Demand assessment and test of commercial viability of crop insurance in Bangladesh

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Abstract

The aims of the study presented in this paper are to assess the demand for and test the commercial viability of a crop insurance scheme in different natural disaster-prone areas in Bangladesh, as an alternative poverty alleviation and natural disaster mitigation strategy. In a large scale household survey carried out at the end of 2006, 3600 riverine and coastal floodplain residents in Bangladesh were asked for their preferences for crop insurance schemes using the double bounded contingent valuation (CV) method. For example, asking them for their willingness to pay (WTP) for crop insurance schemes to eliminate future catastrophe risks. We find crop insurance demand to be positively correlated with household head’s primary occupation, land ownership and size of agricultural farm land. Our study further reveals that crop damage cost and households’ willingness to pay to reduce damage vary significantly across the nature of the disaster risk. Using the data collected through household survey, we tested our simple analytical model of commercial viability of a crop insurance scheme by comparing the future value of expected premium receivable by insurer, with the expected indemnity payable to the insured. Assuming zero administrative cost and 10\% interest rate per annum, we find crop insurance schemes are marginally viable in riverine flood plain areas (both embanked and unembanked). The difference between the average expected indemnity payment and the future value of expected insurance premium is way too high for the nature of risk and amount of damage cost faced by households living in haor basin and coastal floodplain areas.

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Table of Content

1. Introduction 1
2. Analytical framework 2
3. General Survey design 4
4. Sample characteristics, disaster risk exposure and extent of crop damage 7
5. Floodplain residents’ preferences and willingness to pay for crop-insurance schemes 9
6. Testing the commercial viability of the crop insurance contract 12
7. Discussion and conclusion 14

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Poverty Reduction and Environmental Management (PREM)

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1. Introduction

Agriculture contributes one quarter of the Bangladesh GDP and is the source of employment for more than eighty percent of the rural population. More than half of agricultural production in Bangladesh is contributed by the crop sub-sector. The management of inherent risk associated with agricultural crop production has remained the key challenge in the development and poverty reduction program of Bangladesh for the past few decades. Traditionally, the management of catastrophe risks in Bangladesh agriculture has revolved around infrastructural measures such as building embankments and ex-post disaster relief measures, including increased access to post-disaster credit facilities etc. In recent years, the concept of ‘pro-active adaptation’ has gained increased attention in poverty alleviation programs in Bangladesh to deal with natural disaster risks. The National Adaptation Programme of Action (NAPA), prepared by the Ministry of Environment and Forest (MOEF), suggests exploring options for spreading natural disaster risks by investigating the potential of crop insurance markets so that agricultural farmers are better prepared to cope with the increased risk of crop damage. Two feasibility studies, one by the Ministry of Commerce and another by the Department of the Environment, are currently underway to test the feasibility of crop insurance in the most calamity prone areas of Bangladesh.

The body of literature related to crop insurance scheme is vast and diverse. Advocates argue that crop insurance can play a vital role as an alternative ex-ante risk coping instrument to enable poor farmers in developing economies to cope with weather related production risk. They may significantly contribute to poverty alleviation (ProVention/IIASA, 2005; Hazell, 2001). On the other hand, some economists describe catastrophic crop insurance as uninsurable and unsustainable in the long run as the transfer of losses from affected groups to the community at large is not feasible at an affordable premium rate (Skees et al., 1999). Associated costs of providing crop insurance schemes historically outweighed the gains from risk spreading. Although the experience and available information are too limited to reach any conclusion about such schemes, overall, crop insurance has not been very successful based on standard commercial criteria throughout the world. Especially in developing countries where the poorest parts of the population often find themselves in a spiral of recurrent damages due to natural calamities, disaster insurance schemes fail to earn enough premium income to cover payouts as well as administrative costs (Hazell et. al, 1986; FAO 1991; Anderson 2001; Quiggin et. al, 1993; Spaulding et. al, 2003, Gurenko and Mahul, 2004)

The aims of the study presented here are to assess the demand for and test the viability of crop insurance schemes in different natural disaster-prone areas in Bangladesh as an important alternative poverty alleviation and natural disaster mitigation strategy. In a large scale household survey carried out at the end of 2006, 3600 riverine and coastal floodplain residents in Bangladesh were asked for their preferences for crop insurance schemes using the double bounded contingent valuation (CV) method, i.e. asking them for their willingness to pay (WTP) for crop insurance schemes to eliminate future catastrophe risks. Our study reveals that demand for crop insurance scheme is significantly correlated with the household head’s primary occupation, land ownership and size of agricultural farmland. Households, who are directly related to crop farming and own large parcels of farmland, demand a crop insurance scheme to reduce variability in crop production due to weather related risk. Our study further reveals that damage cost and households’ willingness to pay to reduce damage vary significantly across the nature of the disaster risk. Groups of households who suffer from the highest aver-
age crop damage per catastrophe are willing to pay the lowest premium to avoid damage risk. To test the commercial viability of crop insurance scheme in different disaster risk areas, we compared the future value of expected insurance premiums with the expected average indemnity payment for crop damages. Assuming a zero administrative cost and interest rate of 10% per annum, our study results reveal that a crop insurance scheme is marginally commercially viable in both riverine embanked and unembanked floodplain area. In the haor (wetland) basin and coastal zones, we find a huge discrepancy between the expected insurance premium and the expected indemnity payment.

