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ORIGINAL ARTICLE

# Examining the effect of climate vulnerabilities on the discounting behaviour of farmers

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**Abstract**

In agriculture, the possibility of climatic hazards negatively impacting small farmers' livelihood is high. Thus, there are reasons to contend that climate vulnerabilities could determine economic behaviour. This paper investigates whether discounting behaviour varies with exposure to natural hazards. We analyse data from a survey involving an experiment in which farmers made choices between a smaller immediate payment compared with larger future amounts. The results show that 58% heavily discounted the future in favour of the immediate payment. Among the climatic shocks examined, flood, drought and salinity were the main hazards farmers faced on their plots. However, these natural hazards varied across locations. Our examination of the effect of the experience of natural hazards and the severity of climate vulnerability on farmers' discounting behaviour suggests that experience and vulnerability had different impacts on discounting behaviour. Recent exposure to drought and flood reduces patience. However, the opposite is the case for a recent experience of salinity. This paper shows that under circumstances of climate vulnerabilities, farmers may be willing to make decisions that result in immediate albeit lower rewards in place of potential higher rewards in the future. The implication is that experience and vulnerability to natural hazards might affect farmers' decision-making to the extent that it prevents them from a speedy economic recovery post-disaster.

**KEYWORDS**
climate change, decision-making, disaster, discounting, impatience, time preference

**JEL CLASSIFICATION**
C90, D81, D91, Q54

## 1 | INTRODUCTION

Global climate change has increased climate-related hazards and disasters (AghaKouchak et al., 2020; Munawar, 2020). Compared to most occupations, farming is disproportionately vulnerable to climate change impacts. Climate change negatively impacts crops and livestock production systems, and it destroys the social and economic foundations of farming communities (Aryal et al., 2020; Uddin et al., 2014). Several studies examining a non-farming population (e.g. Callen, 2015; Li et al., 2012; Méon et al., 2021; Sawada & Kuroishi, 2015) have found that the experience of a disaster influences decision-making processes, and such experience determines the extent to which people discount the future. However, the findings have so far been mixed. For instance, Callen (2015) found exposure to tsunamis increased patience (i.e. preference for larger financial payoff in the future), while Sawada and Kuroishi (2015) found that people who experienced flooding were significantly more impatient. Crucially, very few studies focused on farmers in developing countries despite smallholder farmers being highly threatened by climate change. Thus, so far, there is limited understanding of whether and how much exposure to climatic threats affects farmers' discounting behaviour.

Generally, farming requires long-term commitment, which involves making decisions with consequences that become apparent only as time progresses. Thus, evaluating the effect of climatic risks on discounting behaviour of farmers is crucial in understanding the decision-making consequences of such natural hazards. The benefit that accrues from investigating and subsequently understanding post-disaster decision-making is that intervention and management can be targeted to enhance the economic recovery of farmers. Such evidence-based intervention will prevent farmers from making suboptimal decisions following such events. This paper, therefore, focuses on examining the effect climate vulnerabilities have on the discounting behaviour of farmers. Respondents faced incentivized hypothetical choices in which they were asked if they preferred to have an amount of money immediately or a larger amount of money in 1 year. We relate the choices they made to previous exposure to natural hazards. We present empirical evidence that climate vulnerability is an important determinant of discounting behaviour. The paper offers several advancements and contributes to improving our understanding of the effect of climatic hazards on decision-making and how behavioural experiments can be integrated with real-life experience to predict behaviour. The paper also contributes to the broader decision-making literature on experimental elicitation of time preferences.

The remainder of this paper consists of six sections. Section 2 reviews relevant literature, Section 3 presents a description of the study area, Section 4 explains the methodology, Section 5 puts the experiment and data in context, Section 6 reports the findings and discusses the results, while Section 7 concludes the paper.

## 2 | LITERATURE REVIEW

In the literature, impatience has often been used interchangeably with impulsivity. However, there are several distinctive definitions of impatience. According to Takahashi et al. (2012), impatience refers to a decision maker's (DM's) greater liking for smaller immediate rewards over larger future rewards. In Koopmans (1960), impatience is when aggregate utility declines with respect to time. Bartels and Urminsky (2010) opined that impatient DMs are short-sighted and, on every occasion, will choose the immediate smaller outcome notwithstanding if the later larger outcome is adequate to compensate for the delay. Following the definition of Becker and Mulligan (1997), the context in which we refer to a DM as being impatient in this paper is a case when the DM discount rate is high, which corresponds to a low rate of time preference[1]. Assuming farmers have to choose between receiving an amount today and the same amount in a year's time, it is expected that most (if not all) farmers will choose to be paid today over a year. However, in choosing between a smaller amount immediately and a larger amount in 1 year, choices would differ based on the individual farmers' discount rate. Recent findings have shown that DMs show very high discount rates—appearing to weigh the future less than the present.

Two discounting models dominate the literature that examines a DM's discounting behaviour. An assumption of stable preferences drives the first models (e.g. exponential discounting arising from the perspective of Expected utility theory where economists have taken behaviour as given, and treated them as stable). In this case, the relative preference for sooner over future rewards is determined by the temporal distance which separates the rewards. The second perspective assumes time-variance e.g. hyperbolic discounting, which is credited with explaining obvious contraventions of the predictions of normative models.

The elicitation methods used across several discounting models are either choice based or matching. These two methods account for over 83% of studies on discounting (Hardisty et al., 2013). In the choice-based method, DMs are given a series of binary comparisons from which their indifference point and discount rate can be estimated. Typically, it takes the form of choosing between receiving a smaller immediate reward versus a larger reward at a later date or a smaller reward in the near future versus a larger reward at a later future. The matching method, on the other hand, requests DM to provide the indifference point by asking directly about the reward that would make the DM indifferent between a smaller immediate reward versus a larger reward at a later date, or a smaller reward in the near future versus a larger reward at a later future. However, there are concerns about the

[1] Time preference defined by Frederick, Loewenstein and O'donoghue (2002) refers to a DM's preference for immediate utility over delayed utility.

huge variability in discounting behaviour found in various studies. Frederick et al. (2002) postulated that this may be partly due to elicitation methods. Hardisty et al. (2013) reported that either method has merits and limitations. For instance, they found the choice-based method to be more reliable in predicting real-life behaviour; however, it is more time-consuming to implement.

