

CLIMATE CHANGE AND FOOD SECURITY IN NEPAL

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ABSTRACT

Climate change is posing a threat on present and future food security in low income countries. But, the actual effect of the climate change on food security is not known. Using secondary data reported by the government, the paper examines the effects of climate change on food security in Nepal in the context of policies of commercialization of farm production. Statistical analysis is used to delineate the situation of food security in the country and regression analysis for exploring the effects of global warming on domestic production of major cereals. The results are discussed at global, national, household and individual levels empirically and qualitatively. The results suggest that a rise in minimum temperature decreases the productivity of rice increasing threat of food insecurity. The paper suggests some policy measures for improving food security situation in the country and open up some areas for further research.

Key words: Agriculture, climate-change, commercialization, crop-yield, food-security, Nepal

INTRODUCTION

Global warming and related climate changes are widely accepted by the scientific communities. World Meteorological Organization (WMO, 1992) and International Panel of Climate Change (IPCC, 1995) outline the climate change in their own contexts. For WMO, the climate change encompasses all forms of climatic inconstancy regardless of their statistical nature or physical causes such as changes in solar emission, long-term changes in the earth's orbital elements, natural internal processes of the climate system, or anthropogenic forcing through increasing atmospheric concentrations of greenhouse gases (GHG). By the definition, the climate change is a change in mean values of meteorological elements such as temperature and precipitation in the course of a certain period over their longer term trends (WMO, 1992). In the contest of scarce resource the climate change attract policy interventions only when it poses risk of a significant change in terms of economic, environmental and social effects.

United Nations Framework Convention on Climate Change (UNFCCC) uses the term climate change for a change of climate attributed to human activity altering the composition of the global atmosphere in addition to the natural climate variability observed over comparable periods (IPCC, 1995). IPCC refers to internal changes within the climate system or in the interaction among its components, or because of changes in external forcing, either for natural reasons or human activities (IPCC, 1995). In this study climate change is taken as change in climatic parameters affecting agricultural production through any route.

Climate change affects green sectors more than other sectors of the economy. Agriculture production depends on nature and gets affected by the change in the climatic parameters such as extreme weather events. Studies report expected changes in frequency, duration intensity and geographic distribution of rainfall and snowfall and increased frequency, duration and intensity of droughts (FAO/NRCB, 2008). Effects of climate change on agriculture are particularly sensitive as the agriculture produces food and provides the primary source of livelihood for large chunks of weaker sections of the society. Climate change in expected to influence crop and livestock production, hydrological balances, input supplies and other components of agricultural systems (Moench et al. 2003; Ludi 2009; IFPRI 2009). FAO (2006) reports that climate change will affect all four dimensions of food security, namely food availability, access to food, stability of food supplies and food

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utilization. If agricultural production in Nepal is adversely affected by the climate change, the livelihoods of two-thirds of the labor force, particularly of the rural poor will be at risk.

Agricultural policies in Nepal emphasize commercialization through increasing the production of high value cash crops. Under the conditions of limited arable land and difficulties in increasing cropping intensity due to limited availability of water and seasons suitable for crop growing, an increase in area under the non-food cash crops can lead to a decrease in the areas under the food crops. If the cropped area shrinks and the climate change impedes the increase in crop productivity, a landlocked country like Nepal, with some isolation from global market, can face serious threat of food insecurity. Policy makers, researchers, civil society organizations and media persons need better understanding of the climate change regimes affecting food security. Considering the seriousness of the issue this paper examines effects of climate change on food security in the country in the context of policies of commercialization of farm production.

METHODOLOGY

The study was based on literature review and analysis of secondary data. Literatures relating to the climate change and food security were reviewed in addition to the national policies relating to the food security directly and indirectly.

Time series secondary data were obtained from publications of then Ministry of Agriculture and Cooperatives (MOAC) and Department of Hydrology and Meteorology (DHM). Food production data for national level and district Kapilvastu were obtained from MOAC for last two decades. Temperature data were obtained from DHM for the same period for Bhairahawa station located in the study area.

