a devastating effect on crop production (Abrol & Ingram, 1996; Adams, Hurd, Lenhart, & Leary, 1998; McCarl, Adams, & Hurd, 2001).

Despite such a high degree of vulnerability to climate change for agriculture vis-à-vis welfare in developing countries, there are limited researches conducted in case of developing countries (Boubacar, 2010; Holst, Yu, & Grun, 2010; You, Rosegrant, Fang, & Wood, 2005; Mendelsohn, 2009) and very few in the case of Nepal (Malla, 2008). The vast majority of such researches are done in developed countries (Kim & Pang, 2009; Carew, Smith, & Grant, 2009; Isik & Devadoss, 2006; Chen, McCarl, & Schimmelpfennig, 2004; Lobell & Asner, 2003; Stooksbury & Michaels, 1994). There are very limited literatures in the case of developing countries, which are going to be adversely affected by predicted climate change (Intergovernmental Panel on Climate Change, 2007; Isik & Devadoss, 2006; Lobell & Asner, 2003; Stooksbury & Michaels, 1994; Rosenzweig & Parry, 1994; Chen, McCarl, & Schimmelpfennig, 2004). Therefore, this study analyzes the effect of climate variables on yield of major food-crops in Nepal based on historical data. An understanding of the national impacts of recent climate trends on major food-crops would help to anticipate impacts of future climate changes on food self-sufficiency of the country.

Methodology

Temperature, precipitation, and solar radiation are the three most widely used climate variables to assess climate change and its impact. However, solar radiation has a closer positive correlation with maximum temperature. In general, higher solar radiation leads to a higher maximum temperature and lower solar radiation leads to a lower minimum temperature because of radiative cooling (Peng, et al., 2004). This shows the direct correlation between temperature and solar radiation. Therefore, to overcome the possible correlation among the independent variables, this study considers only temperature and precipitation. Rainfall is the most important form of precipitation in terms of meeting water requirement of agricultural crops. Daily mean air temperature is the widely used temperature variable to assess the effects of global warming on grain yield. The use of mean air temperature assumes no difference in the influence of day versus night temperature. However, the inclusion of minimum and maximum temperature in the assessment will capture differential effects of day and night temperature (Peng, et al., 2004) as well as climate extremities to some extent.

Simulation models and regression models are widely used to estimate the effects of environmental changes on crop productivity levels. Most studies on the possible impact of climate change on crop yields used mainly indirect crop simulation models that make use of crop biophysical simulation. There are relatively limited studies based on regression model (Boubacar, 2010; Mendelsohn, 2009; Isik & Devadoss, 2006; You, Rosegrant, Fang, & Wood, 2005; Peng, et al., 2004). Crop simulation type of study will help to understand the physiological effects of high temperature on crop yield but not the effects of small increase in temperature associated with global warming (Schlenker & Roberts, 2008). In addition, though it is unequivocal that global warming is inevitable in the coming century, even if emission of green-house gases is stabilized at current level, there exists debate and uncertainty on the extent of warming as well as other related changes (Intergovernmental Panel on Climate Change, 2007; Rosegrant, Ewing, Yohe, Ian Burton, & Valmonte-Santos, 2008). Thus, predictions of the yield changes in response to changes in climate variables, from regression models based on historical climatic and yield data for specific crops are relatively accurate (Boubacar, 2010; Isik & Devadoss, 2006; Lobell & Asner, 2003; Lobell & Field, 2007; Mendelsohn, Nordhaus, & Shaw, 1994; Lobell, Ortiz-Monasterio, Asner, Matson, Naylor, & Falcon, 2005). This can be done through application of production function as follows (Nicholls, 1997; Lobell & Field, 2007);

$$\Delta Yield = m + r_y \Delta Climate + \varepsilon$$

Here,

ΔYield is the observed trend in yield, *m* is the average yield change due to management and other non-climatic factors (e.g. increased CO_2), ΔClimate is the observed trend in temperature and rainfall, r_y is the yield response to this trend, and ε is the residual error.

Detrending of the yield and climate variables and using the residuals to calculate quantitative relationships between variation in climate and yield can remove non-climatic influences such as adoption of new cultivars and changes in crop management practices (Lobell & Field, 2007; Nicholls, 1997; Lobell, Ortiz-Monasterio, Asner, Matson, Naylor, & Falcon, 2005). Detrending can be done by using the first-difference time series for yield and climate variables i.e., the difference in values from one year to the next.