Discounting behaviour is content and context dependent. For instance, DMs have been observed to have higher discount rates when faced with immediate rewards versus future rewards compared to two different times in the future (e.g. Thaler, 1981). There is also evidence that discounting is higher for smaller than larger rewards, greater when a DM is faced with choices framed as gains than losses, and higher in the non-monetary decision compared to the monetary decision (Chapman, 1996). The experimental procedure has also been found to significantly affect discount rates. For example, in Robles et al. (2009), DMs displayed lower discount rates when the experiment was presented in descending order of earlier rewards.

The literature has witnessed an increase in the number of studies that applied experiments on intertemporal choices to real-world decision-making. For example, Sutter et al. (2013) focused on savings, Burks et al. (2009) and Saunders and Fogarty (2001), Paserman (2008) on employment decisions, while Meier and Sprenger (2013) examined the decision to acquire knowledge. Other areas that have been studied include consumption and health behaviour (Khwaja et al., 2007; Richards & Hamilton, 2012), and energy conservation, among others[2]. However, the findings on the effect of natural disasters on discounting behaviour are limited. Across different studies on mixed occupations, Bchir and Willinger (2013), Sawada et al. (2018) and Cassar et al. (2017) found that experience of natural disaster decreases patience. In Contrast, Callen (2015), Conzo (2018) and Méon et al. (2021) found that experience of natural disasters increases patience.

Specifically, regarding the common climatic hazards, some empirical studies, for example Chantarat et al. (2019), find that experiencing flooding increased patience in Cambodia which corroborates the finding of Di Falco et al. (2019). However, Samphantharak and Chantarat (2015) found no correlation between flood and patience. So far, the evidence on whether a farmer's future economic decision is affected by the experience of a natural disaster is still scarce. Only a few papers examine the relationship between regular weather events and discounting behaviour. For example, see Damon et al. (2011) in Ethiopia; Li et al. (2012) in China; Samphantharak and Chantarat (2015) in Thailand; Sawada et al. (2018) in the Philippines and Chantarat et al. (2019) in Cambodia. Also, the evidence of recurring natural hazards on farmers' discount rates is sparse. Drawing conclusions regarding farmers' discount rates from findings from mixed occupations could be misleading, especially if the disaster wipes out current savings and income, and future income depends on the weather. Further justification for this study arises from our postulation that there may be a difference in the discount rate after a rare natural hazard (which has been the focus of most previous studies) compared to the more frequent natural hazards. Thus, we test the following hypotheses:

***H1***: The discounting behaviour will change after experiencing a climatic hazard.

**H2**: The discounting behaviour will change with perceived severity of climate vulnerability.

There is growing evidence that intertemporal behaviour cannot be overlooked if any intervention aimed at improving farmers' economic status is to be successful in the long term. Under such circumstances, farmers may be willing to make decisions that result in immediate albeit lower monetary rewards in place of potential higher monetary payments in the future. Moreover, given the economic status of most farmers in developing countries, the experience of natural disasters could exacerbate their economic vulnerability.

## 3 | THE STUDY REGION

Bangladesh, which is the focus country of this study, is one of the most vulnerable countries in the world in terms of climate change impact (Ferdushi et al., 2019). Historical data show that Bangladesh has experienced several natural disasters and is increasingly suffering from climatic hazards. Bangladesh's location in the world's largest river delta (the Ganges, Brahmaputra and Meghna rivers) exposes the country to frequent river, and coastal floods brought about by runoffs, cyclones and storm surges (Basak et al., 2015; Dastagir, 2015; Mehzabin & Mondal, 2021). Particularly in the monsoon, the heavy rains lead to a rise in the tidal water and overflow of nearby rivers, resulting in flooding. Frequent flooding is attributed to Bangladesh's low-lying deltaic topography and over 310 rivers and tributaries. There have also been several cases of soil salinity exceeding the threshold. Notably, some areas in the southern coastal region with reduced cases of salinity at the onset of the cropping stages become increasingly saline as the flood water recedes and evaporates, consequently leading to crop losses (CCC, 2009).

Generally, Bangladesh is exposed to drought at least once in 5 years (Ramamasy & Baas, 2007). Drought occurs

[2] Urminsky and Zauberman (2015) reviewed these studies in detail.

due to varying rainfall patterns that stem from the monsoon rain arriving much later or earlier than normal or even complete failure of the monsoon. The north-western region is at the greatest risk of drought, and divisions such as Rajshahi fall within the severe drought zone. The impact of drought in the country has been devastating. For example, between 1984 and 2013, north-western Bangladesh is reported to have experienced severe drought approximately 10 times between the years 1984 and 2012 (Habiba et al., 2013; Islam et al., 2017). Habiba et al. (2013) reported an estimated 25%–30% reduction in crop production due to these hazards.

These climatic threats have consequences on the lives and livelihood of farmers ranging from altered productivity, damaged crops, loss in income and household food shortages to loss of lives (Ali et al., 2021; Rabbani et al., 2018; Rahman & Rahman, 2015; Toufique & Islam, 2014). Rabbani et al. (2018) reported findings from the Department of Agricultural Extension of Bangladesh, which showed that decrease in Bangladesh rice production by up to 4 lakh tons (approximately 4.41 MT) across 5 years was attributed to the salinity caused by cyclone Sidr. In addition, food insecurity is increased with saltwater intrusion as sea levels in low-lying plains rise (World Bank, 2016). Figure 1 shows the vulnerability to natural hazards by region in Bangladesh. A significant proportion of the country is vulnerable to natural disasters ranging from drought to flooding and natural hazards in between.

In Bangladesh, rice is the dominant crop (Shelley et al., 2016). As shown in Figure 2, rice covers over 75% of the total cropped area and represents 90% of total cereal production (Abdur et al., 2013; GOB, 2009) and makes approximately 70% contribution to agricultural GDP (Sayeed & Yunus, 2017). In addition, a significant source (accounting for two thirds and a half, respectively) of caloric need and protein consumed in the region is rice (Sayeed & Yunus, 2017). However, no previous study has focused on examining the discounting behaviour of rice farmers in this region post-disaster. This gap is addressed in this paper.

## 4 | DATA

The data in this paper are obtained from the 2014 IRRI South Asia Rice Monitoring Survey (RMS-SA) Project to monitor rice systems that capture varietal turnovers over time (Yamano, 2014). Respondents consisted of those involved in the farm decision-making. The survey included an experiment designed to reveal respondents' time preferences using binary-choice tasks. The data contain 1500 farmers from six of the seven administrative divisions obtained by randomly selecting 10 farmers from 150 randomly selected villages. However, we analysed the response of 1468 farmers who had complete data.