The remainder of this paper is organized as follows. Section 2 presents and details the analytical framework underlying this study, and Section 3 the survey design. General characteristics of the floodplain residents included in our sample and the nature and extent of the flood damages suffered are described in Section 4. We discuss the willingness to pay findings in Section 5, followed by our main findings on the commercial viability of crop insurance scheme in Section 6. Section 7 concludes.

2. Analytical framework

The conditions of financial robustness and affordability in the crop insurance business are often considered the most challenging criteria to be fulfilled in developing economies, given the nature of the environmental and financial risks faced by the insurer, and the financial constraints faced by the insured. Catastrophic risks are characterized by systemic correlated losses across farmers and geographical regions. As a result, the standard principle of paying out damage compensation to affected clients by pooling resources from non-affected clients is not applicable due to the scale and nature of the disaster risk, and the scope of reinsurance for disaster insurance scheme is marginal or the cost of reinsurance extremely high (ProVention/IIASA, 2005). On the other hand, in low-income economies insurance demand is often substantially low due to limited financial resources and has therefore been found inadequate to ensure risk pooling even within the community or region. Based on the assumption that an individual can correctly assess and estimate the probability of a catastrophe and associated possible losses, factors that have been found to have a significant effect on insurance demand are wealth, loss probability, insurance premium, the kind of product exposed to damage risk and the nature of the individuals’ utility function (Smith, 1968). Households exposed to the risk of natural catastrophe in poor economies usually make up the poorer segments of society. In a previous case study in one of the most flood prone areas in Bangladesh we show that poor households are indeed more exposed to the risk of flooding than wealthier households, who are furthermore able to better cope with preventing damage costs (Brouwer et al., in press). This study also revealed that poorer households suffer from relatively higher damage costs as a result of flooding. Another study conducted in the same floodplain area revealed that sixty percent of the floodplain residents refuse to pay for the construction of a protective embankment (an implicit insurance scheme) in the region. Eighty percent of these floodplain residents are unable to pay because of a lack of financial means (Brouwer et al., 2006). The study furthermore reveals a positive relation between willingness to pay (WTP) for flood protection through the construction of an embankment and average annual household income, which suggests that higher income households are willing to spend more money (i.e. pay a higher flood protection premium) to protect themselves against flood damage risk. The findings of these two studies explain why poorer segments in low-income economies are under-insured. Floodplain residents are
much more aware of the risk exposure level they face than anyone else. However, they exhibit low demand for flood insurance because of a lack of adequate financial income resources.

In the context of both low demand and supply of natural disaster insurance schemes, we construct a model to test the commercial viability of crop insurance scheme in Bangladesh. The theoretical model of this study is adopted from a simple analytical model used by Hazell (1992) to evaluate the sustainability of public crop insurance programs in seven countries from different parts of the world. According to this study, the premium collected on an insurance scheme must exceed average payouts in order to ensure the viability of the insurance contract, where average payout is modeled by summing up both administrative costs per insurance contract and indemnities. The condition for a viable and sustainable insurance contract is of the following form (Hazell, 1992):

\[
\frac{A + I}{P} < 1
\]  

(1)

Where,

\( A \) = average administrative costs per insurance contract;

\( I \) = average indemnities paid;

\( P \) = average premiums paid.

Hazell (1992) uses time series data over the period 1975-1989 for seven different countries to test the long-term viability and sustainability of crop insurance programs. In our study we do not have actual insurance data in view of the fact that an insurance market does not exist yet. Instead, we estimate the above model using expected values of indemnity and household’s WTP as premium per insurance scheme using data obtained from a large-scale rural household survey. Hence, the average costs and revenues in Hazell’s (1992) formula are replaced by expected values.

We assume a zero administrative cost in the model. The term ‘Indemnity’ refers to the compensation sum that insurers make to the holder of the insurance contract upon post assessment of crop damage due to an officially acknowledged natural disaster. We hypothesized a simple design of indemnity function of the following form:

\[
I = D \quad \text{If} \quad \text{Disaster event strikes}
\]

\[
I = 0 \quad \text{If} \quad \text{Disaster event does not strike}
\]

Where,

\( I \) = indemnity paid;

\( D \) = crop damage incurred by insured.

