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## Determinants of drought risk coping mechanisms among the farmers of Northern region of Bangladesh

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### Abstract

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Drought is a major constraint on agricultural production and livelihood in the north-western region of Bangladesh. An understanding of the effects of drought and farmers' coping mechanisms is essential in designing technological and policy interventions for effective drought mitigation. The current study investigates the impacts of drought, examines farmers' coping strategies for drought induced crop failure and the determinants of their mechanism choices by employing both quantitative and qualitative approach. Multiple data sources, including semi-structured interview survey with 218 randomly selected farmers; and four focus group discussions with farmers, local leaders, NGO workers, and government officials were used to capture various aspects of drought risks and coping practices. 'Multinomial logit' model was adopted to analyze the factors affecting the decision of coping strategies in response to drought. Results of farm household survey data indicates that the respondents experienced 3.15 droughts on an average in last five years which affected about 15 percent of their crop land and resulted more than 17 percent crop loss per year. Focus group discussions confirm that farmers followed various traditional ex ante and ex post coping strategies in order to avoid crop loss and minimize livelihood constraints. The coping mechanisms mostly adopted by farmers among others were borrowing money, cultivating less water consuming crops and cutting meals. Findings of multinomial logistic regression model reveal that the environment determinant of the choices of coping options was frequency of drought and main socio-economic determinants of coping choices were crop loss due to drought and land holding systems.

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### Introduction

Changing climate pattern affects the livelihoods of people adversely in the developing world who are excessively dependent on the agricultural sector (IPCC, 2014 and IPCC, 2012). The negative consequences of natural disasters in the low-income countries range from material, economic, environmental losses to human development (UNISDR, 2008). The people have to tolerate the negative consequences of climate change not only because of their higher dependence on natural resources but also their inadequate capabilities to cope with the changing environment.

Bangladesh is one of the countries subjects to the devastating impacts of climate change and each year people of this country have to tolerate the devastating consequences of various natural disasters like flood, drought, river bank erosion, cyclones, etc. Besides other calamities, in Bangladesh, there exists a probability that 41 percent to 50 percent of land of the country experience drought in a year and there is also possibility to increase the intensity (IPCC, 2013). The nature and severity of disasters in different parts of Bangladesh vary and people of northern part of Bangladesh are experiencing severe drought but different dimensions of this incident remained unexplored yet (Farid, *et al.*,

2015). Literatures highlighting on negative impacts of drought ranged from agricultural perspectives to socio-economic dimensions (Afroz and Rahman, 2013 and Paul, 1998). These include agricultural losses, income and asset disruption and the resultant social crises, etc. (Islam *et al.*, 2014). However, farmers' response to the negative effects of drought on agriculture varies widely and alteration of coping mechanisms occurs depending on climatic conditions, farm types and other economic and institutional factors (Hisali *et al.*, 2011; Reidsma *et al.*, 2010). Similarly, to combat the crises, farmers of northern region employ different combinations of drought coping strategies. They usually adopt short-term responses to deal with the immediate impacts of droughts. These responses can be defined as proactive (anticipatory adaptation and psychological preparedness), made in anticipation of an event, or reactive, made after an event (Aspinwall, 2011). In the context of developing countries, coping strategies are generally the short-term responses to an immediate inaccessibility to food and these strategies largely refer to a set of measures to meet physiological, social, and economic needs of life (Richardson *et al.*, 2011). Thus, addressing successful coping mechanisms in the context of global climate change requires a thoughtful consideration of prevention and preparedness (Ball, 2008). The unique nature of coping methods raises the

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necessity of the context and area specific study of drought mechanisms. So, the area and context specific documentation of survival mechanisms is necessary for development intervention.

Only a few studies have been conducted so far addressing factors influencing coping mechanisms due to climate induced drought in the northern part of Bangladesh. Literatures are found emphasizing on drought losses and the resultant adaptation priorities (Rawlani and Sovacool, 2011; Paul and Routray, 2011; Shahid and Behrawan, 2008). The identified adaptation options are water harvesting, water resource exploitation and crop intensification (Habiba *et al.*, 2012). These adaptation priorities are not sufficient to capture the full picture of drought affected rural livelihoods. An understanding of farmers' coping mechanisms and inhibiting factors behind them will help to design more effective drought mitigation measures. Because, the factors that influence their coping decisions, especially by the resource-poor farmers need to be understood so that their drought mitigation plans can be enhanced properly. In this regard, present study aims to examine the drought coping mechanisms adopted by the farmers of the northern Bangladesh. In this paper, emphasize has been given on what coping strategies households employ before or after drought, and what determines the choice of coping strategies. The specific objectives are: to document drought experiences and its effects in the study area; to identify drought coping mechanisms adopted by the farmers; and to examine the influencing factors for adopting coping mechanisms by the farmers.