### 4.1 | Experimental procedure

The choice-based method was used to elicit time preference. The use of experiments is important to control factors that could influence subjects' behaviour. Subjects are presented with a choice list from which their indifference point and discount rate were determined. Specifically, respondents were told '*We would ask you hypothetical questions that we would like you to answer as if the situation was a real one. Now I would like to ask you a few questions about whether you would prefer to have an amount of money right now, or a larger amount of money one year from now*'. Although subjects were given a hypothetical task, the expectation was that their answers will be as realistic as possible to a real-life case. This was ensured by the subjects being informed as part of the larger survey that there would be actual payment for one of their choices chosen at random. In the questions that followed, all respondents were asked if they preferred to have an amount of money immediately (a small immediate payment—SIP hereafter) or a larger amount of money in 1 year from the experiment (a large future payment—LFP hereafter) as shown in Table 1.

We elicited the level of patience from the switching pattern. Assuming a subject decides to take a future payment of 'BDT 206 in 1 year' over 'BDT 130 immediately' (Task-rank 4 in Tables 1), it can be inferred that the respondent's annual discount rate interval is 58.46 and 98.46. If the subject chooses all future (or all immediate) options, the minimum (or maximum) level of patience is assigned to the respondent. That is, being extremely patient (−∞ and 9.23) or extremely impatient (7838.46 and ∞).

In addition to the time task, subjects' risk preferences were also elicited. This was achieved by asking respondents to choose between a series of guaranteed payments and a 50/50 chance of either a smaller or larger payoff than the guaranteed payment. The use of hypothetical tasks in this paper is justified because these smallholder farmers may reveal their true preferences better than a situation using real payments. The argument is that they may be more inclined to choose the immediate payment in the latter situation, given their economic situation, low social trust and the possible uncertainty associated with future payments.

### 4.2 | Eliciting climate vulnerability

To elicit information on the experience of climate hazards, respondents were asked the following questions:

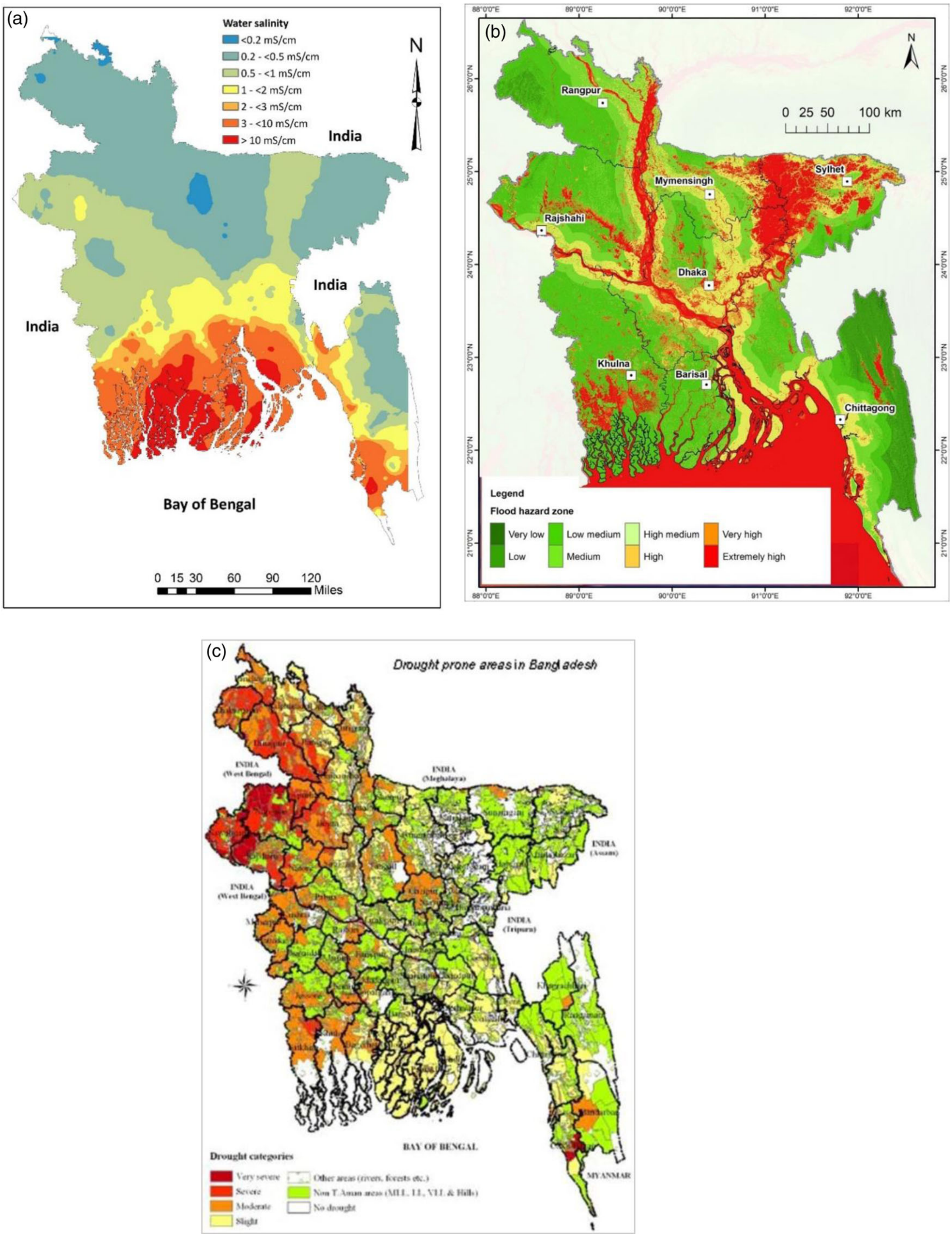


**FIGURE 1** Maps showing vulnerability to natural hazards in Bangladesh. *Source*: (a) salinity (Naser et al., 2020), (b) flood (Uddin et. al., 2021) and (c) drought (Miyan, 2015)

'Out of the last 5 years, how many years has your land been totally submerged for at least one day'?

'Out of the last 5 years, how many years has drought been a problem'?

'Out of the last 5 years, how many years has salinity been a problem'?

Respondents were also asked to report their opinion on whether the risk of weather hazard was increasing or not (i.e. getting worse, staying about the same or getting less problematic) for their plots.

