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Who perceive seasonality change? A case of the Meghna basin, Bangladesh

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Abstract

Global climate change is a scientifically demonstrated phenomenon, but there are great discrepancies in different societies about how people perceive it. It has been claimed that people's correct perceptions to climate change are necessary for mitigation and adaptation; however, most research in this regard has focused on knowledge about temporal trends of climate: no reports have examined people's perceptions of climatic regularity and patterns, i.e., seasonality change. In this study, we investigate people's perception to seasonality change in the Meghna basin, Bangladesh where catastrophic flooding occurs and the number of seasons in an annual calendar year is reported to have decreased from six to four. We conduct interviews with 7 experts and surveys with 1011 respondents. With the data, we empirically characterize participants' perceptions to seasonality change in relation to sociodemographic factors and life experiences. The results show that dependence on natural resources in profession, experiences of natural disasters and life history in the residential area shape people's accurate perception to climate seasonality.

Key Words: Perception to seasonality change; natural resource dependence; experiences of natural disasters; life history; Bangladesh

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1 Introduction

Climate change impacts on the seasonal distribution of the weather anomalies worldwide. Such changes of weather will impact more in the areas where water availability and timing are important factors to control ecosystem (Weltzin et al., 2003). Climate change altered the seasonal distributions of rainfall in tropical areas (Easterling et al., 2000, Feng et al., 2013). Bangladesh is located in the tropical region and climatically endangered (Mechler and Bouwer, 2015). Islam and Kotani (2016) identify that, in Bangladesh, seasonality of temperature and precipitation patterns have changed over the last 25 years. Formerly, there were six seasons in Bangladesh and now there are just four. One of the main concerns of this seasonal change in Bangladesh is that many poor inhabitants will fall in the poverty trap due to their dependance on nature in subsistence life. To ensure the seasonal change adaptation and sustainable development, it is important to understand the possible important factors that shape individuals seasonal change perception. Therefore, this paper address the issue by conducting field survey in rural and urban areas of Bangladesh.

A group of research focus on the importance of personal experience of natural disaster on climate change perception based on the primary information by using questionnaire survey in various disaster-prone countries in the world. Frondel et al. (2017) identify that, in Germany, personal experiences of adverse events are strong drivers of climate risk perception. They establish that disaster experience guides individuls to shape their climate change perceptions. Dai et al. (2015) show that, in China, physical or financial damages due to extreme weather events are positively correalted with global climate change beliefs. Zaalberg et al. (2009) conduct survey on flood victims and non-victims in the Netherland and identify that victims perceive themselves as more vulnerable than non-victims to future flooding. Siegrist and Gutscher (2006) select the respondents from high and low flood risk areas of Switzerland and identify that respondents experiences of flooding is positively related with their flood risk perceptions. Overall, these studies identify that experience of disaster shaping individual's climate risk perception in different countries.

Several studies prioritize the importance of geographic location on correct perception of climate changes. Leiserowitz (2006), Gromet et al. (2013), Kahan et al. (2011), McCright and Dunlap

(2011) notice that climate change perceptions very geographically as a function of cultural and ideological factors. Generally, people live in same region for longer period of time cluster together based on these factors. Akerlof et al. (2013), Egan and Mullin (2012), Goebbert et al. (2012), Hamilton and Keim (2009), Howe et al. (2013), Capstick and Pidgeon (2014) conclude that geographic location is correalted with personal experience of extreme weather events and climate variability which shape individuals climate change perceptions. Overall, these studies identify that geographic location of individuals can be an important factor to shape individual's climate change perception.

