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ORIGINAL ARTICLE

Is there a commercially viable market for crop insurance in rural Bangladesh?

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Abstract The study aims to assess the commercial viability of a potential crop insurance market in Bangladesh. In a large scale household survey, agricultural farm households were asked for their preferences for a hypothetical crop insurance scheme using double bounded (DB) contingent valuation (CV) method. Both revenue and production cost based indemnity payment approaches were applied to assess the commercial viability of a crop insurance program assuming a partner-agent (PA) model of insurance supply. Crop insurance is found marginally commercially viable in riverine flood plain areas. The expected indemnity payable consistently exceeds the expected insurance premium receivable by the insurer for the households living in wetland basin and coastal floodplain. We conclude that a uniform structure of crop insurance market does not exist in Bangladesh. The nature of the disaster risks faced by the farm households and the socio-economic characteristics of the rural farm communities need to be taken into careful consideration while designing such an insurance scheme.

Keywords Crop insurance · Commercial viability · Willingness to pay · Double bounded contingent valuation · Bangladesh

Abbreviations

CV Contingent valuation
DB Double bounded

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DC Dichotomous choice
$\frac{I}{P}$ Indemnity and insurance premium ratio
PA Partner agent
WTP Willingness to pay

1 Introduction

Agriculture contributes one quarter of the Bangladesh GDP and is the source of employment for more than 80% of the rural population. Weather related risk is a major source of income fluctuations for agricultural households in Bangladesh. Both coastal as well as inland farm households face natural disaster risks due to its geographical location and very low land elevation. The increased volume of rainfall and other catastrophic events caused by climate change during the past decades have intensified the livelihood risk faced by agricultural farmers in this part of the world. The management of inherent and increased amount of risk associated with agricultural crop[1] production has remained the key challenge in the poverty reduction program of Bangladesh for the past few decades. Traditionally, the management of catastrophe risks in Bangladesh agriculture has revolved around infra-structural measures such as building embankments and ex-post disaster relief measures, including increased access to post-disaster credit facilities. Following the overwhelming success of micro-credit in Bangladesh, there is a growing optimism in micro-insurance solutions to protect rural farmers from income shocks resulting from catastrophic risks. The aim of the proposed disaster micro-insurance is to spread the risks of natural disasters especially for the poor counterpart of the population in order to make them better prepared to cope with increased climatic disasters such as floods, cyclones and storm surges.

Whilst the use of micro-insurance to cover life and health risks is prevalent to some extent, the use of micro-insurance to hedge against natural disaster losses in rural areas of Bangladesh is still only emerging. The National Adaptation Program of Action (NAPA 2005), prepared by the Ministry of Environment and Forests, 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 Environment, are currently underway to test the feasibility of crop insurance in the most calamity prone areas of Bangladesh.

Although micro-insurance is often referred to as an effective tool for reducing, sharing or spreading climate-related costs and risks (ProVention/IIASA 2005; Hazell 2001), the commercial viability of such insurance schemes has been a key challenge for poor developing economies as the transfer of losses from affected groups to the community at large is not feasible at an affordable premium rate. 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 counterparts 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 (Anderson 2001; Spaulding et al. 2003; Gurenko and Mahul 2004).

The aim of the study presented here is to assess the financial viability of a potential crop insurance market in Bangladesh, one of the poorest and most disaster prone countries in the

[1] Rice is the prime agricultural crop in Bangladesh.

world. In a large scale household survey carried out at the end of 2006, 3,600 riverine and coastal floodplain residents in Bangladesh were asked for their preferences for crop insurance schemes using the double bounded (DB) contingent valuation (CV) method, i.e. asking them for their willingness to pay (WTP) for crop insurance schemes to eliminate future catastrophe risks. Although application of CV to estimate crop insurance demand is fairly widespread now-a-days (Patrick 1988; Fraser 1992; Vandeveer and Loehman 1994; van Asseldonk et al. 2002; McCarthy 2003), such an extensive and explicit feasibility test of a potential crop insurance market in a severely natural disaster prone developing country is currently lacking. Previous studies mainly focused on estimating average WTP and in determining the factors that affect demand for crop insurance. The current study goes beyond estimation of average WTP, using the data obtained through an extensive DB CV survey, by testing a simple analytical model of long term sustainability and commercial viability outlined by Hazell (1992). Although there are numerous relevant actuarial issues associated with an insurance design as well (e.g. premium setting, adverse selection, moral hazard), they fall outside the scope of the current study. We are primarily interested in testing potentiality of a future crop insurance market based on basic cost recovery criteria across spatially dispersed geographical areas that differ in terms of environmental risks and socio-economic characteristics.

