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Six or four seasons? Perceptions of climatic changes and people's cooperative attitudes toward flood protection in Bangladesh

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Abstract

Bangladesh is vulnerable to climatic changes, and there has been a serious debate about the occurrence and the relationship of a change in climate to the frequency of flooding. For example, areas of Dhaka are hypothesized to possess four seasons rather than the six seasons that have traditionally comprised the annual calendar. Despite the importance of this topic, it has received little research attention. Thus, we examine (i) whether a change in climatic patterns is occurring, and (ii) the perceptions and attitudes of people living in this area. We conducted face-to-face surveys with 1,011 respondents of different social and demographic strata and seven experts in Bangladesh. Using these data, we analyze how closely people's perceptions align with climate data, and whether six seasons are becoming four seasons. Finally, we characterize the determinants of people's cooperative attitudes toward flood controls by examining their willingness to pay (WTP). We obtain the following principal results. First, most people correctly perceive the nature of climate variables. Moreover, people's perceptions and our statistical analysis of climate are identical in indicating that the annual calendar is transitioning to four seasons. Second, people who correctly perceive climatic changes tend to express a higher WTP than those who do not. Overall, these findings suggest that a change in seasonal climatic patterns is occurring in the area. Informational and educational efforts related to accurate climate perceptions are keys to increasing cooperation into managing climatic change and related disasters.

Key Words: Climatic change, seasonal change, perception, willingness to pay, flood

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1 Introduction

Bangladesh is one of the most disaster-prone countries in the world because of its geographical setting [1]. 80% of the country's land is the floodplains, 10% is 1 m above the mean sea level (MSL) and one-third is under tidal influence. Thus, Bangladesh will be affected by more intense and frequent flood events in the future due to climate change [2, 3]. Despite the importance of this issue, few studies have examined people's perceptions of climatic change and cooperative attitude toward the associated flood controls. Therefore, this paper seeks to address these issues.

There is a rich body of literature on climate change and its potential impact on society. Some research claims that humans are a main cause of altered climatic patterns [4, 5, 3]. Temperature shows an increasing trend, and rainfall also reveals a significant increase in heavy precipitation and more variation over northern hemisphere land and the tropics [6, 7, 4, 5, 8, 9]. In particular, the rainfall is reported to increase the frequency of floods [8, 10, 11]. People's knowledge, perceptions of climate, and the relationship of these factors with attitudes are equally important because these issues are directly linked to the formulation of policies for climate change [12, 13].

In developed countries, numerous studies have examined the above questions. Previous research claims that highly educated people understand climate change, and express their knowledge in surveys [14]. Moreover, people who are more confident about the issue tend to be more cooperative, expressing a higher WTP for preventive actions toward climate change [15, 16, 17, 18]. In contrast, other studies show that socio-cultural and psychological factors impede cooperative attitude toward the preventive actions, even when people are knowledgeable about or confident about the issue [19, 20, 21, 22, 23]. Therefore, the relationship between knowledge and attitude toward climate change remains unsettled.

In developing countries, there have been relatively few studies on this subject. For instance, several works have examined local people's perceptions of climate change [24, 25, 26, 27]. The studies have found that people in developing countries demonstrate less understanding of climate change compared to people in developed countries and mis-perceive the temporal trends of key climate variables. Few works have examined the link between local people's perceptions and their cooperative attitudes or actions toward climatic change and the related disaster.

Given this gap in the literature, we study the perceptions of local people in Dhaka, Bangladesh as a representative case in a developing country. We clarify the relationship between people's perception and collective preventive action against climate change-related disasters. More specifically, we address the extent to which people in Bangladesh correctly perceive climate change by considering both climate data taken from weather stations and perceptions elicited in surveys. Furthermore, we examine whether people who correctly perceive climatic change, at least in a qualitative manner, are more cooperative toward flood controls. In this analysis, we use a "willingness to pay" measurement for flood controls as a good proxy of cooperative attitudes because the occurrence of climatic change in Bangladesh is known to increase the frequency of flooding in Dhaka [3].

To this end, we conducted a questionnaire survey of 1,011 respondents and seven experts to elicit their perceptions on key climate variables as well as their WTPs for flood controls. Additionally, we obtained corresponding climate data from three meteorological stations located in the same area. Using these two data sets, we first examine people's perceptions and compare them with actual climate data. Given these results, we derive a binary variable that takes the value of 1 when a respondent possesses correct perceptions of a climate event or variable, at least in a qualitative manner, and otherwise takes the value of 0. Using the binary and other factors as independent variables, we run a Tobit regression of WTP for flood controls to characterize people's cooperative attitudes in relation to correct perceptions of climate.

Based on this approach, our research addresses the following questions:

1. How close are people's perceptions of climate change to the climate data obtained from weather stations?

2. Is Bangladesh subject to four seasons or six seasons in an annual calendar, and what are people's perceptions of this possible seasonal change?

3. What factors affect WTP for flood damage protection, and do correct perceptions of climatic change lead to higher WTP?

None of the above questions have been explicitly addressed in the literature. Each question relates people's perceptions to their cooperative attitudes about climatic issues. Most importantly, our research poses a critical question of four or six seasons. Many people wonder that Bangladesh is now a four-season country when six seasons have traditionally comprised the annual calendar.

2 Study area and data collection

2.1 Study area

The Meghna Basin area of Bangladesh was selected as a study area because it is vulnerable to climatic changes and frequent flooding. Within the Meghna Basin area in central Bangladesh, the administrative Upazilas—Narsingdi Sadar and Raipura were chosen. The two Upazilas are characterized by different production potentials. Figure 1 is a map of the research area. The household is a unit of analysis, because it is the decision-making unit in livelihood processes, with the senior and earning male person household member as the decision maker. The survey was conducted in 2011 and 2012. The climatic conditions in Raipura and Narsingdi Sadar have relatively uniform temperatures, high humidity, and heavy rainfall. Heavy rain usually occurs from June to September. The average annual temperature ranges from 13°C to 35°C. The rivers in the Upazilas are Meghna (the most important), Old Brahmaputra, Arial Khan and Kakan. Because Raipura Upazila and Narsingdi Sadar Upazila are plain lands, the Meghna floods, especially in the rainy seasons.

[Figure 1 about here.]

