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Perceptions to climatic changes and 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 with the frequency of flooding. For example, in Dhaka, further flood controls are claimed to be necessary due to a change of climatic patterns and more frequent flood events. Despite the importance of this topic, it has received little research attention. Thus, we examine (i) whether a temporal change in climate variables is occurring, (ii) local people's perceptions to climate and (iii) cooperative attitudes toward flood controls. 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 first derive a temporal trend of climate variables and analyze how closely people's perceptions align with the climate data. Second, we examine the willingness to pay for flood controls as a proxy of cooperative attitudes, and characterize the determinants in relation to perceptions to climate as well as socio-economic characteristics. We obtain the following principal results. First, some climate variables are identified to exhibit clear upward or downward trends, but most people correctly perceive such temporal changes. More specifically, people's perceptions and our statistical analysis are identical in the qualitative changes of climate. Second, people who correctly perceive climatic changes tend to express a higher WTP than those who do not. Overall, these findings suggest that accurate climate perceptions are keys to increasing cooperation into managing climate change and related disasters.

Key Words: Climate change, perception, willingness to pay, flood

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Contents

Nomenclature

MSL Mean sea level

WTP Willingness to pay

1 Introduction

Bangladesh is one of the most disaster-prone countries in the world because of its geographical setting (Brouwer et al., 2007). Bangladesh is part of the Bengal Basin, one of the largest geo-synclinal countries in the world. It lies in the northeastern part of South Asia, between latitudes $20°$ $34'N$ and $26°$ $38'N$ and longitudes $88°$ $01'E$ and $92°$ $41'E$ and has a gross area of approximately 147,570 km^2. Approximately 80% of the country's land is the floodplains of three large rivers, the Ganges, the Brahmaputra and the Meghna. Only 10% of Bangladesh is $1m$ above the mean sea level (MSL) and one-third is under tidal influence.

Bangladesh is likely to be affected by more intense and frequent flood events in the foreseeable future due to potential climate changes and the associated MSL rise (Schiermeier, 2011a,b). This is an issue of great concern, because the location and geography of Bangladesh make it both particularly susceptible to the effects of climate change, and extremely difficult to protect. Despite the importance of this issue, few studies have examined people's perceptions and behavior with regard to climate and flood controls in relation to historical climate data. Thus, 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 (Stern, 2006, Cline, 2007, Schiermeier, 2011b). For instance, Rockstrom et al. (2009) suggest that we have already exceeded the planet's "safe operating space" in the climate system, and a warmer world has more extreme rainfall occurrences. This is because the amount of water vapor that the atmosphere holds increases rapidly with temperature. Rainfall data also reveal significant increases of heavy precipitation over much of northern hemisphere land and the tropics. Overall, these tendency of climate are reported to increase the frequency of floods (Parry et al., 2007, Pall et al., 2011, Min et al., 2011).

Although scientific evidence confirms occurrences of climatic change, people's knowledge, perceptions to climate, and the relationship of these factors with attitudes are equally important. This is because these issues are directly linked to the formulation of policies for climate change (Tobler et al., 2012b,a). Several works demonstrate that abstract explanations of climate change without actual experiences of these "changes" are ineffective to convey what is actually occurring and to affect people's mindsets and behavior (see, e.g., Spence et al., 2011). The greatest barrier to public perceptions of climate change is the difficulty of cultivating correct perceptions of temporal trends and the natural variability of climate, especially among people whose daily life is not dependent upon weather or climate (Hansen et al., 1998, Balling Jr. and Cerveny, 2003, Hansen et al., 2012). In this situation, critical questions arise "How well does or can an individual detect climate change, given the stochastic nature of local weather and climate from day to day and year to year?" and "How do correct perceptions of climate relate to attitude and actions?"

In developed countries, numerous studies have examined the above questions. Previous research claims that highly educated people understand climate, and express their knowledge in surveys (Viscusi and Zeckhauser, 2006). Moreover, people who are more confident about the issue tend to be more cooperative, expressing a higher WTP for actions to prevent adverse effects of climatic change (Semenza et al., 2008, Akter and Bennett, 2011, Akter et al., 2012, Spence et al., 2011). In contrast, other studies show that some socio-cultural and psychological factors impede preventive actions for climate change, even when people are knowledgeable about or confident about the issue (Henderson-Sellers, 1990, O'Connor et al., 1999, Leiserowitz, 2006, Dessai and Sims, 2010, Osbahr et al., 2011). Therefore, the relationship between knowledge (or understanding) and attitude toward climate change remains unsolved.

In developing countries, there have been relatively few studies on this subject. For instance, several works have used surveys to examine local people's understanding of climate change (Vedwan and Rhoades, 2001, Adelekan, 2005, Vedwan, 2006, Mertz et al., 2009). These studies have found that people in developing countries often demonstrate less understanding of climate change compared to people in developed countries and that they tend to qualitatively misunderstand the changes of key climate variables. Furthermore, few previous works have examined the link between local people's understanding and their cooperative attitudes or actions toward climatic change.

Given this gap in the literature, we study the perceptions of local people to climate change in Dhaka, Bangladesh as a representative case in a developing country. We then analyze the relationship between the perceptions of people and cooperative attitudes to flood controls (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 or not people who correctly perceive climate change are more cooperative toward flood controls. In this analysis, we use a "willingness to pay" (WTP) measurement for flood controls as a good proxy of cooperative attitudes because the occurrence of climate change in Bangladesh is known to increase the frequency of flooding (Schiermeier, 2011b).[1]

For the aforementioned purposes, 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 derive a temporal trend of climate variables, 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 variable of climate perceptions 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 their 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. What factors affect WTP for flood damage protection, and do correct perceptions of climate change lead to higher WTP?

None of the above questions have been explicitly addressed in the literature. Our analysis yields

[1] It is likely that most Bangladeshi people have difficulty reaching a common understanding of the terminology for climate change, so we avoid using this terminology to assess cooperative attitudes.

the following main results. First, some key climate variables show clear upward or downward time trends, but most people correctly perceive the temporal trends of the climate variables at least in a qualitative manner. More specifically, both people's perceptions and our statistical analysis are identical in the qualitative changes of climate variables. Second, those who correctly perceive climatic changes tend to express a higher WTP than those who do not, implying that the WTP is positively affected by correct perceptions of climate. Overall, these findings suggest that information provision and correct perceptions of climate are keys to improving cooperation in addressing climate change and possible related disasters.

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. Raipura has relatively higher agricultural potential, whereas Narsingdi Sadar has lower agricultural but higher industrial potential. 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.

[Figure 1 about here.]

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.

2.2 Questionnaire and field survey

The structured questionnaire is employed to collect the 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 weather or climate changes. Regarding the elicitation of WTP, we use an open-ended question format, following Markantonis et al. (2013) and Ghanbarpour et al. (2014) that also elicited WTP for flood controls. To be more specific about the flood event, we asked respondents their WTPs toward preventive measures and controls when the flood event of the same scale with each of major flood events that occurred in 1988, 1998, 2004 and 2007 is assumed to occur in the future. For example, we asked respondents their WTP under the scenario that the flood like the one that occurred in 1988 is assumed to occur in the future. We elicited WTP under each scenario for the flood events in 1998, 2004 and 2007, respectively. We chose this way, because setting a specific scenario by mentioning the past flood events give respondents a relatively uniform understanding for flooding in our pilot survey.

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. Our survey also included seven well-reputed experts in Bangladesh specializing in meteorology and flood controls, who also answered questions related to weather or climate changes, perceptions of climate risks, and whether six seasons are becoming four seasons in study areas. The questionnaire was developed interactively. Theoretical findings and primary field surveys were used to design a first draft of the questionnaire. Then, the questions were carefully modified to ensure that understanding and answering these questions would not require an academic background or expert knowledge.[2] Another questionnaire was designed to elicit expert opinions on the various issues of climate and flooding, which was used only for the experts' interviews. The results of experts' interviews are not used in the statistical analysis that follows, however, these results were referenced when necessary for qualitative judgments in the analysis. Fifteen villages

[2]The original questionnaire is in Bengali. The translated version is available upon request.

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 weather data were collected from the Bangladesh Meteorological Department. The data includes daily rainfall, daily average temperature, daily maximum temperature and daily minimum temperature. First, to capture local climatic changes in the last 25 years, we examined data from three nearby weather stations from 1985 to 2010 to ensure the robustness of our qualitative results. An average value for the climate data taken from 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, and the data are of good quality with few missing observations. Therefore, we present the analysis using the data from the three stations. Finally, figure 2 summarizes the data collection procedure consisting of a primary field survey, a household survey, an expert interview and the collection of meteorological data.