The remainder of this paper is organized as follows. Section 2 presents 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 crop damages suffered are described in Section 4. We discuss the WTP 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 analytical framework of this study is based on a simple model used by Hazell (1992). According to Hazell (1992), 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 term ‘indemnity’ refers to the compensation sum that insurers make to the holder of the insurance contract upon post assessment of damage due to a disaster event. We hypothesized a simple design of linear indemnity payout function of the following form for a specific insurance scheme i:

$$\begin{array}{lll} I_i = D_i & \text{If} & \text{Disaster event strikes} \\ I_i = 0 & \text{If} & \text{Disaster event does not strike} \end{array}$$

Where,

I_i indemnity paid by the insurer
D_i damage incurred by the insured

Therefore, the condition for a viable and sustainable insurance contract takes the following form (Hazell 1992):

$$\frac{A+I}{P} < 1 \tag{1}$$

where

A average administrative costs per insurance contract
I average indemnities paid
P average premiums received

Hazell (1992) uses time series data over the period 1975–1989 for seven countries to test the long-term viability and sustainability of crop insurance programs. In view of the fact that an insurance market currently does not exist in Bangladesh, Hazell's (1992) model was estimated using expected values. Expected indemnity payment for crop insurance was proxied by average crop damage costs incurred by households in a disaster event prior to the survey year. Expected premium per contract for crop insurance was estimated on the basis of data originating from a CV survey through a DB DC elicitation method. Respondents, under this valuation method, are 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:

$$\begin{array}{ll} \mathrm{WTP}=1 & \text{Rejecting both the start bid } (\mathrm{c_i}) \text{ and follow} - \text{up bid } (\mathrm{b_i}) \\ \mathrm{WTP}=2 & \text{Rejecting the start bid } (\mathrm{c_i}) \text{ and accepting the follow} - \text{up bid } (\mathrm{b_i}) \\ \mathrm{WTP}=3 & \text{Accepting the start bid } (\mathrm{c_i}) \text{ and rejecting the follow} - \text{up bid } (\mathrm{d_i}) \\ \mathrm{WTP}=4 & \text{Accepting both the start bid } (\mathrm{c_i}) \text{ and follow} - \text{up bid } (\mathrm{d_i}) \end{array}$$

The average WTP for crop insurance was estimated using standard statistical software. The estimated average WTP values were used to calculate future values of expected insurance premiums receivable by the insurers using the following formula:

$$P_e = \mathrm{WTP} * \frac{(1+r)^n - 1}{r} \tag{2}$$

where

P_e future value of insurance premium (per insurance contract)
r interest rate
n number of payments
WTP estimated average willingness to pay for crop insurance

A partner-agent (PA) model of institutional framework was assumed for insurance supply. In a PA model, insurance companies and micro-credit providers collaborate to jointly offer the insurance schemes. Generally, insurance companies bear the full risk, while micro-credit providers carry out most of the field level operational and administrative work through their established extensive client network. Administrative cost of offering, distributing and maintaining insurance contracts under such a model is reduced either to zero or to a very negligible amount per insurance contract.

3 General survey design

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 the Department

Table 1 Distribution of sample across different districts and different disaster types

Disaster type	District	Sub-district	Sample size
Riverine flood	Comilla	Homna	1,802
	Comilla	Meghna	
	Manikganj	Harirumpur	
	Bogra	Sariakandi	
	Pabna	Bera	
Water logging	Kushtia	Veramara	601
Coastal cyclone	Bhola	Char fassion	601
Flash flood	Netrokona	Mohanganj	595
	Netrokona	Madan	
	Netrokona	Khaliajhuri	
Total			3,599

of Environment, Government of Bangladesh and policy planners at the Water Resource Planning Organization. It appeared from the key informant interviews that crop damage in Bangladesh occurs due to four major types of natural disasters, namely riverine flood, water logging[2], flash flood and 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 the lowest in terms of return period compared to flash flood and coastal cyclone. On the other hand, flash flood and coastal cyclone are shorter in duration compared to other two types of disaster.