2.2 Questionnaire and field survey

The structured questionnaire was used to collect qualitative data on household socio-economic characteristics, such as socio-demographic status, information sources at the household level, approximate losses in four major floods (in 1988, 1998, 2004, and 2007 in Bangladesh), WTP for flood protection, and perceptions of climate change. The participants were local people from various backgrounds including farmers, businessmen, teachers, public officials and others. The heads of the households usually answered the survey questions. Pilot field surveys were conducted to improve a first draft of the questionnaire. Then, the questionnaires was carefully modified to ensure that understanding and answering the questions would not require an academic background or expert knowledge.

Our survey included seven well-reputed experts in Bangladesh specializing in meteorology and flood controls, who also answered questions related to climatic change and whether six seasons are becoming four seasons. The results of experts' interviews are not used in the analysis, however, these results were referenced when necessary for qualitative judgments of the analysis. Fifteen villages in Narsingdi Sadar Upazila were selected; one was excluded because of poor accessibility. Of 14 selected villages in Raipura, all were successfully surveyed. In each village, households were chosen by random sampling. The interviews were conducted by 16 field research assistants during the period from December 24, 2011 to January 14, 2012. The survey involved 1,011 residents from 14 villages, including low-, medium- and high-density population areas.

2.3 Meteorological data

Daily climate data were collected from the Bangladesh Meteorological Department. They include daily rainfall, daily average temperature, daily maximum temperature and daily minimum temperature. First, to capture local climatic changes, we examined data from three nearby weather stations from 1985 to 2010. An average value of the daily climate data over the three stations was used as a benchmark throughout this analysis. The average distances of the stations from our survey areas are as follows: Dhaka, 38.4 km, Comilla, 71.44 km and Chandpur, 77.64 km. We found no significant qualitative difference among these three stations with respect to the data quality and the corresponding climatic pattern. The data are of good quality with few missing observations. On the one hand, to identify a change from six to four seasons, we used only Dhaka station's data from the last 57 years because the station has unique data covering more than 50 years and is closest to the study area. Figure 2 summarizes the data collection procedure.

[Figure 2 about here.]

3 Methodology and data analysis

3.1 Climatic change

We focus first on climate variables related to rainfall and temperature for our analysis. Eight important climate variables were selected (table 1), however, the only one of them is presented with the detailed graphical analysis in this paper for the purpose of illustration: precipitation in monsoon. For the rest of the seven variables, we present only the final result. We analyzed these climate variables over the years 1985 to 2010 and derive a temporal trend of each climate variable. A time series plot of the climate variables is drawn and we estimate the coefficient of the temporal trend in these climate variables by regression analysis. If the value of the coefficient is larger than 1%, it is considered "increasing." If it is less than −1%, it is "decreasing." When the absolute value is less than 1%, it is "no change."

[Table 1 about here.]

Respondents were asked what the climate in the study areas were like 25 years ago to access their perceptions of normal climate patterns. We then asked what the climate are like today and posed some further questions related to changes in climate variables over time. Each respondent was asked to give at least a qualitative answer of "increasing," "no change," or "decreasing". When their qualitative perceptions of climate variables were identical to the coefficients of temporal trends estimated from climate data, we say that the respondents correctly perceive the change in climatic patterns.

3.2 Seasonal change from six to four seasons

An annual calendar in Bangladesh traditionally comprises six seasons of the Bangla calendar (table 2). In our survey, a large share of respondents claim that it is changing to four seasons. To test whether people's perceptions of seasonal changes are in line with climate data, we analyze four climate variables: average daily maximum temperature, average daily minimum temperature, average daily mean temperature and average daily rainfall.

[Table 2 about here.]

We examined all possible pairs of two consecutive seasons in the Bangla calendar to identify whether the two seasons are merging into a single season. First, we began with a simple graphical analysis to observe the temporal trend of climate variables over the years of 1953 to 2010 in each season of the two. We applied non-parametric Mann-Whitney tests by dividing the sample of a climate variable in each season into two subsamples. Each subsample represents data from 1953 to 1984 as a "old" subsample of the season or data from 1985 to 2010 as the "recent" subsample.

Mann-Whitney tests were used to compare the subsamples of a climate variable in the same period (old or recent periods). The hypotheses can be posed as follows:

- H_0: The two "old" (or "recent") subsamples of a climate variable over the two consecutive seasons follow an identical distribution.
- H_A: The two "old" (or "recent") subsamples of a climate variable over the two consecutive seasons follow different distributions.

The tests conclude whether a pair of two neighboring seasons within the six-season calendar are converging. When the two seasons do not merge, the Mann-Whitney test rejects the null for both old and recent subsamples of the two seasons. When the two seasons are converging, the null hypothesis is rejected with the old subsamples, but not with the recent subsamples. This means that the two seasons were different, but not in the recent period.

3.3 WTP for flood controls

To identify the determinants of people's cooperative attitudes toward flood damage protection, a Tobit regression is applied. In our survey, respondents indicated their WTP for flood protection by considering the four major floods that occurred in the last 25 years in Bangladesh. The basic assumption is that WTP may be a good proxy for people's cooperative attitudes and may depend on their socio-economic household characteristics, knowledge, information, correctness of climate perceptions and experiences. The underlying regression is formulated as follows:

$$\text{WTP} = f(\text{socioeconomic characteristics, experiences and correctness of perceptions}) + \epsilon,$$

where table 3 summarizes the definition of explanatory variables included in the Tobit regressions.[1]

[Table 3 about here.]

4 Results and discussion

4.1 Climatic change

Figure 3 plots the average rainfall on rainy days for each monsoon season. All four monsoon months in subfigures 3(a), 3(b), 3(c) and 3(d) show that the average monthly

[1]Correctness of perception is a dummy variable which takes the value of 1 when a respondent correctly answered the temporal trend of a climate variable in the survey. As mentioned earlier, the estimated coefficient of the temporal trend is larger than 1%, it is considered "increasing." When a respondent answered "increasing," then the dummy becomes 1, otherwise 0.

rainfall over each month increased from 1985 to 2010. Pooling the monthly plot from June to September, subfigure 3(e) also shows the increasing trend over time with the estimated coefficient of 2%.[2]. Our survey results suggest that people's perceptions are consistent with the change in this climate variable. Of 1,011 individuals, 744 respondents, approximately 72.6% of the sample population, answered "increasing" in the survey and correctly perceived the change in monsoon rainfall (figure 4, column 1), but 27.4% of the sample population underestimated the change (figure 4, column 1).

