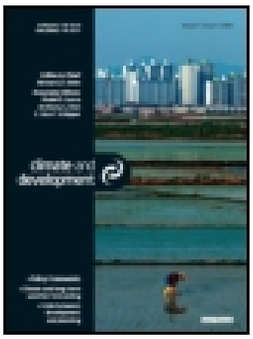

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Private disaster expenditures by rural Bangladeshi households: evidence from survey data

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ABSTRACT

This paper investigates household's private expenditures to cope with the harmful losses of climate change and disasters. Using household-level survey data from Bangladesh, this paper finds that disaster-affected rural Bangladeshi households allocate between $499 and $1076 in disaster-related expenditures. Such expenditures are always greater than their relevant precautionary savings, implying that those households may debt-finance their defensive measures. Households with greater precautionary savings spend more: a 100% increase in precautionary savings can increase disaster expenditures by 5%. Moreover, there are considerable regional heterogeneities in household's disaster expenditures. Increased public sector allocations in addition to carefully designed affordable market-based financing instruments can potentially ease the pressure on disaster-affected households in their fight against the harms of climate change and disaster.

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Bangladesh; climate change; climate finance; disaster; disaster expenditures; disaster risk; expenditures; precautionary savings

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1. Introduction

Investigations on climate- and disaster-related finances are predominantly focused on contributions from national governments and international donors (e.g. Weikmans & Roberts, 2019), and in the process, portray the households as mere beneficiaries (e.g. Bhandary et al., 2021). However, especially in developing countries where many important markets (such as credit, land, and property rights) are often absent or limited in capacity, individual households make considerable private investments against the harms of climate change and disasters. Both the academic and policy literature ignore this contribution, and thereby ignore the potential complementarity between public allocations and individual households' private expenditures. This research makes an important contribution to literature by identifying household-level private expenditures as an integrated part of climate and disaster risk management strategies, and thereby reinforcing the importance of public supports to reduce the private burden that the disaster-affected households experience in developing countries.[1]

This paper considers the case study of Bangladesh, which is among the most vulnerable countries to the risk of climate change and disasters, where frequent exposure to disasters and growing risks of slow onset climate change historically resulted in significant casualties and adverse economic impacts (EMDAT, 2021; Parven et al., 2022). Climate change and disaster events hit agricultural production particularly hard: for example, sea level rise is predicted to reduce the country's agricultural GDP by 1.23% by 2030, compared to 0.11% for overall GDP (Banerjee et al., 2015). This is particularly important for Bangladesh since rural Bangladeshi people are primarily dependent on agriculture: the sector employs around 41% of the labour force (aged 15 years and above) and contributes around 15% to GDP (Bangladesh Bureau of Statistics, 2017). Rural Bangladeshi households often resort to regressive response strategies that might undermine economic development (Mueller & Quisumbing, 2011). For example, Karim and Noy (2016) found that poor households smooth their food consumption by reducing non-food expenditures such as their expenditures on health and education. There can also be longer term welfare impacts of such disaster events on children, unless immediate mitigating measures are taken (Eskander & Barbier, 2022).

Due to the subsistence nature of agricultural production and widespread poverty in the rural areas of Bangladesh, affected households often lack the means to finance their essential disaster actions. In this context, this paper calculates household-level expenditures to recover damages done by disaster exposure, and then links those investments with their precautionary savings. Investigating the hypothesis that such disaster expenditures are positively related to precautionary savings, this paper provides evidence on households'

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contribution to the costs of fighting climate and disaster events, and therefore asserts that households are partners, rather than being mere beneficiaries, in the joint effort against climate risks. In doing so, this paper extracted household-level data on precautionary savings (intended for recovery from disaster risks) and disaster-related expenditures from three rounds of the Bangladesh Integrated Household Survey (BIHS) for the households who reported to be exposed to a disaster in the previous year. This paper then adopted a pooled ordinary least squares regression specification for investigating the relationship between precautionary savings and disaster expenditures. Results of this investigation have important implications for Bangladesh and other climate- and disaster-vulnerable countries. Especially for a climate-vulnerable developing country like Bangladesh where poverty-stricken rural population predominantly depends on subsistence economic activities, increased public allocations are important in helping households to adapt to climate and disaster risks.