Seven districts from different parts of Bangladesh were selected to cover the four different kinds of natural disaster risks. 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 the biggest Flood Control and Irrigation Project in the country). One coastal district surrounded by Bay of Bengal and lower Meghna at the southern end of Bangladesh and one district in north-east zone of Bangladesh covering flash flood prone wetland basin were selected for the survey. Seven sub-districts (called 'upazilla') from these six main districts that lie closest to the main rivers and sea were selected. In total around 600 household heads were interviewed in each sub-district. The area-wise distribution of the sample is presented in Table 1. See Fig. 1 for the geographical location of these study areas.

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. The questionnaire used in this case study was developed from focus group discussions 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. Three thousand six hundred household heads were interviewed during the final survey from the third week of August until the first week of October 2006 by 20 trained and experienced interviewers. The interviewers used for the general survey also participated in the pre-tests and were trained during a 3 day long training session. The final survey questionnaire consisted of around 50 questions and was divided into three sections: (1) Socio-demographic respondent characteristics (e.g. age, occupation, educational background, family size, sources of income, assets, standard of living); (2) Type and

[2] Water logging is an outcome of faulty design of the embankment and poor maintenance of the drainage systems within the embankment.

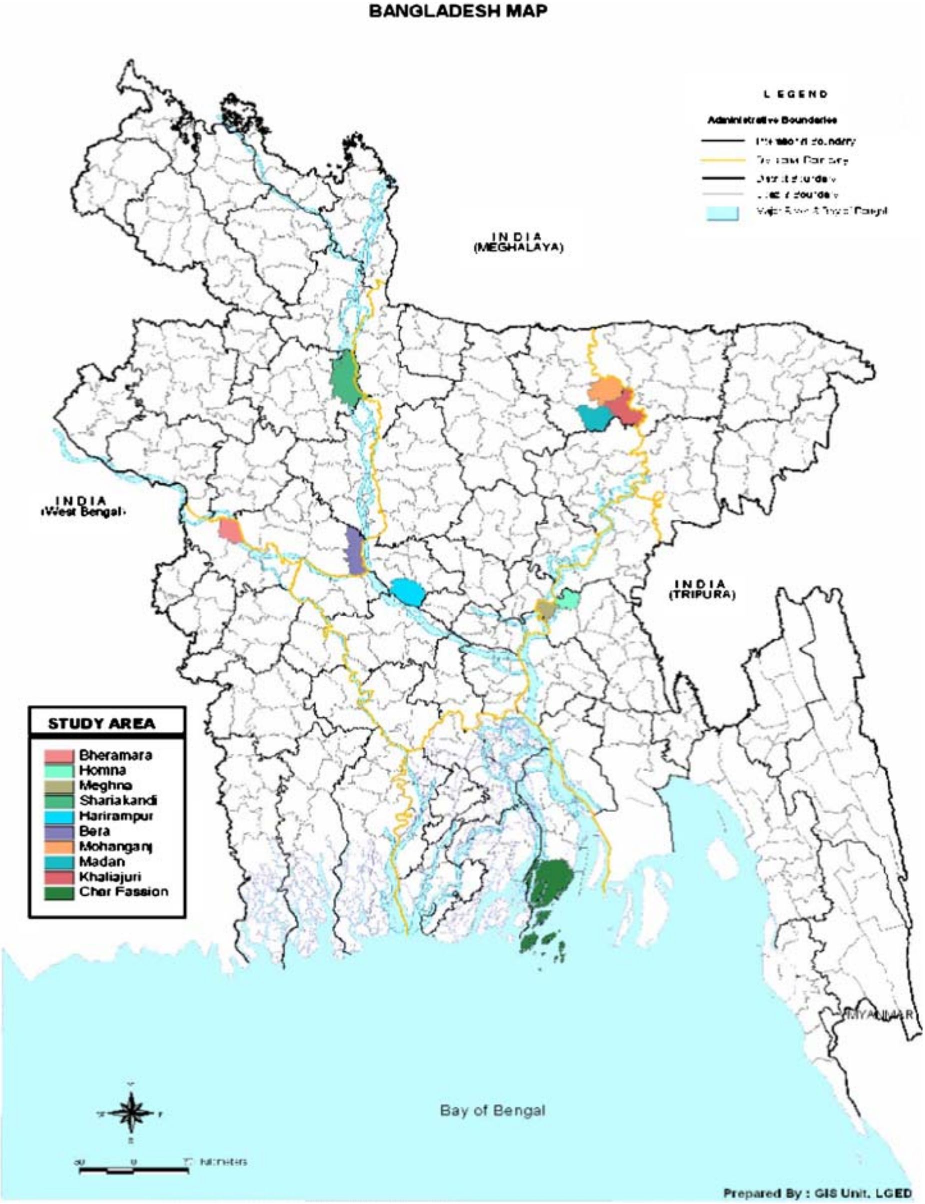

Fig. 1 Geographical location of the study sites

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); (3) DB CV questions. In the DB CV part of the questionnaire, respondents were able to freely choose payment frequency, insurance provider and insurance scheme. The ‘insurance scheme’ 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 - 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 receive compensation 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. The terms and conditions of your insurance scheme are protected by law.