The analyses were done using statistical and econometric techniques. Means and ratios were estimated for food production and related variables. Regression analysis was done for estimating the effects of temperature on food production in Kapilvastu district using back-filter method of estimation.

$$Y = \alpha + \beta_i X_i + \gamma T + e$$

Where, Y is annual change in productivity per unit of land ($Y_t - Y_{t-1}$), X_i is monthly average of maximum temperature during warm season and that of minimum temperature during cold season ($i=1, 2, 3, \dots, 12$), T is technology and e error term. The coefficients α , β and γ are estimated.

Change in yield due to rise in temperature in ith month $= \partial y / \partial x_i$ which is the first derivative of the function estimated, and i ranges from 1 to 12 and is relevant to the crop during its growing season.

RESULTS

Food required in Nepal is largely met by domestic production and food inadequacy during bad production years is about five percent of the total consumption. The bad production comes mainly from widespread droughts and sometimes from localized floods. Food sufficiency at the national level during good crop harvest, however, not necessarily mean food security at the household and individual levels in the country due to unavailability, poor access, poor utilization and vulnerability at different parts of the country and for many households. Food security is analyzed at four levels—global, national, household and individual. The results are presented in following four sections.

FOOD SECURITY AT THE GLOBAL LEVEL

At the highest level, global food security prevails when aggregate production in the year is enough for the existing population on the earth. In case the global food insecurity occurs,

global food price increases affecting most to the people of low income net food importing countries like Nepal. Millennium Development Goals report (United Nations, 2010) draws attention to the challenges facing the world in eradicating extreme poverty and hunger (goal 1). The hunger reduction target of halving the proportion of people who suffer from hunger by 2015 (using 1990 as the baseline) is unlikely to be met on a global basis (Nelson et al., 2010). Simulation studies on the effects of climate change report price rise of major staples from 10 to 60% by 2030 (Hertel et al. 2010). A number of studies have quantified the impacts of climate change on food security (Fischer et al. 2002; Schmidhuber and Tubiello, 2007). The climate change will not only decrease the food production but also increases the food price and also damages food supply chain infrastructure (Gregory et al 2005). Almost all the studies report an increase in risks of hunger under different climate change scenarios but with varying effects on different parts of the world. The findings more or less converse on the point that food production will get affected more on the hot regions than in the cold regions. The reason is clear that in the hot regions of the world both heat stress and other parameters such as moisture and pest spread affect the production whereas in the cold regions the heat stress is less expected. However, some crops like apple can have risk of heat stress even in cold regions. There may be other crops getting affected in such regions but information is very limited. Thus, the climate change is feared to increase risks of global food insecurity.

Even the global food security is assured in aggregate, some countries particularly less developed ones suffer more from short supply, imperfect food trade and price rise. Vulnerability of such countries depends on domestic food self-sufficiency. More food sufficient is a country it becomes less vulnerable to the external shocks on food trade and price.

FOOD SECURITY AT NATIONAL LEVEL

Food security at the national level prevails when food supply is greater than or equal to the demand, and food demand is greater than or equal to the needs of the existing population. The supply can either be through own production or import or both. For short period of shortfall the supply can also be ensured through the national food reserve. Nepal has maintained only 25,000 metric tons of national buffer stock and 8,000 metric tons of the regional food reserve of South Asian Association for Regional Cooperation (SAARC) food bank. Developing countries with low level of food buffer stock, low level of technology and meager domestic support for adjustments by farmers will be hit hardest by climate change and will face bigger declines in crop yields and production than industrialized countries (von Braun, 2009). In Nepal, the food supply is greater than food demand only in the years of good harvest. Food security at the national level is perhaps best described as a satisfactory balance between food demand and food supply indicated by food price.