Climate seasonality is likely to become more pronounced in Bangladesh, where daily life is dependent on the weather anomalies. Citizens may be able to reduce the impact of seasonal variability by adapting or adjusting their daily lives in response to weather stimuli. However, not all individuals may respond similarly to seasonal changes. To estimate the impact of future climate change, it is necessary to develop a predictive framework towards understanding who should adapt to seasonal changes and how and why they should do so. It could be hypothesized that there are several important determinants of individuals correct perception of the climate seasonality. To test this hypothesis, a field survey was conducted on the local residents of Bangladesh, where the dependance on natural resources in profession, natural disaster experience, and life history in the residential area are identified as important determinants of the climate seasonality perception.

2 Methods

We consider people's perception to climate seasonality as a main variable of our interest. In the study region, it has been hypothesized that the temperature and rainfall trends over the last 25 years have become less variant. The changes in the seasonal patterns are documented to be more clearly visible through visual observations and experiences to climate in the region, such as shorter winter, longer summer, less rainfall and so on (Alam and Rabbani, 2007). Islam and Kotani (2016) empirically establish that the annual calendar in the study region transitions from six seasons to four seasons by applying nonparametric statistical analyses to the meteorological data over the last 50 years. Building upon the evidences in the study region demonstrated by past literature, we address who perceive such climate seasonality by statistical analyses that will follow.

2.1 Study area

We choose the Meghna Basin area of Bangladesh as our study area because of frequent flooding and climate seasonality. Within the Meghna Basin, we select the administrative upazilas of Narsingdi Sadar and Roypura, because they are characterized by different production potentials. Narsingdi Sadar includes villages 1 – 14 (figure 1). Narsingdi Sadar is located between 23°46′ and 23°58′ north and between 90°36′ and 92°50′ east. According to the census of 2011, the total area of Narsingdi Sadar was 52 742 acres where 149 820 households lived, the population was 707 525 and the population density was 3315 km^{-2}. Roypura includes villages 15 – 37 (figure 1). Roypura is located between 23°55′ and 24°4′ north and between 90°44′ and 90°59′ east, and the area is 77 287 acres. There were 110 520 households, and the population was 535 796. The population density of Roypura was 1713 km^{-2}. Narsingdi Sadar had a higher industrial potential and Roypura a relatively high agricultural potential.[1]

[Figure 1 about here.]

The study areas had relatively uniform climate conditions with respect to temperature, high humidity, and heavy rainfall. They are located at a low altitude, and the average annual temperature ranges from 13 °C to 35 °C. Heavy rainfall usually occurs from June to October, which is the monsoon season. Three major rivers — the Meghna, Old Brahmaputra and Arial Khan — are the main water source for the area. Local agriculture is completely dependent on the natural water supply. During the monsoons, flooding is a normal part of the local ecology. The 1998 flood was the most serious in that region, destroying the economy of the whole area. It inundated over 70 % of the total land area and caused severe damage to lives and properties. In all, over 30 million

[1] Census 2011 information is available at www.bbs.gov.bd.

people were affected as were about 1 million homesteads. Riverbanks in the Meghna Basin are not protected by embankments. Locals have to resort to adaptation strategies to reduce the impacts of floods.

2.2 Data

This study uses primary data collected from the field survey. We design the survey to examine public perceptions to seasonality changes and the related issues: the aim is to elicit individual perceptions and obtain insight into the reasons for the correct perceptions. We use a general household as the unit of analysis and regard the earning male as the decision maker. A structured questionnaire is employed to collect the data. Care is given with the items in the survey questionnaire to ensure that respondents do not require expert knowledge to answer. The data were collected through interviews by research assistants using stratified random sampling. We conducted the survey with 1020 households. However, nine households did not complete the questionnaire, and we omitted them from the analysis. Thus, the final sample comprises 1011 respondents. We also survey seven experts that specialize in flood control; they answer the questions related to climate changes and perceptions of flood risk in the study area. We design a separate questionnaire to elicit the expert responses about various issues concerning climate change and flooding there. The results of the experts' interviews are not included in the statistical analysis; however, we reference their responses to ensure qualitative judgement throughout the study.