2. Literature review

Different private mechanisms facilitating household-level disaster risk preparedness and recovery in Bangladesh and other low-income countries are well discussed in the literature. Specific examples include social protection (e.g. Tenzing, 2020), networks (e.g. Eskander et al., 2018; Fafchamps & Lund, 2003; Giannelli & Canessa, 2022; Islam & Nguyen, 2018), access to finance (Akter, 2012; Crick et al., 2018; Fenton et al., 2015, 2017a), and autonomous strategies (e.g. Fenton et al., 2017b).

Tenzing (2020) provides a comprehensive account of social protection against climate risks including cash and in-kind transfers, safety net programs, and access to credit facilities. Such measures can increase adaptive capacity and increase climate and disaster resilience of affected households (e.g. Crick et al., 2018).

Family and social networks can be useful in the aftermath of a disaster (e.g. Eskander et al., 2018; Fafchamps & Lund, 2003). Using primary survey data from four villages in northern Philippines, Fafchamps and Lund (2003) showed that disaster-affected households received more gifts and informal loans from within their social networks. Eskander et al. (2018), on the other hand, showed that resource-constrained households receive unconditional transfers from their family networks when needed. For Bangladesh, Giannelli and Canessa (2022) showed that remittances can work as a coping strategy for flood-affected households.

Islam and Nguyen (2018) used a primary survey in Bangladesh to identify the disaster coping mechanisms and investigate the facilitation of risk-sharing within informal network. Among others, households use own money, borrow from banks/NGOs/moneylenders, seek help from relatives/neighbors, sell assets, and receive relief for disaster recovery actions including addressing health shocks, and repairing houses and damaged assets. However, they found that households affected by cyclone Aila were not able to mitigate shocks by sharing resources with their social and family network members.

Fenton et al. (2017b) conducted an in-depth examination of the specific nature of vulnerability to riverine floods and subsequent adaptation decisions on 38 households from Satkhira district in Bangladesh. Affected households adopt various autonomous adaptation strategies including changing composition of poultry stocks, homestead and plinth improvements, domestic and international migrations, conversion of agricultural lands for aquaculture, halting of summer cultivation, and taking up wage labour. On most occasions, such initiatives do not receive any formal support from the local government. The paper also highlighted the existing inequality in access to finance – socioeconomically disadvantaged households usually do not have access to credit from commercial banks and rather depend on NGOs who provide smaller loans at higher interest rates. In addition, households can also use land rental transactions (e.g. Eskander & Barbier, 2023) and livestock (Fafchamps et al., 1998) to compensate for disaster losses.

In Bangladesh, multiple projects under different ministries and departments are dedicated to addressing disaster- and climate-change-related affairs. Despite these public initiatives, private expenditures are practically impossible to avoid especially since market-based insurances and other financing instruments are either unavailable or insufficient compared to market demand. Climate and disaster management actions by households mostly consist of immediate coping strategies to overcome consumption risks, post-disaster recovery of productive capacity and longer-term preparedness for similar future risks. Common adaptation practices in response to disaster exposure in Bangladesh include migration and increased labour supply to agricultural and non-agricultural sectors (Banerjee, 2007; Mueller & Quisumbing, 2011; Penning-Rowsell et al., 2013). Farmers adapt to changing temperature and rainfall by switching to more climate-resilient crops (Moniruzzaman, 2015), and can overcome part of their disaster-inflicted financial losses through land rental transactions (Eskander & Barbier, 2023).

Some market-based climate finance instruments have recently been introduced in Bangladesh. However, despite the optimism, for example, around the adoption of microinsurance, insufficient accountability within the current policy regimes necessarily hinders the effectiveness of microinsurance as a disaster finance mechanism (Akter, 2012). On the other hand, while microcredit programs can potentially improve adaptive capacity by increasing access to finance for rural households (Fenton et al., 2017a), microfinance institutions can also be vulnerable to climate change (Fenton et al., 2015). Against these backdrops, Fenton et al. (2017b) found that Bangladeshi households are autonomously adopting 'a mixture of incremental and transformational adaptations' to flooding. This is consistent with Wamsler and Lawson (2011) who found that a range of bottom-up approaches adopted by NGOs in the global south can improve climate and disaster resilience.