[Figure 2 about here.]

3 Methodology and data analysis

3.1 Climatic and weather change

Rainfall and temperature are the most significant climate variables affecting human activities. Therefore, we focus on climate variables related to rainfall and temperature for our analysis. For farmers, the distribution and periodicity of rain events and temperature variation within a growing season or a single year and the effectiveness of the rains in each precipitation event may affect farming practices. For other land users, these rainfall and temperature events may have some importance for everyday life.

We selected eight important climate variables that affect the daily life of local people. Table 1 shows the variables chosen to identify a change in climatic pattern and the corresponding reasons for their selection. We analyze these climate variables over the years 1985 to 2010 and derive a temporal trend in climate variables. We plot historical observations of climate variables for each month or each season. Finally, to determine the overall trend in climate variables, we estimate a coefficient of the time trend by running regression analysis. The estimated regression is drawn on the time series plot of climate variables.

[Table 1 about here.]

Respondents were asked what the weather and climate were like 25 years ago to access their perceptions of normal climate patterns. We then asked what the weather and 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’’ for these questions. Their perceptions of the changes in climate variables over time were compared to the meteorological records collected from three nearby stations where this field work took place.[3]

To judge whether a respondent’s perception is qualitatively consistent with the time series climate data or not, we employ the following procedure. First, we draw the time series plot of the climate variable of our interest, say, average summer temperature, from 1985 to 2010. Second, we run the simple regression by taking a time trending variable as an independent variable, yielding

[3] We initially attempted to incorporate questions related to the perceptions of the risk or standard deviations of climate variables in a survey. However, our pilot survey revealed that it is difficult to create a uniform understanding of this issue among Bangladeshi people partly due to the difference in educational background compared to developed countries. Therefore, we avoided directly asking questions related to the risk of climate change. Instead, we attempted to translate this risk-related question into frameworks that could be easily understood (e.g., an increase in frequency of extreme rainfall).

an estimated coefficient of time trending. If the estimated coefficient is more than 1%, we consider it as "increasing." If it is less than -1%, it is "decreasing." Otherwise, no change. Our survey also elicits each respondent's perception to each climate variable; increasing, decreasing and no change. If the respondent's perception is the same as the qualitative change concluded from a time trending regression, we consider the perception to be correct or consistent with time series climate data. Note that we use the 1% criteria to judge whether a certain climate variable is increasing, decreasing or no change based on our experts' survey. The experts say that an annual or monthly 1% increase (decrease) as a time trend becomes more than 10% increase (decrease) in 10 years later. It is considered significant enough to say an increase or decrease in the context of Bangladesh climate.

3.2 WTP for flood controls

To identify the determinants of people's cooperative attitudes toward flood damage protection, a Tobit regression is applied, because our samples for WTPs include approximation 150 observations of zero. 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, climate stimuli, correctness of perceptions and experiences. More formally, the underlying regression is formulated as follows:

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

where

- WTP represents the willingness to pay for flood protection. In our sample, WTP 1988, WTP 1998, WTP 2004 and WTP 2007 correspond to the respondents' WTP to collectively control the damage under the scenario that a flood event like the one that occurred in 1988, 1998, 2004 and 2007 is assumed to occur in the future.

- Socio-economic characteristics correspond to the variables of education, income, conditions, family structures, residential time, some knowledge about climate change, and advance access to flood information.
- Experience represents whether respondents have suffered from floods in the 1988 and 1998. When they reported to have suffered, this variable indicates the corresponding economic loss in each flood event.
- Perception represents whether respondents correctly perceive seasonal and climate changes. For this, we only choose climate variables and the corresponding perceptions that are directly relevant to the occurrence of flooding. More specifically, all climate variable related to rainfall and precipitation are included in the regression. This perception variable is binary taking the value of 1 when respondents correctly perceive the time trend of a climate variable in a qualitative manner. Otherwise, it takes 0.[4]
- ϵ is an error term.

Tables 2 and 3 provide the definition of explanatory variables and the summary statistics of all the variables included in the Tobit regressions, respectively.

[Table 2 about here.]

[Table 3 about here.]

[4]In this judgment of whether the dummy variable of correct perception is set to 1, we use the coefficient of the temporal trend for a climate variable estimated from the time series climate data in the previous section. For instance, the coefficient is positive with more than 1% (or negative with less than -1%); we consider it "increasing" (or "decreasing"), and those who answered "increasing" (or "decreasing") in the survey are considered to have correct perceptions. In some cases, we also obtain the coefficient of a temporal trend that is positive or negative, but very close to zero with the absolute magnitude of less than 1% (e.g., an estimated coefficient of 0.0025 is considered to be no change, since it is less than 1% in absolute value). In such a case, we consider it as no change and the answer "no change" from the respondents is correct. We determine to use this 1% criteria based on our experts' survey as mentioned earlier.

4 Results and discussion

4.1 Climatic change

4.1.1 Change in rainfall

Figure 3 (in five subfigures) 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 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. The slope of the linear trend derived from the plot in subfigure 3(e) implies that average rainfall on rainy days increased by 2.28 mm within 25 years. 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.]

We now aim to identify a consistent trend in the rainfall extremes in monsoon months from the data analysis. Figure 5 shows that the time trends in monsoon extreme rainfall were generally positive over the years of our analysis, although a negative trend was found in October. The overall trend in the data pooled from each month shows an increasing temporal trend from 1985 to 2010 (Subfigure 5(e)). A high percentage of participants (849/1,011, 84%) correctly perceived the "increasing" trend in the extreme rainy days, but 16% underestimated the change (figure 4, column 2). Perceptions of extreme rainfall are important for understanding and predicting floods in monsoon seasons, and our findings of a change in extreme rainy days suggest that the Bangladeshi people recognize the flooding risk.

[Figure 5 about here.]

Next, we consider average rainfall for eight months of each year as non-monsoon months, six of them show a downward trend of the rainfall from 1985 to 2010 (figure 6). Although two months show a minor increase, one of them is the month just after the monsoon seasons. We examine the overall trend in this climate variable by pooling the data from all non-monsoon months. Figure 7 shows a 2% decrease in rainfall from 1985 to 2010. People's perceptions of the change agree with the time series plots in figures 6 and 7. Surprisingly, 954 of 1,011 respondents (94.36%) correctly answered "decreasing"; only 5.64% of people overestimated the change (figure 4, column 3).

[Figure 6 about here.]

[Figure 7 about here.]

We now examine the dry spell for individual non-monsoon months and for an overall non-monsoon season. Figure 8 shows that most of non-monsoon months demonstrate an increasing trend or no temporal trend of the longest dry spell. An overall trend derived from pooling the data of all the non-monsoon months also shows a similar outcome, slightly increasing or close to zero (figure 9). We judge that the magnitude of the temporal trend is approximately "no change" where the value of overall temporal trend in the longest dry spell is 0.0042 (< 0.01). The exceptions are May and October. This may be because these months are immediately before and after the monsoon months, respectively. A majority of respondents (854/1,011, 84.47%) correctly perceived "no change" in the longest dry spell in non-monsoon months (figure 4, column 4), whereas 15.53% of people underestimated the change.[5]

[Figure 8 about here.]

[Figure 9 about here.]

[5] As mentioned earlier, if the absolute value of the temporal trend is less than 0.01, we consider it to represent "no change."

4.1.2 Change in temperature

Figure 10 shows an increasing trend in the frequency of extremely hot days in summer months from 1985 to 2010, although the first month of summer shows a decreasing trend due to the effect of the preceding cold months. The other two months show a stronger effect in this regard, and the number of extremely hot days in April and May increased by approximately 13% and 38%, respectively, from 1985 to 2010. The number of extremely hot summer days increased by 5% (Subfigure 10(d)). Surprisingly, the surveyed population consistently (886/1,011, 87.64%) answered correctly that the number of extremely hot summer days has increased; only 12.36% of people underestimated the trend (figure 4, column 5).

[Figure 10 about here.]