After a detailed description of the insurance scheme, respondents were asked three WTP questions. First, respondents were asked whether or not they were willing to participate in an insurance scheme, in principle, to reduce the risk of various forms of damages caused due to natural disasters. Respondents who replied positive to the first WTP question were then asked how frequently they would want to pay for their most preferred insurance scheme and who they would prefer to have as the provider of the insurance scheme. The valuation question was introduced after this, asking respondents for a weekly premium ranging between Tk 5 (US$ 0.07)[3] and Tk 50 (US$ 0.71). A total of six different start bids were used. The bid levels were assigned randomly across respondents to avoid starting point bias (Mitchell and Carson 1989). The weekly premiums were 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 was followed up by two closed-ended WTP questions, asking participants whether they would be willing to pay a higher or lower amount. Participants who refused to pay a bid amount were asked why they were not willing to pay.

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

Ninety-nine percent of the 3,600 household heads interviewed were men. The average age of the respondents was 44 years. About half of the respondents were unable to read and write. Just over a quarter finished primary school and only 13% finished high school. The households consisted, on average, of six family members. Around half (47%) of our sample households were involved in agricultural activities to support their livelihood. In addition, approximately 12% of the sample population consisted of agricultural day laborers. Trade (15%), transport (taxi, ferry) (4.5%), service (administrator) (6.5%) and construction worker (3.2%) comprised the remaining livelihood strategies of the sample households. A tube well was the main source of drinking water for a majority (99%) of the households and only 21% of the households had a sanitary latrine in their dwelling. Forty-five percent of sample households did not have an electricity connection. Most of the households used leaves, twigs and cow dung as their main source of energy.

Two thirds of the sample households owned agricultural land. The average size of the farm land owned by the farmers was one hectare. Average yearly crop income accounted for 56% of yearly household income. Average annual household income (related to the past 12 months) was about US$ 1,143, while half of the sample population earned US$ 763 per

[3] The exchange rate used here is 65 taka per US $.

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), 48% of the residents included in the sample appears to live below this poverty threshold. According to the report of Household Income and Expenditure Survey 2000 (BBS 2003), 49% of the total population in Bangladesh lives below the upper poverty line. We hence conclude that our sample is fairly representative in terms of household and per capita income levels.

A majority of 98% of interviewed residents was exposed to regular natural disasters like flooding, water logging, flash flood and coastal cyclones. Average frequency of disaster incident varied significantly (Kruskal Wallis $\chi^2=1,862.25$; $p<0.001$) depending on the types of disaster. Households living within an embanked area suffered damages due to water logging inside the embankment once every 6 years while residents living without any flood protection embankment experienced disaster flooding once every 5 years. Residents in the wetland basin suffered from flash flood related damage once every 3 years and coastal inhabitants suffered from coastal cyclonic disasters at least once every year.

Average crop damage incurred by the households due to natural disaster equaled to US$ 606 which was 53% of average annual household income and 93% of average annual crop income. Trimming off the crop damage cost for 5% lower and higher values the average crop damage cost equaled to US$ 388. Median crop damage costs was two thirds of this amount (US$ 261). Dividing this by the median value for household income, the share of crop damage in household income was slightly lower, namely 34%. The minimum crop damage cost was US$4 and the maximum US$ 15,384. Crop damage cost varied across disaster types. Figure 2 presents average (5% trimmed average) and median crop damage