We used the amount of average crop damage incurred by households during the latest natural disaster as average expected compensation amount that insurers need to pay upon submission of a legitimate compensation claim. Expected indemnity payment for crop insurance scheme is proxied by average crop damage costs incurred by households in different risk areas during the last disaster.

In order to characterize demand for catastrophe insurance under non-existence of formal markets we used the non-market contingent valuation method. Using CVM, farmers are presented with a hypothetical insurance market. Expected premiums per contract for different insurance products are estimated on the basis of data originating from a large-scale CV survey. In this study, we use a double-bounded dichotomous choice (DB DC) elicitation method. The DC CV format was originally developed to increase the incentive-compatibility of the valuation question (e.g. Mitchell and Carson,
1989). It matches the way consumers make choices in the market (they either decide to buy or not to buy a product at a given price) or, to a lesser extent, the way voters decide in political referenda. Kriesel and Randall (1986) show that this format gives respondents the most appropriate incentive to reveal their preferences. The DC method does not reveal the maximum WTP amount, only a discrete indicator of maximum WTP. Different mean WTP values can be calculated depending on the statistical specification of the valuation function and the applied truncation strategies. Mean and median WTP are inferred from the underlying statistical distribution of the probability that respondents say ‘yes’ or ‘no’ to different bid levels (Hanemann and Kanninen, 1999). This means that relatively large samples are needed to calculate expected average WTP with the same accuracy as methods that ask respondents directly for their maximum WTP amount. Respondents were asked two WTP questions: do you accept a start bid $c_i$ and do you accept a follow-up bid $b_i$. Based on these two questions, four possible intervals for WTP can be constructed, namely:

- $WTP=1$: Rejecting both the start bid ($c_i$) and follow-up bid ($b_i$);
- $WTP=2$: Rejecting the start bid ($c_i$) and accepting the follow-up bid ($b_i$);
- $WTP=3$: Accepting the start bid ($c_i$) and rejecting the follow-up bid ($d_i$);
- $WTP=4$: Accepting both the start bid ($c_i$) and follow-up bid ($d_i$).

In other words,

- $WTP=1$ if $WTP < b_i$;
- $WTP=2$ if $b_i < WTP < c_i$;
- $WTP=3$ if $c_i < WTP < d_i$;
- $WTP=4$ if $WTP > d_i$.

Using standard statistical software and model we estimate the expected WTP for crop insurance schemes and use estimated WTP numbers to calculate future value of insurance premiums by insurers using the following equation:

$$P_e = WTP \times \left(1 + \frac{1}{r}\right)^n - 1$$

Where,

- $P_e =$ Future Value of insurance premium (per insurance contract);
- $r =$ interest rate;
- $n =$ number of payments;
- $WTP =$ average willingness to pay for crop insurance scheme.

More detailed description of future value calculation is included in section 5.

3. General Survey design

Crop damage in Bangladesh mainly occurs due to four major types of natural disasters: 1) riverine flood, 2) water logging, 3) flash flood and 4) coastal cyclone. These different types of natural disasters vary in terms of their frequency, timing, duration and extent of damage. Frequency of riverine flood is lowest in terms of return period compared to flash flood and coastal cyclone. Both flash flood and coastal cyclone are short in duration compared to other two types of disaster. Water log-
ging is not all due to nature related reasons. Rather this is an outcome of faulty design and poor maintenance of drainage systems inside the embankment, which causes a massive accumulation of rainwater and thereby causes damage to crop and other household assets. In a cost-benefit analysis carried out on Meghna Dhomogoda Irrigation Project, we show that damage cost inside the embanked area due to water logging is half of the damage cost due to disaster flood in an unprotected area with similar geographic characteristics (Haque et al., forthcoming).

A preliminary short list of study sites was prepared after studying the available documents on history and trends of natural disaster in Bangladesh. For selection of the case study areas at the final stage, we relied on information collected through a series of key informant interviews. We interviewed the Director of Flood Forecasting and Warning Center in Bangladesh Water Development Board, officials at Climate Change Cell in Department of Environment, Government of Bangladesh and policy planners at the Water Resource Planning Organization (WARPO). Based on all available information and discussion with our key informants, we selected seven districts from different parts of Bangladesh to cover the four different kinds of natural disaster risk. Four un-embanked riverine districts located near or at the two major rivers in Bangladesh (Meghna and Jamuna) were selected on the basis of damage intensity levels observed and monitored during the 2004 disaster flood. One district was selected inside the Ganges-Kobadak project (one of the oldest and biggest Flood Control and Irrigation (FCDI) Project in the country) to cover damage risk related to water logging inside the protected area. Furthermore, one coastal district surrounded by Bay of Bengal and lower Meghna at the southern end of Bangladesh and one district in northeast zone of Bangladesh covering flash flood prone haor basin were selected for the survey.