Another strong indicator of climate change in Bangladesh is the change in temperatures. The three measures of temperature are average daily maximum, minimum and mean, calculated to elucidate the overall trend in summer months. Figure 11 shows a slightly rising trend for March, April and May (Subfigures 11(a), 11(c) and 11(e)). Aggregating the data from the three months does not change this trend, irrespective of the minimum, maximum and mean temperatures (Subfigures 11(b), 11(d) and 11(f)). The average mean temperature increased by 1.2%, and the average minimum and maximum temperatures increased by 1.3% and 1%, respectively (temporal trend lines, subfigures 11(b), 11(d) and 11(f)). The respondents' answers are consistent with this meteorological data analysis. 830 respondents (830/1,011, 82.1%) identified an increasing trend in summer temperatures (figure 4, column 6). However, 17.9% of the respondents underestimated this change.

[Figure 11 about here.]

We now investigate the temporal trend of extremely cold days in winter seasons. Figure 12 shows that the number of the extremely winter cold days is decreasing over time (-6.6% in aggregated observations from January to December; temporal trend line, subfigure 12(c)). Accordingly, 798 respondents (798/1,011, 79%) correctly perceived this trend, and only 21% of the respondents overestimated the change (figure 4, column 7).

Finally, we plot the average daily mean, maximum and minimum winter temperatures, which have remained relatively constant (figure 13). As expected, 904 respondents (904/1,011, 89.4% in column 8 of figure 4) correctly perceived "no change"; only 10.6% of the respondents overestimated the change. From the above analysis and from the graphical representation in figure 4, we conclude that Bangladeshi people correctly perceive the change in climatic patterns over time, at least from a qualitative perspective. Based on our survey, approximately more than 80% of the respondents correctly perceived the temporal trends of eight climate variables that are important in Bangladesh.

[Figure 12 about here.]

[Figure 13 about here.]

4.2 People's cooperative attitudes and WTP regression

Table 4 represents the regression results for WTP corresponding to floods in 1988, 1998, 2004 and 2007, respectively.[6] The table also contains the marginal effect representing the change in WTP when an independent variable increases by one unit. The results show that the education of the head of household is statistically significant and increases WTP for flood damage protection for all regressions of the floods in 1988, 1998, 2004 and 2007. The magnitudes of the marginal effects of education on WTP in other regressions are similar, indicating the strong positive relationship between education and WTP for flood protection.

[Table 4 about here.]

Household income, house condition, family structure and residential time have the same qualitative results on WTP for all of the regressions. These independent variables are statistically

[6]Initially age, farmer, type of job, amount of cultivable land and cattle ownership were added to the model. However, they were dropped, because they were not significant in any case of WTP and have no impacts on other independent variables included in the analysis. In other words, we confirmed a robustness of our result.

significant and increases WTP for flood protection; the corresponding marginal effects are not economically negligible. However, household members and household distance from the river negatively affect the WTP, although not always with statistical significance. This result implies that WTP declines as the number of household members and the distance from the river increase, consistent with intuition.

Next, we examine the independent variables of Loss 1988 and Loss 1998. As mentioned, these two variables indicate whether the respondent experienced a large, well-known flood that occurred in Bangladesh and the corresponding economic damage. Contrary to our hypothesis, the variables are not economically significant implying that the marginal effect is not large enough to be economically meaningful. Although some of the regressions show statistical significance, the experience of these floods does not affect WTP in a practically meaningful way.

We turn our attention to the variables of knowledge, information and perceptions related to flooding and climate change. "Knowledge of climate change" and "advance access to flood information" correspond to these key independent variables. In general, table 4 shows strong positive effects of these variables on WTP for all regressions. This result suggests that people who have 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. These results are consistent with previous literature.

Finally, we review 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." Recall that these are included as perception-related variables because they are directly related to the risk of flooding in the study region. Table 4 presents that all of the coefficients on 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 temporal changes in climate variables tend to exhibit higher WTP. To the best of our knowledge, this is the first study demonstrating that correct perception to climate leads to higher WTP or more cooperative attitude toward the mitigation of climate-change related disasters.

Overall, the results of our research, especially related to knowledge and perceptions, suggest some important implications. It is reported that many people, especially in developed countries, are skeptical about climatic changes, exhibiting non-cooperative attitudes toward mitigation policies (see, e.g., Cookson, 2009). Sometimes, these non-cooperative behaviors are attributed to uncertainty and ambiguity associated with the occurrence of climate change. However, our results imply that these attitudes may be changed if they become to possess correct perception, information and education regarding climatic changes. In other words, people who have knowledge and information as well as who correctly perceive the temporal change of climate variables tend to be more cooperative. Based on these arguments, we suggest that experience, information provision and education that can reduce ambiguity (or uncertainty) associated with climate and flooding are keys to improving cooperation in managing climate change and related natural disasters.

5 Conclusion

This paper examined climate data, people's perception to climatic changes and attitudes toward flood controls in Bangladesh. For the data collection, we conducted face-to-face surveys with 1,011 respondents and seven experts from different socio-economic backgrounds in Dhaka and elicited their perceptions of climate change and WTP for flood controls associated with climate change. Our results have some important implications. First, key climate variables are identified to exhibit clear upward or downward trends suggesting some possibility of a change in climate. However, most Bangladeshi people in our survey correctly perceive the temporal trends of climate variables. More specifically, people's perceptions and our statistical analysis of climate are consistent with each other in that they show the qualitatively same direction of temporal changes. Second, people who correctly perceive climate changes and have knowledge 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 information provision and education associated with correct perceptions of climate are keys to improving cooperation in managing climate change and its related disasters.

Finally we note some of our study's limitations. For instance, our survey does not cover all parts of Bangladesh. We focus only on Dhaka because there are three weather stations nearby with high-quality of daily climate data and few missing observations. The data quality was crucial to reliable analysis in our study. In the future, if climate data accumulates in other weather stations, the same type of analysis should be conducted to produce more robust results. Second, we did not ask any question explicitly related to people's perceptions of "risks" because we had difficulty explaining the word "risk" in a uniform way that every respondent could understand. It is our belief that recognition of risk is another important dimension in the climate-change debate when climate change includes uncertainty and ambiguity.

Although there are some limitations and shortcomings in our study, we believe that the results of this study could be important in untangling the relationship between people's perceptions and attitudes toward climatic changes and related natural disasters. We are surprised that a majority of Bangladeshi people correctly perceive the time trend of climate variables and exhibit higher cooperative attitudes. However, note that this debate still lacks a policy to translate the willingness to prevent disasters associated with climate changes into collective action yet. We hope that the results of our research can serve as a reference for decision making of collective climate-change policies and disaster management in the future.

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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