Against this backdrop, the study of expenditures associated with private actions that households undertake for disaster risk preparedness and recovery is important especially for a resource-constrained least-developed country like Bangladesh.

3. Study area, materials and method

3.1. Disasters in Bangladesh

One of the most vulnerable countries in terms of climate change and climate-induced disasters, Bangladesh ranks

sixth in the world's most disaster-prone countries (UNU-EHS, 2015). Bangladesh tops the list of Asian developing countries at relatively high mortality risk and is second on the list of Asian developing countries at relatively high economic risk from multiple hazards (ADB, 2013). Its subtropical monsoonal climate is characterized by heavy seasonal rainfall, moderately warm temperature, and high humidity. Geographic location and land characteristics both contribute to the country's disaster-prone status: 26% of the population is affected by storms and 70% lives in flood-prone regions (Cash et al., 2013). Cyclonic storms primarily affect the southern coastal regions whereas flooding is more significant in the north.

Large disasters with profound impacts on lives and livelihoods include the cyclones of 1970, 1991, 2007 and 2009 and the floods of 1988 and 1998. The 1970 Great Bhola cyclone is often considered the deadliest tropical cyclone ever, with around 0.3 million deaths and economic impacts of $86.4 million in current prices. In 1991, cyclone Gorky killed 0.14 million people and caused almost $1.8 billion in economic damages. Thanks to early warning systems and cyclone shelters, more recent cyclones caused lower casualties (around 4000 deaths from cyclone Sidr in 2007 and 190 from cyclone Reshmi in 2009) but economic damages were considerably higher (around $2.3 billion in 2007 and $270 million in 2009). Floods usually result in fewer casualties, but their longer durations disrupt economic (especially agricultural) activities, resulting in huge financial losses. The death tolls from floods were 2379 in 1988 and 1050 in 1998, with corresponding economic damages of $2.14 billion and $4.3 billion (EMDAT, 2021). There were also many smaller disasters with considerable harmful effects.

3.2. Data and method

This paper extracts household-level disaster-related data and information from three rounds of the Bangladesh Integrated Household Survey (BIHS). The BIHS is a USAID-funded survey designed and supervised by the International Food Policy Research Institute, administered by Data Analysis and Technical Assistance, Dhaka, Bangladesh, and approved for publication by the national government. The first round of data collection took place between October 2011 and March 2012; the second round from January to June 2015; and the third round from November 2018 to May 2019 (Ahmed, 2013, 2016; IFPRI, 2020). BIHS is a nationally representative panel dataset of 6503 households representing all the agro-economic zones of rural Bangladesh. For our empirical analysis, the relevant sample consists of the households that reported to incur any disaster expenditures. Therefore, our relevant sample includes 1564 households from BIHS 2011, 1607 from BIHS 2015 and 1847 from BIHS 2018 (Table 1).

Table 1. Variable description and summary statistics.

Variables	BIHS 2011	BIHS 2015	BIHS 2018
Total savings	313.7	474.7	634.9
	(921.6)	(1178)	(1806)
Total precautionary savings	196.7	334.8	510.1
	(685.5)	(956.5)	(1673)
Savings intended for building and repair	21.91	37.43	45.59
	(169.1)	(329.3)	(357.8)
Savings intended for emergencies	174.8	297.4	464.6
	(666.8)	(909.1)	(1644)
Total disaster-related expenditures	573.9	1141	1192
	(916.7)	(2649)	(1345)
Disaster exposure (% of relevant households)	72.6	45.6	49.2
No. of obs.	1564	1607	1847

Notes: Mean values are reported, with standard deviations in parentheses, for three rounds of the Bangladesh Integrated Household Survey (BIHS) data. All monetary values are converted to US$ at the exchange rate of BDTk 1 = $0.012.