## Materials and Methods

To examine the factors determining decision to drought mechanisms under climate change scenario in northern Bangladesh, two upazilas namely, Parbatipur under Dinajpur district and Sherpur under Bogura district were selected purposively for field inquisition since these sites are affected by climate change particularly by the drought (Habiba *et al.*, 2011 and FAO, 2009). One union from each upazila was selected randomly. These unions were Boro Chandipur of Parbatipur and Garidaha of Sherpur upazila. After that, four villages from each union, i. e. total 8 villages namely Boro Chandipur, Chaitapara, Jharuardanga, and Kalikabaridanga from Boro Chandipur union and Ramnagar, Kanupur, Hatgari, and Bonga from Garidaha union were selected randomly. All the farmers of these eight villages were the population of the present study. In order to select the sample, a list of all farmers of the study villages were prepared first and then sampling frame was prepared accordingly. After that a list of sample farmers constituting a total of 264 farmers (129 from Parbatipur and 135 from Sherpur) was prepared taking approximately 10 percent and 15 percent of the population from each village by following simple random sampling. Then the farmers who were agreed

and gave consent to participate in the survey during visit by the data enumerators become the final sample of the present study. Therefore, the actual sample size was 218 (108 from Parbatipur and 110 from Sherpur).

Data collection was carried out through interview survey based on a semi-structured pre-tested schedule, which means the main source of primary data was sample survey. Moreover, four focus group discussions (FGD) were also organized to get overall insights on the existing drought risk and associated coping options in the study areas. Various descriptive and inferential statistical techniques were applied for getting meaningful results. Furthermore, to investigate the coping decision in the study areas, multinomial logistic (MNL) model was adopted to see determinants of choosing different coping mechanisms. In order to determine the factors motivating farmers' choice of any or combination of coping mechanisms to climate induced drought, the probability model was used where the dependent variable is categorical. MNL model helps to capture the collective influence of different independent variables on the dependent variable. The dependent variable is discrete in nature with multiple choices, so the appropriate model for drought risk mechanism is MNL model (Legesse *et al.*, 2013; Tessema *et al.*, 2013). MNL model was used to determine the influence of explanatory variables on the choice of coping mechanisms to drought. The equation is as follows-

$$P\left(y = \frac{j}{x}\right) = \frac{\exp(x\beta_j)}{[1 + \sum_{h=1}^j \exp(x\beta_h), j = 1, \dots, J]}$$

Where,  $\beta_j$  is  $K \times 1, j = 1, \dots, J$ .

## Results and Discussion

### Socio-economic characteristics of the study sample

Background characteristics of respondents are presented in Table 1 and Table 2. Agriculture was the primary occupation of 89 percent of the respondents followed by business (5 percent), service (4.6 percent), and other occupation (1.4 percent), respectively. Majority of farmers belonged to small to medium category farm. On an average, the farmers of the Parbatipur owned about 276 decimals of cultivable land, whereas this share was very low for the farmers of Sherpur owning only 93 decimals. As a result, most of the farmers (about 86 percent) of Sherpur were small farmers and about 42 percent farmers of Parbatipur were in medium category. The education level among farming population was low as about 18 percent were illiterate, 33 percent completed primary level education and only five percent were graduates. Average annual household income and expenditure of the farmers of studied upazilas were about Tk. 167.5 thousand and Tk. 118.5 thousand, respectively.

**Table 1. Distribution of respondents based on socio-economic characteristics**

Characteristics	Categories	Parbatipur (N=108)	Sherpur (N=110)	Total (N=218)
Level of education	Illiterate	17 (15.7)	22 (20)	39 (17.9)
	Primary	25 (22.2)	48 (43.6)	72 (33)
	Secondary	48 (44.4)	33 (30)	81 (37.2)
	Higher secondary	12 (11.1)	3 (2.7)	15 (6.9)
	Graduate	7 (6.5)	4 (3.6)	11 (5)
Occupation	Agriculture	91 (84.3)	103 (93.9)	194 (89)
	Business	10 (9.3)	1 (.9)	11 (5)
	Service	5 (4.6)	5 (4.5)	10 (4.6)
	Other	2 (1.9)	1 (.9)	3 (1.4)
Training status	percent of N	44(40.7)	20(18.2)	64(29.4)
Land holdings (decimal)		276	93	184.5
Average annual income ('000)		182	153	167.5
Average annual expenditure ('000)		115	122	118.5