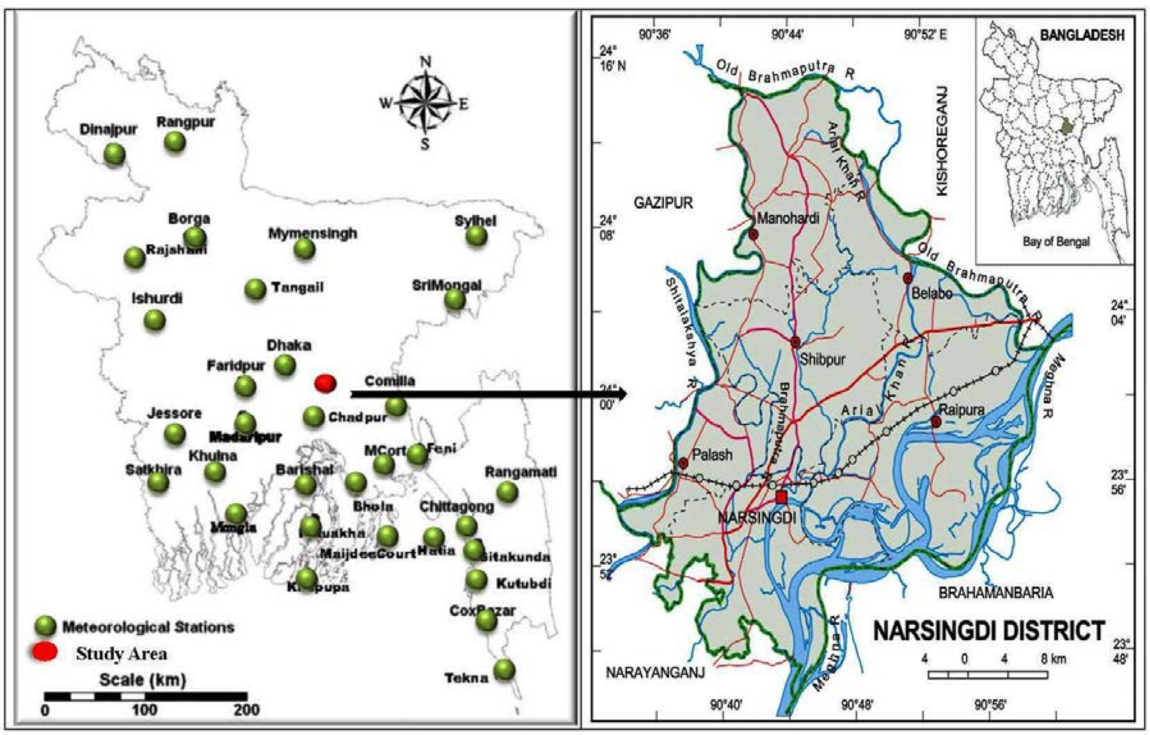
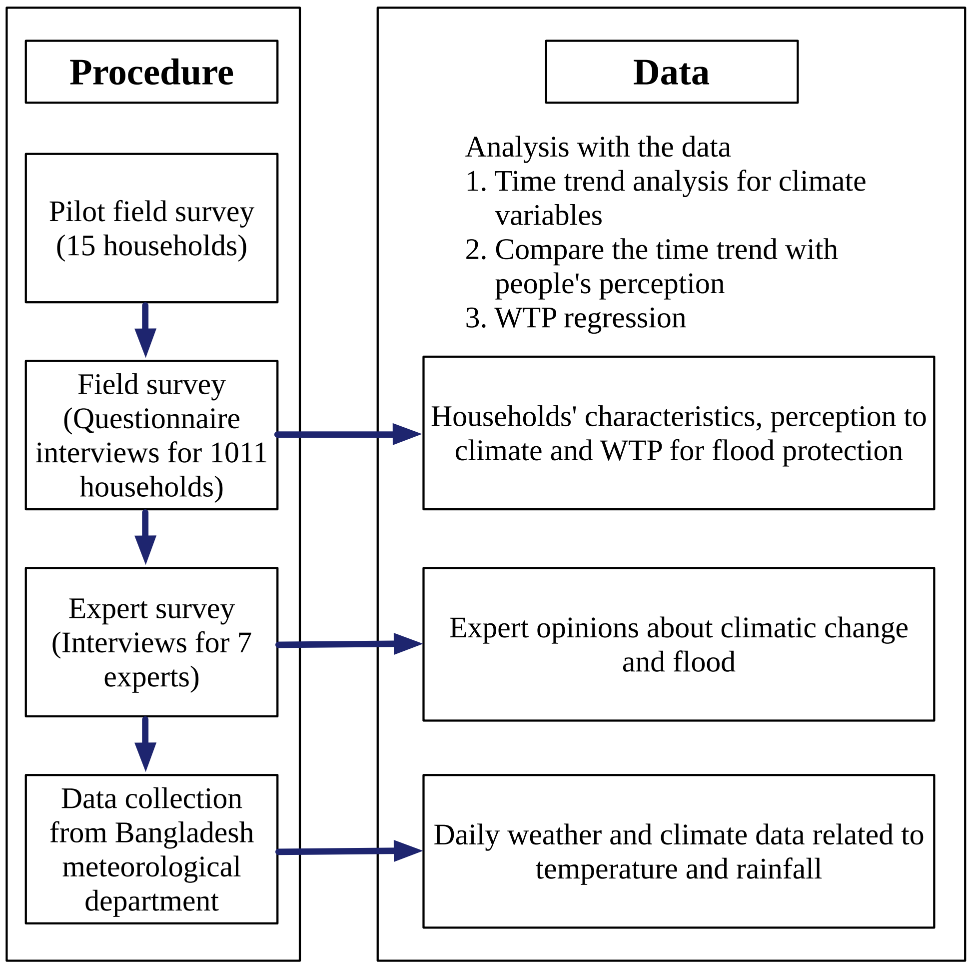
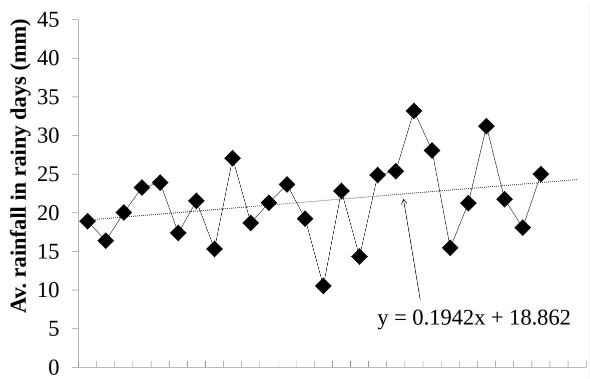
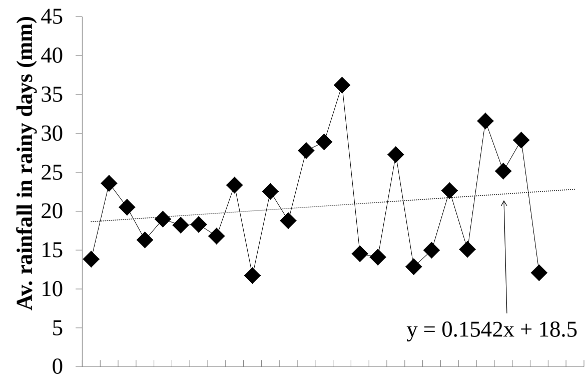


Figure 2: The entire procedure of data collection





(a) June



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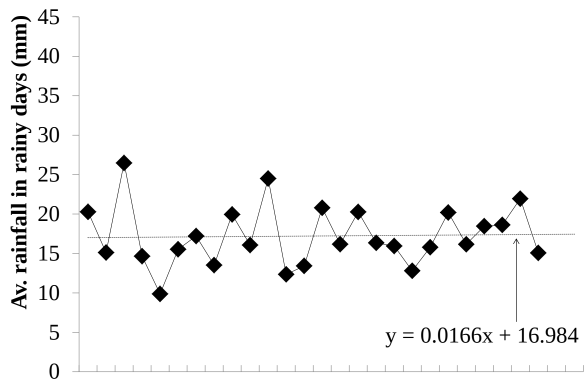

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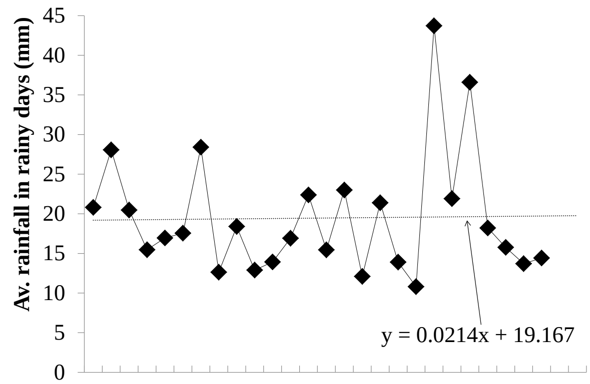