In the absence of complete and more direct measures for household's disaster-related expenditures, this paper uses relevant information from BIHS on (1) precautionary savings as a measure of ability to spend and (2) disaster-related cost of repairs as a reliable proxy for actual expenditure.

First, BIHS collected itemized savings information for all members of each surveyed household. Intended uses of savings include, among others, 'building and repairing houses' and 'preparing for difficult times/or danger'. This paper includes any savings for these two intended uses as precautionary savings, which is a measure of ability to contribute towards disaster-related risk reduction activities (see, for example, Eskander et al., 2018).[2]

Next, BIHS collected itemized expenditure information for all members of each surveyed household. this paper includes annual expenditure items 'disaster-related maintenance/repair' and 'other routine maintenance/repair' as disaster-related expenditures.

This paper first calculates precautionary savings and disaster expenditures at the household level. National estimates are then supplemented by regional estimates for seven administrative divisions of Bangladesh. For both measures, this paper calculates the averages for the households who reported to be exposed to a disaster in the previous year. Therefore, any extrapolation of our estimates can only account for total number of disaster-affected households.

As shown in Table 1, the majority of total precautionary savings comes from such saving intended for emergencies, with those intended for building and repairs forming only 9–11% of total precautionary savings. However, precautionary savings as a whole form the majority of total savings: 63% in 2011 which has then increased to 71% in 2015 and 80% in 2018.

Almost 73% of relevant households from the 2011 survey reported to be affected by a disaster, with an average disaster-related expenditure of US$574. While a smaller percentage of households were affected by disasters in next two survey rounds, i.e. 46% in 2015 and 49% in 2018, their disaster-related expenditures have increased to $1141 in 2015 and $1192 in 2018.

Finally, since household's disaster expenditures at least partially depend on precautionary savings (e.g. Crick et al., 2018), this paper investigates the relationship between them using the following pooled ordinary least squares regression specification:

$$DE_i = \beta_0 + \beta_1 PS_i + \epsilon_i, \quad (1)$$

where DE_i and PS_i denote *Inverse Hyperbolic Sine* (IHS) transformations of disaster expenditure and precautionary savings by household i, respectively. Both disaster expenditures and precautionary savings are expressed in US$ at the exchange rate of BDTk 1 = $0.012. Since our objective is to

identify the underlying relationship for disaster-affected households, this paper restricts the estimation to affected households only. Results for total savings TS_i are also reported as a robustness check.

There are many zero values in both disaster expenditures and precautionary savings, making a log transformation unsuitable. We, instead, adopt an IHS transformation which transforms a variable x containing zero and/or negative values according to

$$\sinh^{-1}(x) = \log\left(x + (x^2+1)^{\frac{1}{2}}\right). \quad (2)$$

Unlike either dropping zero and negative values or adding a constant positive number to transform all values to positive numbers, IHS transformation retains the entire range of values while performing the monotonic transformation (Burbidge et al., 1988). Figure 1 plots IHS transformations of disaster expenditures and precautionary savings against the values at level.

Figure 2 shows the kernel density plots for the dependent variable DE_i, explanatory variable PS_i, and the residuals. The IHS transformations have reduced skewness especially in DE_i and residuals. In particular, DE_i is now normally distributed around the mean value of 6.8 with a standard deviation of 0.95. On the other hand, residuals are normally distributed with zero mean and a standard deviation close to 1: $E(\widehat{\epsilon_i}) = 0$ and $\sigma^2_{\hat{\epsilon}} = 0.95$. Altogether, they reasonably satisfy the statistical properties for an OLS specification of Equation (1).

Despite being different than usual log transformation, estimated coefficients can be interpreted as elasticities especially for large values of all the transformed variables (Bellemare & Wichman, 2020). Therefore, the coefficient, $\hat{\beta}_1$, denotes the savings elasticity of disaster expenditures. This paper takes robust standard errors to control for potential heteroskedasticity issue.