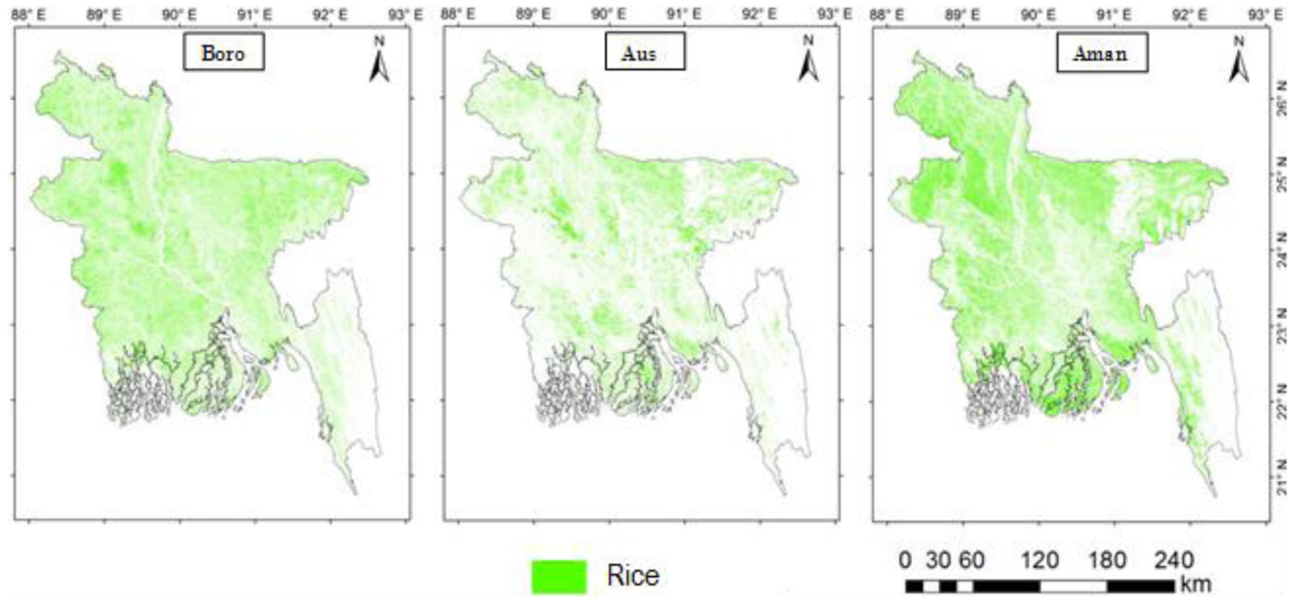


**FIGURE 2** Seasonal distribution of rice in Bangladesh. *Source*: Singha et al. (2019)

**TABLE 1** Time preference task outcomes and corresponding discount rates

| SIP (BDT) | LFP (BDT) | Annual interest rate[a] | Range of discount in each row of switching[a] |
|---|---|---|---|
| 130 | 142 | 9.23% | $-\infty < \delta < 9.23$ |
| 130 | 155 | 19.23% | $9.23 < \delta < 19.23$ |
| 130 | 181 | 39.23% | $19.23 < \delta < 39.23$ |
| 130 | 206 | 58.46% | $39.23 < \delta < 58.46$ |
| 130 | 258 | 98.46% | $58.46 < \delta < 98.46$ |
| 130 | 387 | 197.69% | $98.46 < \delta < 197.69$ |
| 130 | 645 | 396.15% | $197.69 < \delta < 396.15$ |
| 130 | 1290 | 892.31% | $396.15 < \delta < 892.31$ |
| 130 | 2580 | 1884.62% | $892.31 < \delta < 1884.62$ |
| 130 | 10320 | 7838.46% | $1884.62 < \delta < 7838.46$ |

*Note*: Delay duration = 1 year, 1 BDT is roughly equal to 0.012 USD.
*Source*: Authors estimation from the IRRI South Asia Rice Monitoring Survey (2014) data.
[a]Respondents were not shown these columns.

'On your plots, in the past 10 years, the submergence is …'

'On your plots, in the past 10 years, the drought is …'

'On your plots, in the past 10 years, the salinity is …'

We categorize the first three questions as experience of climate hazards and the last three as severity of climate vulnerability.

## 4.3 | Methodology

This paper examines the association between climate vulnerabilities and discounting behaviour of farmers by estimating an interval regression model:

$$y_i^* = x_i'\beta + u_i \qquad u_i \sim N\left(0, \sigma^2\right). \tag{1}$$

Since $y_i{}^*$ is not observed, we assume that the relationship $y_i{}^*$ has with the observable variable $y_i$ is

$$0 < y_i{}^* < r_1$$

$$r_1 < y_i{}^* < r_2$$

$$\vdots$$

$$r_{10} < y_i{}^* < \infty,$$

where $r_j$ for $j = 1, \ldots, n$ represents the interval boundaries and $x_i$ is a vector of farm- and farmer-specific variables presented in Table 2. $\beta$ estimates the effect of $x_i$ on $y^*$, $u_i$ represents the independently and normally distributed residuals and $y_i$ is the $i$th subject's observed discounting behaviour. The variables included in our model

**TABLE 2** Explanatory variables of the regression model predicting impatience

| Variable | Description |
|---|---|
| Experience of natural hazard | |
| Experienced flood | Number of years farmer experienced submergence |
| Experienced salinity | Number of years farmer experienced salinity |
| Experienced drought | Number of years farmer experienced drought |
| Vulnerability to flood | |
| | 1 = Staying about the same, 0 otherwise |
| | 1 = Uncertain, 0 otherwise |
| | 1 = Getting less problematic, 0 otherwise |
| | 1 = Getting worse, 0 otherwise |
| Vulnerability to salinity | |
| | 1 = Staying about the same, 0 otherwise |
| | 1 = Uncertain, 0 otherwise |
| | 1 = Getting less problematic, 0 otherwise |
| | 1 = Getting worse, 0 otherwise |
| Vulnerability to drought | |
| | 1 = Staying about the same, 0 otherwise |
| | 1 = Uncertain, 0 otherwise |
| | 1 = Getting less problematic, 0 otherwise |
| | 1 = Getting worse, 0 otherwise |
| Age | Age in years at time of survey |
| $Age^2$ | Age squared |
| Gender | 1 = Male, 0 otherwise |
| Education | 1 = No formal education, 0 otherwise |
| Marital Status | 1 = Farmer is married, 0 otherwise |
| Dependants | Number of children |
| Risk preference | Level of risk tolerance |
| Plot ownership | Number of plots owned |
| Cultivated variety | |
| Flood resistant variety | 1 = If cultivated flood resistant variety, 0 otherwise |
| Drought resistant variety | 1 = If cultivated drought resistant variety, 0 otherwise |
| Salinity tolerant variety | 1 = If cultivated salinity tolerant variety, 0 otherwise |
| Location | |
| | 1 = Lives in Chittagong division, 0 otherwise |
| | 1 = Lives in Dhaka division, 0 otherwise |
| | 1 = Lives in Khulna division, 0 otherwise |
| | 1 = Lives in Rajshahi division, 0 otherwise |
| | 1 = Lives in Rangpur division, 0 otherwise |
| | 1 = Lives in Barisal division, 0 otherwise |