[Figure 3 about here.]

[Figure 4 about here.]

As mentioned earlier, we only presented the time series plots of the one climate variables out of the eight variables for an illustrative purpose. For the rest of the seven climate variables, we conducted the same type of analysis and the corresponding results are summarized in figure 4. More concretely, we developed a time series plot of each month in the season of monsoon, non-monsoon or winter as well as the aggregate time series plot of pooling the climate data of each month. After this, we estimate the coefficient of the temporal trend and compare it with climate perceptions of the respondents. Finally, we calculate how many percentage of the respondents correctly perceive the temporal trend of a climate variable in a qualitative manner. From figure 4, we can see that a majority of Bangladeshi people in the study areas correctly perceive the temporal trend of the climate variables with the percentage of more than 80%.

4.2 Seasonal change from six to four seasons

We examine whether six seasons become four seasons in the Bangla annual calendar. To test this hypothesis, we analyzed all possible pairs of neighboring seasons. However, only

[2]Note that the estimated coefficient of the temporal trend is derived from regression analysis of the time series data of the climate variable plotted in subfigure 3(e)

the results of the two pairs are presented in this subsection, because they are the only pairs that support the "merging" hypothesis.

4.2.1 Rainy season vs. pre-autumn season

The rainy and pre-autumn seasons are consecutive Bengali seasons (table 2). However, we hypothesize that in recent years, the seasons have been converging. We focus on average daily minimum, maximum and mean temperatures and rainfall for the rainy and pre-autumn seasons (figure 5). Subfigures 5(a), 5(b) and 5(c) are the time series plots of the average daily minimum, maximum and mean temperatures for the rainy and pre-autumn seasons from 1953 to 2010, respectively. They show an increasing temporal trend, and the coefficients of the trend lines in each subfigure are greater for pre-autumn season than for the rainy season. The pre-autumn temperatures were lower than those for the rainy season, but the two seasons are converging over time. The trend lines for the pre-autumn season cross those in the rainy season in all three subfigures 5(a), 5(b) and 5(c).

[Figure 5 about here.]

Regarding rainfall, figure 5(d) plots the daily average rainfalls in the rainy and autumn seasons from 1953 to 2010. This figure shows that the temporal trend in the rainy season is constant, whereas it is increasing in the pre-autumn season. Consequently, the trend lines for the two seasons cross (see figure 5(d)). The single crossover suggests that the daily average rainfalls in the rainy and pre-autumn seasons are converging. The Mann-Whitney tests for the rainy *vs.* pre-autumn seasons examine the null hypothesis of "merging" that the two subsamples (the rainy *vs.* pre-autumn seasons) of the old (or recent) period (1953-1984) follow an identical distribution for each climate variable. Table 4(a) shows that climate variables in the rainy and pre-autumn seasons differ in old subsamples, but not in recent subsamples, supporting our hypothesis that the rainy and pre-autumn seasons are converging.

[Table 4 about here.]

4.2.2 Summer season vs. rainy season

The summer and rainy seasosn are consecutive Bengali seasons (table 2). These two seasons are hypothesized to be converging. For this, we follow the same procedure as before. Figure 6 consists of four subfigures with time-series plots of climate variables for the two seasons. Each subfigure shows that climate variables of the two seasons are becoming closer over time. In particular, subfigures 6(a), 6(c) and 6(d) are consistent with this trend for the minimum, mean temperature and rainfall, respectively. The two trend lines (summer *vs.* rainy) for each climate variable cross except the maximum temperature of subfigure 6(b). Based on the observations summarized in figure 6, the rainy and summer seasons are converging. Subtable 4(b) presents the result of Mann-Whitney tests, suggesting that for old subsamples, minimum temperature, maximum temperature and rainfall differ, while mean temperature does not. For recent subsamples, only maximum temperature significantly differ. The results supports that the rainy and summer seasons are converging.

[Figure 6 about here.]

The results presented in this subsection for this seasonal change is quite consistent with the perceptions of local people. According to the household survey from the study area, 660 respondents (660/1,011, 65%) perceived the change from six to four seasons (figure 4, column 9). In contrast, 351 respondents did not perceive any such change. Furthermore, seven experts asserted that this change is occurring. Overall, the statistical analysis, people's perceptions and experts' opinions are consistent in this regard.

4.3 People's cooperative attitudes and perceptions

Table 5 represents the regression results for WTP (taka) corresponding to floods in 1988, 1998, 2004 and 2007, respectively. The table contains the marginal effect representing the change in WTP when an independent variable increases by one unit. We only focus on knowledge of climate change, advance access to flood information and perceptions. For the other independent variables with statistical and economic significance in the result, most of them follow our intuition and are not our focus. Therefore, we omit the interpretation of the independent variables.

Table 5 shows strong positive effects of these variables on WTP for all regressions. This result suggests that people who have some degree of knowledge related to climate change as well as access to information on flooding prior to the event are willing to pay more for control measures. Finally, we focus on the perception-related independent variables including "a seasonal change from six to four seasons," "precipitation in the monsoon season," "precipitation in the non-monsoon months," and "extremely rainy days." All of the coefficients of these perception variables are positive and statistically significant. In addition, the marginal effect on WTP are economically significant. These results imply that people who correctly perceive changes in climate over time tend to exhibit higher WTP.

[Table 5 about here.]

5 Conclusion

Our results have some important implications. First, most Bangladeshi people in our survey correctly perceive trends in climate variables. Moreover, people's perceptions and our statistical analysis of climate are consistent with each other in a seasonal change, i.e., the annual calendar in Bangladesh is changing from six to four seasons. Second, people who correctly perceive climatic changes tend to express a higher WTP than those who do not, implying that WTP is positively correlated with correct perceptions of climate. Overall, these findings suggest that a change in seasonal climatic patterns is occurring in the area and that information provision and education associated with correct perceptions of climate are keys to improving cooperation in managing climate change and its related disasters.

6 References

[1] Roy Brouwer, Sonia Akter, Luke Brander, and Enamul Haque. Socioeconomic vulnerability and adaptation to environmental risk: A case study of climate change and flooding in Bangladesh. *Risk analysis*, 27(2):313–326, 2007.

[2] Q. Schiermeier. Extreme measures. *Nature*, 477:148–149, 2011.

[3] Q Schiermeier. Increased flood risk linked to global warming. *Nature*, 470(7334):316, 2011.