Food balance sheet in Nepal includes edible portion of the major cereals—rice, maize, wheat, millet and barley (MOAC, 2011). Availability of the edible portion of the food grain from domestic production shows that rice contributes nearly a half (45%) to the total edible food grain production. Another half of the food grain is contributed by maize and wheat

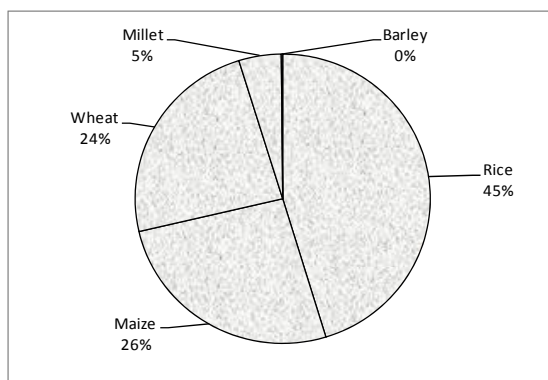


Fig.1: Share of crops on net domestic food production, three year ending 2010/11 (MOAC, 2011).

(Fig.1). The food security in the country depends more on the production of rice than other crops.

Availability of the milled rice after deducting for all other purposes is taken as edible portion of the rice. Though some fluctuations are observed year after year, the edible amount of the rice is increasing at a rate of 1.81% per annum (Fig.2). Edible portion of maize increases faster than the rice (2.36%) after deducting for all other purposes including feed, seed and storage losses. The contribution of millet in the food basket is much smaller

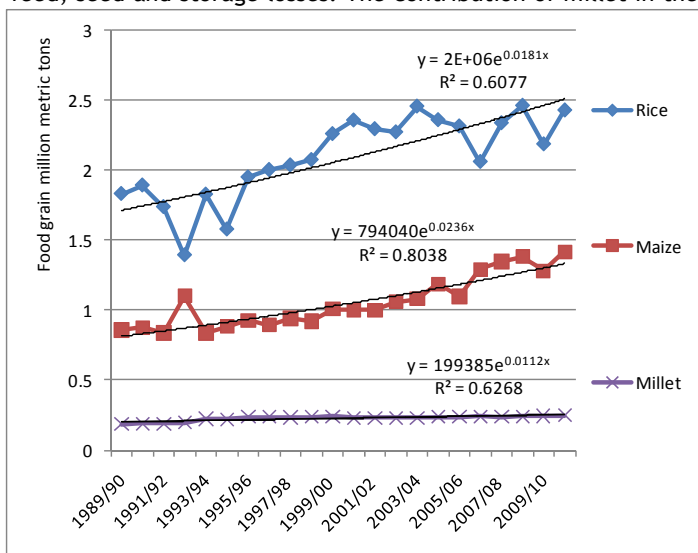


Fig.2: Exponential growth rates of rice, maize and millet (MOAC, 2011).

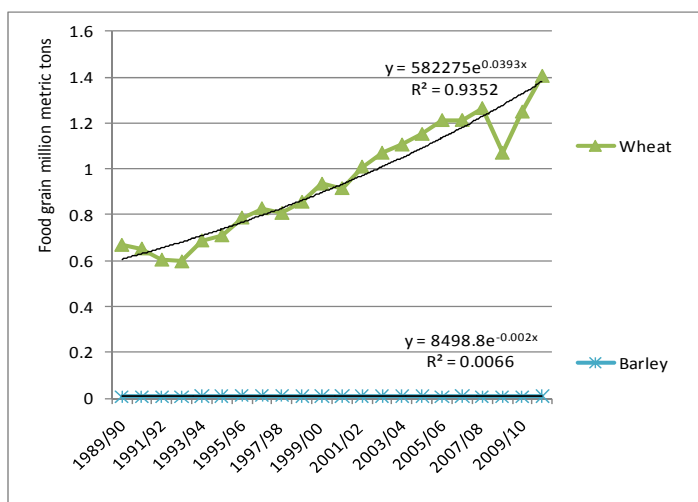


Fig.3: Exponential growth rates of wheat and barley (MOAC, 2011).

than that of other fall season crops and growth rate is also small (1.12%).

Though the contribution of wheat in the food basket is third in the rank, it grew fastest (3.93%) during last two decades (Fig.3). However, wheat production and its contribution to national food balance decreased in 1992 and 2008. The contribution of barley is very small and declining, and its importance in food basket is underscored.