Paddy, maize, millet, wheat, barley, and potato are the major food-crops of Nepal as these crops are used to meet the basic food requirement of its population (Subedi, 2003). Paddy, maize, potato and millet are the main food-crops cultivated during the summer season (from May to August), whereas wheat and barley are the main winter crops cultivated from November to February. Annex 1 shows the crop calendar of these major food-crops in Nepal.

Due to consistency in the availability of climate data from the maximum number of stations existing in the country, the period from 1978 to 2008 is taken into consideration. A period of more than 30 years is qualified for study of the impact of climate variables on yield of the food crops as response to climate change (Intergovernmental Panel on Climate Change, 2007). Average national yields of the food-crops for 1978 to 2008 were compiled from different publications of the Ministry of Agricultural and Cooperatives. Similarly, crude data on climate variables, i.e. temperature and rainfall were obtained from Department of Hydrology and Meteorology, Nepal, on monthly basis from 1977 to 2008. Rainfall data from 235 weather stations distributed along the elevation from 72 masl to 3803 masl, and temperature data from 45 stations distributed along the elevation from 72 masl to 2680 masl were compiled for the purpose of this study. Rather than using annual averages for each climatic variable, we defined an effective growing season for each crop based on the contiguous months within the growing season for major ecological regions.

Results and discussion

Trend of food-crops' yield

The yield trend of the food-crops based on the regression coefficient against time shows that time has significant (P-value < 0.00) effect on yield of all the food-crops. However, the trend of yields for the six major food-crops shows very different patterns (Figure 1). Potato has the highest regression coefficient against time variable. Yield of potato is growing by 0.26 ton/ha every year. Thus, yield of potato has increased from 5.5 ton/ha in 1978 to 13.3 ton/ha in 2008 contributing the yield growth rate of 3.32 percent. Except for the year 1985, during which the yield of potato declined sharply, potato yield has been continuously increasing. There is no relation with climate variables for such sharp decline in yield. Wheat also shows better performance in terms of yield growth. With the regression coefficient of 0.035 against time variable, yield growth rate of wheat is 2.32 percent. Yield growth rate of only these two crops is higher compared to population growth rate (2.3%) of the country. Yield of paddy and maize is also growing but the growth rate is well below the population growth rate. Yield of paddy and maize is growing at the rate of 1.7 and 1.49 percent respectively. Sharp decline in the yield of paddy and maize in 1982 can be linked to sharp decline in summer rain in the same year. Yield decline in paddy and maize is directly associated with summer rain (Figure 1, and Figure 2). Yield growth of barley and millet, which are also a minor food-crops are relatively stagnant, growing at the rate of below 1 percent.

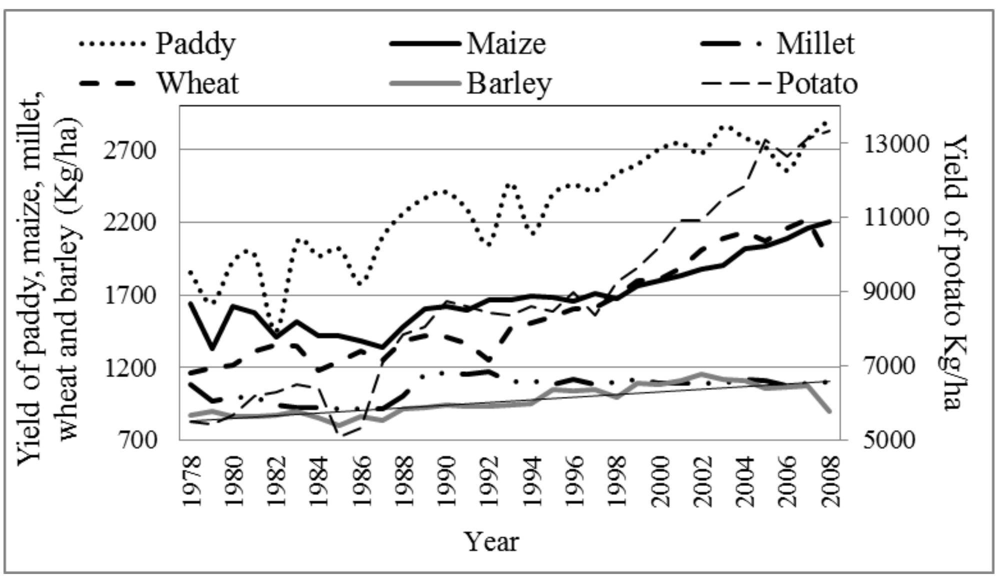

Figure 1. Yield trend of major food-crops

Source: Ministry of Agriculture and Cooperatives, 2009; Ministry of Agriculture, 1990