The questionnaire for general respondents comprises the following range of items: perceptions to climate change, in particular, seasonality changes; socioeconomic conditions and variables; damage from and experiences of major floods; participation in disaster risk management and adaptation measures; and life history in the residential area. We use the variables listed in table 1 for statistical analysis. Note that we have collected the climate data concerning seasonal changes in Bangladesh, demonstrating that the distributions of seasonal mean temperatures and mean rainfall anomalies have become homogeneous among the seasons. More specifically, climate variation has declined in the way that the annual calendar in the study area transitions from six to four seasons

(Islam and Kotani, 2016). Our survey is designed to check whether the respondents perceive such seasonality changes.

[Table 1 about here.]

Households in the study area are subject to the risks of seasonal flooding, and those who meet the criteria and participate in the survey were compensated for their time with a gift of an equivalent value. All the items in the questionnaire had to be answered. We categorize the flood experiences of respondents based on their financial losses from the 1998 flood. Three questions concerning climate change on local flood, sea level rise and climate change are posed as variables of information access. Bangladeshis have a moderate level of awareness of climate change. Figure 2 presents the respondents' overall climate change awareness and attitudes. Surprisingly, 78 % of respondents have knowledge about climate change. However, only 50 % consider climate change as an important issue. To obtain the respondents' perceptions of seasonality changes, we ask "Have you noticed seasonal changes in your area over the last 25 years?" Most respondents (65.28 %) think that such changes have not been evident, while the impact of climate change on the Meghna Basin should be considerable (Mirza, 2003, Masood and Takeuchi, 2015).[2]

[Figure 2 about here.]

2.3 Statistical analysis

We apply logit regression to model the respondents' perception to climate seasonality in relation to sociodemographic variables, experiences and information access. Whether or not a respondent perceives climate seasonality is expressed as a binary-choice model of logiti regression, assuming that the perception depends on observable factors. Let Y_i be a dummy variable taking $Y_i = 1$ when respondent i perceives seasonality change, otherwise $Y_i = 0$. The probability for respondent i to perceive climate seasonality, denoted by $\mathrm{Prob}(Y_i = 1)$, is assumed to follow

[2]That region will have played a major role in the occurrences of flooding in Bangladesh over the next several decades (Mirza, 2003). The peak flow of water in the basin is predicted to increase by 39.10 % during the monsoons and decrease up to 26.90 % in the dry season (Kamal et al., 2013).

the distribution function F evaluated at $X_i\boldsymbol{\beta}$ where X_i is a $1 \times (k+1)$ vector of explanatory variables for respondent i ($X_i = (1, x_{i1}, \ldots, x_{ik})$) and $\boldsymbol{\beta}$ is a $(k+1) \times 1$ vector of parameters ($\boldsymbol{\beta} = (\beta_0, \beta_1, \ldots, \beta_k)'$). The logit regression takes the following form of a distribution function:

$$\mathrm{Prob}(Y_i = 1) = \frac{\exp(X_i\boldsymbol{\beta})}{1 + \exp(X_i\boldsymbol{\beta})} \tag{1}$$

A specification of equation (1) enables us to estimate parameters $\boldsymbol{\beta}$ via maximum likelihood and the probability for a respondent to perceive climate seasonality in relation to explanatory variables (Wooldridge, 2016, 2010).

The explanatory variables used in this study include (1) education of household heads, (2) income, (3) natural resource dependence in profession, (4) losses in the 1998 flood, (5) flood information from neighbors, (6) living in an inherited house, (7) 20 years of residence in the study area, (8) distance of a house from nearest river and (9) information access about local flood risk, sea level rise and climate change risks. The definitions of the variables are summarized in table 1. We are also interested in identifying the marginal effect of each explanatory variable on the response probability of $\mathrm{Prob}(Y_i = 1)$, holding all other variables fixed. More specifically, we estimate the marginal impact on the probability for a respondent to perceive climate seasonality when one explanatory (dummy) variable increases by one unit (or changes from zero to one) via equation (1).