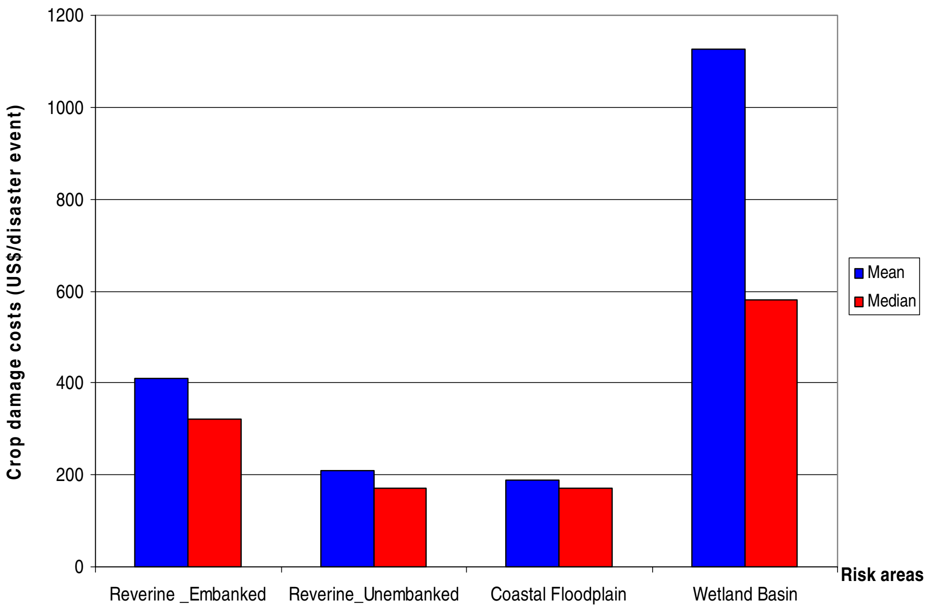

Fig. 2 Comparison of crop damage costs in four different risk areas

incurred by households per disaster event in different risk areas. The differences in mean and median crop damage costs across different disaster risk areas were, furthermore, statistically significant (mean difference: Kruskal Wallis χ^2=732.63, p<0.001; median difference: Kruskal Wallis χ^2=531.18, p<0.001). Farm households living in flash flood region suffered from the highest amounts of crop damage compared to other three regions. What is interesting to observe is that the crop damage inside the protected area was higher than the crop damage in 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 farm land including low lying lands for crop growing because of the existence of the flood protection embankment. Therefore, a breaching or poor functioning of the protection causes a larger amount of damage compared to the unprotected area.

5 Floodplain residents' preferences and WTP for crop-insurance

Around half of all the households interviewed agreed to participate in the proposed disaster insurance program in principle (n=2,016). Respondents who refused to participate in the insurance program referred to 'limited financial income' (40%) and 'dislike of the terms and conditions of the proposed flood insurance scheme' (35%) as the two main reasons for not participating. Respondents denying to participate in the insurance scheme due to income constraints indeed earned significantly less income on average than groups who denied to participate for other reasons (Mann–Whitney Z=−13.57, p<0.001). Regarding the disliked terms and conditions, the most unpopular feature of the proposed insurance scheme was that the insured would not be given any monetary return in case of no disaster (mentioned by 65% of the respondents who stated 'dislike of terms and conditions' as their main reason for non-participation).

In general, insurance was found to be a widely unknown concept to the sample respondents. Less than 2% of the sample respondents had ever bought insurance whereas more than two thirds of the sample respondents were completely unfamiliar with how an insurance contract works. We detect significant positive relationship (χ^2=336.28, p<0.001) between respondents' levels of insurance familiarity and insurance participation decision. Respondents who were more familiar with the notion of how an insurance scheme helps in risk pooling among communities were willing to participate more than the respondents who were less familiar (see cross tabulation result in Table 2 for details). Furthermore, education was found to have statistically significant positive correlation with insurance familiarity (r=0.216; p<0.001), which indicates that respondents with higher level of education were more familiar with insurance.

Table 2 Cross tabulation results between insurance familiarity and insurance participation decision

	Buy insurance	
Familiar with insurance	Yes	No
Not familiar at all	27% (n=38)	73% (n=104)
Not familiar	37% (n=415)	63% (n=702)
Somewhat familiar	66% (n=851)	34% (n=446)
Familiar	69% (n=612)	31% (n=271)
Completely familiar	71% (n=113)	29% (n=47)
Total	56% (n=2,029)	44% (n=1,570)

Table 3 Cross tabulation results between primary occupation and crop insurance demand

Buy crop insurance	Farming primary occupation	
	Yes	No
Yes	78% (n=1,111)	22% (n=320)
No	36% (n=215)	64% (n=383)
Total	65% (n=1,326)	35% (n=703)

A majority of 70% of those households who agreed to buy an insurance scheme in principle wanted to buy crop insurance. As expected, households who depended primarily on crop farming for their livelihood exhibited a higher demand for crop insurance than households who did not primarily depend on agricultural farming (see Table 3) (χ^2= 323.65; p<0.001). We find crop insurance demand varying significantly across agricultural land ownership. Land owners were more likely to buy crop insurance than landless farmers (see Table 4) (χ^2=377.71; p<0.001). Crop insurance demand, furthermore, varied within the land owners. Respondents who were willing to participate in a crop insurance program, on an average, owned significantly higher parcel of crop land than respondents who did not want to participate (Mann–Whitney Z=−9.147, p<0.001).