**TABLE 3** Summary statistics of selected characteristics

| Characteristics | Percentage | Min | Max |
|---|---|---|---|
| Marital status | | | |
| Single | 5.13 | | |
| Married | 94.73 | | |
| Others | 0.14 | | |
| Gender | | | |
| Male | 84.27 | | |
| Female | 15.73 | | |
| Education | | | |
| No formal | 13.47 | | |
| Primary | 36.93 | | |
| Secondary | 45.00 | | |
| Graduate degree | 3.53 | | |
| Post-graduate degree | 0.73 | | |
| Other | 0.20 | | |
| Division | | | |
| Barisal | 29.33 | | |
| Chittagong | 13.33 | | |
| Dhaka | 12.00 | | |
| Khulna | 12.00 | | |
| Rajshahi | 20.00 | | |
| Rangpur | 13.33 | | |
| | Mean | | |
| Age | 44.66 | 16 | 90 |
| Dependants | 2 | 0 | 12 |
| Risk preference | 3.67 | 1 | 5 |
| Plot ownership | 2.43 | 0 | 20 |

are informed from past literature that focused on farmers in developing countries and discussed in Section 2.

## 5 | RESULTS

Table 3 summarizes the demographic characteristics of the respondents. The average age of farmers in the region is 44 years. About 86% were educated to at least primary school level. The average household size was six people, and the average number of children in a household was two. Male-headed households made up about 84% of the sample. A total of 94% of respondents were married. On average, a farmer owned two separate plots.

As presented in Table 4, approximately 22% reported that in the past 10 years, the submergence was getting worse, while 27% mentioned that on their plots, drought is becoming worse. The results also show that about 38% of the farmers had experienced drought, while 61% had experienced submergence in the last 5 years.

**TABLE 4** Experience of climate hazard and severity of climate vulnerability

| | Flood (%) | Drought (%) | Salinity (%) |
|---|---|---|---|
| Experience | | | |
| None | 38.89 | 61.64 | 89.26 |
| 1–3 years | 54.64 | 30.62 | 7.87 |
| >3 years | 6.47 | 7.74 | 2.87 |
| Vulnerability | | | |
| Getting worse | 22.41 | 26.57 | 7.81 |
| Staying about the same | 46.23 | 32.18 | 29.62 |
| Getting less problematic | 12.74 | 8.61 | 7.27 |
| Uncertain | 18.61 | 32.64 | 55.30 |

A summary of the experience of climatic hazards by division is presented in Figure 3. Rajshahi experienced the least occurrence of flood (accounting for about 88% having no experience of flood) compared to 4% in Chittagong and 25% in Rangpur. On the other hand, the experience of drought by division indicates that in Rangpur, 92% of farmers have experienced at least 1 year of drought compared to only 5% in Rajshahi, even though both divisions fall within the drought risk zone. Figure 3 also shows that overall, the proportion of Bangladesh farmers who experienced salinity compared to drought and flood was low. For instance, in Rajshahi, there was no reported experience of salinity. Similarly, at least 70% of respondents did not experience salinity in the other divisions.

The distribution of respondents according to discounting behaviour is presented in Figure 4. Four per cent do not discount the future much, and we classify these farmers as being extremely patient. On the other hand, 40% were impatient, while 18% of respondents were extremely impatient. The extremely impatient respondents preferred the immediate payment over a future payment across all the choice tasks. Thus, they heavily discounted the future. Overall, the majority (58%) are impatient—a finding consistent with several studies in the literature.