While this paper expects the savings elasticity of disaster expenditure to be positive, i.e. $\hat{\beta}_1 > 0$, the range of value have important implications for household's self-sufficiency and need for assistance when fighting disaster risks. In particular, less-than-unit elasticity, i.e. $\hat{\beta}_1 < 1$, implies that the households are saving insufficient amounts in comparison to what they are actually spending in disaster risk management. Therefore, a positive but less than unit value for $\hat{\beta}_1$ necessarily implies financing of disaster risk management actions by alternative means such as by adopting debts, seeking help from extended family members, and cutting down expenditures on other essential items such as consumption of basic food and nutrients.

Finally, as an additional robustness check, this paper also reports regression results with district and survey year fixed effects to control for any district or year specific heterogeneity in the severity of disaster.

4. Main results

4.1. Disaster expenditures by households

Table 2 reports average precautionary savings and disaster expenditures for affected households using BIHS 2011, 2015 and 2018 data. On average, disaster-affected surveyed households have spent \$499 in 2011, \$855 in 2015, and \$1076 in 2018 in disaster-related repairs and other home repairs and improvements. During the same period, their precautionary savings were \$233, \$267, and \$354, respectively.

Although both the precautionary savings and disaster expenditures have increased over time, average disaster expenditures always exceeded precautionary savings, indicating that households might have adopted alternative means to finance their disaster expenditures.

4.2. Regional variations

Next, Table 3 reports precautionary savings and private disaster expenditures for seven administrative divisions of Bangladesh.[3] Consistent with the results in Table 2, all the regions have disaster expenditures greater than precautionary savings. However, since the survey is not representative of administrative regions, these region-specific estimates might suffer from measurement errors and therefore should be interpreted carefully.

In Barisal, precautionary savings went down from \$360 in 2011 to \$251 in 2015, then went up again to \$451 in 2018. On the other hand, disaster expenditures considerably increased between 2011 and 2015, from \$523 to \$1193, followed by a further moderate increase to \$1243 in 2018.

Chittagong, another coastal region, also experienced similar fluctuations in precautionary savings (from \$169 in 2011 to \$123 in 2015 to finally \$356 in 2018), although disaster expenditures steadily increased from \$963 to \$2137.

Disaster-affected households from Dhaka, the central region, have relatively lower precautionary savings that ranged between \$179 and \$310. However, they have quite sizeable disaster expenditures that increased over time from \$579 to \$1064.

Khulna, another coastal region, has precautionary savings between \$273 and \$409, and its disaster expenditures increased steadily from \$353 in 2011 to \$1127 in 2018.

North-western regions of Rajshahi and Rangpur and north-eastern region of Sylhet have lower precautionary savings and disaster expenditures compared to other regions.

In general, regions with traditionally higher incidences of poverty, i.e. Khulna, Rajshahi, and Rangpur, and relatively well-off regions of Dhaka and Sylhet have lower household-level private disaster expenditures.[4] There can be different explanations: while the affected households from Khulna, Rajshahi, and Rangpur may have lower spending abilities, apparent from their relatively lower precautionary savings, those from Dhaka and Sylhet may instead rely more on public expenditure on disaster risk reduction and management. Moreover, Dhaka and Sylhet have more non-agricultural income opportunities which are less vulnerable to disaster risks, which may explain their lower levels of precautionary savings.

4.3. Savings elasticity of disaster expenditure

Finally, Table 4 reports regression results for disaster expenditures on precautionary savings, according to Equations (1) and