[4] Nicholas Stern. *The economics of climate change*. Cambridge university press, 2006.

[5] William R. Cline. *Global warming and agriculture: Impact estimates by country*. Peterson institute, 2007.

[6] James Hansen, Makiko Sato, Jay Glascoe, and Reto Ruedy. A common-sense climate index: Is climate change noticeable? *PNAS*, 95:4113–4120, 1998.

[7] W.N. Adger, S. Huq, K. Brown, D. Conway, and M. Hulme. Adaptation to climate change in the developing world. *Progress in development studies*, 3(3):179–195, 2003.

[8] M. L. Parry, O.F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson. *Climate change 2007: Impacts, adaptation and vulnerability*. Intergovernmental Panel on Climate Change, 2007.

[9] J. Hansen, M. Sato, and R. Ruedy. Perception of climate change. *PNAS*, 109(37):E2415–E2423, 2012.

[10] P. Pall, T. Aina, D. A. Stone, P. A. Stott, T. Nozawa, A. G. J. Hilberts, D. Lohmann, and M.R. Allen. Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000. *Nature*, 470(7334):382–385, 2011.

[11] S. K. Min, X. Zhang, F. W. Zwiers, and G. C. Hegerl. Human contribution to more-intense precipitation extremes. *Nature*, 470(7334):378–381, 2011.

[12] Christina Tobler, Vivianne H.M. Visschers, and Michael Siegrist. Consumers' knowledge about climate change. *Climatic change*, 114:189–209, 2012.

[13] Christina Tobler, Vivianne H.M. Visschers, and Michael Siegrist. Addressing climate change: Determinants of consumers' willingness to act and to support policy measures. *Journal of environmental psychology*, 32:197–207, 2012.

[14] W. Kip Viscusi and Richard J. Zeckhauser. The perception and valuation of the risks of climate change: A rational and behavioral blend. *Climatic change*, 77(1-2):151–177, 2006.

[15] Jan C. Semenza, David E. Hall, Daniel J. Wilson, Brian D. Bontempo, David J. Silor, and Linda A. George. Public perception of climate change: Voluntary mitigation and barriers to behavior change. *American journal of preventive medicine*, 35:479–487, 2008.

[16] Sonia Akter and Jeff Bennett. Household perceptions of climate change and preferences for mitigation action: The case of the carbon pollution reduction scheme in Australia. *Climatic change*, 109(3):417–436, 12 2011.

[17] Sonia Akter, Jeff Bennett, and Michael B. Ward. Climate change scepticism and public support for mitigation: Evidence from an Australian choice experiment. *Global environmental change*, 22:736–745, 2012.

[18] A. Spence, W. Poortinga, C. Butler, and N. F. Pidgeon. Perceptions of climate change and willingness to save energy related to flood experience. *Nature climate change*, 1(1):46–49, 2011.

[19] A. Henderson-Sellers. Australian public perception of the greenhouse issue. *Climatic change*, 17(1):69–96, 1990.

[20] Robert E. O'Connor, Richard J. Bord, and Ann Fisher. Risk perceptions, general environmental beliefs, and willingness to address climate change. *Risk analysis*, 19(3):461–471, 1999.

[21] Anthony Leiserowitz. Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climatic change*, 77(1):45–72, 2006.

[22] Suraje Dessai and Catherine Sims. Public perception of drought and climate change. *Environmental harzard*, 9:340–357, 2010.

[23] Henny Osbahr, Peter Dorward, Roger Stern, and Sarah Cooper. Supporting agricultural innovation in Uganda to respond to climate risk: Linking climate change and variability with farmer perceptions. *Experimental agriculture*, 47(2):293–316, 2011.

[24] Neeraj Vedwan and Robert E. Rhoades. Climate change in the Western Himalayas of India: A study of local perception and response. *Climate research*, 19:109–117, 2001.

[25] Ibidun O. Adelekan. Analysis of the public perception of climate change issues in an indigenous African city. *International journal of environmental studies*, 62:115–124, 2005.

[26] Neeraj Vedwan. Culture, climate and the environment: Local knowledge and perception fo climate change among apple growners in Northwestern India. *Journal of ecological anthoropology*, 10:4–18, 2006.

[27] Ole Mertz, Cheikh Mbow, Anette Reenberg, and Awa Diouf. Farmers perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental management*, 43(5):804–816, 2009.

Figure 1: A map of the study area. The left map depicts the positions of 34 ground-base weather stations located in Bangladesh with each station marked by a circle on the map. The right map shows the position of Narsingdi Sadar and Raipura Upazilas in Narsingdi District, where we conducted surveys