Using the statistical assumptions underlying interval regression (e.g. Hanemann et al. 1991; Alberini 1995), the interval regression model was estimated (in Gauss) using the Maximum Likelihood method. The estimation results are presented in Table 5. The estimated DB WTP for crop insurance ranged between US$ 0.41 to US$ 0.71 per household per week in different risk areas. What is interesting to observe in Table 5 is the differential WTP pattern across the risk areas. Households living inside the protected area were willing to pay the highest average risk premium in absolute term to share the crop damage risk. On the other hand, households in the flash flood region, who suffered from the highest average crop damage costs, were willing to pay the least to reduce their damage risk. These paradoxical WTP values can be explained by the variations in income and livelihood patterns in these two different risk areas. Households in the flash flood prone wetland basin earned a significantly lower (Kruskal Wallis χ^2=447.551, p<0.001) average yearly income than other risk areas included in this study. The widespread poverty in the wetland basin was due to the limited livelihood opportunities other than agricultural farming and the cyclical exposition to destructions caused by natural disasters.

On the other hand, households living inside the protected area earned the highest average income per year. The high income in the protected area was due to the embankment which enables enhanced agricultural income opportunities as a result of year round availability of irrigation water. Furthermore, there are 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 WTP in different risk areas can be

Table 4 Cross tabulation results between crop insurance demand and land ownership

Own land	Buy crop insurance	
	Yes	No
Yes	85% (n=1,109)	15% (n=192)
No	44% (n=322)	56% (n=406)
Total	70% (n=1,431)	30% (n=598)

Table 5 Estimated average WTP for crop insurance scheme in different risk areas

Risk area	WTP (US$/week)	Standard Error	95% Confidence Interval		Observations
Riverine (embanked)	0.71	0.023	0.66	0.76	305
Riverine (un-embanked)	0.52	0.014	0.49	0.54	517
Coastal	0.60	0.060	0.49	0.75	91
Flash flood	0.41	0.015	0.38	0.44	516

explained by household ability to pay. Although average crop damage costs incurred by coastal and riverine floodplain residents were fairly close, coastal floodplain residents' estimated average WTP was higher than that of riverine floodplain residents' WTP. However, the standard deviation of coastal residents' WTP was higher which resulted in a larger confidence interval for average WTP.

6 Testing the commercial viability of the crop insurance contract

Table 6 presents the future value of the insurance premium receivable by the insurer across different risk areas. The future value of average WTP was calculated assuming a market interest rate of 10% per annum. The number of payments to be made by the insured is calculated by taking into account the average frequency of natural disaster in each risk area[4]. The future value of the insurance premium receivable by the insurer (as outlined in Eq. 2 in Section 2) varies positively with the estimated WTP and negatively with the frequency of natural disaster. In other words, other things remaining the same, a higher value of the estimated average WTP for crop insurance will result a higher future value of the expected insurance premium. Conversely, a higher frequency of disaster events (or a lower disaster return period) will generate lower number of premiums paid by the insured (lower value of 'n' in Eq. 2) and, therefore, the future value of the expected insurance premium will decrease. For example, the frequency of disaster event was the lowest in riverine embanked area (once in every 6 years) and average WTP was the highest; therefore, in Table 6, the future value of insurance premium for riverine embanked area is the highest. On the other hand, the future value of the expected insurance premium is the lowest in the coastal area. Although the average WTP value of coastal floodplain residents was higher than the riverine unembanked and flash flood region, the lowest future value in this area is the outcome of the highest frequency of disaster event.

Tables 7 and 8 summarize the results of commercial viability test. Assuming a zero administrative cost of implementation in a PA institutional framework, the insurance premium payable by the insured and indemnity payout payable by the insurer were compared using Eq. 1 presented in Section 2. Due to a substantial difference between the mean and median crop damage costs in the survey data, two different estimates of indemnity and insurance premium ratio $\left(\frac{I}{P}\right)$ were presented based on mean and median crop damage costs. In view of the fact that the indemnity payment could be based on either a revenue loss principle or a production cost principle, two separate feasibility tests were conducted to check the robustness of the results.