Trend of climate variables

Trend of climate variables are analyzed on a seasonal basis to coincide the growing seasons of the crops considered for the study. Average of temperature for the effective growing season based on the data obtained from all meteorological stations is taken into consideration, whereas in case of rainfall, average monthly rainfall of four winter months added to get total rainfall for the season is considered. Accordingly, trend of minimum temperature, maximum temperature, and rainfall for summer and winter is presented in Figure 2 and 3 respectively. Here, only maximum temperature for winter and summer season shows significant (P-value < 0.00) increase over time, whereas minimum temperature and rainfall for both season show insignificant association with time variable.

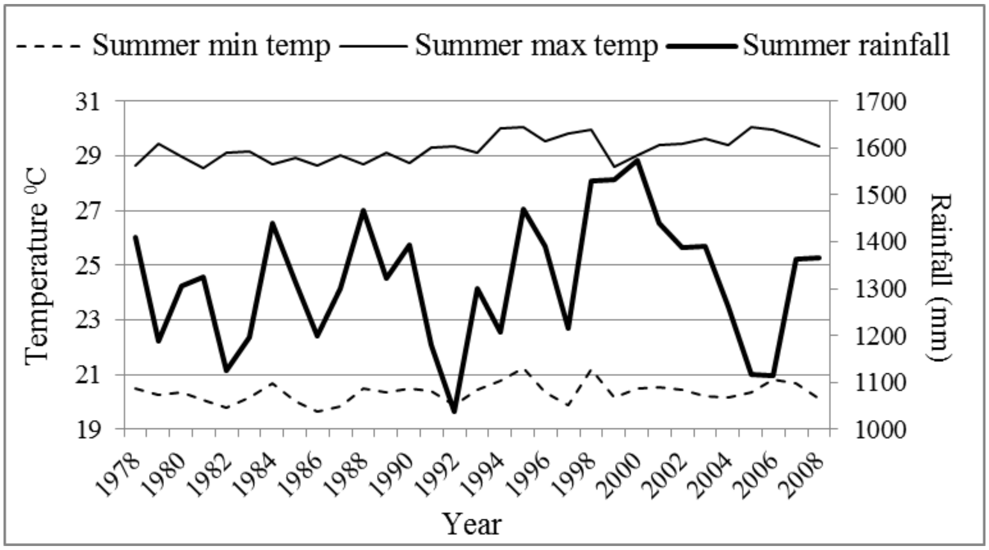

Figure 2. Trend of total summer rainfall, and average summer minimum and maximum temperature

Note: Summer season includes months of May, June, July and August

Source: Raw data from Department of Hydrology and Meteorology (DHM), Nepal

Rainfall fluctuates over the years with less degree of predictability. However, it is in increasing trend for summer season, but in decreasing trend for winter. The coefficients suggest that summer rainfall is increasing by 2.2 mm every year whereas winter rainfall is decreasing by 0.63 mm every year. Rainfall in Nepal is concentrated in summer. Around 75 percent of rainfall occurs during this season. The positive coefficient for summer rainfall and negative coefficient for winter rainfall indicates that rain in summer is becoming more intense, which could hamper yield of summer food-crops due to water borne disaster like flood and landslides. However, still the relationship between rainfall and yield show positive correlation, i.e. yield will grow with increased rainfall and shrink with decreased rainfall.

Coefficients of temperature for both seasons are positive except for winter minimum temperature. Winter maximum temperature is increasing at higher rate compared to summer maximum temperature. Summer and winter maximum temperature is increasing at the rate of 0.03^0C and 0.05^0C each year between 1978 and 2008 respectively. Summer minimum temperature is also increasing every year by 0.01^0C. However, winter minimum temperature is decreasing each year but at very low rate 0.001^0C every year. Increase in temperature up to 2^0C will increase the food-crops yields in Nepal (Malla, 2008). Therefore, the increase in temperature during the period from 1978 to 2008 i.e. below 2^0C would be favorable for growth in yield of food-crops. However, decline in minimum winter temperature could hamper the yield of winter crops as frost frequency caused by decline in minimum winter temperature influence wheat yield adversely (Nicholls, 1997).

