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## Climate Change Impacts on Agriculture and Food Security in Nepal, India and Bangladesh

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### **Abstract:**

*Background: climate change is the global problem which causes a direct effect on food and water security, poverty, energy security, economic instability etc. As the average temperature is increasing, the climate is also changing at global level. The impacts of climate change are becoming apparent in almost all the countries including Nepal, India and Bangladesh. Objective: the objective of this study is to assess the impacts of climate change on agriculture system including food security issues. Methodology: the study followed descriptive as well as analytical cross-sectional research design and covered 420 households, 140 HH from each country. The respondents were selected by following simple random sampling and structured questionnaires were applied. The data were analysed by using descriptive and inferential statistics such as frequency table, cross tabs and chi-square. Results: The study found the impacts of climate change on agriculture systems and the food security. This has been tackled by changing the types of crops. The food insufficiency is also reported in the study area for about five months and the communities are practicing off-farm production as an adaptation measure. In all three countries, market was reported as the first major reason for crop-related changes followed by land and labor. Conclusion: there was significant association found among the three countries regarding the changes of crops. Similarly, significant association was also reported between the new crops adoption, sufficiency of food production and status of food insure among three countries.*

**Key words:** Adaptation, Climate change, Food security, Impacts

### **1. Introduction**

Climate change refers to a phenomenon of global environmental change. Some of the global problems of our century are food security, water security, poverty, energy security, economic instability and more importantly the climate change. A significant increase to global temperature was already felt during decade of 1980s (Silver & DeFries, 1991, p. 63). The scientific evidence of climate change is now overwhelming making climate change a serious global threat demanding an urgent global response (Stern, 2006, p. vi).

Climate change is one of the biggest challenges of the coming decades, threatening to exceed the planetary boundaries (Rockström et al. 2009) and is now at the center of attention of science and policy, with a major focus on mitigating the anthropogenic interference with the climate system (IPCC, 2007; Rupert Seidi, 2010).

The effect of climate change distributes around the globe and fragile ecosystem like ours having higher and lower altitudes is even more precarious. Because of the rise of temperature, there is much concern on food securities and other agricultural issues. Rise of temperature has resulted some change in cropping pattern as the rainfall pattern is changing. Overall, change in temperature has both direct and indirect impact to the gross domestic product (Bhatta, 2013).

Amidst an increasing climate change impacts in underdeveloped South Asian countries like Nepal, India and Bangladesh, the general development works needs to be geared towards managing impacts. The maximum impacts on agriculture and food security have been reported to be in this part of the region.

The sites have been carefully chosen for this study. These fall under three countries namely Nepal, Indian and Bangladesh. Some major reasons behind such selection are namely, they lie in monsoon corridor, they have rain fed agriculture system, their vulnerability to small farmers are almost similar, they all are facing climate change impacts, these countries still are in food deficit state, there is rise of total population etc. However, with all these similarities, the locations also show a distinct difference in terms of the impacts of climate change. Nepal has more snow melting due to global warming resulting in soil and water erosions. Indian planes using more green revolution technologies would have degradation of soil and water quality including deepening ground water level. Whereas, the coastal area of Bangladesh distinctly show the sea water rising due to global warming resulting in inland sea water that has caused havoc due to ever increasing salinity problems.

The impact of climate change in these countries is high, but there is little knowledge on what exactly is the value being added by adaptation as such in terms of reducing vulnerability apart from poverty alleviation being focused by general development activities (Ayers & Huq, 2009, p. 688). This is the main area of work covered in this study. The study provides an opportunity to assess the climate change impacts on agriculture systems and the food security scenarios of the study area. This study is based on a long term research on the climate change impacts on agriculture and food security of the farming communities by examine their knowledge, skills and practices on the climate change issues.

**2. Methodology**

The study was based on descriptive as well as analytical cross-sectional research design. It was conducted in 2013 among 420 households of Nepal, India and Bangladesh. Thus, 140 HH were selected from each country. The study areas were selected purposively representing the typical agro-zone (normal monsoon, upland and low land mix, potentiality to intervene a wide range of crops – cereals, vegetables and other cash crops, irrigated and rain fed areas). Similarly, simple random sampling was used to select the household for study. Structured questionnaires survey was carried out to collect the data. Frequency table, cross tab and chi-square test were applied to analyze the data.