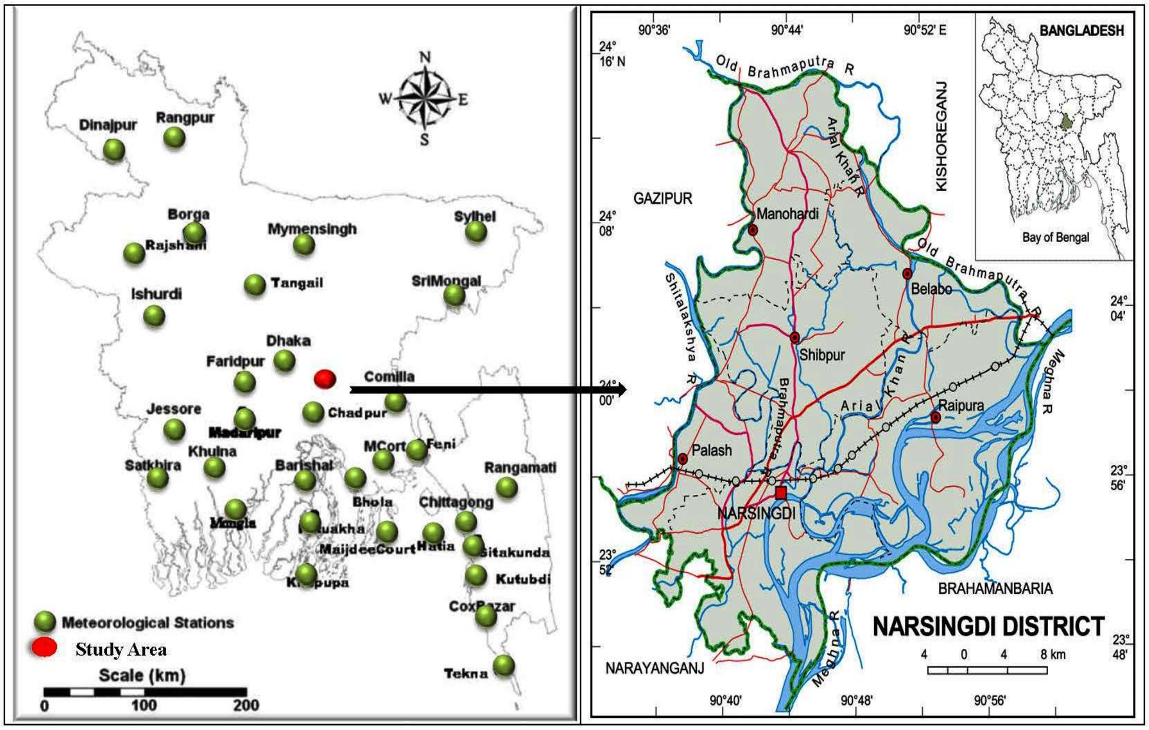
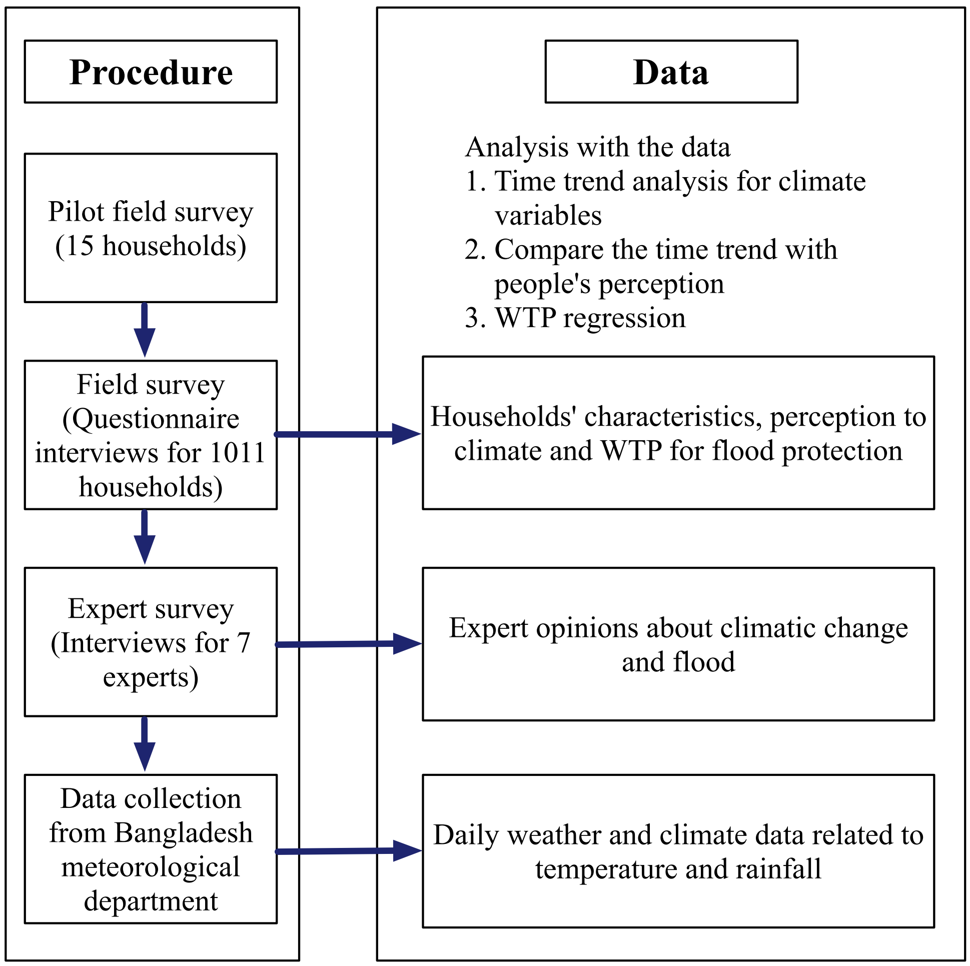
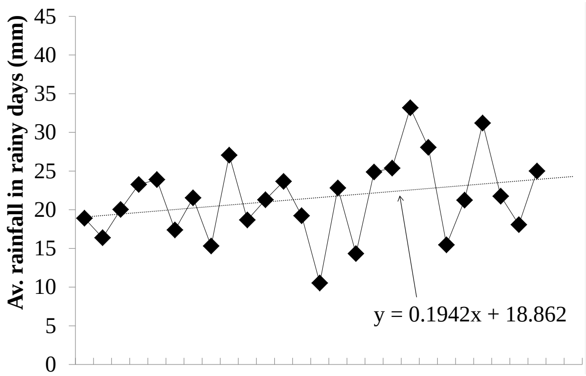
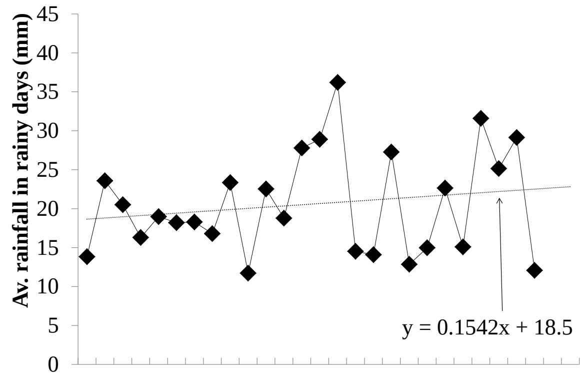