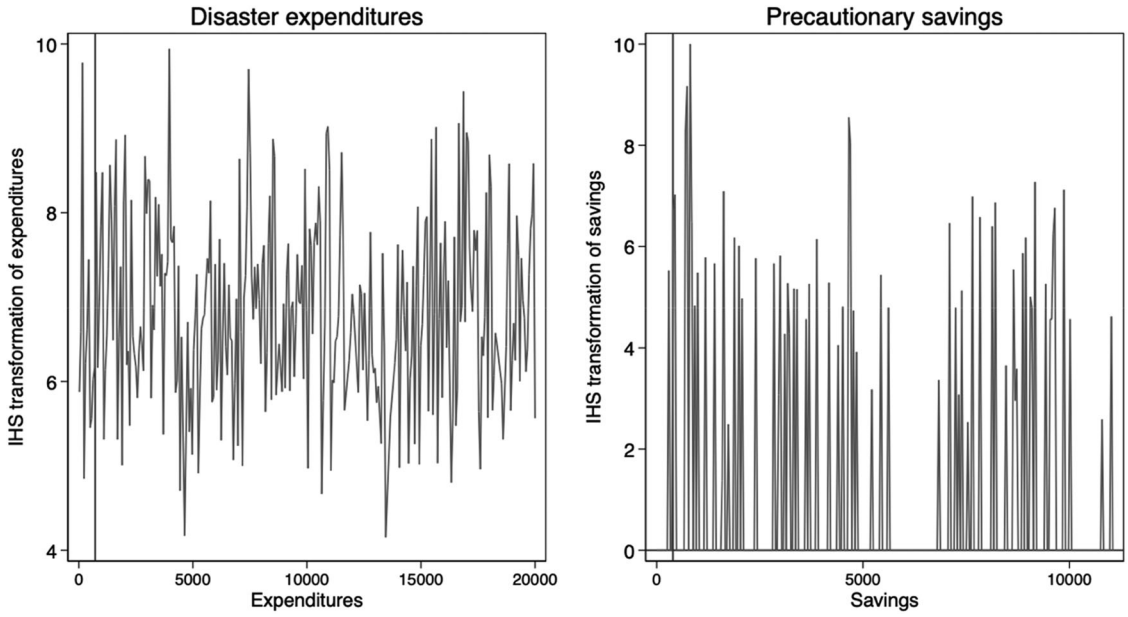

Figure 1. IHS transformation of variables.

(2). The estimated coefficient can be interpreted as the 'savings elasticity of expenditure'. In addition to the main regression for all the households, this paper also runs separate regressions for seven administrative divisions of Bangladesh.

Overall, the savings elasticity of disaster expenditure is 0.049, implying that a 100% increase in precautionary savings will increase private disaster expenditures by about 5%. Despite the results being insignificant for some of the regions, all the regions have positive estimates of the savings elasticity of disaster expenditure, which ranges between 0.005 (i.e. 0.5%, for Rajshahi) and 0.126 (i.e. 12.6%, for Chittagong). Moreover, results for total savings and those additionally controlling for district and survey year fixed effects produce consistent estimates throughout.

5. Discussion and policy implications

This paper estimated small positive values for the savings elasticity of disaster expenditures and, as evident from results in Tables 2–5, disaster-affected households outspend their precautionary savings, implying that household-level precautionary savings are not sufficient for covering total disaster-related expenditures that the affected households incur. Households must rely on alternative sources of financing such as debt-financing, seeking help from extended family members, and cutting down expenditures on other essential items, and reallocating savings intended for other purposes when spending on recovering from the damages done by disasters. Such expenditures can limit household's private expenditures on other essentials including food, health, and education. Often the recovering households are already resource-constrained, making such trade-offs even more difficult. On the other hand, longer-term effects include lower adulthood health, schooling, and consumption outcomes of children affected by a disaster during their childhood (e.g. Eskander & Barbier, 2022). Therefore, increased supports will be necessary to lessen the burden of disaster finance on the affected households. Such supports can come from different sources including direct support from the government and foreign aid from international donors, in addition to the development of market-based instruments such as insurance and access to finance. Moreover, targeted interventions such as developments of infrastructural facilities to reduce rural-urban differences and local-level livelihood opportunities in rural areas to benefit especially the females and female-headed households will be necessary to reduce the financial burdens of disasters and recovery from them.