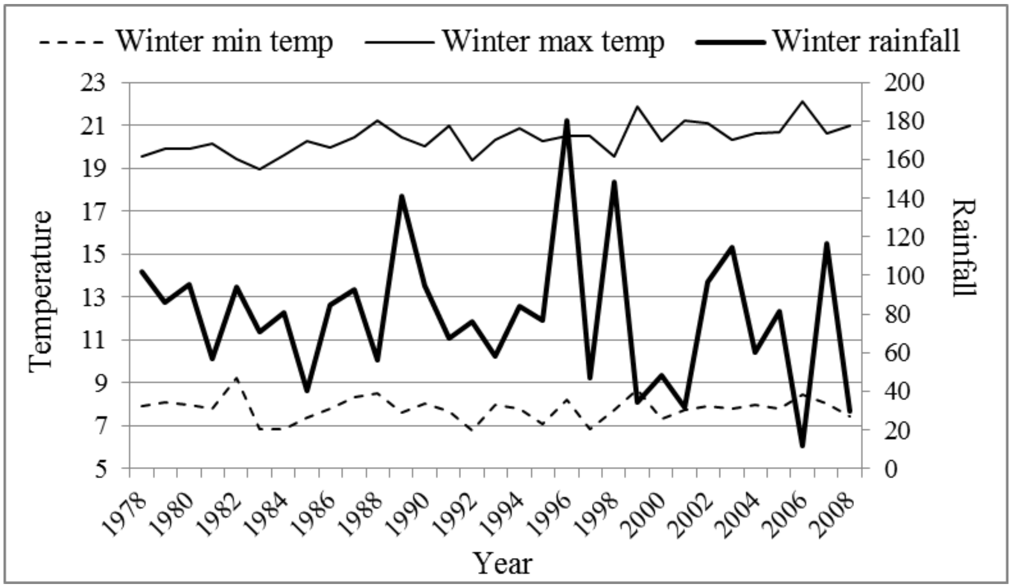

Figure 3. Trend of total winter rainfall, and average winter minimum and maximum temperature

Note: Winter season includes months of November and December of preceding year and January, and February of succeeding year

Source: Raw data from DHM, Nepal

Climate yield relationships

Multivariate regression analysis of first difference in yield of the crops considered for this study is presented separately for both summer crops and winter crops in Table 1, and 2, respectively.

Table 1. Relationship between yield of summer food-crops and summer climate variables

Variable	Paddy		Maize		Millet		Potato	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Sumrain	0.012 (0.004)	0.01***	-0.002 (0.002)	0.43	-0.001 (0.001)	0.56	0.003 (0.013)	0.79
Summintemp	-0.15 (0.12)	0.25	0.07 (0.06)	0.32	0.02 (0.03)	0.55	0.21 (0.38)	0.58
Summaxtemp	0.06 (0.11)	0.61	-0.13 (0.06)	0.04**	-0.04 (0.03)	0.19	-0.02 (0.35)	0.95
R^2	0.40		0.18		0.08		0.07	

Note: *** Significant at the 0.01 level, and ** significant at the 0.05 level, Sumrain – summer rainfall, Summintemp – summer minimum temperature, Summaxtemp – summer maximum temperature, figures in parentheses indicates standard error.

The results suggest that the model is able to describe a variation in food-crops yield ranging from 40 percent in the case of paddy to only 2 percent in the case of barley. Though, the regression results show very few significant relationships between yield and climate variables, such coefficient can be used to assess real effect of climate variables in change of yield of food-crops considered for this study (Nicholls, 1997). In addition, sign of coefficients give direction of movement of yield against change in climate variable. Climate variables show significant relations with paddy and maize only. The coefficient indicates that paddy yield increase significantly with increase in summer rainfall. Maize yield shows negative relation with summer maximum temperature, i.e., if summer maximum temperature increases yield of maize will decline sharply.