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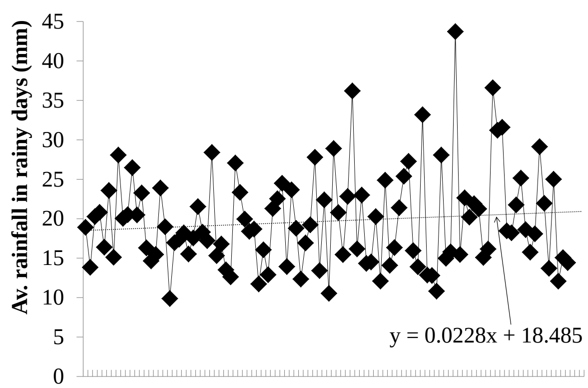
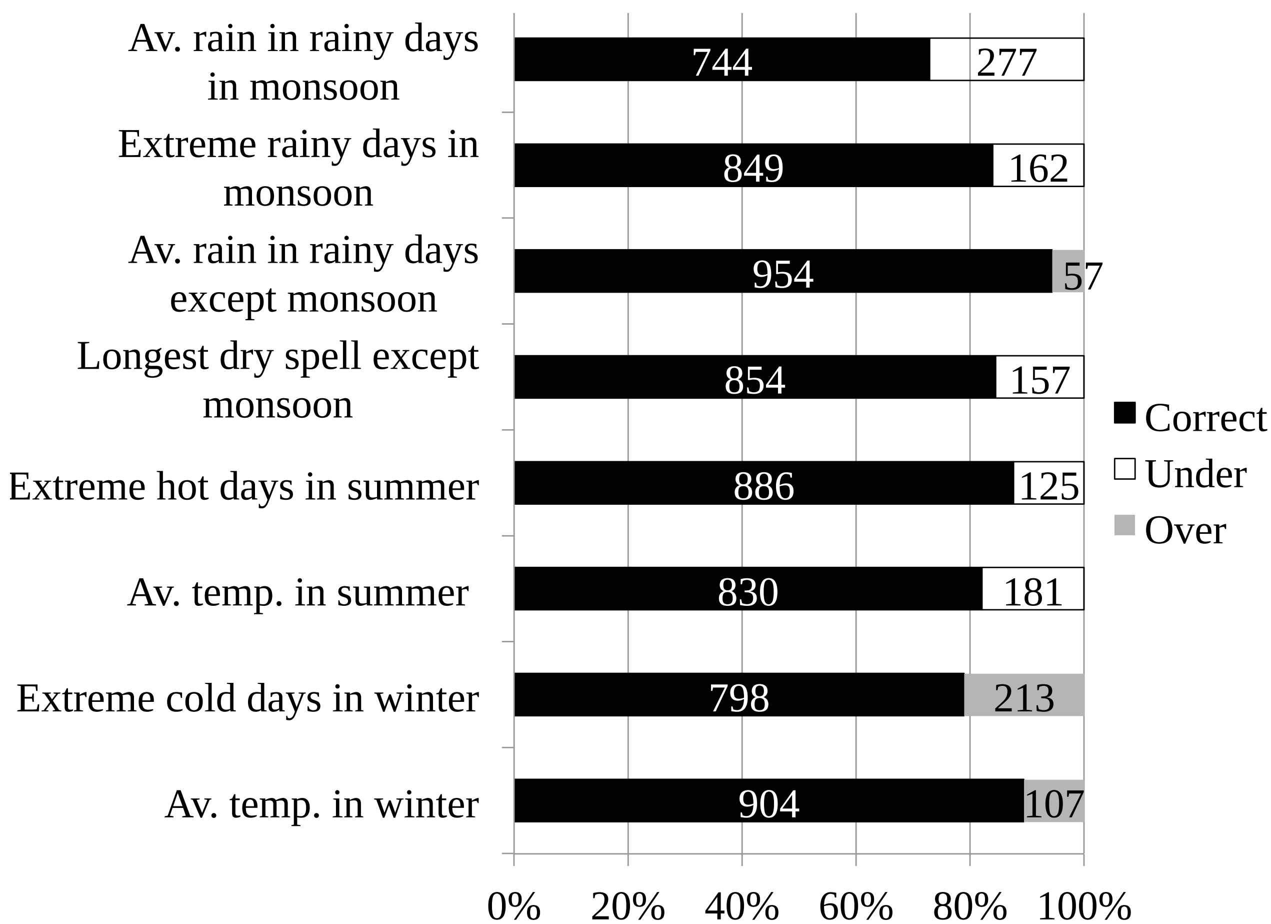
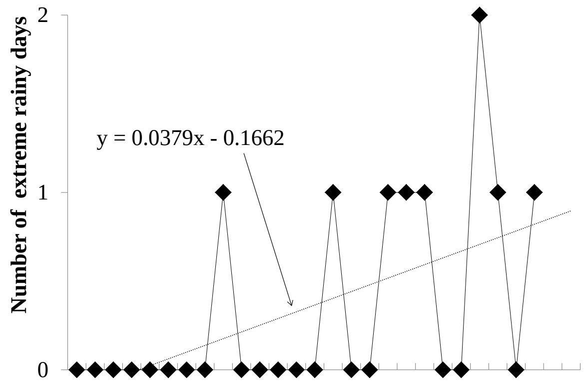


(e) Average rainfall on rainy days for monsoon months by pooling all monsoon months of June, July, August and September

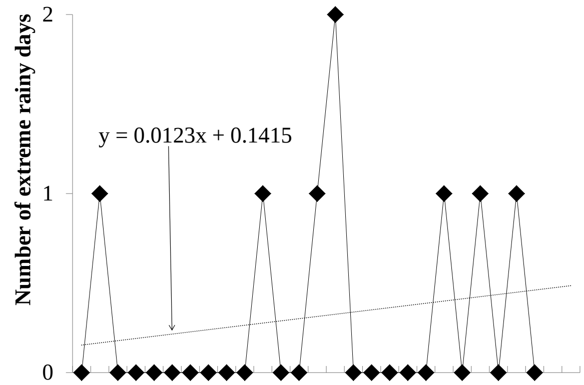
Figure 3: Average rainfall on rainy days for monsoon months from 1985 to 2010

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





(a) June



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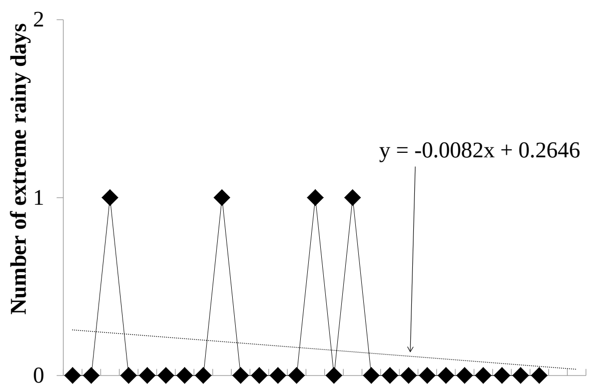

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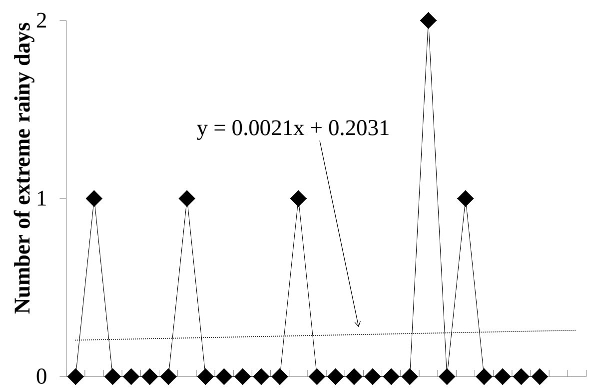

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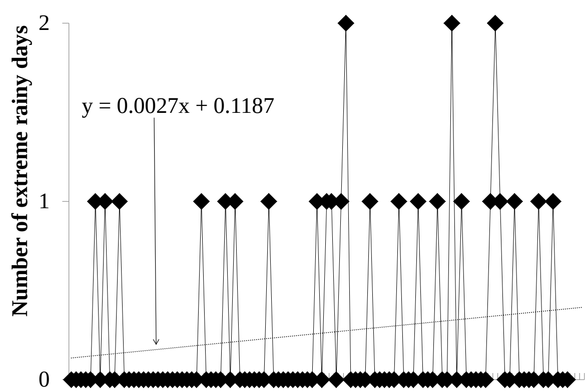
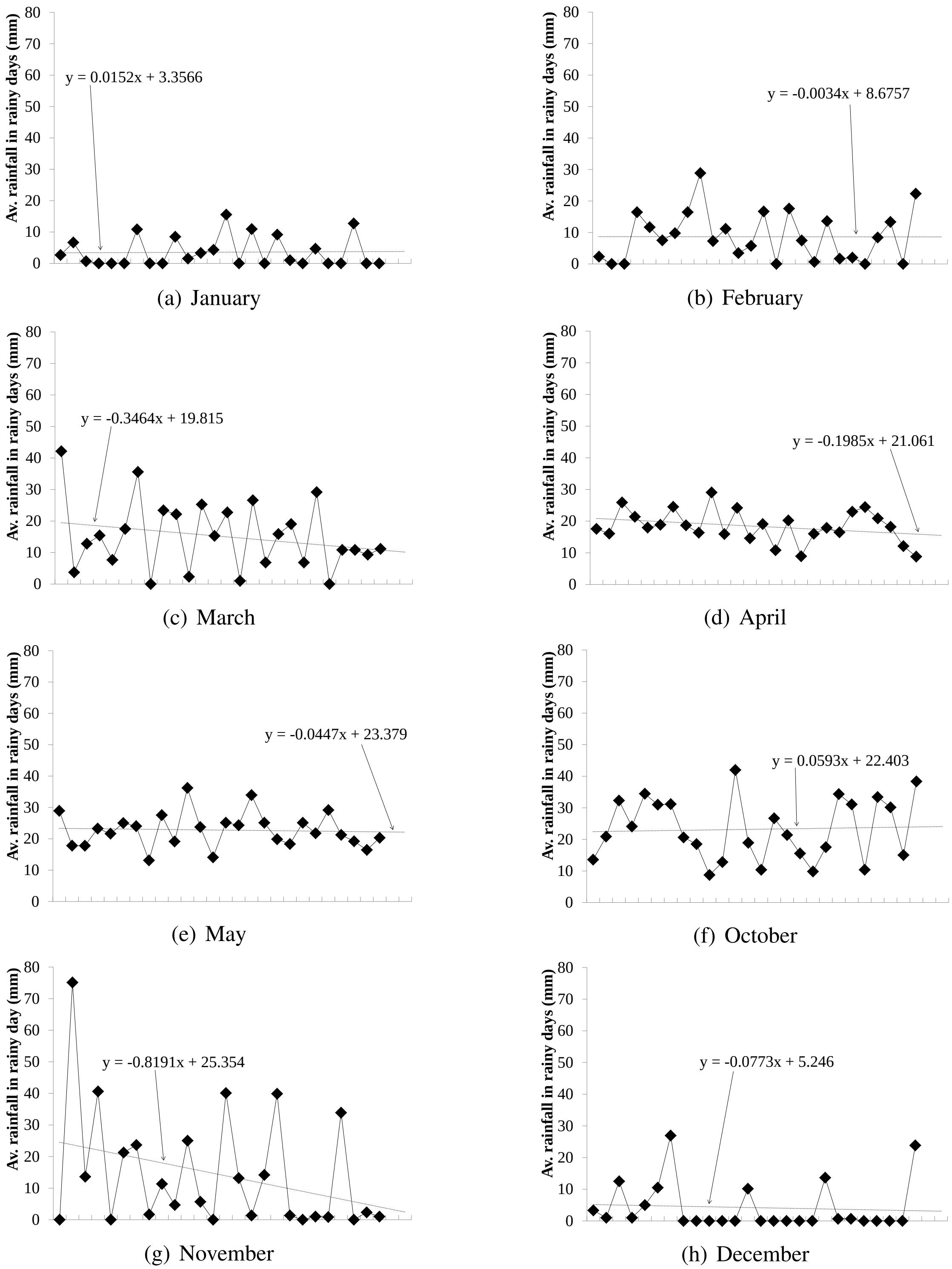