3 Results

In our analysis, the perception of seasonal changes in Bangladesh is the outcome variable which is guided by different socioeconomic, geographic, demographic and regional climate knowledge variables. The estimated coefficient of the variables and the marginal effect is reported in table 2. The binary logit model results identify the relationship between the seasonal change perception and the control variables we use in the model. We notice that education of the household head is an important variable to improve the probability of correct seasonal change perception. The marginal effect of the logit model shows that educated respondent have 6 % higher probability of correct perception than those without any formal education. These findings reflect the result of Kvaløy et al. (2012), where they identify positive correlation between education and the perception of global warming. Education improve the concern of seasonal changes and shape individual's perception of weather anomalies inconsistent patterns compared to previously experienced conditions.

[Table 2 about here.]

Income is one of the key indicators of individual's socioeconomic condition. This income level impacts on seasonal change perception in Bangladesh. In our analysis education is considered as a categorical variable and constructed 9 different categories after carefully observing the range of national level income group classifications. The average gap between each income group is approximately 5000 BDT (USD 65). Our logit regression result shows that change of income category from one group to the next increase the probability of correct seasonal change perception by 5 %. This change can be related with the fact that the low income group, who are more vulnerable to changing climate are less concerned about the seasonal changes in Bangladesh.

Livelihood and occupation in Bangladesh are not free from the dependence of nature. Traditional agriculture, fishery and agricultural related business are highly dependent on the changes of weather anomalies (e.g; rainfall, temperature). Having an occupation dependent on natural resources exerted a clear influence on perceiving climate seasonality. The regression results showed that the coefficient for such occupations was positive and significant. According to the estimated marginal effect, respondents with such occupations were 21 % more likely to perceive climate seasonality than other participants. Farming has a close interaction with the natural anomalies. As of our knowledge, no literature empirically analyze the individual's perception on seasonality change in relation to the natural resource dependence in occupation. Our result clearly shows that natural resource dependence in occupations have important impact on shaping the perception of weather anomalies. Climate change and natural disasters adversely impact production in many agriculture-dependent households. Thus, farming households are aware of climate variability and can identify the most common climate factors.

We observe that natural disaster victims have significant positive relationship to seasonal change perception. We found a clear difference between flood victims' and non-victims' knowledge and perceptions of seasonal change. Recently flood losses have sharply increased in Bangladesh. For instance, 1998 flood is one of the most devastating disasters Bangladesh has ever experienced and affected almost the whole country. We clearly notice that the probability of making a correct response to changes in seasonal trends by a 1998 flood victim as significantly positive. An household head who experienced losses of 1 lach BDT (1300 USD) had a 13 % higher probability of perceiving climate seasonality than one who did not suffer any loss. In addition, residents who received flood information from neighboring households had an 11 % higher chance of perceiving climate seasonality. These findings suggest that flood loss and information shape perceptions of climate change in Bangladesh. From our empirical findings, it is evident that local flooding experience provides opportunities to engage with the seasonality change perception. People may not take necessary action to mitigate climate change if they lack first-hand experience of its consequences. Better understanding of the mechanism that influences such perception may be relevant to communication strategies for risk management. Individuals having direct experience of incidents directly linked with seasonal change may undertake sustainable behavior.

We consider the residence time as a geographic factor that indicates individuals experience with the local weather. Long residence in an area allows people to observe climate changes and patterns. They can accurately compare previous and present conditions of climate variables. Long residence also allows the sharing of experience with others. We notice that inherit householders have interaction with local residents as well as with local environment. In addition, the experience from the ancestors also help to shape their personal perception in local Bangladesh. Our respondents share their experience beyond the structural questionnaire and most of them noticed their ancestor face less environmental variations than the present time. Our analysis suggest that individuals who have an inherit house in the area have 7 % higher possibility to perceive the changing seasonality in local Bangladesh compared to the individuals who don't receive any house inherently.