We selected seven sub-districts (called ‘upazilla’) from these six main districts that lie closest to the main rivers and sea. Lower administrative units such as ‘district unions’ and ultimately individual villages were chosen from these sub-districts based on random sampling. Approximately hundred and twenty interviews were conducted in four villages in one union. In total around six hundred household heads were interviewed in each sub-district. The area-wise distribution of the whole sample is presented in Table-1. See Figure 1 for the geographical location of these study areas.

Table 1 Distribution of sample across different districts with different disaster types.

<table>
<thead>
<tr>
<th>District Name</th>
<th>Sub-District name</th>
<th>Disaster type</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comilla</td>
<td>Homna</td>
<td>Riverine Flood</td>
<td>1802</td>
</tr>
<tr>
<td>Comilla</td>
<td>Meghna</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manikganj</td>
<td>Harirumpur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bogra</td>
<td>Sariakandi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pabna</td>
<td>Bera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kushtia</td>
<td>Veramara</td>
<td>Water logging</td>
<td>601</td>
</tr>
<tr>
<td>Bholia</td>
<td>Char fassion</td>
<td>Coastal cyclone</td>
<td>601</td>
</tr>
<tr>
<td>Netrokona</td>
<td>Mohanganj</td>
<td>Flash flood</td>
<td>595</td>
</tr>
<tr>
<td>Netrokona</td>
<td>Madan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netrokona</td>
<td>Khaliajhuri</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>3599</strong></td>
</tr>
</tbody>
</table>
The selection of households in each of the villages followed a systematic random sampling method where every fifth household located along the right side of the main village road was interviewed. Only the household heads (all male) were interviewed in this survey. The questionnaire used in this case study was developed from one focus group discussion and three pre-tests with approximately 40 individual household heads in different parts of the study area. Questionnaire design started in June and lasted until August 2006. 2400 household heads were interviewed during the final survey from the 3rd week of August until the 1st week of October 2006 by twenty trained and experienced interviewers. The interviewers used for the general survey also participated in the pre-tests and were trained during a three-day long training session. The questionnaire that was used for the final survey consists of around 50 questions and is divided into three sections: 1) Socio-demographic respondent characteristics (e.g. age, occupation, educational background, family size, sources of income, assets, standard of living etc.); 2) Type and extent of suffering from annual and incidental natural disaster (e.g. frequency of natural disaster, duration of disaster, inundation level, damage (type and extent), level of preparedness etc.); 3) CV questions. Each interview lasted on average about 30 minutes.

We use a DB-DC CV format to elicit respondent WTP for different flood insurance schemes. In the CV part of the questionnaire, respondents are able to freely choose payment frequency, insurance provider and insurance products. The ‘insurance product’ was offered to the respondents in the following form:
“I would now like to ask you a number of questions related to the potential of introducing an insurance scheme in this area. The principle of the proposed insurance scheme is as follows: you pay a fixed amount of money for the next five years - an insurance premium - every week, two weeks or month depending on your preferred payment frequency. Only in the case of an officially acknowledged disaster you will get compensated for any losses you suffered due to the disaster. In case of natural disaster which is not officially recognized, you will not receive any compensation. If there is a natural disaster and you claim compensation, an independent surveyor will visit you and assess the extent of damage you suffered. Based on the surveyor’s independent assessment you will be compensated accordingly, up to the maximum of your insurance sum. The terms and conditions of your insurance scheme are protected by law.”

After a detailed description of the insurance scheme, respondents are asked three WTP questions. First, respondents are asked whether or not they are willing to participate in an insurance scheme to reduce the risk of various forms of damage caused due to natural disaster. Respondents who reply positive to the first WTP question are then asked how frequently they want to pay for their most preferred insurance scheme and who they prefer to have as the provider of the insurance scheme. The valuation question is introduced after this, asking respondents for a weekly premium ranging between Tk 5 (US$ 0.07)\(^1\) and Tk 50 (US$ 0.71). A total of 6 different start bids are used. The bid levels are assigned randomly across respondents to avoid starting point bias (Mitchell and Carson, 1989). The weekly premiums are based on a previous large-scale CV survey carried out in March 2005 to test household WTP for a flood protection embankment in one of the study areas (for details see Brouwer et al, 2006) and thorough pre-testing in three pre-tests.

The yes/no DC question is followed up by two closed-ended WTP questions, asking participants whether they would be willing to pay a higher or lower amount. Participants who refuse to pay a bid amount are asked why they are not willing to pay. Respondents who refer to their limited cash income or limited financial resources as the main reason for not willing to pay the offered weekly premium are asked whether or not they are willing to pay in kind. Respondents who agree to pay in kind are then asked in open-ended format how much they are willing to pay in kind.