During last two decades the food production is increasing at the rate of 2.35% per annum whereas the requirement for the existing population is growing by 2.09%. It seems that the food self sufficiency at the national level has improved over the decades. But, the civil society organizations and media persons find difficult to accept this claim. Increasing food import provides strengths on their views.

The per capita edible food grain availability by type of grains is presented in Table 1. For the year 2010/11, availability of rice from domestic production is 91 kg/capita contributing nearly 48% to the total food grain requirement in the country. Maize and wheat contribute nearly 28% each to the domestic requirement. The government statistics show that food production in year (2010/11) is 8.60% higher than the domestic requirement. But, at the

same time, net food grain import is 6.54 percent of the total requirement. If domestic food production is sufficient for consumption, it is not clear why the market has a large quantity of net import. One can claim that either it is exported informally or some coefficients used in food balance sheet, such as feed use, are not realistic. Later point seems stronger as nearly a half of the food grain imported is maize from India and Argentina and poultry rearing and feed based improved cow herding for milk production are increasing. As the demand for feed is increasing, negative effect of the climate change on maize production will force the country to import more maize.

Table 1. Per capita food availability and requirement, 2010/11 (MOAC, 2011)

	Food source and sink	Food grain (kg/capita)	% contribution to the requirement
1	Rice	91.21	47.89
2	Maize	53.20	27.94
3	Wheat	52.74	27.69
4	Millet	9.31	4.89
5	Barley	0.36	0.19
6	Production	206.82	108.60
7	Net import	12.46	6.54
8	Total availability	219.28	115.14
9	Requirement	190.44	100.00
10	Unknown sink	28.84	15.14

Analyzing food self-sufficiency is not enough for understanding food security in the country. Food self-sufficiency takes into account the aggregate food production in the country as the sole source of supply. But, at the age of trade and commerce, self production is not only the source of food. Food security considers food availability through domestic production, imports and food aid, affordability of the households and utilization at individual level. As the food trade in the country is fully liberalized, the government links the food security

issues with domestic production to hook up the development programs to the food security. The development programs that aim to increase domestic food production also help in poverty reduction among the farmers, and stabilize food price in the country benefitting the poor.

Considering the role of temperature rise in whole biophysical system of the crops, effect of average monthly minimum and maximum temperatures during the crop growing main season on crop yield is assessed for Kapilvastu district using time series data on crop yield and temperature.

The results are mixed (Table 2). Yields of some crops significantly decreased with rise in temperature and those of some others increased. For example, it is empirically found that every degree rise in average minimum temperature during the month of September decreases rice yield by 365 kg/ha. Similarly, every degree increase in average minimum temperature during January decreased the yield of barley by 38kg/ha. However, each degree rise in minimum temperature increased wheat yield by 233 kg/ha. It is clear that magnitude of the effects of the rise in the monthly minimum temperature is more than that of the rise in the maximum temperature. However, the technological trend does not affect the crop yield significantly except for barley. The technological trend is the aggregate effects over the years and not like an individual technology that increases the crop yield. Though the signs of the coefficients are clearly negative, no effect of temperature rise is found significant in maize and millet yields.

Some tests are made for judging the validity of the equations estimated. None of the equations estimated has any omitted variable. Ramsey RESET test for omitted variables is not significant. Similarly, none of the equation estimated was suffering from the problem of heteroskedasticity. Breusch-Pagan test for heteroskedasticity is not significant for any of the equations.