Table 2. Relationship between yield of winter food-crops and winter climate variables

Variable	Wheat		Barley	
	Coefficient	**P-value**	**Coefficient**	**P-value**
Winrain	0.003 (0.004)	0.52	0.001 (0.002)	0.69
Winmintemp	0.04 (0.03)	0.15	-0.002 (0.02)	0.87
Winmaxtemp	0.008 (0.03)	0.78	0.01 (0.02)	0.54
R^2	0.17		0.02	

Note: Winrain – winter rainfall, Winmintemp – winter minimum temperature, Winmaxtemp – winter maximum temperature

Change in yield due to climate trend

Change in food-crops' yield due to climate variables is calculated using coefficient of the climate variables for the respective crops and observed change in the climate variables during the study period i.e., $\Delta Y_i=(\beta_{1i}*\Delta R)+(\beta_{2i}*\Delta T_{min})+(\beta_{3i}+\Delta T_{max})$. Here, ΔY_i is observed change in yield of i^{th} crop due to climate variable, and β_{1i}, β_{2i}, and β_{3i}, are coefficient of rainfall, maximum summer temperature, and minimum summer temperature respectively for i^{th} crop. Similarly, ΔR, ΔT_{min}, and ΔT_{max} are observed changes in rainfall, summer minimum temperature, and summer maximum temperature respectively during the study period.

The current trend in climate variables has contributed positively to yield of both winter crops namely wheat and barley. In the case of wheat, there is 814 kg increase of yield during the study period, out of which 35.1 kg is contributed by the current climate trend. Here, decreasing winter rain and winter minimum temperature offset the positive effect of increased winter maximum temperature. For barley, the current climate trend contributed around 50 percent of the yield increase. Such increase can be attributed to increased winter maximum temperature and decreased winter minimum temperature. In the case of summer crops, only paddy is favored by the current climate trend. It has contributed 41 kg increase in yield in case of paddy. An increase in summer rain and increase in summer maximum temperature have contributed highly in such increase in paddy yield. Other crops especially maize are adversely affected by the current climate trend in Nepal. The adverse impact of increased summer maximum temperature and summer rain are the main factors which caused suppression of yield by 106 kg/ha, and 30 kg/ha for maize and millet respectively. In the case of potato, it is adverse impact caused by increase in summer maximum temperature that offsets positive impact of increased summer rain and summer minimum temperature. Here, the current climate trend suppress the yield of potato by 98 kg/ha.

Conclusion

This paper analyzed the impact of current climate trend on yield of six main food-crops in Nepal. These food-crops are divided into two groups based on their growing season, namely; summer and winter season crops. The impact is assessed for each crop based on the growing season of respective crop. Yield of potato, wheat, paddy, and maize is in growing trend, but fluctuates over the years, whereas yield of millet and barley, two minor cereal crops, is growing very steadily. In summer, each of the climate variables is in increasing trend, whereas in winter, rainfall and minimum temperature is decreasing. In summer, increase in rain and maximum temperature has contributed positively to yield growth of paddy. Similarly, increase in wheat and barley yield is contributed by current climate trends. However, increased summer rain and maximum temperature suppressed the yield growth of maize and millet, whereas negative impact of increase in summer maximum temperature outweighed positive impact of increased summer rain and summer minimum temperature in the case of potato.

This study thus concludes that food-crops grown in summer are adversely affected by the current trend of climate. Except for paddy, which has high water demand and thrives on water logging condition, other summer crops are adversely affected by increase in rainfall and maximum temperature. On the other hand, though rainfall is at declining trend in winter, increase in temperature has positively contributed to the yield growth of both winter crops. With this, we can recommend that any program dealing with minimizing adverse impact of climate change on food-crops production should first consider the crops like maize and potato, which are being affected at higher degree compared to other food-crops. Moreover, these two crops are important staple food in case of Nepal, especially in Mountain and Hills that are also exposed to higher degree of vulnerability to climate change. The main shortcoming of this study is treating the whole country as one basket despite the huge diversity existing within. Therefore, it is highly recommended to conduct similar studies considering the variation caused by ecological and administrative division of the country.

Acknowledgement

We are thankful to Global Environmental Leaders Education Program for Designing a Low- Carbon Society, Graduate School for International Development and Cooperation, Hiroshima University for providing research grant to accomplish this research.