Besides, the communication exposure was evaluated to get an insight on the possibility of getting agriculture related information from other people as well as from social media. Contact with various communication media like local leaders, dealers, and UAO, participation in agricultural related meeting and use of communication media was very low for the farmers of Sherpur compared to the farmers of Parbatipur which has been shown in Table 2.

**Table 2. Communication exposure (percentage of respondent)**

Categories of personnel/media	Parbatipur	Sherpur
Contact with local leaders	89.8	36.4
Contact with dealers	89.8	66.4
Contact with block supervisor	77.8	49.1
Contact with UAO	43.5	2.7
Participation in agricultural related meeting	40.7	1.8
Attending result demonstration meeting	31.5	0.9
Watching agriculture related programmes in radio/TV	88.9	70.9

The respondents of the study area maintain varied forms and ranges of communication with various important communication media. Communication scores were calculated based on these varied ranges of communication. The various ranges of communication included weekly, monthly, quarterly, and yearly communication with no communication as well. Communication scores range from 0-20. The communication score was categorized into four groups of equal range (dividing highest score 20 by 4). Communication score up to 5 indicates lower communication, whereas, scores 6–10 and 11–15 indicate medium and higher scores. Communication score above 15 implies very high communication. About 54 percent of the respondents at Sherpur were on communication score up to 5; on the other hand, only 11 percent of the respondents of Parbatipur were on this score. At Parbatipur, 35 percent of the respondents were on communication score 11 to 15, whereas only 6 percent of the respondents were on this score at Sherpur.

More respondents at Parbatipur were on communication score more than 15; on the other hand, at Sherpur this was negligible. In total, highest 39 percent of the respondents were in medium category and only about 9 percent of the respondents were in very high category of communication (Table 3). Moreover, the chi-square value is significant at 10 percent level of significance, which indicates that there was a significant difference in the extent of communication among the farmers of two region.

**Table 3. Distribution of the respondents based on the extent of communication**

Extent of communication (score)	Upazila		Total	Pearson Chi-Square
	Parbatipur	Sherpur		
Low (Up to 5)	12 (11.1)	59 (53.6)	71 (32.6)	71.931*
Medium (6 – 10)	40 (37.0)	45 (40.9)	85 (39.0)	
High (11 – 15)	38 (35.2)	5 (4.5)	43 (19.7)	
Very high (15 – 20)	18 (16.7)	1 (0.9)	19 (8.7)	

Note: Figures in the parentheses indicate percentage

### Drought and its effect

Drought is a recurrent phenomenon in the northern Bangladesh. Table 4 shows the distribution of respondents based on drought experience. 45 percent of total respondents experienced drought almost 3 times during last five-year period. Besides, about 28.5 percent of the respondents had to go through 4–5 times drought during this period. On the contrary, only 3.2 percent of total respondents experienced single drought in a five-year time period. So, it can be deduced that drought is a common phenomenon in this area and this finding is also supported by the study of Habiba *et al.* (2011) who also mentioned that the studied areas are drought-prone.

**Table 4. Frequency of drought during five-year period**

Frequency of drought	Parbatipur	Sherpur	Total	Mean	Std. deviation
1	0.9	5.5	3.2	3.15	1.055
2	3.7	42.7	23.4		
3	61.1	29.1	45.0		
4	10.2	14.5	12.4		
5	24.1	8.2	16.1		

About 26 percent of the respondents at Sherpur reported that no land was affected by drought, whereas the percentage of respondents reporting the same was about 7.4 at Parbatipur. At Parbatipur, almost 30 percent of the respondents said that 21 to 30 percent land area was affected by drought; on the other hand, 23 percent of the respondents mentioned it at Sherpur. Besides, about 4 and 26 percent of total respondents said that more than 30 percent and 21-30 percent of their land was affected by drought, respectively (Table 5). That means, almost 30 percent of the respondents reported that more than 20 percent of their lands were affected by drought. They incurred severe losses due to frequent droughts.