Within the *Bangladesh Climate Change Strategy and Action Plan* (BCCSAP) and Green Climate Fund (GCF) frameworks,[5] different ministries and departments of the Government of Bangladesh are implementing wide ranges of climate and disaster adaptation and mitigation projects under different programs including *National Adaptation Programme of Action 2005* (revised 2009), *Bangladesh Climate Change Strategy and Action Plan 2009*, *Roadmap for Developing a National Adaptation Plan for Bangladesh 2015*, *Nationally Determined Contribution Implementation Roadmap* (draft, 2017), and *National Appropriate Mitigation Action*. The Ministry of Finance is responsible for identifying, maximizing, and managing sources and fund applications for financing climate-resilient and disaster risk-reducing actions. Because disasters are consequences of a changing climate, this paper treats disaster coping and adaptation strategies as climate actions, and defines all government and donor contributions for climate change and disaster risk reduction actions as public finances, including direct climate budgets allocated according to the BCCSAP framework.

Table 5 reports the annual climate and disaster management budgets for fiscal years 2014–2015 to 2019–2020. The data is based on government's final allocations, except for the year 2019–2020 where the revised allocation is reported. The government's total nominal allocation was around $2.74 billion for 2019–2020, up from $1.21 billion in 2014–2015.

Total climate budget is steadily increasing over time which has significant implications for both post-disaster public

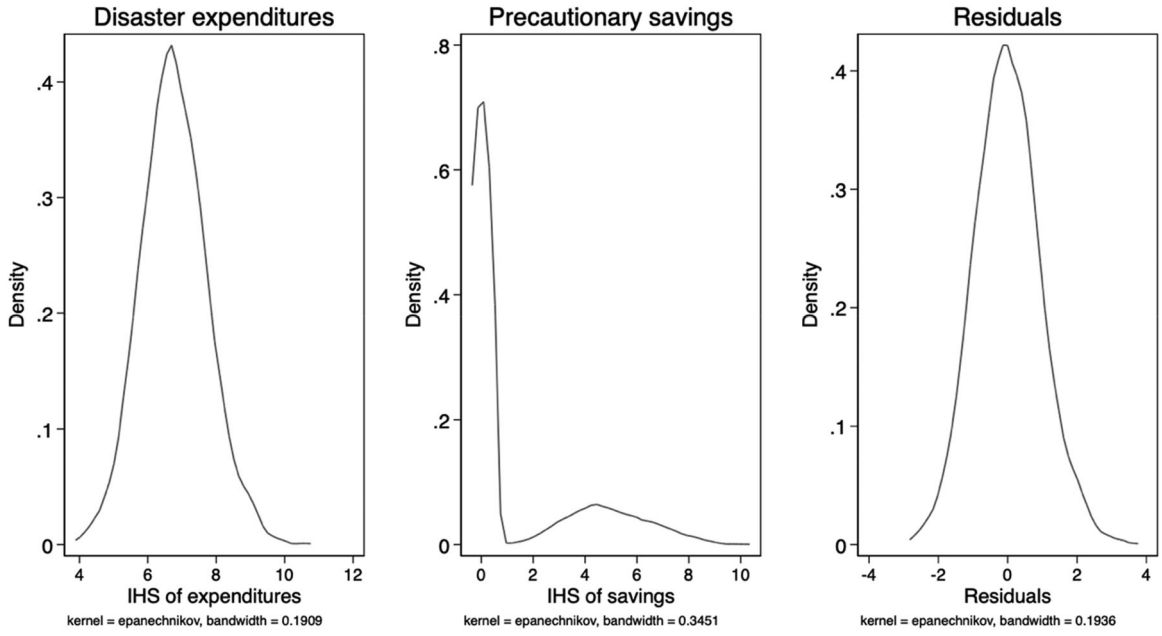

Figure 2. Kernel density plots.

allocations and burden on individual households in recovering from disaster-induced damages. Despite experiencing multiple disasters every year that directly affect over 3% of total population, whereas 70% population lives in flood-prone regions (Cash et al., 2013), total post-disaster emergency allocations are manageable in Bangladesh – around 1% of total government expenditures. However, household's private expenditures also went up considerably from $499 in 2011 to $1076 in 2018, implying that public allocations are insufficient to reduce household's burden of disaster risks.