We also identify the distance of households from rivers as a geographic factor and it is an important variable regarding flood vulnerability. People living closer to rivers are concerned about water-related disasters. Riverbanks in the Meghna Basin lack embankments. Therefore, local communities are completely dependent on self-adaptation strategies. In this analysis, 53 % of respondents had been living in the study area for over 20 years. We found that longer residence could increase the probability of correct perception of climate change by 6 %. Long-term residence in an area promotes accurate understanding of local weather trends. Longer residence helps increase communication, which builds a stronger sense of community; it helps establish networks to share information and inspire people to adapt.

We find that information about flood risk among residents guided them in developing accurate perceptions of seasonal changes at the local scale. According to our estimated marginal effect, knowledge of local flood risk increased the likelihood of perceiving local climate change seasonality by 9 %. We observed no relationship between information about global climate change and perceptions of local seasonal changes. Our findings suggest that efforts to enhance public information about global climate change are not the crucial factor in improving perceptions of local seasonality change issues. Rather, information about local climate change risk is more appropriate for increasing local seasonality perceptions.

4 Conclusion

The present study examine the influence of profession, disaster experience, and socio-economic factors on perceiving climate seasonality. The development of mitigation and adaptation policies targeting local communities is guided by perceptions of climate change. This paper offers insights into adaptation to climate change by improving socioeconomic characteristics: it addresses the existing lack in the literature—especially in developing regions—and it presents an approach to recognizing climate seasonality. This empirical study finds that without personal experience, it is difficult for individuals to accurately perceive climate change. Having an occupation that is dependent on natural resources also increases an understanding of climate seasonality. Experience of flood damage raised the likelihood of correctly perceiving seasonal changes. Education also played an important role. Our results offer potentially important guidance for public risk perception. Simply considering people's risk perception may be insufficient, but it is important for resilience. To develop disaster-resilient communities towards finding better ways to manage risks for extreme and catastrophic events; perception of climate change is a key determinant in this regard.

Understanding and perceiving changed seasonality by natural-resource users is potentially important: it has an influence on their adaptation practices. We may hypothesize that people with flood experience are more likely to engage with climate change issues. Perceiving changes in local weather patterns is an important precursor to proactive adaptation to climate change. Individual perceptions of changes in local climate play an important role in shaping vulnerability to global climate change, adaptive behavior, and support for adaptation and mitigation policies. There is a wide discrepancy between climate change and accurate perception. Better education guide citizens to give greater weight to the local climate changes; that in turn shapes risk perceptions of the general public.

Awareness of climate change is particularly important in regions where much of the population is highly exposed and sensitive to the impacts of such changes. Understanding climate risks is important: it can influence adaptation practices and disaster management. The World population is going to be concentrated in urban cities within next 50 years and so on. Urbanization is taking place in Asia and Africa, and 65–75% of the world population will be concentrated in urban cities in Asia and Africa (Wigginton et al., 2016, McDonnell and MacGregor-Fors, 2016, Henderson et al., 2016). However, the perception about changing seasonality and climate change may become less likely to be predicted by the urban people who are less dependent on nature for their daily life. Therefore, it will be very difficult for the majority of population to become concerned about ongoing climate changes. This is alarming in the way that without clear climate change perception, societies may become reluctant to reduce the activities which can directly and indirectly affect the success of climate policies.