**Table 5. Percentage distribution of respondents based on land area affected by drought**

Percentage of land area	Upazila		Total
	Parbatipur	Sherpur	
0	7.4	25.5	16.5
1-10	26.9	21.8	24.3
11-20	32.4	26.4	29.4
21-30	29.6	22.7	26.1
30+	3.7	3.6	3.7
Total	100.0	100.0	100.0

Drought has negative impact on crop production. In Sherpur, more than 30 percent of the respondents mentioned that there was no crop loss in case of drought, whereas Parbatipur showed different phenomena. At Parbatipur, 28 percent of the respondents mentioned about 21 to 30 percent crop loss due to drought; on the other hand, this figure is 14 percent in case of Sherpur. The respondents of Parbatipur experienced twice crop loss compared to Sherpur. As a whole, 17 percent of the respondents of two areas lost more than 30 percent of their crop. About four-fifths of the respondents experienced crop loss to some extent. Moreover, the significant value of chi-square at 10 percent level of significance indicates the significant difference in crop loss between Parbatipur and Sherpur. The percentage distribution of farmers based on crop loss experiences due to drought is shown in Table 6.

**Table 6. Percentage distribution of farmers based on crop loss due to drought**

Percent of crop loss	Upazila		Total	Pearson Chi-Square
	Parbatipur	Sherpur		
0	5.6	30.9	18.3	
1-10	18.5	32.7	25.7	
11-20	16.7	20.0	18.3	55.531*
21-30	27.8	13.6	20.6	
30+	31.5	2.7	17.0	
Total	100.0	100.0	100.0	

### Drought risk coping mechanisms

Respondents in the study areas have developed various survival mechanisms to cope with problems of drought. The higher dependence on agriculture, illiteracy and poor economic condition forces farmers to take mechanisms just to face immediate losses. The various mechanisms adopted by the farmers to cope with the effects of drought were categorized into *ex ante* and *ex*

*post* mechanisms. Traditional local *Ex ante* mechanisms were adopted before the occurrence of drought in order to cope with this climatic event, which were helpful to reduce risk. These mechanisms included along with others diversification of agricultural enterprises, diversification of production activities, crop diversification, switching from farm to non-farm activities, varietal selection, planting various crops in separate plots, adjustment of allocated crop area depending on the climatic conditions, postpone or adjust timing of crop planting, etc. On the other hand, *ex post* mechanisms were adopted for reducing the impact of risk after the drought has occurred. The important *ex post* mechanisms were cutting down expenditure, migration of one or more family members, consumption loans, consuming less, asset liquidation, reliance on charity, loans from non-economic organizations, etc. Respondents who were exposed to drought risk used one or more strategies in different combinations to ensure their survival. Some of these strategies like selecting less water consuming varieties were incorporated into the nature of the farming system over a long period of time. Some others were employed only under certain risky situation that is just after the occurrence of drought.

For this study, six coping strategies, which were important according to the participants and most widely adopted by them, were separated for further statistical analysis. These strategies were separated based on the perceptions of the participants discussed during the focus group discussions. These were leaving lands fallow, cultivating less water consuming crops, borrowing money from others, migration of family members, working as laborers in others' farm and cutting meals. The distribution of farmers by their choices of coping mechanisms presented in Table 7 reveals that a larger proportion (67.0 percent) of the farmers preferred borrowing money as a coping method to combat drought; followed by cultivating less water consuming crops and cutting meals by 49.1 percent of the respondents in both cases. However, migration of family members (16.1 percent) and work as laborer in other's farm (25.2 percent) were the least preferred coping measures by the farmers. The percentage of respondents who cultivate less water consuming crops was higher (64.4 percent) at Parbatipur than at Sherpur (33.6 percent). On the other hand, borrowing money at Parbatipur was double than at Sherpur. Involvement of the respondents to others' farms as labourer was higher in Parbatipur, approximately two times than that of Sherpur. The more respondents of Parbatipur had to work to others' farms as laboureres and borrow money in order to meet their basic needs. The adoption of survival mechanisms was higher for Parbatipur because the severity of drought was higher at Parbatipur than Sherpur.