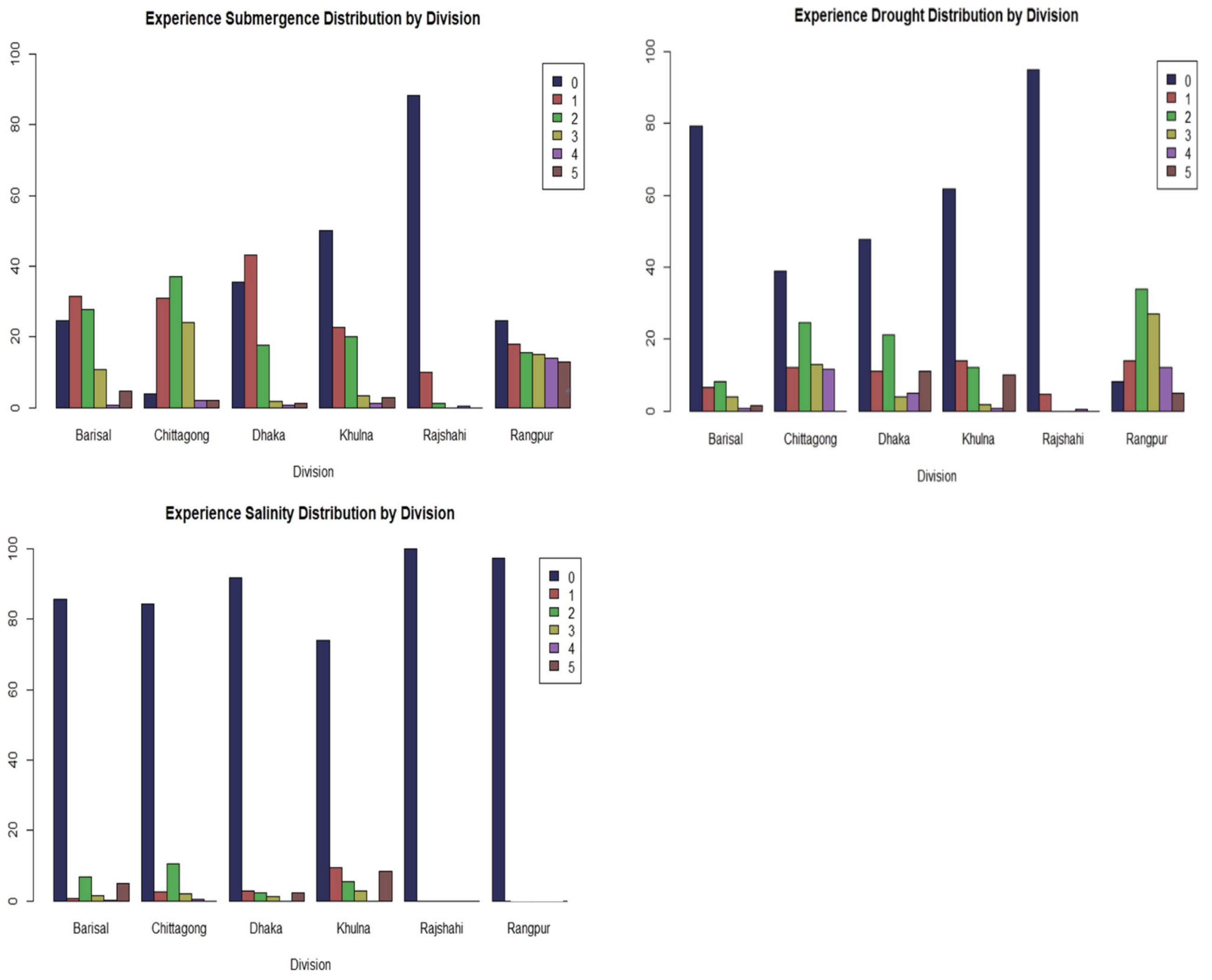


**FIGURE 3** Submergence, drought and salinity experience by number of years (up to the past 5 years)

**TABLE 5** Mean and median subjective discount rate by division

| Division | Discount rate (Arithmetic mean) | Discount rate (Geometric mean) | Chi square | df | *p*-value |
|---|---|---|---|---|---|
| Barisal | 2254.46 | 2508.32 | 277.95 | 5 | <0.001 |
| Chittagong | 754.71 | 897.24 | | | |
| Dhaka | 537.60 | 496.74 | | | |
| Khulna | 3568.61 | 3418.24 | | | |
| Rajshahi | 2579.27 | 2471.11 | | | |
| Rangpur | 3400.62 | 2993.60 | | | |

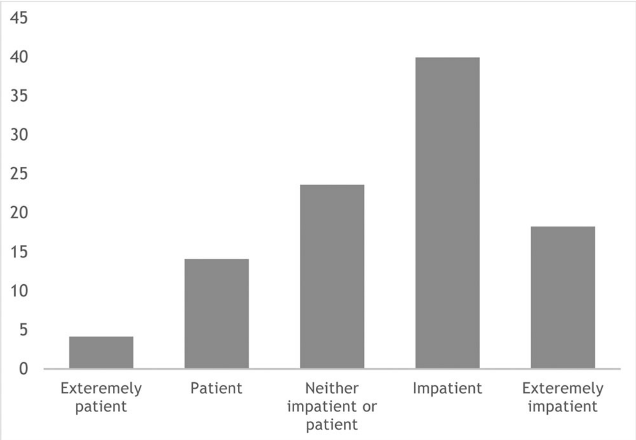


**FIGURE 4** Distributions of respondents by category of patience (%)

The discounting behaviour of farmers by division in Table 5 shows that, on average, farmers in Chittagong, Dhaka, Barisal and Rajshahi are more patient than in Rangpur. Farmers in Khulna, however, are more impatient. A Kruskal–Wallis test was conducted to compare the mean discount rate. The test showed that there is a significant association between location and discounting behaviour. There was very strong evidence of a difference ($\chi^2(5) = 277.95$, $p = 0.0001$) in the discounting behaviour between at least one pair of the locations. We also test for differences in discounting behaviour across gender but do not find any statistical difference.

In Figure 5, we compared discounting behaviour by division and found significant variation in the level of patience division wise. Specifically, farmers in Rangpur and Khulna were more impatient, while farmers in Dhaka were more patient. This indicates that farmers in the richest divisions may be financially better off and hence tend to be more patient. The relationship between wealth and patience is evident in Figure 6. We categorized respondents into three groups (poor, medium and rich) using the number and type of assets owned. We observe that the richer farmers are more patient, which aligns with previous studies globally. This implies that the discounting behaviour of poor, medium and rich farmers is impacted differently by the same extreme climatic event. Therefore, choosing a short-term/long-term benefit will vary with the financial stability of the farmers. Poor farmers will be more inclined to make decisions that would result in immediate financial returns over higher returns in the future and vice versa.

The regression results of the interval regression model estimating the effect of climate vulnerabilities on discounting behaviour are presented in Table 6. The inclusion of farm- and farmer-specific characteristics as predictor variables jointly results in a statistically significant improvement in model fit (LR test: Full vs. Restricted $\chi^2(16) = 227.50$, $p < 0.001$).

The results show that experience of different natural hazards had different effects on discounting behaviour. Specifically, heavy discounting of the future is higher among farmers who have experienced flood or drought but lower among those who experienced salinity. In other words, the experience of flood and drought tends to reduce patience, while the experience of salinity increases patience. Our findings that the experience of flood tends to reduce patience do not align with previous studies on flooding that found that experiencing flooding increases patience in Cambodia (Chantarat et al., 2019) or in rural Ethiopia (Di Falco et al., 2019). However, the findings from studies in developing countries that the experience of drought tends to reduce patience, for example Holden (2013) and Damon et al. (2011), are corroborated by our study. Thus, we fail to reject the hypotheses that the discount rate will change after experiencing a climatic hazard.

Vulnerability to salinity had a significant effect on impatience. Specifically, farmers who were uncertain or observed that their exposure to salinity did not change in recent years were more patient than farmers who reported the exposure to be getting worse. However, uncertainty about the vulnerability of flood and drought increases the discount rate suggesting a greater level of impatience compared to those farmers who reported their exposure to natural hazards as getting worse. Similarly, we fail to reject the hypothesis that the discount rate will change with perceived severity of climate vulnerability.