(e) Number of extreme rainy days for monsoon months by pooling all monsoon months of June, July, August and September

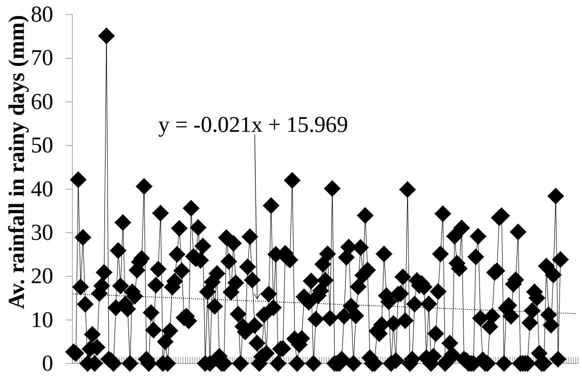
Figure 5: Number of extreme rainy days in monsoon months from 1985 to 2010 (rainfall in a day exceeding 100 mm)



(a) January (b) February (c) March (d) April (e) May (f) October (g) November (h) December

Figure 6: Average rainfall on rainy days for non-monsoon months from 1985 to 2010

Figure 7: Average rainfall on rainy days for non-monsoon months by pooling the data from all non-monsoon months (January, February, March, April, May, October, November and December)



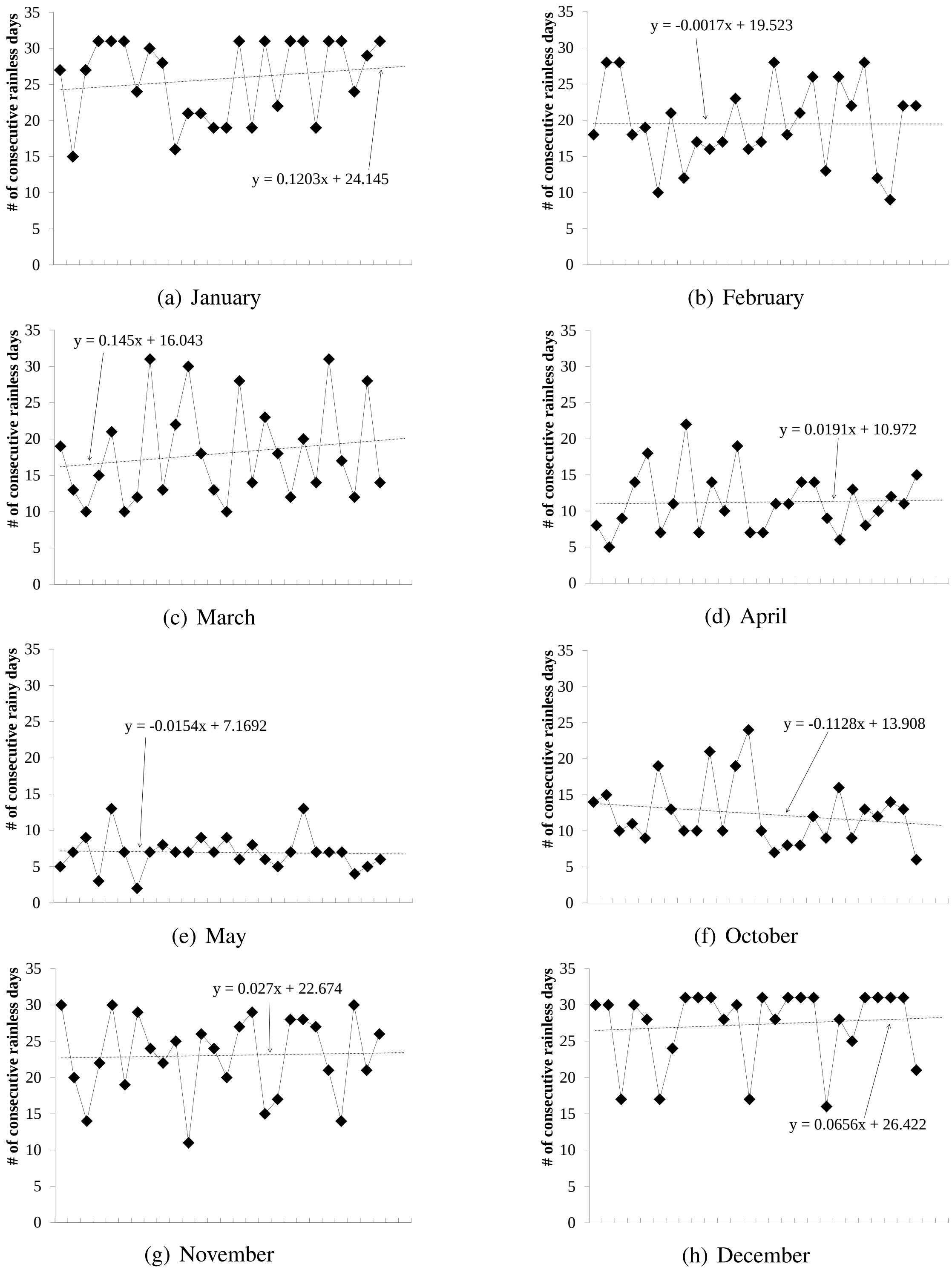


Figure 8: Change in the longest dry spell for each non-monsoon month

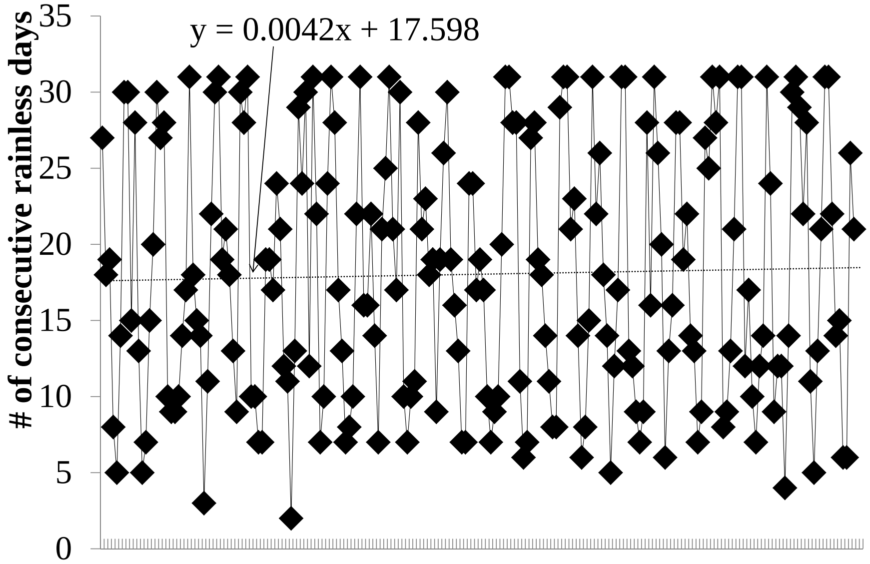


Figure 9: Change in the longest dry spell for non-monsoon season by pooling the data of non-monsoon months from 1985 to 2010