**Table 7. Survival mechanisms adopted by the respondents (percentage of households)**

Mechanism	Parbatipur		Sherpur		Total	
	Yes	No	Yes	No	Yes	No
Leave the lands fallow	27.8	72.2	26.4	73.6	27.1	72.9
Cultivate less water consuming crops	64.8	35.2	33.6	66.4	49.1	50.9
Borrow money	89.8	10.2	44.5	55.5	67.0	33.0
Migration of family members	20.4	79.6	11.8	88.2	16.1	83.9
Work as laborers in others' farm	33.3	66.7	17.3	82.7	25.2	74.8
Cutting meals	53.7	46.3	44.5	55.5	49.1	50.9

**Factors responsible for farmers' coping mechanisms decisions**

There exists variation among drought affected respondents on frequency of adoption of drought coping mechanisms. Respondents' socio-economic status and environmental exposure led them to undertake different coping mechanisms during drought. Fig. 1 indicates that mean mechanism score was 2.32 with a standard deviation of 1.363. It implies that majority of the farmers usually adopted more than one mechanism and this range was between 2 to 3. The total percentage of farmers was 49.5 who employed 2 or 3 coping mechanisms (Table 8).

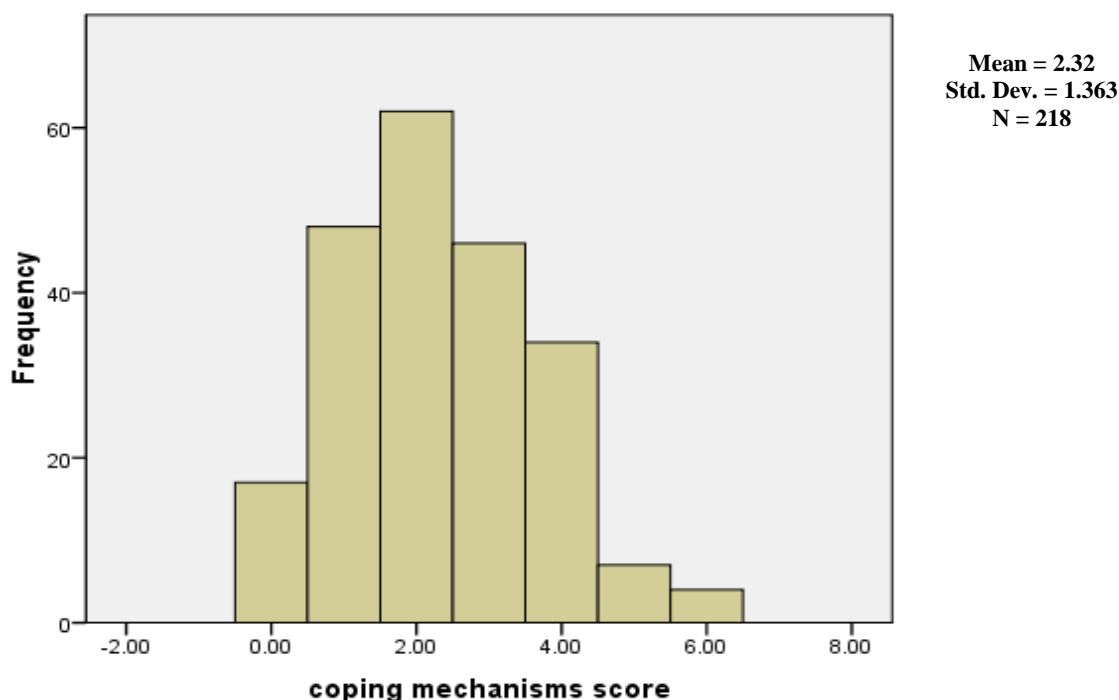


Fig. 1. Coping mechanism score

**Table 8. Distribution of farmers based on frequency of mechanism adoption**

No. of mechanisms	Frequency of adoption	Percentage of farmers	Cumulative percentage of farmers
0	17	7.8	7.8
1	48	22.0	29.8
2	62	28.4	58.3
3	46	21.1	79.4
4	34	15.6	95.0
5	7	3.2	98.2
6	4	1.8	100.0