4. Sample characteristics, disaster risk exposure and extent of crop damage

Ninety nine percent of the 3600 household heads interviewed are men. Most people (86%) are furthermore born and raised in the sub-district where they are interviewed. The average age of the respondents is 44 years. About half of the respondents are unable to read and write. Just over a quarter finished primary school and only thirteen percent finished high school. The households consist, on average, of six family members. Around half (47%) of our sample households are involved in agricultural activities to support their livelihood. In addition, approximately 12 percent of the sample population consists of agricultural day labourers. Trade (15%), transport (taxi, ferry) (4.5%), service (administrator) (6.5 %) and construction worker (3.2%) comprise the remaining livelihood strategies of our survey households.

\(^1\) The exchange used here is 65 taka per US $.
Almost all households own the house they live in, and a majority of 61 percent own the land they grow their crops on. A tube well is the main source of drinking water for a majority (99%) of the households and only 21% of the households has a sanitary latrine in their dwelling. 45% of sample households do not have an electricity connection. Most of the households use leaves, twigs and cow dung as their main source of energy.

Average annual household income (related to the past 12 months) is about US$ 1143, while half of the sample population earns US$ 763 per year. Dividing the median yearly income by average household size and 12 months, average per capita income equals US$ 11 per month, which is less than the national average rural per capita income (US$ 14) (BBS, 2005). Using the poverty income definition of the Bangladesh Bureau of Statistics (poverty threshold value of US$ 125 per capita per year), forty eight percent of the floodplain residents included in the sample appear to live below this poverty threshold. According to the report of Household Income and Expenditure Survey, 2000, 49 percent of the total population in Bangladesh lives below the upper poverty line. We hence conclude that our sample is more or less representative in terms of household and per capita income levels.

Two thirds of the sample households own agricultural land. The average size of the farmland owned by the farmers is one hectare. Average yearly crop income accounts for 56 percent of yearly household income. A majority of 98 percent of interviewed floodplain residents are exposed to regular natural disasters like flooding, water logging, flash flood and coastal cyclones. Average crop damage incurred by households due to natural disaster equals to US$ 606, which is 53% of average annual household income and 93% of average annual crop income. Trimming off the crop damage cost for five percent lower and higher values the average crop damage cost equals to US$ 388. Median crop damage costs is two third of this amount (US$ 261). Dividing this by the median value for household income, the share of crop damage in household income is slightly lower, namely 34 percent. The minimum crop damage cost is US$4 and the maximum US$ 15,384.

Crop damage varies significantly across disaster types (see Table 2 for test results). Figure 2 presents average (5% trimmed average) and median crop damage incurred by households per disaster in different areas. Households in flash flood regions suffer from substantially high amounts of crop damage compared to other three regions. What is interesting to observe is the crop damage inside the protected area is higher than crop damage in the unprotected riverine and coastal floodplain area. The result is plausible because farmers inside the embanked area follow different cropping patterns and use larger amounts of land including low lands for crop growing because of the protection. Therefore, a breakdown or poor functioning of the protection causes a larger amount of damage compared to the unprotected area. Please note that, the damages refer to the value of crops destroyed per disaster incident (not per year). Average frequency of disaster incident varies significantly (Kruskal Wallis $\chi^2 = 1862.250; p<0.001$) depending on the type of disaster. Households living within an embanked area suffer damages due to water logging inside the embankment once every six years while residents living without any flood protection embankment experience disaster flooding once every five years. Residents in the haor basin suffer from flash flood related damage once every three years and coastal inhabitants suffer from coastal cyclonic disasters at least once every year.
Figure 2  Comparison of crop damage in four different risk areas.

Table 2  Results of Statistical Significance Test of Crop Damage Difference in Four Different Risk Areas.

<table>
<thead>
<tr>
<th></th>
<th>Average Crop Damage</th>
<th>Median Crop Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>732.635</td>
<td>531.178</td>
</tr>
<tr>
<td>df</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Asymptotic Significance</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

5. Floodplain residents’ preferences and willingness to pay for crop-insurance schemes

Fifty six percent of 3600 household heads interviewed for this survey replied positively to the first willingness to pay question where they are asked whether or not they would buy an insurance scheme in principle. Respondents who answered negatively were subsequently asked in a follow-up question why they do not want to buy insurance. The two most common reasons for not buying an insurance scheme in principle are ‘limited financial income (42%)’ and ‘disliking of terms and conditions of proposed flood insurance scheme (33%)’. Respondents not wishing to purchase a crop insurance scheme due to income constraints indeed earn a significantly ($\chi^2=90.739, p<0.001$) low average yearly income compared to other groups who declined buying insurance for other reasons. The two most unpopular features of the proposed insurance scheme were i) that the insured will not be given any monetary return if there is no disaster (91% of cases) followed by the ii) that the insured will get compensated only if the disaster is officially acknowledged (30% of cases).