Table 1: Effects of temperature on crop yield (MOAC, 2011; DHM 2010)

Variable	Rice		Maize		Millet		Wheat		Barley	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1 January							233.26**		-38.71*	
2 February							-102.31		-7.68	
3 March							-42.61		-13.08	
4 April			10.34				-10.36		-11.10	
5 May			-43.41							
6 June	54.16		0.23							
7 July	-55.47		-41.92		-102.8					
8 August		39.43			-80.53					
9 September		-365.13*			-103.28					
10 October					-21.57					
11 November							63.17		-7.30	
12 December							-93.16		-11.35	
13 Technology	8.26		4.16		7.61		-4.88		6.58***	
14 Constant	7788.83		2499.21		8895.74		1538.42		2056.05***	
Observations#	30		34		28		27		27	
R ²	0.194		0.013		0.109		0.311		0.546	
Ramsey RESET test (F) for omitted variables	0.36		0.76		0.85		0.87		1.22	
BPagan test (χ^2) for heteroskedasticity	0.47		0.25		0.69		0.09		0.73	

The national level food security shows that Nepal is almost food secure but the global temperature rise is putting challenge on rice production, which is the staple crop of the country. Even a food sufficiency at the national level does not guarantee food security at the household level.

FOOD SECURITY AT HOUSEHOLD LEVEL

Food security at the household level is more challenging than at the national level. To be food secure every household should have command for food higher than or at least equal to their needs.

Poor have no or limited commands on resource such as land, irrigation water and capital goods making them more vulnerable to extreme weather events and price rise. Increase in population and demand of the agricultural land for development purposes is increasing pressure on the farm lands. Climate change alters the heat and water stresses to the crops and indigenous farming technologies are getting obsolete. Those households particularly with limited land resource and those with no enough income to buy required food are food insecure. Such people sometimes even cut down their health and education expenditures resulting into low quality of life and livelihood (FAO, 2010). The household level of food security is important in Nepal as the income comes to the household as a whole and resource allocation decisions are made at the household level mostly by the head of the household.

Household level vulnerability to food insecurity is affected by the geographic region in which the household is located, ecological conditions of the farmland, economic conditions, and demographic structures of the households. The limited land resources are unevenly distributed among the hill slopes and river basins and among the poor and better off households. Economic characteristics such as occupation, level of income and size of

landholding affects food security at the household level. Demographic characteristics like size of family and female headed households are other factors affecting food security.

The households are said to be food secure if their entitlements or demand for food is greater than or equal to their household needs. Amartya Sen developed the entitlement theory in order to provide a more convincing answer to household level food insecurity. Entitlements are the set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that s/he faces (Sen, 1981). A household can produce food, buy food, borrow food or get food transferred from the state. Major categories of entitlements are production-based entitlements, own-labor based entitlements, trade-based entitlements, and inheritance and transfer entitlements. The production-based entitlements among the households are affected by land endowments. The land includes the size and quality of the land, irrigation facility and weather conditions available in the land. Small holding size (0.70 ha/household), large number of fragments (2.9 per holding), limited availability of irrigation (54% of arable land) and low soil depth due to high slope of most of the farm lands in hills and mountains cause low level of land endowment (CBS, 2011). Rise in temperature and related degradation of the land endowment reduce the production-based entitlement of the farmers.

The own-labor entitlement relates to the sale of labor power for earning food in kind or cash for buying food. Limited availability of employment in the country decreases the chance for this entitlement. Outflow of labor for foreign employment is increasing own labor entitlement through remittance flow, but the women and children left at home feel insecure in the absence of men and decreases own-production entitlement. The trade-based entitlement is good for the employed people residing in accessible areas. Remote areas, particularly hill and mountains of mid-western and far western region, have very low level of trade-based entitlements. The inheritance and transfer entitlement relates to the right over ancestor farmland and transfer from the state. In the areas where the quality of the farmland is poor the inheritance does not help much in food security. Government transfer in the country includes old age, disabled and widow pensions and transport subsidy on food for remote districts. Food for work and food for education are other types of transfer available from the state and state collaborated agencies.

Household level food security differs from household to household and a generalization is not possible. However, the people residing in remote areas and those having no gainful employment suffer more from the household level food insecurity. Subsistence with limited off-farm income source and dependence on market for food increases the risks of food insecurity. High dependence on markets for food is particularly increasing vulnerability of the poor due to market imperfections and escalated price for the consumers.