Multinomial logistic (MNL) model was adopted to see determinants of choosing different coping mechanisms. The dependent variable for MNL model used in this study was respondents' decision on coping options due to drought. The alternative drought risk strategies included leave the lands fallow, cultivate less water consuming crops, borrowing money, migration of family

members, working as laborers in others' farm and cutting meals. For simplicity, the coping options were divided into three categories, namely, adopting no mechanism, adopting 1 to 3 mechanisms and adopting more than 3 mechanisms. Thus, the dependent variable in the model was a categorical variable taking a discrete value of 1, 2, and 3 representing the above choices. Independent variables determine whether or not a respondent takes some mechanism to cope with the drought impact. Table 9 illustrates the results of MNL models showing the probability of choosing any of the three options. The base category was respondents' decision of adopting more than 3 mechanisms. The odds ratio of land holding is 2.780, which implies that a unit increase in land holding increases the probability of a respondent to shift from the category of adopting more than three mechanisms to adopting no mechanism category by 178 percent. The reason may be that most of the options available to respondents were related to

coping mechanisms not adaptation options. Large farmers were more able to cope with drought with their existing solvency without adopting any income or consumption smoothing option. At the same time, a unit increase in the crop loss due to drought decreases the probability of a respondent to adopt no mechanism by 12.30 percent. This result also supports the previous argument.

A unit increase in the frequency of drought decreases the probability of a respondent to shift from adopting more than 3 mechanisms to adopting only 1 to 3 mechanisms by 93.11 percent. Because when the frequency of drought increases then respondents needed to take several survival mechanisms and most often they are bound to adopt more than three existing coping mechanisms. Similarly, one unit increase in crop loss due to drought decreases the probability of using 1 to 3

mechanisms to more than 3 mechanisms by 3.7 percent. It is clear that respondents were forced to undertake several mechanisms and they did so when they had no other options remained. For instance, when they had inadequate amount of land to support them during crises, they took such techniques to regularize consumption and income to certain extent. On the contrary, when they could tackle the situation without such adjustments, they preferred to do so. For example, respondents who had larger amount of land could apply modern techniques effectively to combat drought. These techniques might take in the forms of using drought tolerant varieties to use better irrigation practices. They did not need to take the given traditional coping mechanisms rather they could choose different adaptation options. At the same time, the larger land holdings might increase the probability of lands that might be remained safe in times of drought.

**Table 9. Results of multinomial logistic model**

Independent variables	Adopting no mechanism			Adopting 1 to 3 mechanisms		
	$\beta$	S.E.	Odds Ratio	$\beta$	S.E.	Odds Ratio
Intercept	.921	1.397		2.961***	.850	
Frequency of drought	-.459	.335	.689	-.440**	.190	.689
Communication score	-.113	.092	.854	.004	.047	1.038
Land holding	1.005**	.430	2.780	.336	.251	1.465
Education	.263	.383	1.396	.186	.234	1.283
Training	.111	.527	1.120	.055	.296	1.024
Crop loss due to drought	-.168***	.042	.877	-.068***	.014	.963

Note: The reference category is adopting more than 3 mechanisms. \*\* $p < 0.05$  and \*\*\*  $p < 0.01$  are the levels of significance.  $\beta$  denotes regression coefficient and S.E. denotes standard error of the regression coefficient.

## Conclusion

The study sought farmers' existing drought coping strategies and inhibiting factors behind such mechanisms in northern Bangladesh. It is evident from the results of the study that drought coping mechanisms were mainly short-term responses to face the immediate circumstances. Recurrent drought resulted in disruption of production which acted as an exerting force to develop and adopt coping mechanisms to recover from drought. These were still mostly the traditional coping mechanisms including leaving lands fallow, borrowing money and eating fewer amounts, etc. However, as the drought's frequency and severity are anticipated to enlarge in near future, so these traditional coping mechanisms will no longer be adequate for meeting the emerging challenges. This inference is also similar with Pandey *et al.* (2007). The results of multinomial logit (MNL) model portray that the possibility of farmers' decision of confining to just 1 to 3 coping mechanisms rather than adopting more than 3 traditional mechanisms were influenced negatively by both frequencies of drought and crop loss due to drought. At the same time, land holding has positive influence on taking no such traditional mechanism in contrast with adopting more than 3 mechanisms. Because farmers who have sufficient amount of land were solvent enough and they did not need to adopt the survival mechanisms immediately to cope with drought. Besides, large rich

farmers can think about possible adaptation priorities for future which can be a tough choice for small and marginal poor farmers. We can, therefore, conclude that small and marginal farmers are more susceptible to drought risks and the subsequent losses. Further study needs to be done in exploring small and marginal poor farmers' coping strategies more rigorously so as to design more comprehensive policies for helping those farmers effectively. Policies should support land holdings of farmer which is expected to resolve consumption as well as income crises during and after drought in the long run through bringing more effective adaptation practices. Similarly, the modern and sustainable adaptation options should be available to farmers. Thus, it will help the resource poor farmers to reduce the economic, social and environmental losses of drought.

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