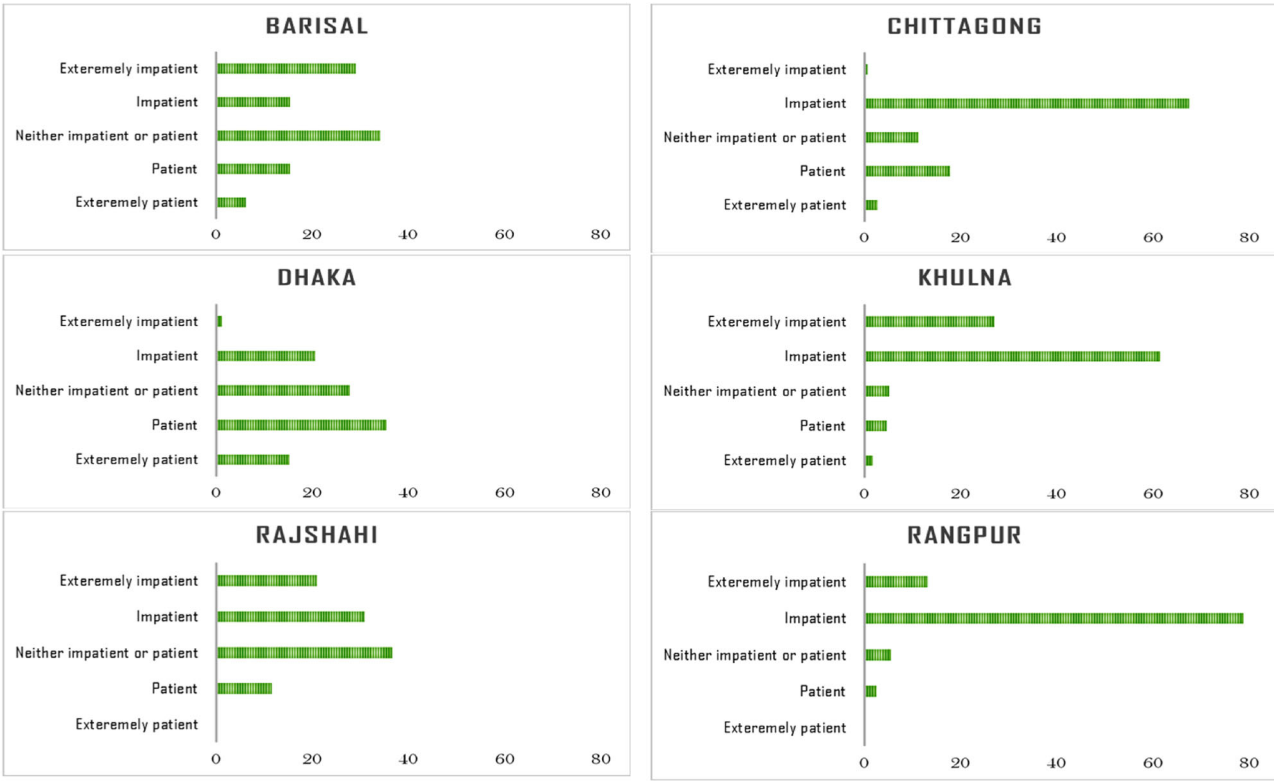


**FIGURE 5** Distributions of respondents by patience (%) and division

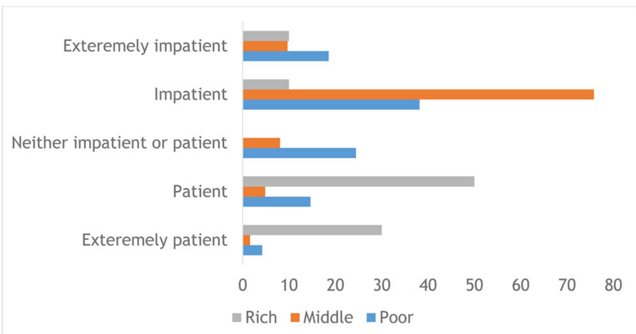


**FIGURE 6** Distributions of respondents by patience (%) and financial status. $N = 1422$ (poor), 64 (Middle), 10 (Rich)

Farm characteristics (plot ownership and location) and farmer characteristics (education and risk preference) significantly affect discounting behaviour. Individuals with more plots and those with lower education are more likely to select money available immediately to a larger amount of money in 1 year. On the other hand, more risk-tolerant farmers are more likely to select a larger amount of money in 1 year over an immediate smaller payment.

## 6 | DISCUSSION

In this paper, we investigated the association between climate vulnerabilities and discounting behaviour of farmers. We analyse data from a representative sample which implies it is more likely it will accurately reflect the behaviour of the larger population. We contribute with new insights to the limited number of studies that examine climate risk impact on discounting behaviour. Our results show that under circumstances of climate vulnerabilities, farmers may be willing to make decisions that result in immediate albeit lower rewards in place of potential higher rewards in the future. Crucially, our findings suggest that the nature of natural hazards differed in their effect on patience. This result highlights the importance of empirically examining the impact of specific natural disasters over generalizing findings and consequently implementing inappropriate interventions.

The behaviour observed in this paper (i.e. decreased patience arising from the experience of climate hazards) could be explained from the perspective that the damage and subsequent losses from drought and flooding are substantial. Thus, it increases the uncertainty about the future which, consequently, drives greater discounting of future investments or payoffs. This is also attributable to different hazards requiring different adaptation strategies as highlighted in Anik et al. (2021).

Considering the concerns highlighted in past studies (e.g. Cannon, 2002; Rahman, 2013) that climate change would exacerbate the vulnerable position of women disproportionately to men, we do not observe any statistically significant difference in the discounting behaviour

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**TABLE 6** Interval regression estimating the effect of climate vulnerabilities on discounting behaviour