[4] For example, for an area that suffers from natural disaster risk once every 5 years, number of payments (n in Eq. 2) equals to 260.

Table 6 Future value of expected insurance premium for crop insurance contract

Risk area	Future value of expected insurance premium (in US$)
Riverine—unembanked	176.24
Riverine—embanked	304.78
Coastal	33.20
Flash flood	75.76

Table 7 summarizes the feasibility test results based on a revenue loss indemnity payment principle. The $\frac{I}{P}$ ratios presented in Table 7 show interesting patterns across different risk areas regardless of the mean and median crop damage costs. In almost all risk areas the $\frac{I}{P}$ ratios for crop insurance scheme exceed one which implies that the expected average premium floodplain households were willing to pay was too low to cover the expected average indemnity, even at a zero administrative cost. However, the extent to which the expected indemnity exceeds expected insurance premium varies across different risk areas. As expected, due to the highest average crop damage cost per disaster event and lowest average WTP, largest amount of discrepancy between expected indemnity and expected insurance premium is observed in flash flood area (the $\frac{I}{P}$ ratios for a 95% confidence interval of average WTP range between 6 and 15). Similar discrepancy between expected indemnity payout and expected insurance premium is witnessed in coastal floodplain area (the $\frac{I}{P}$ ratios for a 95% confidence interval of average WTP range between 3 and 7). Although the crop damage cost estimates obtained for the coastal farm households was the lowest among all risk areas, the highest frequency of disaster event in this area produced a low value of expected insurance premium relative to the expected indemnity payment which consequently generated relatively higher $\frac{I}{P}$ ratios. For riverine embanked and unembanked areas, the $\frac{I}{P}$ ratios range between 1 to 2. In unprotected riverine floodplain area, the $\frac{I}{P}$ ratio lies marginally below one when indemnity payment is calculated on the basis of median crop damage. A crop insurance scheme appears to be marginally commercially viable in the unprotected riverine floodplain area when damage is estimated using median crop damage costs.

Table 8 summarizes the results of the feasibility test that was conducted on the basis of a production cost based indemnity payment principle. Given the fact that the true production cost data was not collected during the household survey, the production cost was estimated based on the available revenue loss information. The $\frac{I}{P}$ ratios presented in Table 8, furthermore, are calculated based on two different production cost estimates, namely a lower bound (cost of production=0.7*revenue) and an upper bound (cost of production=

Table 7 Financial viability of crop insurance contracts assuming zero administration costs of implementation: a revenue based approach

Risk area	$\frac{I}{P}$ (based on mean crop damage)	$\frac{I}{P}$ (based on median crop damage)
Riverine—unembanked	1.2 (1.28–1.2)	0.9 (0.96–0.87)
Riverine—embanked	1.3 (1.41–1.2)	1.0 (1.08–0.94)
Coastal	5.8 (7.13–4.7)	4.6 (5.66–3.72)
Flash flood	14.2 (15.6–13.4)	7.3 (8.02–6.91)

95% Confidence Interval values in parentheses

Table 8 Financial viability of crop insurance contracts assuming zero administration costs of implementation: a production cost based approach

Risk area	$\frac{I}{P}$ (based on mean crop damage)		$\frac{I}{P}$ (based on median crop damage)	
	(Cost=70% of the revenue)	(Cost=90% of the revenue)	(Cost=70% of the revenue)	(Cost=90% of the revenue)
Riverine—unembanked	0.84 (0.90–0.81)	1.1 (1.15–1.05)	0.63 (0.67–0.61)	0.8 (0.87–0.78)
Riverine—embanked	0.91 (0.98–0.86)	1.2 (1.26–1.10)	0.7 (0.76–0.66)	0.9 (0.97–0.85)
Coastal	4.06 (4.99–3.29)	5.2 (6.42–4.23)	3.22 (3.96–2.61)	4.1 (5.09–3.35)
Flash flood	9.94 (10.91–9.41)	12.8 (14.03–12.10)	5.11 (5.61–4.84)	6.6 (7.21–6.22)

95% Confidence Interval values in parentheses

0.9* revenue). The test results portray slightly brighter prospects of a crop insurance market in revirine floodplain areas depending upon the level of crop production cost. When the lower bound of crop production cost is considered, the $\frac{I}{P}$ ratios remain below one for embanked and unembanked reverine areas for both mean and median crop damage cost estimates. At a substantially high cost of crop production, the $\frac{I}{P}$ ratios remain below one for reverine floodplain area when median damage cost is considered whereas the $\frac{I}{P}$ ratios exceed one for mean crop damage costs. On the other hand, regardless of the level of crop production costs, the $\frac{I}{P}$ ratios exceed one in flash flood and coastal cyclone zones for both mean and median crop damage costs.