**3. Results**

Altogether 420 respondents were selected for this study. Based on the analysis of data it shows that 73.6% male followed by 26.4% female participated from Nepal in this study. Similarly, 69.3% male and 30.7% female from India and 71.4% male and 28.6% female from Bangladesh were there as respondents respectively. In total 71.4% male and 28.6% female participated in this study from all three countries. Majority of respondents were from the scheduled caste (48.1%), among them 86.4% in Nepal, 31.4% in India and 26.4% in Bangladesh followed by OBC (25.2%) among them 2.9% in Nepal, 40.0% in India and 32.9% in Bangladesh and 21.4% from the general caste where 7.9% in Nepal, 19.9% in India and 38.6% in Bangladesh and 22 respondents did not mention their caste during the research. As education wise, 73.6% respondents had secondary or above level education in Nepal followed by 22.1% from primary and 2.1% were illiterate and 2.1% literate. Comparatively, 95.7% literate and 4.3% illiterate from Bangladesh and 90.7% literate and 9.3% illiterate from India participated in study. It was indicated from the data that comparatively more educated respondents participated from India and Bangladesh in study. Data show the patriarchy society in all three countries. 73.6% Male from Nepal, 98.6% India and 92.9% from Bangladesh are head of family. Comparatively, more female are head of family in Nepal than other countries.

		Crosstab				Pearson Chi-Square
		address of respondents			Total	
			Nepal	India	Bangladesh	
Change in crops in last 10 years	No crops related change	Count	0	0	14	14
		% within Change in crops in last 10 years	0.0%	0.0%	100.0%	100.0%
		% within address of respondents	0.0%	0.0%	10.0%	3.3%
	Changes in 1 crop	Count	1	11	3	15
		% within Change in crops in last 10 years	6.7%	73.3%	20.0%	100.0%
		% within address of respondents	0.7%	7.9%	2.1%	3.6%
	Changes in 2 crops	Count	135	2	7	144
		% within Change in crops in last 10 years	93.8%	1.4%	4.9%	100.0%
		% within address of respondents	96.4%	1.4%	5.0%	34.3%
	Changes in 3 crops	Count	4	127	116	247
		% within Change in crops in last 10 years	1.6%	51.4%	47.0%	100.0%
		% within address of respondents	2.9%	90.7%	82.9%	58.8%
Total	Count	140	140	140	420	
	% within Change in crops in last 10 years	33.3%	33.3%	33.3%	100.0%	
	% within address of respondents	100.0%	100.0%	100.0%	100.0%	

Value = 388.518  
Df = 6,  
Asymp. Sig. (2-sided) .000 (S)

Table 1: Change in crops in last 10 years

Sources: Field study, 2013

In Nepal, when asked what the three major crops they are growing are, most of the respondents mentioned rice, wheat and mustard. They were then asked about what changes they had made to their farming system/practices over the last ten years and for

which crops they made changes. Looking at the proportion of households who have made changes to one or more of their most important crops, we found that all households have made at least one change to at least one of their main crops. The result (table 1) shows that 2.9% households made changes up to three crops. Almost all of them (96.4 %) of respondents reported that there were changes in two types of crops in existence and 1% had changes in one crop in last ten years.

In India, respondents reported that 90.7% had changed up to three types of crops followed by 7.9% had changed one type of crops and only 1.4% changed two types of crops. In Bangladesh, 82.9% household reported that they had changed up to three types of crops in last 10 years followed by 5% had changed two types, 2.1% had changed one type and 10% had reported that they had not changed any types of crops in last 10 years. In total, 58.8% had made changes in three types of crops followed by 34.3% made in two types of changes, 3.6% in one type and 3.3% had made no changes in crops since last one decade.

Changing in crops types was found similar between India and Bangladesh but found different in Nepal. Majority of Nepalese had changed up to two types of crops in last 10 years but in India and Bangladesh, majority had changed up to three types. In Bangladesh still 10% households had been practicing the same crops since last 10 years; no changes in types of crops but in Nepal and India had changed at least one type of crop.

There was significant association ( $p = .000$ ) found among the three countries regarding the changes of crops.

Crosstab							Pearson Chi-Square
		address of respondents			Total	Value = 94.758 Df = 4, Asymp. Sig. (2-sided) .000 (S)	
		Nepal	India	Bangladesh			
Adoption of new crops/varieties over the last 10 years	No introduction of new crops or varieties	Count	7	4	25		36
		% within Adoption of new crops/varieties over the last 10 years	19.4%	11.1%	69.4%	100.0%	
		% within address of respondents	5.0%	2.9%	17.9%	8.6%	
	Have introduced 1 or 2 new crops and/or new varieties	Count	55	95	19	169	
		% within Adoption of new crops/varieties over the last 10 years	32.5%	56.2%	11.2%	100.0%	
		% within address of respondents	39.3%	67.9%	13.6%	40.2%	
	Have introduced 3 or more new crops and/or varieties	Count	78	41	96	215	
		% within Adoption of new crops/varieties over the last 10 years	36.3%	19.1%	44.7%	100.0%	
		% within address of respondents	55.7%	29.3%	68.6%	51.2%	
Total	Count	140	140	140	420		
	% within Adoption of new crops/varieties over the last 10 years	33.3%	33.3%	33.3%	100.0%		
	% within address of respondents	100.0%	100.0%	100.0%	100.0%		

Table 2: Adoption of new crops/varieties over the last 10 years  
Sources: Field study, 2013

In Nepal, finding shows that households had made some changes in this regards. With respect to how many households in the last 10 years had introduced new crops or new varieties, we found that 5% of households had not introduced any new crops or varieties, 39.3% had introduced one or two new crops or varieties, and similarly, 55.7% of households had incorporated three or more new crops or varieties into their farming systems over the last 10 years.