| Variable | Full model Coefficient (*SE*) | *z* | *p* > \|*z*\| | Restricted model Coefficient (*SE*) | *z* | *p* > \|*z*\| |
|---|---|---|---|---|---|---|
| Experience of natural hazard | | | | | | |
| Experienced flood | 0.02 (0.009)** | 2.13 | 0.033 | 0.008 (0.009) | 0.89 | 0.372 |
| Experienced salinity | −0.052 (0.013)*** | −3.98 | 0.000 | −0.055 (0.013)*** | −4.09 | 0.000 |
| Experienced drought | 0.02 (0.01)* | 1.89 | 0.059 | 0.016 (0.01) | 1.55 | 0.121 |
| Vulnerability to flood[a] | | | | | | |
| Staying about the same | −0.007 (0.027) | −0.26 | 0.796 | −0.083 (0.028)*** | −2.93 | 0.003 |
| Uncertain | 0.125 (0.036)*** | 3.45 | 0.001 | 0.106 (0.038)*** | 2.76 | 0.006 |
| Getting less problematic | 0.032(0.036) | 0.89 | 0.375 | −0.007 (0.038) | −0.18 | 0.856 |
| Vulnerability to salinity[a] | | | | | | |
| Staying about the same | −0.119 (0.05)** | −2.36 | 0.018 | −0.129 (0.052)** | −2.45 | 0.014 |
| Uncertain | −0.109 (0.051)** | −2.16 | 0.03 | −0.176 (0.052)*** | −3.41 | 0.001 |
| Getting less problematic | −0.071 (0.056) | −1.26 | 0.206 | −0.097 (0.059)* | −1.65 | 0.099 |
| Vulnerability to drought[a] | | | | | | |
| Staying about the same | −0.011 (0.032) | −0.34 | 0.732 | −0.01 (0.033) | −0.31 | 0.760 |
| Uncertain | 0.077 (0.036)** | 2.14 | 0.033 | 0.086 (0.037)** | 2.32 | 0.020 |
| Getting less problematic | 0.100 (0.041)** | 2.43 | 0.015 | 0.132 (0.043)*** | 3.1 | 0.002 |
| Age | 0.004 (0.004) | 0.91 | 0.362 | | | |
| $Age^2$ | 0.00 (0.00) | −1.22 | 0.224 | | | |
| Gender | 0.036 (0.026) | 1.36 | 0.175 | | | |
| Education | 0.066 (0.027)** | 2.47 | 0.014 | | | |
| Marital Status | −0.033 (0.047) | −0.7 | 0.485 | | | |
| Dependants | 0.006 (0.007) | 0.84 | 0.399 | | | |
| Risk preference | −0.046 (0.007)*** | −6.44 | 0.000 | | | |
| Plot ownership | 0.01 (0.005)* | 1.77 | 0.076 | | | |
| Cultivated variety | | | | | | |
| Flood resistant variety | 0.088 (0.07) | 1.25 | 0.211 | | | |
| Drought resistant variety | −0.004 (0.05) | −0.08 | 0.939 | | | |
| Salinity tolerant variety | 0.035 (0.06) | 0.57 | 0.566 | | | |
| Location[b] | | | | | | |
| Chittagong | −0.195 (0.031)*** | −6.24 | 0.000 | | | |
| Dhaka | −0.196 (0.035)*** | −5.64 | 0.000 | | | |
| Khulna | 0.146 (0.034)*** | 4.3 | 0.000 | | | |
| Rajshahi | 0.076 (0.031)** | 2.44 | 0.015 | | | |
| Rangpur | 0.104 (0.037)*** | 2.8 | 0.005 | | | |
| Constant | 0.323 (0.117)*** | 2.76 | 0.006 | 0.389 (0.049)*** | 8.00 | 0.000 |
| *N* | 1468 | | | 1468 | | |
| Wald $\chi^2$ | 328.14 | | | 100.64 | | |
| $p > \chi^2$ | 0.000 | | | 0.000 | | |
| Degree of freedom | 28 | | | 12 | | |

*Note*: Higher discount rate corresponds to lower level of patience.

[a]Reference category is 'getting worse'.

[b]Barisal is the reference category.

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

across gender. This suggests that the increased vulnerability of women after a climatic disaster may more likely be associated with limited resources prior or disparity in access to adaptation resources rather than behavioural factors.

The findings in this paper have significant livelihood implications. Natural disasters constitute an increasing threat to rural economies and livelihood of farmers especially in developing countries where formal climate risk insurance for farmers is almost non-existent. As a result, in the outbreak of a natural hazard that results in large losses, farmers become trapped in a vicious cycle of poverty with little or no resilience to future shocks. Crucially, experience and vulnerability to climatic hazards may affect farmers' decision-making in a manner that may prevent them from a speedy economic recovery post-disaster. Besides, previous experience may result in overweighting the chances of a future occurrence, while experiences may cumulate to have a greater negative influence on economic behaviour, judgement and decision-making.

The empirical evidence from this paper is helpful to justify government and stakeholders' investments in actions aimed at reducing climate risks. For example, considering over 60% have experienced flooding, and the high probability of it getting worse, government building coastal defences in flood-risk areas could mitigate the negative impact of flooding on discounting behaviour. Besides, the findings of such studies are crucial to tailoring ex ante and ex post intervention and in designing future formal or informal insurance. Disaster risk assessment that accounts for behavioural adaptation would result in a better characterization of risks. This, in turn, will help ensure that future risk management strategies and investments are effective.

## 7 | CONCLUSION

Although significant progress has been recorded in understanding the link between discounting behaviour and natural disaster, little is known about the discounting behaviour of farmers generally and how any heterogeneity in such behaviour may relate to the farmer characteristics. The existence of systematic variation in the time preference of DMs could have major economic implications for affected farmers. Additionally, if natural hazards affect preferences, then understanding the linkage and accounting for heterogeneity in behaviour of the affected farmers post-disaster is pertinent to efforts targeted at economic recovery by tailoring interventions and support. Using a representative sample that cuts across the main rice-growing regions in Bangladesh, this paper links experiment with real-life experience. We obtain the implicit 1-year time preference by estimating the discounting behaviour following the observation of a switch in respondents' choice from the amount of money available immediately to a larger amount of money in 1 year. Under circumstances of experiencing natural hazards, we find that farmers are willing to make decisions that result in immediate albeit lower monetary reward in place of potential higher monetary payments in the future. Thus, recent exposure to natural hazards (drought, salinity and flood) influenced discounting behaviour. The implication of this behaviour is that farmers may make decisions that may prevent them from a speedy economic recovery post-disaster. The results in this paper thus contribute to research on both natural hazard impacts and behavioural economics. Our findings are important in understanding how economic decisions and behaviour are affected by natural hazards and, therefore, relevant for policy targeted at the recovery of farmers affected by these types of events. The finding of significant variation in the level of patience division wise is important as it provides an empirical basis to make division-specific policy rather than one common central policy for the vulnerable farmers.

Our study has some limitations. First, the wider financial and income status and farming activities of the family were not factored in. The data did not allow us to investigate whether the effect of climatic hazard on discounting behaviour diminishes rapidly or remains long term after the experience. Future studies could consider the severity of the impact of the event on crop yield/quality and income, and food supply, and the role insurance and other income sources play in such conditions. Finally, some of the Likert-type questions are subjective. Thus, it is difficult to ensure that respondents have a similar level of understanding and interpretation.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study wobtained from a public repository and is available at: http://ricestat.irri.org/fhsd/php/panel.php

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