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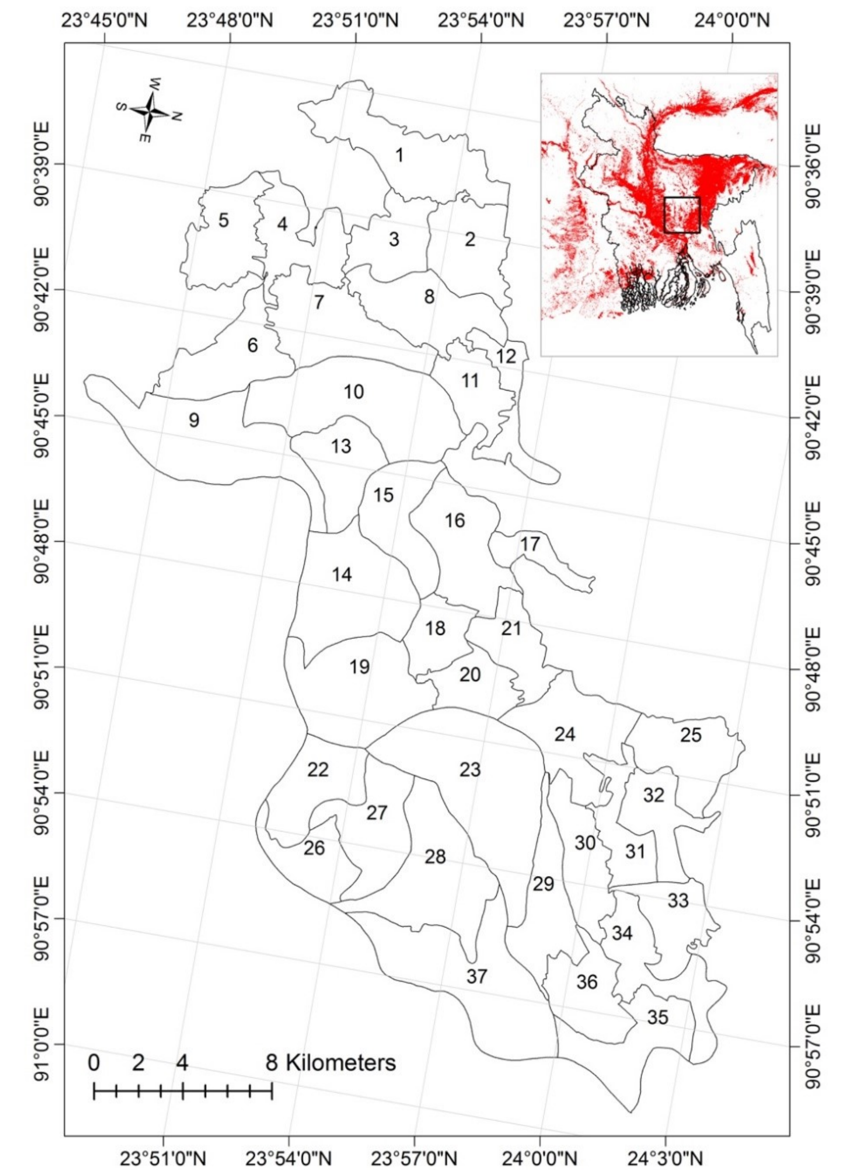
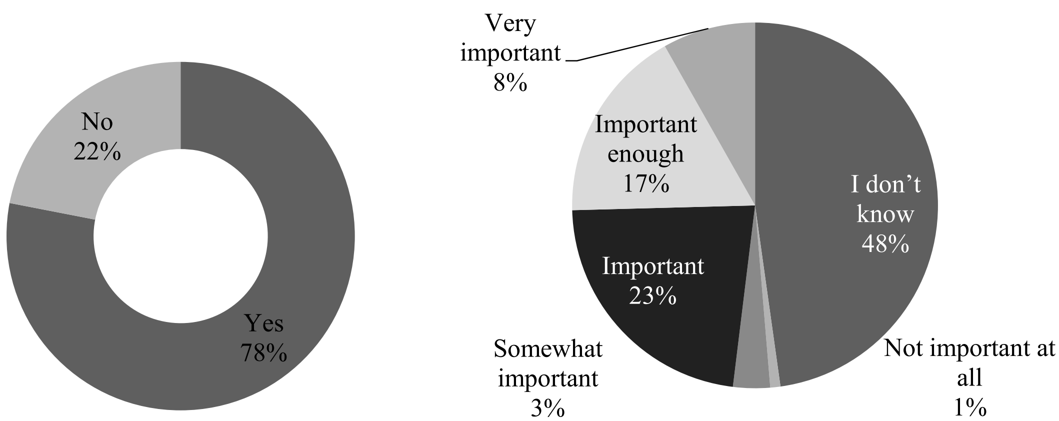
Figure 1: The Meghna basin area of Bangladesh





(a) Do you know about climate change? (b) How important is the climate change issue?