In India, it was found that 2.9% of households had not introduced any new crops or varieties, 67.9% had introduced one or two new crops or varieties, and similarly, 29.3% of households had incorporated three or more new crops or varieties into their farming systems over the last 10 years. In Bangladesh, 68.6% household had introduced 3 or more than 3 new corps in last 10 years followed by 13.6% had introduced 1 to 2 new crops and 17.9% had not introduced any new crops.

In comparison between Nepal, India and Bangladesh, number of household which had not introduced any new corps was found high in Bangladesh than Nepal and India. In total, 51.2% had made adopted 3 or more new crops followed by 40.2% had introduced 1 or 2 new crops and 8.6% had not introduced any new crops in last one decade.

There was significant association ( $P = .000$ ) found between the new crops adoption and 3 countries.

Categories	Nepal		India		Bangladesh	
	N	%	N	%	N	%
Markets	130	92.86	140	100	107	76.43
Weather/climate	2	1.43	120	86	52	37.14
Land	38	27.14	84	60	74	52.86
Labor	46	32.86	92	66	20	14.29
Pests/diseases	22	15.71	70	50	67	47.86
Projects	1	0.71	46	33	3	2.14
Total	239		553		323	

Table 3: Reasons for changing cropping practices, by category  
Sources: Field study, 2013

The respondents were asked why they had made the specified crop related changes. The reasons as reported by households consist under the categories like: markets, climate, land, labor, pests and diseases, and projects. Respondents had given multiple answers as a reason for changing cropping practices.

In Nepal, respondents had given total 239 responses. The results show that 92.86% of households had made changes to their farming practices due to market reasons, 27.14% and 32.86% of HHs cited that they made crops related changes due to land and labor perspectives respectively. Changes due to projects are very nominal (0.71% HHs). The important drivers of change for these households were pest and disease incidence as well (15.71%).

In India, respondents had given total 553 responses. The results show that 100% of households had made changes to their farming practices due to market reasons, followed by 86% reported climatic changes, 60% land and 66% labor, 50% pest and disease incidence and 33% reported projects. Similarly, in Bangladesh, respondents had given total 323 responses. The results show that 76.43% of households had made changes to their farming practices due to market reasons; followed by 52.86% land, 47.86% pest and disease incidence, 37.14% reported climatic changes, 14.29% labor, and 2.14% reported projects.

In all 3 countries, market was reported as the 1<sup>st</sup> major reason for crop-related changes followed by land and labor.

Crosstab							Pearson Chi-Square
		Address of respondents			Total		
		Nepal	India	Bangladesh			
Sufficiency of food Production for the whole year	Food sufficiency	Count	102	0	59		161
		% within Sufficiency of food Production for the whole year	63.4%	0.0%	36.6%	100.0%	
		% within address of respondents	72.9%	0.0%	42.1%	38.3%	
	Food not sufficiency	Count	38	140	81	259	
		% within Sufficiency of food Production for the whole year	14.7%	54.1%	31.3%	100%	
		% within address of respondents	27.1%	100.0%	57.9%	61.7%	
Total	Count	140	140	140	420		
	% within Sufficiency of food Production for the whole year	33.3%	33.3%	33.3%	100%		
	% within address of respondents	100.0%	100.0%	100.0%	100%		

Table 4: Status of food production  
Sources: Field study, 2013

Status of food sufficiency was also identified during the field survey in all three countries. 72.9% HHs of Nepal reported that they had food sufficiency from their own-farm followed by 42.1% HHs of Bangladesh. In India, 100% HHs reported that they had no sufficiency of food from their own-farm for whole one year.

In total, 38.3% HHs had food sufficiency and remaining (61.7%) had to depend on off-farm production to manage their family for whole one year. There is significant association (p=.000) found between the respondents of three countries regarding the sufficiency of food production.