References

Abrol, Y. P., & Ingram, K. T. (1996). Effects of higher day and night temperatures on growth and yields of some crop plants. In F. Bazzaz, & W. Sombroek (Eds.), *Global climate change and agricultural production: Direct and indirect effects of changing hydrological, pedological and plant physiological processes* (pp. 123-140). West Sussex, England: John Wiley & Sons Ltd.

Adams, R. M., Hurd, B. H., Lenhart, S., & Leary, N. (1998). Effects of global climate change on agriculture; An interpretative review. *Climate Research, 11*, 19-30.

Alkire, S., & Santos, M. E. (2010). *Nepal: Country briefing.* Retrieved August 8, 2010, from Oxford Poverty and Human Development Initiative (OPHI) Multidimensional Poverty Index Country Briefing Series: http://www.ophi.org.uk/wp-content/uploads/Nepal.pdf

Boubacar, I. (2010). The effects of drought on crop yields and yield variability in Sahel. *The Southern Agricultural Economics Association Annual Meeting.* Orlando FL: The Southern Agricultural Economics Association.

Carew, R., Smith, E. G., & Grant, C. (2009). Factors influencing wheat yield and variability: Evidence from Manitoba, Canada. *Journal of Agriculture and Applied Economics, 41*(3), 625-639.

Chen, C. C., McCarl, B. A., & Schimmelpfennig, D. E. (2004). Yield variability as influenced by climate: A statistical investigation. *Climate Change, 66*, 239-261.

Food and Agriculture Organization & World Food Programme. (2007). *FAO/WFP food security assessment mission to Nepal.* Rome: Food and Agriculture Organization & World Food Program.

Holst, R., Yu, X., & Grun, C. (2010). Climate change, risk and grain production in China. *2010 AAEA, CAES, WAEA joint annual meeting* (p. 29). Colorado: Agriculture and Applied Economics Association.

Intergovernmental Panel on Climate Change. (2007). *Climate change 2007: Synthesis report.* Cambridge, UK: Cambridge University Press.

Isik, M., & Devadoss, S. (2006). An analysis of the impact of climate change on crop yields and yield variability. *Applied Economics, 38*, 835-844.

Joshi, N. P., Maharjan, K. L., & Piya, L. (2010). Poverty and food insecurity in Nepal: A review. *Journal of International Development and Cooperation*, 1-19.

Kim, M. K., & Pang, A. (2009). Climate change impact on rice yield and production risk. *Journal of Rural Development, 32*(2), 17-29.

Lobell, D. B., & Asner, G. P. (2003). Climate and management contributions to recent trends in U.S. agricultural yields. *Science, 299*(5609), 1032.

Lobell, D. B., & Field, C. B. (2007). Global scale climate-crop yield relationships and the impacts of recent warming. *Environmental Research Letters, 2*(1), 1-7.

Lobell, D. B., Ortiz-Monasterio, J. I., Asner, G. P., Matson, P. A., Naylor, R. L., & Falcon, W. P. (2005). Analysis of wheat yield and climatic trends in Mexico. *Field Crops Research, 94*, 250-256.

Maharjan, K. L., Joshi, N. P., & Piya, L. (2009). Sources of climate change, its impact, and mitigation issues in Nepal. *International Conference on Climate Change, Livelihoods, and Food security.* Jaipur, India: Institute of Development Studies.

Malla, G. (2008). Climate change and its impact on Nepalese agriculture. *The Journal of Nepalese Agriculture, 9*, 62-71.

McCarl, B. A., Adams, R. M., & Hurd, B. H. (2001). *Global climate change and its impact on agriculture.* Texas, USA: Texas A&M University.

Mendelsohn, R. (2009). The impact of climate change on agriculture in developing countries. *Journal of Natural Resources Policy Research, 1*(1), 5-19.

Mendelsohn, R., Nordhaus, W. D., & Shaw, D. (1994). The impact of global warming on agriculture: A Ricardian analysis. *American Economic Review, 84*, 753-771.

Ministry of Agriculture. (1990). *Agricultural statistics of Nepal: 1990.* Lalitpur, Nepal: Agricultural Statistics Division, Department of Food and Agricultural Marketing Services, Ministry of Agriculture.

Ministry of Agriculture and Cooperatives. (2009). *Statistical information on Nepalese agriculture: 2008/09.* Kathmandu, Nepal: Agri-Business Promotion and Statistics Division, Ministry of Agriculture and Cooperatives.

Nicholls, N. (1997). Increased Australian wheat yield due to recent climate trends. *Nature*, 484-485.