A majority of 70 percent of those households who agreed to buy an insurance scheme in principle wanted to buy crop insurance. As expected, our analysis shows households who depend primarily on
crop farming for their livelihood exhibit a higher demand for crop insurance scheme than households who do not primarily depend on agricultural farming (see Table 3) \( \chi^2 = 323.653; p<0.001 \). We find crop insurance demand varies significantly across agricultural land ownership. Landowners are significantly more willing to buy crop insurance scheme than landless farmers (Table 4) \( \chi^2 = 377.710; p<0.001 \). Furthermore, we find crop insurance demand also varies significantly across the size of farmland. Respondent who are willing to buy a crop insurance scheme own significantly larger farm land areas than those who did not want to buy crop insurance (Table 5).

**Table 3** Cross tabulation number of primary occupation and crop insurance demand.

<table>
<thead>
<tr>
<th>Primary Occupation</th>
<th>Willing to buy crop insurance</th>
<th>Not willing to buy crop insurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farming is primary occupation</td>
<td>78% (n=1111)</td>
<td>22% (n=320)</td>
</tr>
<tr>
<td>Not willing to buy crop insurance</td>
<td>36% (n=215)</td>
<td>64% (n=383)</td>
</tr>
<tr>
<td>Total</td>
<td>65% (n=1326)</td>
<td>35% (n=703)</td>
</tr>
</tbody>
</table>

**Table 4** Cross tabulation number of crop insurance demand and land ownership.

<table>
<thead>
<tr>
<th>Land Ownership</th>
<th>Willing to buy crop insurance in principle</th>
<th>Not willing to buy crop insurance in principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own land</td>
<td>85.2% (n=1109)</td>
<td>14.8% (n=192)</td>
</tr>
<tr>
<td>Do not own land</td>
<td>44% (n=322)</td>
<td>56% (n=406)</td>
</tr>
<tr>
<td>Total</td>
<td>70.53% (n=1431)</td>
<td>29.74% (n=598)</td>
</tr>
</tbody>
</table>

**Table 5** Differences between land size and crop insurance demand.

<table>
<thead>
<tr>
<th>Land Area (in hectares)</th>
<th>Willing to buy crop insurance in principle</th>
<th>Not willing to buy crop insurance in principle</th>
<th>MW test Z-statistic (2-tailed sig.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3990</td>
<td>0.6133</td>
<td>-9.147</td>
<td></td>
</tr>
<tr>
<td>(2.29)</td>
<td>(0.80)</td>
<td>(p&lt;0.001)</td>
<td></td>
</tr>
</tbody>
</table>

**Explanatory notes:**
- Mean values (standard deviations in parentheses);
- MW: Mann-Whitney test.

Respondents who agreed to buy an insurance scheme in principle are first presented with an initial bid price ranging between Tk 5 (US$ 0.07) and Tk 50 (US$ 0.71). Based on the initial response the respondent is presented with a new bid price, which is lower if the initial response is negative and higher if the response is positive. A summery of responses to different bids is presented in Table 6.
Table 6  Summary result of bid responses.

<table>
<thead>
<tr>
<th>Response to Bid-1</th>
<th>Response to Bid-2</th>
<th>Response to Bid-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES=57%</td>
<td>YES=81%</td>
<td></td>
</tr>
<tr>
<td>NO=43%</td>
<td>NO=19%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>YES=66%</td>
<td>NO=34%</td>
</tr>
</tbody>
</table>

Different mean WTP values can be calculated depending on the statistical specification of the valuation function and the applied truncation strategies. Various statistical models exist to estimate expected value of double bounded (DB) choice model such as logit or probit models. These models usually produce significantly different results and are an important source of statistical model specification bias in the analysis of CV results. Using the statistical assumptions underlying interval regression (e.g. Hanemann et al., 1991; Alberini, 1995), we estimate this interval regression model (in Gauss) using the Maximum Likelihood (ML) method. Mean WTP values are derived from a simple model where the intervals are regressed on the starting bid (e.g. Hanemann and Kanninen, 1999), following the conventional procedures for binary WTP response data (Hanemann, 1984). Standard errors of the WTP values are calculated based on bootstrap procedures (e.g. Efron and Tibshirani, 1993).