Figure 2: The entire procedure of data collection

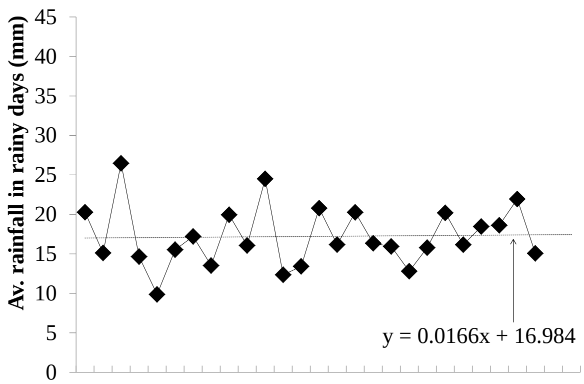




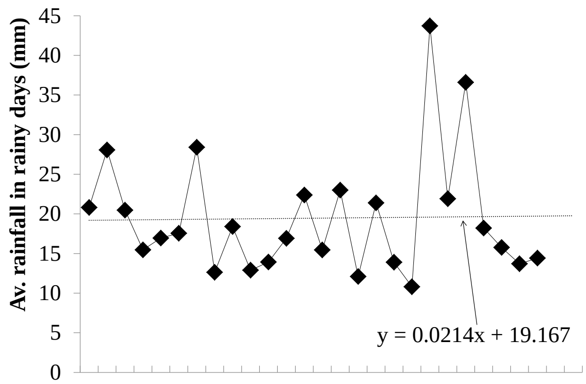
(a) June



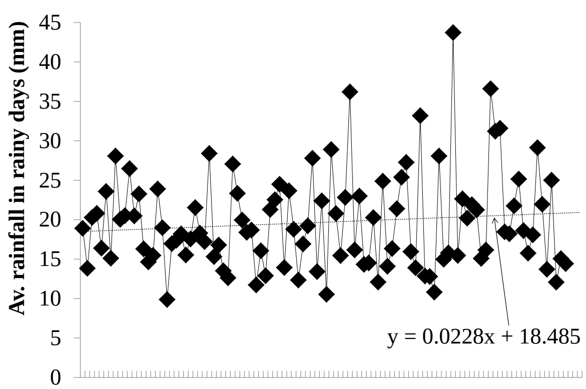
(b) July



(c) August



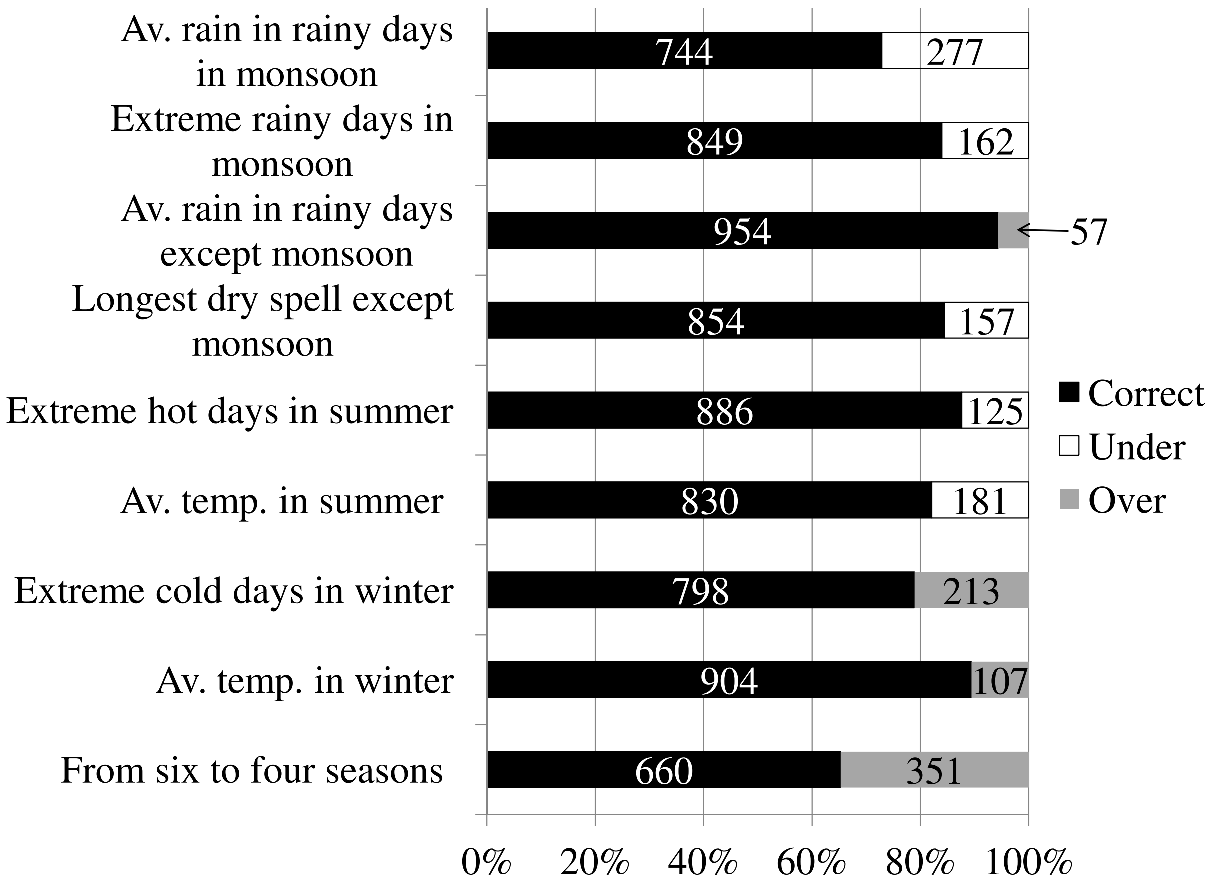
(d) September

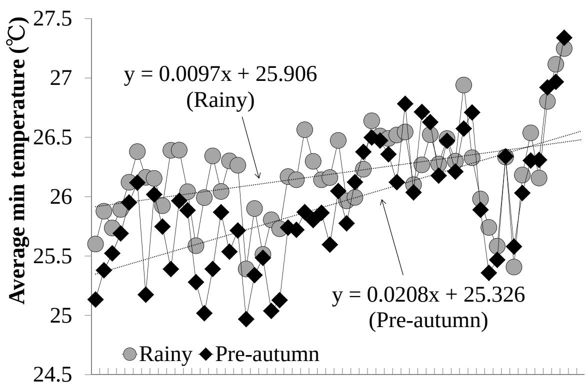


(e) Average rainfall on rainy days for monsoon months by pooling all monsoon months of June, July, August and September

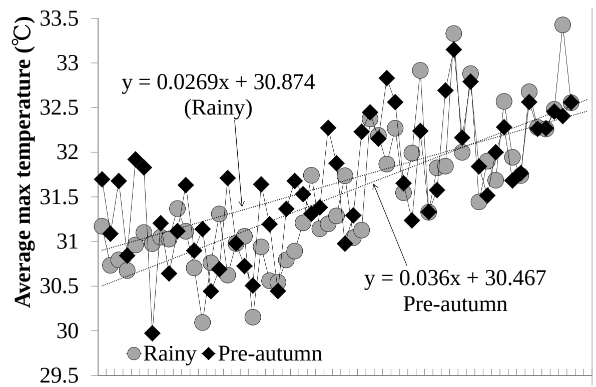
Figure 3: Average rainfall on rainy days for monsoon months from 1985 to 2010