Figure 2: Respondents’ overall idea about climate change in the study area

List of Tables

Table 1: The variables in statistical analysis

Variable	Type	Description	Mean	SD
Dependent variable				
Seasonality change perception	Dummy	Correct perception = 1, otherwise 0	0.65	0.47
Independent variables				
Education[1]	Ordered categories	No eduction (0) to postgraduate (5)	0.11	1.19
Income[2]	Ordered categories	No income (0) to over 40 000 BDT (8)	3.37	1.75
Natural resource dependence[3]	Dummy	Natural resource dependence = 1, otherwise 0	0.95	0.22
Loss in 1998 flood	Continuous	Amount in lakh BDT[4]	0.56	0.9
Flood info from neighbors	Dummy	Flood info from neighbors = 1, otherwise 0	0.13	0.34
Living in an inherited house	Dummy	Living in an inherited house = 1, otherwise 0	0.51	0.50
Residing over 20 years	Dummy	Residing in the area over 20 years = 1, otherwise 0	0.53	0.50
Living near a river	Dummy	Distance to the nearest river $\leq$ 1 km = 1, otherwise 0	0.82	0.38
Information access				
to local flood	Dummy	Information access to local flood = 1, otherwise 0	0.32	0.46
to sea level rise	Dummy	Information access to sea level rise = 1, otherwise 0	0.30	0.46
to climate change	Dummy	Information access to climate change = 1, otherwise 0	0.27	0.45

[1] 0: illiterate, 1: primary school, 2: secondary school, 3: college, 4: bachelor's degree and 5: postgraduate degree
[2] 0: $<$ 5000, 1: 5000 - 9999, 2: 10000 - 14999, 3: 15000 - 19999, 4: 20000 - 24999, 5: 25000 - 29999, 6: 30000 - 34999, 7: 35000 - 39999 and 8: $\geq$ 40000
[3] It is whether a subject's profession is dependent on natural resources or not.
[4] 1 lakh BDT = 100 000 BDT = 1300 USD

Table 2: Estimation of the logit regression for respondents' perception to climate seasonality

Explanatory variable	Model	Marginal effect
Socio-economic		
Education	0.308***	0.059***
	(0.081)	(0.015)
Income	0.253***	0.048***
	(0.055)	(0.010)
Natural resource dependence in profession	1.102***	0.210***
	(0.309)	(0.058)
Natural disaster experience		
Loss in flood 1998	0.649***	0.124***
	(0.164)	(0.031)
Geographic location		
Living in an inherited house	0.360**	0.069**
	(0.157)	(0.030)
Residing over 20 years	0.322**	0.062**
	(0.150)	(0.028)
Living near a river	0.359*	0.069*
	(0.187)	(0.036)
Information		
Flood info from neighbors	0.578**	0.110**
	(0.241)	(0.046)
Information access to		
local flood	0.479*	0.091*
	(0.249)	(0.047)
sea level rise	−0.260	−0.050
	(0.251)	(0.048)
climate change	−0.188	−0.036
	(0.169)	(0.032)
Constant	−2.438***	
	(0.411)	
Sample size	1011	
LR χ^2 statistic	174.680	
Log-likelihood	−565.448	
Pseudo-R^2	0.134	

*** significant at 1 % percent level
** significant at 5 % percent level
* significant at 10 % percent level
Standard errors are in parentheses.