The estimation results are presented in the Table 7. The estimated double bounded (DB) WTP for crop insurance ranged from US$ 0.41 to US$0.71 per household per week in different risk areas. What is interesting to observe is the differential WTP pattern across risk areas. Households living inside the protected area are willing to pay the highest average premium in absolute term to protect their crop from damage compared to other risk areas. On the other hand, households in the flash flood region who suffer from the highest average crop damage due to natural disaster are willing to pay the least to reduce their damage risk. These paradoxical WTP values can be explained by variation in income and livelihood pattern in the risk areas. Households in the flash flood prone haor basin earn a significantly lower ($\chi^2 = 447.551, p<0.001$) average yearly income than other risk areas included in this study. The widespread poverty in this region is caused by limited livelihood opportunities other than agricultural farming, and the cyclical exposition of households to destruction caused by natural disasters. On the other hand, households living inside the protected area earn the highest average income per year compared to other areas. The high income in the protected area is due to the embankment which enables increased agricultural income opportunities due to year round availability of irrigation water and protection from seasonal as well as disastrous flooding. There are also diversified livelihood opportunities due to an improved road transport communication system and other infrastructural development in the region. Therefore to a large extent, differences in willingness to pay in different risk areas can be explained by households’ ability to pay. Although average crop damage costs incurred by coastal and riverine floodplain residents were very close, coastal floodplain residents’ estimated average WTP is higher than that of riverine floodplain residents’ WTP. However, the standard deviation of coastal residents’ WTP is very high which implies a larger amount of fluctuation in average WTP.
### Table 7  Estimated average WTP for crop insurance scheme in different risk area.

<table>
<thead>
<tr>
<th>Risk Area</th>
<th>Median WTP (US$/Week)</th>
<th>Standard error</th>
<th>95% CI</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverine (embanked)</td>
<td>0.71</td>
<td>0.023</td>
<td>0.49, 0.54</td>
<td>305</td>
</tr>
<tr>
<td>Riverine (un-embanked)</td>
<td>0.52</td>
<td>0.014</td>
<td>0.66, 0.76</td>
<td>517</td>
</tr>
<tr>
<td>Coastal</td>
<td>0.60</td>
<td>0.060</td>
<td>0.49, 0.75</td>
<td>91</td>
</tr>
<tr>
<td>Flash Flood</td>
<td>0.41</td>
<td>0.015</td>
<td>0.38, 0.44</td>
<td>516</td>
</tr>
</tbody>
</table>

### 6. Testing the commercial viability of the crop insurance contract

In this section, we present the test result of commercial viability of crop insurance scheme for four different kinds of natural disaster risk (see Table 8). We compare the average expected indemnity paid by insurers and the future value of estimated willingness to pay for a crop insurance scheme. The average expected indemnity is proxied by average crop damage incurred by households in different risk areas. Future value of average willingness to pay for crop insurance is used as expected insurance premium using equation 2 described in Section 2. The future value of average willingness to pay is calculated assuming a market interest rate of 10% per annum. The number of payments made by household is measured by taking into account the average frequency of natural disaster in each area. Information on the frequency of natural disaster events in each different risk area is collected through the household survey. We find the following frequency of natural disaster in our study sites:

- i. riverine_unembanked: once in every five years;
- ii. riverine_embanked: once in every six years;
- iii. flash flood area: once in every three years and;
- iv. coastal area: once every year.

### Table 8  Future value of expected insurance premium for crop insurance scheme.

<table>
<thead>
<tr>
<th>Risk Area</th>
<th>Future value of expected insurance premium (in US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverine_unembanked</td>
<td>176.24</td>
</tr>
<tr>
<td>Riverine_embanked</td>
<td>304.78</td>
</tr>
<tr>
<td>Coastal</td>
<td>33.20</td>
</tr>
<tr>
<td>Flash flood</td>
<td>75.76</td>
</tr>
</tbody>
</table>

The future value of the expected insurance premium presented in Table 8 is affected by two key factors: 1) expected willingness to pay and 2) frequency of disaster event (used to calculate the number of instalments). The higher the estimated WTP for a crop insurance scheme, the higher the future value of the expected insurance premium. On the other hand, the lower the frequency of disaster events, the higher the number of premiums paid by the insured and therefore the higher the future value of the expected insurance premium. The frequency of disaster event is lowest in riverine embanked area (once in every six years) and average WTP is the highest; therefore, in Table 8, the expected future value for riverine embanked area is the highest. On the other hand, the future value of the expected premium is lowest in the coastal area. Although the average WTP value of coastal
floodplain residents is higher than the riverine unembanked and flash flood region, the lowest future value in this area is the contribution of highest frequency of disaster event (once every year).