FOOD SECURITY AT INDIVIDUAL LEVEL

The ultimate food security occurs when all the individuals in the country consume enough food to meet their requirement and they are able to utilize the food consumed. World Food Summit defined at individual level that the food security is a situation when all people at all times have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (WSFS, 2009). To be food secure, every individual should consume more or at least equal to their body needs. Adequate consumption becomes challenging when enough food is not available for consumption. At the individual level the food security also depend on health and hygiene. Even the food is available, some people can not utilize their food due to health problems, some other do not consume enough food either due to rituals and taboos or for maintaining body slim and attractive. Such under consumption and underutilization make the person malnourished leading to low weight and weak. Food insecurity at individual level is also caused by the consumption of junk foods having attractive packing and promotion but poor in nutrition and other quality. Individuals such as young children, old aged, and expectant and lactating

mothers are particularly sensitive to food insecurity. Poor food related education and poor health also affect the food security at the individual level. Thus, the climate change affects the food security at the individual level affecting food use and utilization.

DISCUSSIONS

Food insecurity at the global level increases food price increasing the challenge of affording for food security by the people of low income net food importing countries. Government of Nepal has a policy of increasing food production to meet the domestic food need. But, the food production is getting threatened by climate change affecting food security at the national level. The climate change poses challenges in achieving long term food security.

As ninety-five percent or more of the food-grain consumed in the country comes from domestic production, socioeconomic and biophysical shocks affecting domestic food production increase food insecurity in the country. Agricultural systems are managed ecosystems heavily dependent on climatic conditions and the agriculture plays an elemental role in human welfare (Chatterjee and Khadka, 2011). The socioeconomic shocks include rise in international food price, rise in input prices like that of seed, fertilizers and fuel and decrease in public sector investment in food production. The socioeconomic path is interwoven to the society and even originates in the results of biophysical factors. The changes in crop productivity affects food price affecting the consumption pattern leading to nutritional and health outcomes. Relative change in the price of different crops and non-crop commodities also affects farmers' decisions on crop area allocation further affecting the food security. On the other, climate change influences various biophysical factors affecting crop production and productivity.

The main source of biophysical effects is global warming leading to the climate change. Climate change influences biophysical factors, such as plant and animal growth, water cycles, biodiversity and nutrient cycling, and the ways in which these are managed through agricultural practices and land use for food production (FAO, 2008). More specifically, the major factors are rise in temperature, change in rainfall pattern and intensity, increase in carbon dioxide concentration in the atmosphere. The rise in temperature is all more important than any other changes as it brings so many other changes. For example, the rise in temperature increases evapotranspiration reducing moisture availability, increases pest activities such as weed dynamics, spread of insect pests and virulence of plant pathogens. Climate change affects availability and timing of water supplies and also soil erosion (Adams et al. 1998). The rise in temperature also increases rate of soil formation making the farm better and rate of manure mineralization decreasing the availability of the soil organic matters. All these effects, including natural hazards relating to extreme weathers such as flooding and drought are biophysical routes to affect the food security.

The climate change is an extreme case of externalities and tragedy of the commons. Anthropogenic emission of green house gases (GHG) that is believed to cause the global warming is the case of externality from production and consumption. In the absence of a legally enforceable mechanism for internalization of the costs of climate change to the production and consumption systems, climate change still remains an externality. In addition, the earth's atmosphere is a common property resource. Everybody needs it but nobody take responsibility of protecting it from the pollution emitted in production and consumption. Considering the problem, both mitigation and adaptation measures are necessary to deal with long term and short term problems of climate change.

Mitigation is needed to decrease the rate of release of green house gases to the atmosphere. As an unintended consequence, the mitigation efforts can decrease food security in short run. Diverting the government budget and those of the donors for abatement of climate change through program in sequestering and storing carbons and choosing low carbon paths can decrease investment in food production.

Adaptation to climate change is necessary for adjusting the nature in response to actual or expected climatic stimuli or their effects for reducing harms or benefit from opportunities if any. But, such adjustment involves costs that can reduce investment in food production. More challenging is reaching 3.36 million farm households in Nepal as all the farmers need to adapt to the climate change.