Figure 4: The distribution of people's perceptions of climate variables in terms of correct estimates, overestimates and underestimates

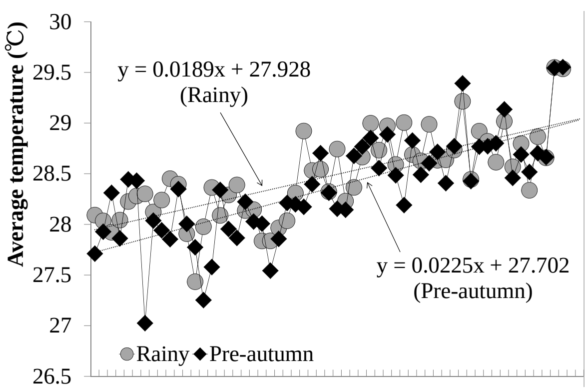




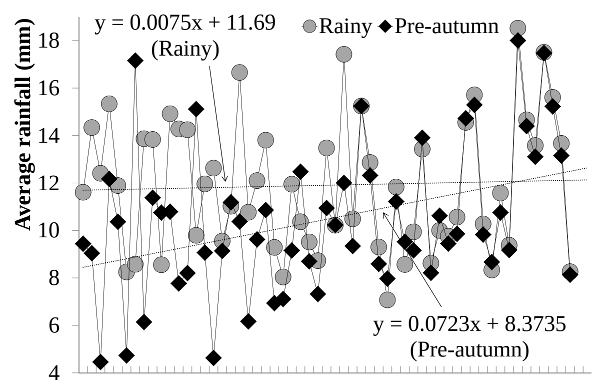
(a) Average daily minimum temperature in the rainy and pre-autumn seasons from 1957 to 2010



(b) Average daily maximum temperature in the rainy and pre-autumn seasons from 1957 to 2010

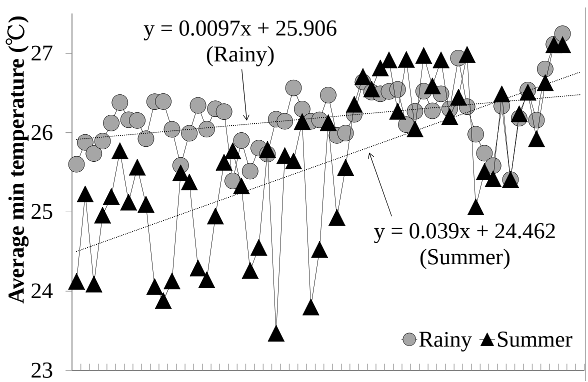


(c) Average daily mean temperature in the rainy and pre-autumn seasons from 1957 to 2010

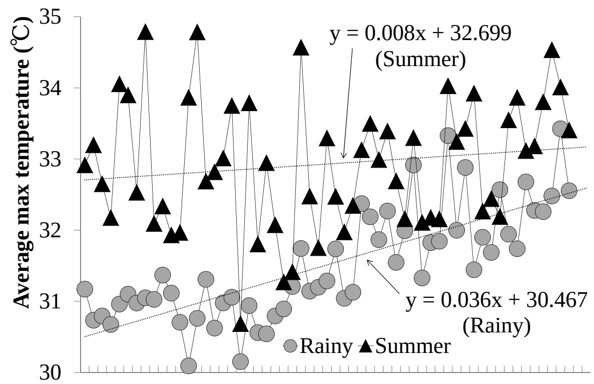


(d) Average daily rainfall in the rainy and pre-autumn seasons from 1957 to 2010

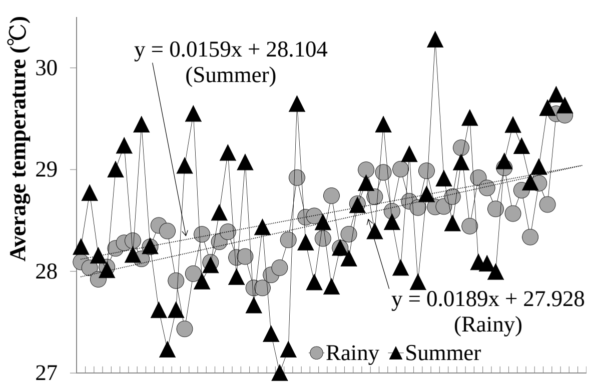
Figure 5: Rainy season vs. pre-autumn season with respect to average daily maximum, minimum and mean temperatures and average daily rainfall



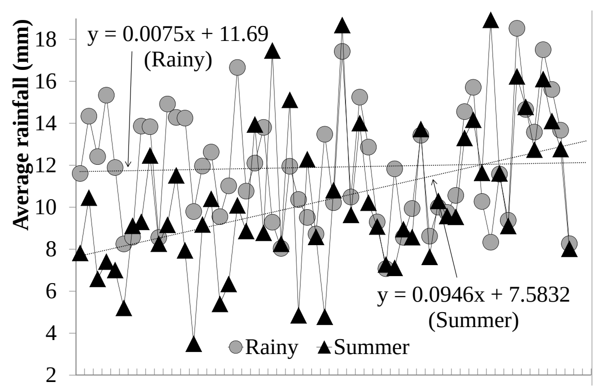
(a) Average daily minimum temperature in rainy and summer seasons from 1957 to 2010



(b) Average daily maximum temperature in rainy and summer seasons from 1957 to 2010



(c) Average daily mean temperature in rainy and summer seasons from 1957 to 2010



(d) Average daily rainfall in rainy and summer seasons from 1957 to 2010

Figure 6: Rainy season vs. summer season with respect to average daily maximum, minimum and mean temperatures and average daily rainfall

Table 1: Climate variables in terms of people's perceptions and the reason for the selection