Table 9 presents our results on the commercial viability test of the crop insurance scheme that we calculate using equation 1 presented in Section 2. Assuming zero administrative cost for implementation of our hypothetical crop insurance scheme, we compare the future value of estimated willingness to pay for the crop insurance scheme and expected indemnity payment by the insurer for different disaster risk areas. Due to a substantial difference between the mean and median crop damage cost in our survey data, we present two different estimates of insurance indemnity and insurance premium ratio (I/P) based on mean and median crop damage. I/P ratios presented in Table 9 show interesting patterns for different risk area irrespective of mean and median crop damage cost. In almost all risk areas the I/P ratio for crop insurance scheme exceeds one, which implies that the expected average premium floodplain households are willing to pay to reduce, crop damage risk is too low to cover the expected average indemnity, even at a zero administrative cost. As expected, due to the highest average crop damage cost per disaster event and lowest average willingness to pay, largest amount of discrepancy between expected indemnity and average willingness to pay is observed in flash flood area. Although the crop damage cost in the coastal area is one of the lowest among all risk areas, the high frequency of disaster event reduced the future value of expected insurance premium in comparison with the expected indemnity payment. For riverine embanked and unembanked areas, the I/P ratio ranges from 1 to 2. In unprotected riverine floodplain area, the I/P ratio lies marginally below one when indemnity payment is calculated on the basis of median crop damage. The numbers in the parentheses in Table 9 refer to the 95% confidence interval value for I/P ratio constructed on the basis of average willingness to pay estimates. The I/P ratio for flash flood and coastal region ranges from 3.7 to 15.3 for 5% variation in estimated WTP value in respective regions. In the riverine area, I/P ratio ranges within 0.8 to 1.4 for variation in WTP value. A crop insurance scheme seems marginally commercially viable in the riverine floodplain area when we used median crop damage cost as the expected indemnity payment.

Table 9  Financial viability of crop insurance contracts assuming zero administration costs of implementation.

<table>
<thead>
<tr>
<th>Risk area</th>
<th>I/P (based on mean crop damage)</th>
<th>I/P (based on median crop damage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverine_unembanked</td>
<td>1.2 (1.25 – 1.1)</td>
<td>0.9 (0.92 – 0.8)</td>
</tr>
<tr>
<td>Riverine_embanked</td>
<td>1.3 (1.4 – 1.2)</td>
<td>1.0 (1.1 – 0.9)</td>
</tr>
<tr>
<td>Coastal</td>
<td>5.8 (7.1 – 4.6)</td>
<td>4.6 (5.7 – 3.7)</td>
</tr>
<tr>
<td>flash flood</td>
<td>14.2 (15.3 – 13.2)</td>
<td>7.3 (7.8 – 6.7)</td>
</tr>
</tbody>
</table>

**Explanatory notes:**

a) 95% confidence interval values in parentheses
7. Discussion and conclusion

The aims of this paper were to assess crop insurance demand in different disaster prone rural areas of Bangladesh and to test the commercial viability of a hypothetical crop insurance scheme. In an extensive household survey 3600 residents facing four different kinds of natural disaster risks were asked about the nature and extent of suffering and damage due to catastrophic events and their willingness to pay to reduce damage risk using the double bounded contingent valuation method.

The results of our study reveal that crop insurance demand varies across household head’s primary occupation, land ownership and size of farmland. We found that it was mainly agricultural farmers who own large parcels of farmland were willing to buy insurance schemes to protect them against the risk of catastrophic damage. Our study further reveals significant variation in crop damage and willingness to pay for crop insurance scheme across the nature of disaster risk faced by households. However, variation in estimated average willingness to pay stems out of variation in average household income rather than differences in average damage cost.

Using average crop damage cost incurred by households in different risk areas as average expected indemnity payable by insurers, we tested our simple analytical model of commercial viability by comparing the future value of expected premium receivable by insurer with expected indemnity payable to the insured. Assuming zero administrative cost and 10% interest rate per annum, we find crop insurance schemes marginally viable in riverine flood plain areas (both embanked and unembanked). The discrepancy between average expected indemnity payment and future value of expected insurance premium is way too high for the nature of risk and amount of damage cost faced by households living in haor basin and coastal floodplain.

Findings of our study indicate that a uniform structure of crop insurance market does not exist in Bangladesh. Crop damage varies depending on nature of catastrophe and willingness to pay varies depending on socio-economic condition of the area. Hence, crop insurance scheme should be developed carefully taking these two key criterions into consideration. In terms of commercial viability our study does not reveal very prospective picture especially for haor basin and coastal floodplain area of Bangladesh. Although for riverine embanked and unembanked floodplain areas the prospect does not seem too bright, a moderate amount of government subsidy seem useful for take off period. However, financial viability results that we portrayed in this study do not include administrative costs. Depending on the institutional set-up of a crop insurance scheme, a positive and considerably high administrative cost may result in a crop insurance scheme being impractical, even in riverine floodplain areas.
References