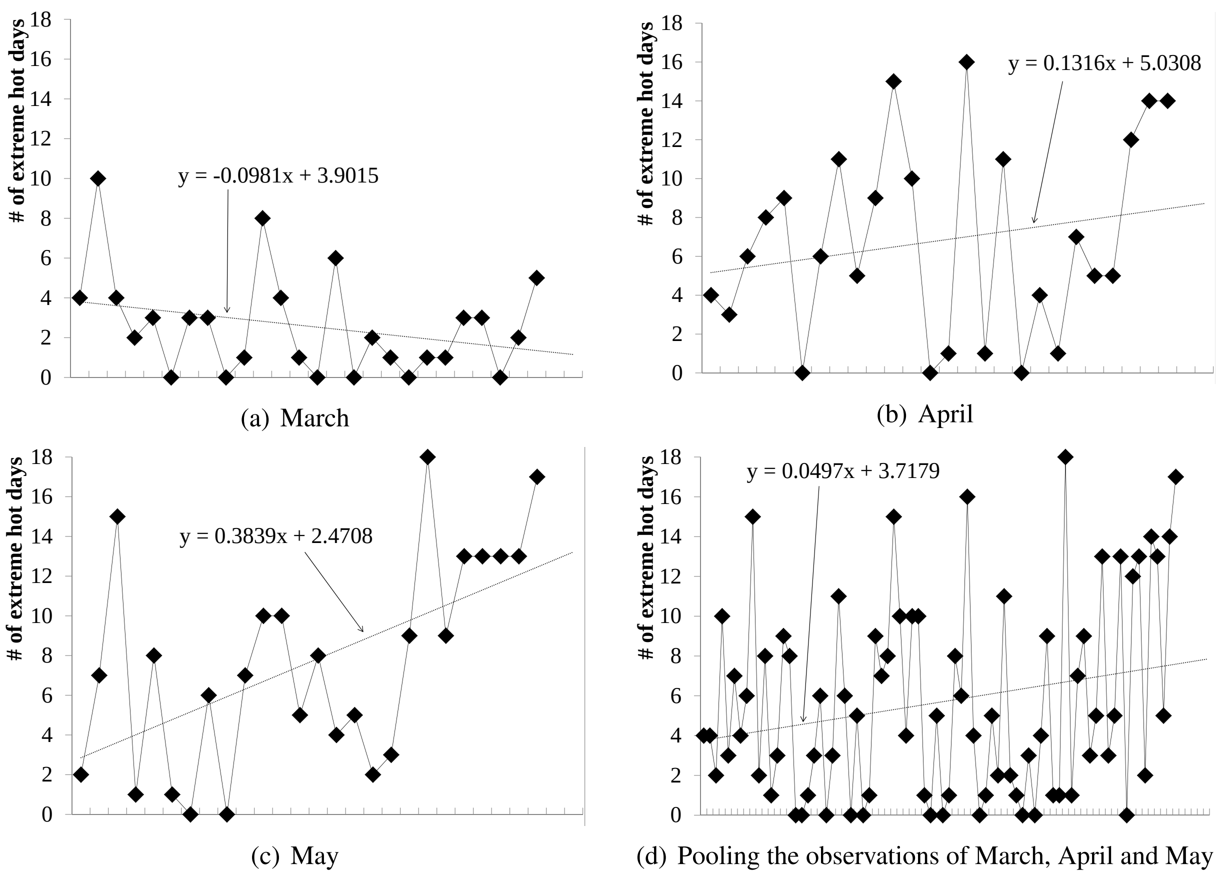
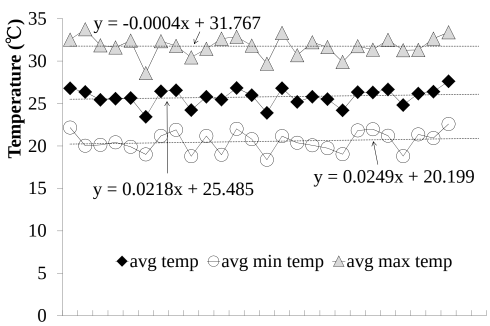
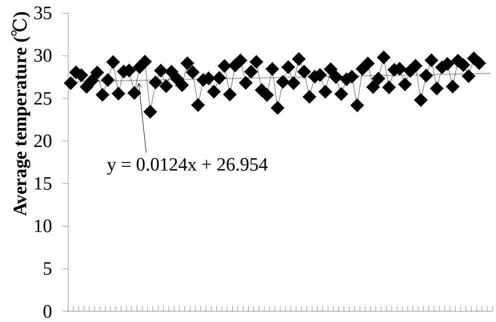


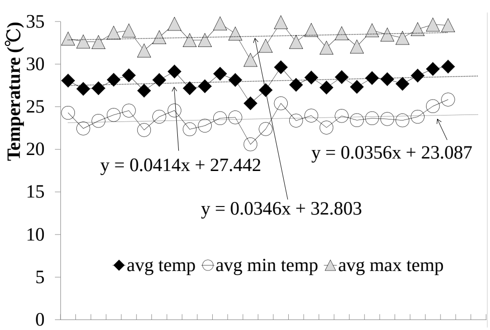
Figure 10: Change in the number of extremely hot days in summer months from 1985 to 2010



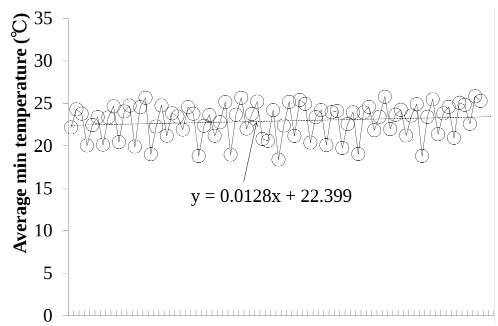
(a) March



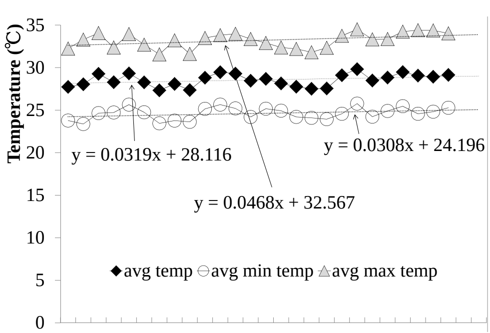
(b) Average daily temperature over summer months from 1985 to 2010