Climate variable	**Definition**	**Reason**
Precipitation in monsoon months[*]	Daily average rainfall in rainy days in monsoon months where rainy days are days with $\geq 2\ mm$ of rainfall.	Represents rainfall
Number of extremely rainy days in monsoon season	Extreme rainy days in monsoon season where $\geq 100\ mm$ of rainfall is observed in a single day	Indicator of excessive rainfall and flood
Precipitation in non-monsoon months[**]	The average rainfall on rainy days in non-monsoon months where rainy days indicate a day with $\geq 2\ mm$ of rainfall.	Represents rainfall
Longest dry spell in non-monsoon months	Number of maximum consecutive rainless days in non-monsoon months	Represents drought and its impact on domestic agriculture
Extremely hot days in summer months[***]	Number of days in which the daily maximum temperature ≥ 35 °C	Responsible for disease outbreaks and natural disasters
Temperatures in summer months	Maximum, minimum and mean temperatures in summer months	Real importance for everyday life and summer agriculture
Extremely cold days in winter months[†]	Number of days where the daily minimum temperature is ≤ 13 °C	Responsible for damage to agriculture and diseases
Temperature in winter months	Maximum, minimum and mean temperatures in winter months	Real importance for daily life and winter agriculture.

∗ "Monsoon months" are June, July, August and September.

∗∗ "Non-monsoon months" are January, February, March, April, May, October, November and December.

∗ ∗ ∗ "Summer months" are March, April and May.

† "Winter months" are December and January.

Table 2: Bangla calendar

Bangla season	**Bangla calendar**	**Gregorian calendar**	**Days**
Summer	Baishakh	14 April - 14 May	31
	Jaishtha	15 May - 14 June	31
Rainy season	Ashar	15 June - 15 July	31
	Shraban	16 July - 15 August	31
Pre-autumn	Bhadra	16 August - 15 September	31
	Ashwin	16 September - 15 October	30
Late-autumn	Karttik	16 October - 14 November	30
	Agrahayan	15 November -14 December	30
Winter	Paush	15 December - 13 January	30
	Magh	14 January - 12 February	30
Spring	Falgun	13 February - 13 March	30*
	Chaitra	14 March - 13 April	30

∗ It becomes 31 in leap year.

Table 3: Description of variables used in WTP Tobit regressions

Explanatory variable	**Description**
Education	Education level of the household head
Household income	Total income of the household
Household condition	Materials of which the house made
Family structure	Single family or joint family
Residential time	How many years the household has been living in this place
Household members	Number of household members
Household distance from river	Distance of the household from the nearest river
Loss 1988	Total amount of loss from 1988 flood
Loss 1998	Total amount of loss from 1998 flood
Flood preparedness	Preparation (to some extent) for flooding
Knowledge of climate change	Whether a respondent has some knowledge of climate change
Access to flood information	Whether a respondent had access to information on flooding in advance of the event
Perception of change from six to four seasons	Whether a respondent thinks that there is a seasonal change from six to four seasons
Perception of monsoon precipitation	Whether a respondent correctly perceives a temporal trend in monsoon precipitation
Perception of non-monsoon precipitation	Whether a respondent correctly perceives a temporal trend in non-monsoon precipitation
Perception of extreme rainy days	Whether a respondent correctly perceives a temporal trend in precipitation on extreme rainy days

Table 4: Mann-Whitney test to compare the two seasons for each climate variable in both old and recent periods

(a) Rainy season vs. Pre-autumn season

Subsample	Min temp	Max temp	Mean temp	Rainfall
Old	4.726^{***}	2.256^{**}	1.772^{*}	3.223^{*}
Recent	0.126	0.34	0.31	0.941

(b) Rainy season vs. Summer season

Subsample	Min temp	Max temp	Mean temp	Rainfall
Old	5.948^{***}	-6.432^{**}	-0.121	3.357^{*}
Recent	-0.708	-4.104^{***}	-0.805	0.437

Note: $*$Significant at the 10% level, $**$Significant at the 5% level, $***$Significant at the 1% level.

	WTP for flood 1988		**WTP for flood 1998**		**WTP for flood 2004**		**WTP for flood 2007**	
	Coef.	$\frac{\partial \mathbb{E}(y\|\mathbf{x})}{\partial x}$	Coef.	$\frac{\partial \mathbb{E}(y\|\mathbf{x})}{\partial x}$	Coef.	$\frac{\partial \mathbb{E}(y\|\mathbf{x})}{\partial x}$	Coef.	$\frac{\partial \mathbb{E}(y\|\mathbf{x})}{\partial x}$
Education	155.19***	107.41***	148.04***	102.12***	121.91***	81.33***	103.39***	67.70***
Household income	72.45***	50.15***	60.46***	41.47***	57.81***	38.56***	60.11***	39.36***
Household condition	81.76**	59.59**	73.57*	50.47*	94.79***	63.24***	87.23***	57.12***
Family structure	132.57**	90.43***	101.01*	68.55*	91.59*	60.38*	105.07**	67.74**
Resident time	57.45***	39.76***	44.26**	30.36**	43.23***	28.84***	34.05***	22.30***
Household members	-13.87*	-9.56*	-8.43	-5.78	-13.32**	-8.88**	-15.69***	-10.28***
Household distance from river	-32.57	-22.54	-36.14	-24.79	-32.13	-21.43	-40.12*	-26.27*
Loss 1988	0.00050	0.00035	0.00024	0.00016	0.00066	0.00044	0.00044	0.00029
Loss 1998	0.0014**	0.0010**	0.0019**	0.0013**	0.00064	0.00042	-0.00011	-0.000074
Flood preparedness	286.48***	208.03***	254.96***	182.53***	236.13***	165.22***	161.06***	109.54***
Climate change knowledge	151.11***	101.62***	179.28***	118.89***	156.09***	100.51***	120.11***	76.25**
Flood information in advance	145.34***	100.31***	162.07***	110.84***	151.80***	100.93***	127.96***	83.52***
Six to four seasons	450.38***	296.48***	466.65***	304.19***	371.28***	236.05***	327.08***	204.11***
Precipitation in monsoon	278.97***	176.73***	271.29***	171.05***	232.46***	142.21***	214.29***	128.08***
Precipitation in non-monsoon	327.57***	215.16***	351.97***	228.41***	248.05***	158.00***	185.56***	116.85***
Extreme rainy days	527.70***	319.30***	541.43***	324.35***	452.93***	264.00***	402.58***	230.03***
Constant	-2101.90***		-2024.21***		-1771.58***		-1453.98***	
F	24.87***		24.09***		21.68***		18.85***	

Table 5: WTP regressions