Peng, S., Huang, J., Sheehy, J. E., Laza, R. C., Visperas, R. M., Zhong, X., et al. (2004). Rice yields decline with higher night temperature from global warming. *Proceedings of the National Academy of Science (PNAS), 101*(27), 9971-9975.

Rosegrant, M. W., Ewing, M., Yohe, G., Ian Burton, S. H., & Valmonte-Santos, R. (2008). *Climate change and agriculture: Threats and opportunities.* Eschborn, Germany: German Technical Cooperation (GTZ).

Rosenzweig, C., & Parry, M. L. (1994). Potential impact of climate change on world food supply. *Nature, 367*(6459), 133-138.

Schlenker, W., & Roberts, M. J. (2008). *Estimating the impact of climate change on crop yields: The importance of non-linear temperature effects.* NBER Working Paper 13799, Massachusetts, USA: National Bureau of Economic Research.

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Science (PNAS), 104*(50), 19703-19708.

Stooksbury, D. E., & Michaels, P. J. (1994). Climate change and large-area corn yield in the Southeastern United States. *Agronomy Journal, 86*(3), 564-569.

Subedi, B. P. (2003). Population and environment: A situation analysis of population, cultivated land and basic crop production in Nepal in 2001. In *Population monograph of Nepal Volume II* (pp. 1-35). Kathmandu, Nepal: Central Bureau of Statistics.

You, L., Rosegrant, M. W., Fang, C., & Wood, S. (2005). *Impact of global warming on Chinese wheat productivity.* Washington DC, USA: International Food Policy Research Institute (IFPRI).

Annex 1. Crop calendar for major food-crops

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Season
Mountain (Rainfed)												
		Mai-P	**Mai-P**				**Mai-H**	**Mai-H**	**Mai-H**			Summer
			Mil-P	**Mil-P**					**Mil-H**	**Mil-H**		Summer
	Pot-P	**Pot-P**				**Pot-H**	**Pot-H**	**Pot-H**	**Pot-H**			Summer
				Whe-H	**Whe-H**					**Whe-P**	**Whe-P**	Winter
			Bar-H	**Bar-H**						**Bar-P**	**Bar-P**	Winter
Hills (Partial irrigation/Rainfed)												
				Pad-TP	**Pad-TP**			**Pad-H**	**Pad-H**			Summer
		Mai-P	**Mai-P**				**Mai-H**	**Mai-H**				Summer
					Mil-P	**Mil-P**			**Mil-H**	**Mil-H**		Summer
		Pot-P	**Pot-P**				**Pot-H**	**Pot-H**				Summer
		Whe-H	**Whe-H**	**Whe-H**					**Whe-P**	**Whe-P**	**Whe-P**	Winter
		Bar-H	**Bar-H**						**Bar-P**	**Bar-P**	**Bar-P**	Winter
Hill (Irrigated)												
		Pad-TP	**Pad-TP**			**Pad-H**	**Pad-H**					Spring
	Mai-P	**Mai-P**			**Mai-H**	**Mai-H**						Spring
		Whe-H	**Whe-H**	**Whe-H**					**Whe-P**	**Whe-P**	**Whe-P**	Winter
Tarai (Rainfed)												
					Pad-TP	**Pad-Tp**		**Pad-H**	**Pad-H**	**Pad-H**		Summer
			Mai-P	**Mai-P**			**Mai-H**	**Mai-H**				Summer
		Whe-H	**Whe-H**						**Whe-P**	**Whe-P**		Winter
Tarai (Irrigated)												
						Pad-Tp	**Pad-Tp**			**Pad-H**	**Pad-H**	Late-summer
	Mai-P	**Mai-P**			**Mai-H**	**Mai-H**						Spring
		Pad-Tp	**Pad-Tp**			**Pad-H**	**Pad-H**	**Pad-H**				Spring
	Mai-H	**Mai-H**							**Mai-P**	**Mai-P**		Winter

Mai-Maize, Mil-Millet, Whe-Wheat, Bar-Barley, Pad-Paddy, P-Plantation, Tp-Transplantation, H-Harvesting

Plantation/transplantation   Crop growing phase   Harvesting

Source: (Food and Agriculture Organization & World Food Programme, 2007), http://www.lanra.uga.edu/potato/asia/nepal.htm