International political economy affects the balance between the mitigation and adaptation. The mitigation is a longer term investment and its beneficiaries are people in the entire globe. Whereas, the adaptation is short term requirement and the effects are mostly local. Developed countries are emphasizing on mitigation whereas developing countries are negotiating for more focus on the adaptation than on mitigation. The main logic of the developing countries for emphasizing on the adaptation is that the climate change is the costs of industrial development in the developed countries and their negative externalities are causing suffering in developing countries.

Food production, processing, consumption and distribution are all affected by the climate change in one or the other way. Food availability through production requires natural resources, inputs, and suitable technology. Climate change affects the availability of the natural resources and also causes the available agronomic technology obsolete. Similarly, the food processing requires supply of raw materials, availability and enforcement of standards and preservation technology for reducing the losses. Climate change can affect the availability of the raw materials and warming increases perishability of food requiring revisions of the food standards and preservation technology. Climate change can affect consumption and utilization of food at individual level through alteration of food hygiene and human health by increased activities of pathogens. Thus, the climate change and related loss of ecosystem services can affect all the aspects of food security directly or indirectly.

Agriculture Perspective Plan (APP), National Agriculture Policy (NAP) and Three Year Plan (TYP) emphasize on commercialization of agriculture through promoting high value crops. Though these plans and policies emphasize on food security through increased food production in the country, added emphasis on high value crops, that are mostly non-food crops, can divert resources away from food production. For example, land most suited for paddy in Jhapa district is now being converted to tea garden because tea is a high value crop benefiting the farmers. The climate change can affect the paddy crop and tea garden differently and relative profitability of these crops thereby affecting the decisions by the farmers to grow these crops. Nepal has very low level of applied tariff (5 to 15%) on agricultural products making its domestic food production vulnerable to the external price and quantity shocks. Domestic support in food production is limited - some research and technology supports and price subsidies on fertilizers at limited scale. Most youths are getting detracted from agriculture with the opportunities of foreign employment. Land fallowing are already observed in some hilly regions due to limitation on labor force. Under such precarious condition of agriculture, the climate change is adding challenge in food production. Thus, Nepalese agriculture is at the cross road posing challenge on the food security particularly among the poor.

CONCLUSIONS

The climate change affects the food security adversely at all four levels—global, national, household and individual. It is realized that among the climate parameters, the rise in minimum temperature reduces yield of rainy season crops affecting national self sufficiency of food grains. The climate change affects the entire food system from production, processing, distribution, consumption and utilization. Food security in Nepal is particularly vulnerable to climate change due to low level of human control over the water and

temperature and fragile ecosystems that get easily affected from the climate change and related extreme weather events.

Developing resiliency is necessary to face challenges of extreme weather events that the farmers face in producing food using the agricultural ecosystems. For developing resiliency to the climate change national and international communities need to spend more on suitable technology generation and their adoption on food and agriculture. Investment for agricultural adaptation to climate change needs to be increased. Government needs to implement social security measures to deal with high food price for empowering poor in accessing food. In addition to agricultural development to increase domestic food production and application of reasonably high tariff for protecting domestic producers from cheap imports, it is necessary to integrate food supply into global trade rules. International communities need to understand the problem of food insecurity in the landlocked mountainous least developed countries isolated mostly from the global market. For generating collective voice in international fora Nepal needs to study suitability of and benefits from its joining to recently established Group of Mountain Landlocked Developing Countries. This Group is raising issues of vulnerability to transportation costs and food insecurity for such countries.

Some studies are necessary for revising the coefficients used in preparing food balance sheet, such as use of food grains for feed and exploring options and opportunities and enhancing food security of small farmers through diversification of income and livelihood opportunities by growing non-cereal food crops, cash crops and participation in carbon markets, watershed management and other environmental services. The ecosystem services provided by the farmers through agricultural multi-functionalities need to be recognized and payment for such ecosystem services needs to be arranged for conserving agricultural ecosystem at the same time providing means of livelihood and food security for the poor farmers.

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