7 Summary and conclusion

The aim of the study presented here was to assess the commercial viability of a hypothetical crop insurance market in rural areas facing four different types of natural disaster risks. Three thousand six hundred residents were asked about the nature and extent of damage costs incurred due to catastrophic events and their WTP to reduce damage risks using the DB CV method. We find around half of the sample households was willing to buy an insurance in principle which indeed indicates low demand for crop insurance. Majority of those respondents who did not agree to buy an insurance indicated lack of money income as reason for not buying insurance. This finding confirms that income constraint is a major demand side obstacle to set-up a disaster insurance market in developing countries. However, a considerably large proportion (33%) of the respondents who did not want to buy disaster insurance in principle indicated that they did not like the terms and conditions of the proposed insurance scheme. This finding is important to take on board while designing a micro-insurance scheme for rural population in Bangladesh as this finding, to some extent, reflects that a completely conventional type of insurance market may not be popular among the target clients.

Our study reveals that crop insurance demand varies across household head's primary occupation, land ownership and size of the farm land. We find that it was mainly agricultural farmers who owned large parcels of farm land were willing to buy crop insurance to protect themselves against the risks of catastrophic damage. Our study further reveals that crop damage cost and household WTP to reduce crop damage vary significantly across the nature of the disaster risks. Households who suffered from the highest average crop damage costs per catastrophic event were willing to pay the lowest premium to avoid crop damage risks. We show that such paradoxical result in estimated WTP arises due to the existing disparity in average household income in different risk areas. However, it is important to note that the demand analysis presented in this paper is primarily based on observed associations and relationships using linear correlations and non-parametric testing procedures. A more extended deterministic model to further test the underlying causal relationships and their directions was beyond the scope of the current study[5].

On the basis of the crop damage cost data obtained from the household survey, we calculate expected average indemnity payment by the potential insurance providers on the basis of two different indemnity payout principles, namely forgone revenue income and production cost. Using average (both mean and median) crop damage cost incurred by farm households in different risk areas, we tested our simple analytical model of commercial viability by comparing the future value of the expected premium receivable by the 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 discrepancy between average expected indemnity payment and future value of expected insurance premium is too large to be converged by the variation in damage cost estimation (mean or median) or the indemnity payout function (forgone revenue income based or production cost based).

Three important policy implications follow from the results presented in this study. First, the findings of the study suggest that a uniform structure of crop insurance market does not exist in Bangladesh. Crop damage varies depending on the nature of catastrophe risks and WTP varies depending on the socio-economic characteristics of rural communities living in different risk areas. Hence, crop insurance scheme needs to be developed carefully by taking these two key criterions into consideration. Second, the feasibility test results presented in this paper demonstrate that the crop damage risks faced by the farm households living in the wetland basin and the coastal floodplain are not insurable. The estimated indemnity payable by the insurers, in these two risk areas, consistently exceeds the expected insurance premium receivable. The estimated discrepancies between expected indemnity and expected premium seem too large to be financed by government subsidy on a continuous basis. Finally, it appears from the empirical results presented in this study that the choice of an indemnity payout function plays a crucial role in determining the commercial viability of crop insurance scheme. On the basis of the feasibility test results it can be concluded that a crop insurance scheme based on a production cost based indemnity payout function is worth further investigation in revirine embanked and un-embanked areas.

However, it is important to note that the financial viability results that we portrayed in this study ignore administrative implementation costs of insurance contract. Essentially, a positive and considerably high administrative cost may result in the crop insurance scheme being impractical, even in riverine floodplain areas[6].

We used this study to set out a methodology for testing commercial viability of a potential micro-insurance market at the preliminary stage of policy implementation. We propose, through the testing of our own case study, that such an analytical model could be useful for policy makers and development practitioners to tailor the insurance product for target clients and to roughly estimate the amount of subsidy that the public provision of such a disaster risk mitigating scheme may require at the very outset.

[5] See Akter et al. (2008a) for a more detailed demand analysis of micro-insurance in Bangladesh.

[6] For a more detailed supply side analysis of micro-insurance provision in Bangladesh see Akter et al. (2008b).

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