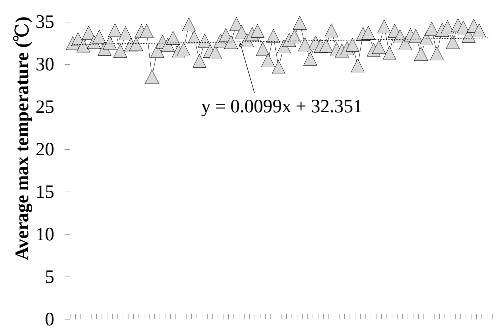
(c) April



(d) Average daily minimum temperature over summer months from 1985 to 2010

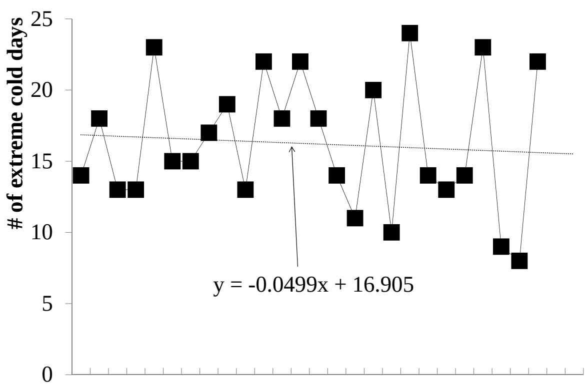


(e) May

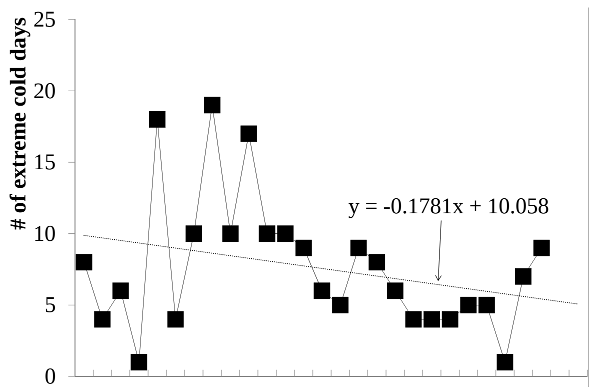


(f) Average daily maximum temperature over summer months from 1985 to 2010

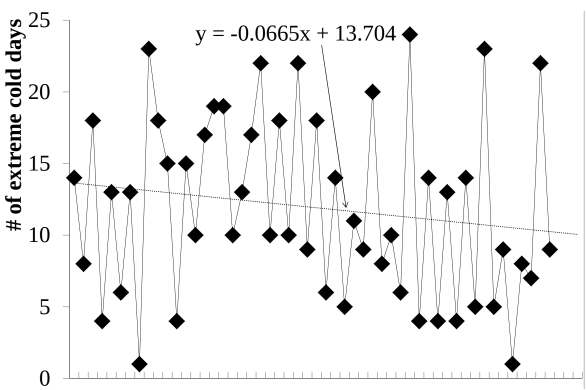
Figure 11: Change in average daily temperature over summer months from 1985 to 2010



(a) January from 1985-2010

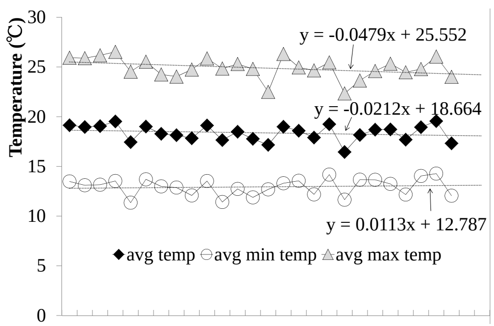


(b) December from 1985 to 2010

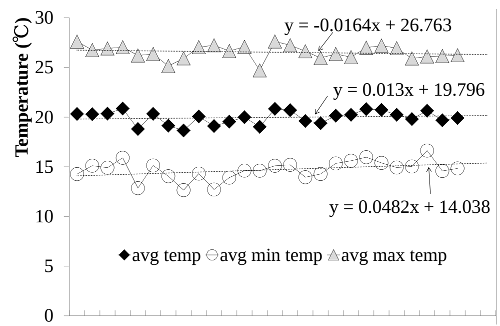


(c) Aggregating the observations of January and December from 1985 to 2010

Figure 12: Change in the number of extremely cold days in winter months from 1985 to 2010



(a) January



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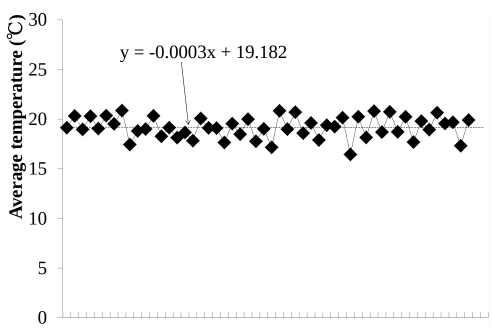
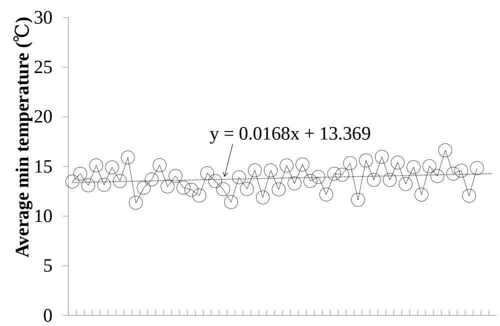
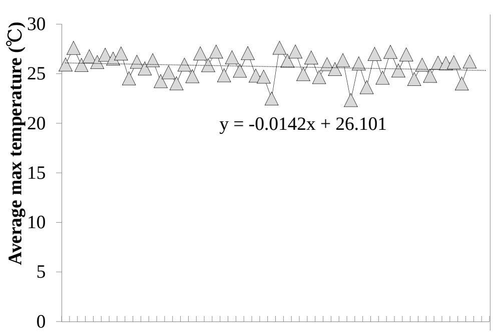


(c) Average daily temperature aggregating observations from the two months of January and December from 1985 to 2010



(d) Average daily minimum temperature aggregating observations from the two months of January and December from 1985 to 2010



(e) Average daily maximum temperature aggregating observations from the two months of January and December from 1985 to 2010

Figure 13: Change in average daily temperature over winter months from 1985 to 2010

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

Climate variable	**Definition**	**Reason**
Average rainfall on rainy days 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: Description of explanatory variables used in WTP Tobit regressions

Explanatory variable	**Description**
Education	Education level of the household head
Household income	Monthly 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 think that there is a seasonal[1] change from six to four seasons
Perception of monsoon precipitation	Whether a respondent correctly perceive a temporal trend in monsoon precipitation
Perception of non-monsoon precipitation	Whether a respondent correctly perceive a temporal trend in non-monsoon precipitation
Perception of extreme rainy days	Whether a respondent correctly perceive a temporal trend in precipitation on extreme rainy days

[1] An annual calendar in Bangladesh is hypothesized to change from six seasons to four seasons. If a respondent say "yes," this variable is 1, otherwise 0. The definition of this variable is determined on the basis of expert surveys and the inclusion of this variable is important, because this seasonal change is believed to be one reason for frequent flooding.

Table 3: Summary statistics of the variables used in WTP Tobit regressions with 1,011 observations

Variable	**Mean**	**Std. dev.**	**Min**	**Max**
WTP for 1988 (BDT/year)[0]	523.11	918.81	0	5,000
WTP for 1998 (BDT/year)	524.91	931.97	0	5,000
WTP for 2004 (BDT/year)	421.49	794.70	0	5,000
WTP for 2007 (BDT/year)	357.85	698.74	0	5,000
Education[1]	1.10	1.19	0	5
Household income (BDT/year)[2]	3.36	1.75	1	8
Household condition[3]	2.51	0.71	0	4
Family structure	0.66	0.47	0	1
Residential time[4]	6.1	1.3	0	8
Household members	7.39	3.72	1	27
Household distance from river[5]	2.60	0.97	0	6
Loss 1988 (BDT)	77,868.45	107,559.60	0	1,000,000
Loss 1998 (BDT)	56,005.93	90,239.90	0	800,000
Flood preparedness	0.22	0.41	0	1
Knowledge of climate change	0.78	0.41	0	1
Access to flood information	0.53	0.50	0	1
Perception of change from six to four seasons	0.65	0.47	0	1
Perception of monsoon precipitation	0.73	0.44	0	1
Perception of non-monsoon precipitation	0.94	0.23	0	1
Perception of extreme rainy days	0.84	0.36	0	1

[0] BDT represents local currency "Bangladesh taka."
[1] Education is represented by an ordered categorical variable, 0: illiterate, 1: primary, 2: secondary, 3: college, 4: bachelor or university and 5: more than master degree in graduate schools.
[2] Household income is represented by an ordered categorical variable, 0: $\leq 5,000$, 1: 5,000-9,999, 2: 10,000-14,999, 3: 15,000-19,999, 4: 20,000-24,999, 5: 25,000-29,999, 6: 30,000-34,999, 7: 35,000-39,999, 8; 40,000 or more.
[3] Household condition represents the degree of strengths in house materials by an ordered categorical variable, 0: slam, 1: bamboo and grass, 2: tin and wood, 3: brick and tin, 4: brick
[4] Residential time represents the years of living in this place by an ordered categorical variable, 0: less than one year, 1: one to three years, 2: three to ten years, 3: ten to twenty years, 4: twenty to thirty years, 5: thirty to forty years, 6: forty to fifty years, 7: fifty to eighty years, 8: more than 80 years.
[5] Household distance from rivers is represented by an ordered categorical variable, 0: less than 100m, 1: 100 to 500m, 2: 500m to 1km, 3: one to two km, 4: two to five km, 5: more than 5km.

	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 ex-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 4: WTP regressions