Crosstab							Pearson Chi-Square
		address of respondents			Total	Asymp. Sig. (2-sided).000 Value= 116.873 Df = 4 (S)	
		Nepal	India	Bangladesh			
Status of food insecure	Less than 3 month	Count	4	28	60		92
		% within Status of food insecure	4.3%	30.4%	65.2%	100.0%	
		% within address of respondents	10.5%	20.0%	73.2%	35.4%	
	Up to 6 months	Count	25	112	11	148	
		% within Status of food insecure	16.9%	75.7%	7.4%	100.0%	
		% within address of respondents	65.8%	80.0%	13.4%	56.9%	
	More than 9 months	Count	9	0	11	20	
		% within Status of food insecure	45.0%	0.0%	55.0%	100.0%	
		% within address of respondents	23.7%	0.0%	13.4%	7.7%	
Total	Count	38	140	82	260		
	% within Status of food insecure	14.6%	53.8%	31.5%	100.0%		
	% within address of respondents	100.0%	100.0%	100.0%	100.0%		

Table 5: Status of food insecurity  
Sources: Field study, 2013

The respondents were asked about the monthly source of food for the family i.e. whether it came mainly from their own farm or elsewhere for every month. The households were also asked from which months of the year they struggled to have enough food to feed their family from any sources.

In Nepal, the table no. 5 shows that food sufficiency for the family across the year from on-farm sources. It was obvious that 23.7% of household get food for more than 9 months from their on-farm followed by 65.8% of households has food sufficiency for up to 6 months and 10.5% have food sufficiency for less than three months from their own farm.

Same question was asked among the 140 HHS of India also. The data found that 80% of household had food sufficiency for up to 6 months followed by 20% had only less than 3 months. No any household had food sufficiency for whole one year from their own farm. Similarly, 13.4% household of Bangladesh reported that they had food sufficiency for more than 9 months followed by 13.4% had up to 6 months and 73.2% had less than 3 months.

It was reported from all three countries that June, July, August, September and October are the months in which less food is available from on-farm sources. Comparatively, India had more food problem than Bangladesh and Nepal.

There was significant association (p=.000) found between the respondents of three countries regarding the status of food insure.

#### 4. Discussions

Above findings clearly elucidate the intricate relationship between climate change and agriculture including food security issues. Studies have shown that the main drivers of agricultural responses to climate change are biophysical effects and socio-economic factors including rising temperatures, changing precipitation regimes, and increased atmospheric carbon dioxide levels (M. L. Parry, 2004). The study shows that in spite of having different ethnic or cultural background or geographical location within Nepal, India and Bangladesh, the impact of climate change to farming is almost similar.

Nepal, India and Bangladesh being in this category are also severely affected by climate change and are having difficult time to cope up with such changes. UNFCCC (2007) has explained that the developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt - socially, technologically and financially. In another study, Mendelsohn (2000) has emphasized that many countries in tropical and sub-tropical regions are expected to be more vulnerable to warming because additional warming will affect their marginal water balance and harm their agricultural sectors (Robert Mendelsohn, 2000).

The study sites are facing the problem of food insufficiency which may be caused by a number of problems including climate change. The findings also revealed that changing crops could be a viable measure of adaptation for the resource-stricken communities in the region.

The cropping, forestry, and livestock sectors are influenced by changes in climatic conditions and also by increases in atmospheric CO. The productivity of crop agriculture and forestry is dependent upon temperatures, the length of the growing season, available soil moisture, atmospheric CO and climate extremes such as droughts and storms (Preston, 2006). The study has also revealed that such factors are also causing heavy impact in all the study countries namely Nepal, India and Bangladesh.

A key factor in determining the magnitude of climate change impacts on agriculture is adaptation. As the climate changes, community and nature should also adjust in the changing environment. It is also necessary to recognize that climate change is just one of many challenges facing the agricultural sector, and that it may not be considered a short-term priority in decision making (Warren, 2004). The findings suggest that local communities are changing the crops as the climate changes indicating that they are looking for the options for adaptation. However, as explained by Warren (2004), it is still not the major priority of development intervention most of the developing countries including Nepal, India and Bangladesh.

The reason behind changes to the farming practices may be different, but in the case of study area, market reasons were considered the major one. Farmers were also motivated to change to crops because of climatic changes, land and labor issues, pest and disease and project related causes.

## 5. Conclusion

The study revealed that the impacts of climate change on agriculture systems and the food security scenarios in the study area is increasing affecting on agriculture and food security of the farming communities. Data show that almost all respondents changed two types of crops in last ten years. There was similarity in changing crops types between India and Bangladesh but found different in Nepal. Number of household which had not introduced any new crops was found high in Bangladesh than Nepal and India. Respondents cited that they made crops related changes due to land and labor perspectives. Changes due to projects are very nominal but the pest and disease incidence were the important drivers of change for these households were as well. It was found that a large proportion of people had to rely on off-farm production to manage their family for whole one year particularly from June to October. Among three countries, the study has revealed that India had more food problem.

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