However, like in many other climate-vulnerable countries, the government of Bangladesh also experiences fiscal deficits in the aftermath of a largescale flood or storm. Being a least-developed country, it also depends on foreign aid from international communities, e.g. donor countries and development agencies, who must play their appropriate roles during such trying times.

Due to the absence or insufficiency of formal facilities and many important markets, households in rural Bangladesh usually rely on the local and central governments for relief and post-disaster reconstruction. If such responses are delayed or insufficient, households complement public supports by using their informal social and family networks for access to finance and other important means for the recovery process. However, Islam and Nguyen (2018) found that such networks may not enable affected households to share resources with their network members and mitigate disaster risks. Especially for a developing country like Bangladesh where informal loans come with large interest rates, disaster-affected households might end up facing increased poverty in such instances.

Inequality in access to formal sources of finance hinders the coping and adaptive capacity of many disadvantaged households (Fenton et al., 2017b). Poorer households, often unable to access larger loans at lower interest rates from commercial banks, mainly rely on smaller loans at relatively higher interest rates from NGOs for financing disaster preparedness and recovery actions. Relaxing conditions for loans from commercial banks in the aftermath of a disaster can widen their outreach and help those in need. In addition, although NGOs provide smaller loans, they have greater coverage and therefore can serve as a quicker source of disaster finance in Bangladesh. Additionally, NGOs can expand their loan deferment facilities during and in the aftermath of a disaster.

It is well documented that instead of pure post-disaster response, especially the farmers can benefit from more proactive ex ante risk management such as investing in high-return risk reduction projects and financial instruments providing post-disaster capital for the recovery process (e.g. Heltberg et al., 2009). For example, access to insurance and other forms of market-based financial instruments can increase disaster preparedness for economic agents (e.g. Crick et al., 2018). Even in presence of insurance programs covering disaster risks, some marginalized households without insurance coverage may require additional attention to promptly receive sufficient public support (Kammerbauer & Wamsler, 2017).

For equitable access to public funding and other sources of disaster finances, regions with greater disaster risks must receive greater public allocations. Moreover, households with different socioeconomic attributes experience disaster risks at different degrees and their adaptive capacities also greatly vary. For example, while wealthier households may experience

Table 2. Disaster expenditures by households.

Variables	BIHS 2011	BIHS 2015	BIHS 2018
Precautionary Savings	233.5	267.2	353.7
	(51.1)	(110.5)	(186.7)
Disaster Expenditures	498.8	854.8	1075.9
	(27.6)	(78.8)	(79.2)

Notes: Standard errors in parentheses. Results are calculated using three rounds of the Bangladesh Integrated Household Survey (BIHS) data. Average savings and expenditures values are calculated for the households that reported to be exposed to disaster in the previous year. All monetary values are converted to US$ at the exchange rate of BDTk 1 = $0.012.

Table 3. Household's private disaster expenditures by regions.

	BIHS 2011		BIHS 2015		BIHS 2018	
Division	Savings	Expenditures	Savings	Expenditures	Savings	Expenditures
Barisal	360.2	522.7	250.5	1193.1	450.6	1242.7
	(125.2)	(48.5)	(290.6)	(236.3)	(667.1)	(264.5)
Chittagong	169.2	962.8	123.3	1307.0	355.5	2137.2
	(261.8)	(96.7)	(450.3)	(339.7)	(555.1)	(293.9)
Dhaka	179.5	579.1	303.3	869.1	310.0	1064.2
	(104.7)	(49.4)	(197.5)	(121.1)	(385.2)	(111.6)
Khulna	306.6	352.8	408.5	688.1	273.5	1126.7
	(88.5)	(45.8)	(303.6)	(182.5)	(632.9)	(264.5)
Rajshahi	72.7	446.2	365.5	823.4	197.5	874.2
	(154.4)	(96.7)	(251.7)	(150.0)	(756.5)	(221.3)
Rangpur	224.2	216.2	114.2	511.3	459.4	832.1
	(197.9)	(112.4)	(290.6)	(188.0)	(348.4)	(129.9)
Sylhet	101.3	528.6	48.8	1227.5	288.0	1149.5
	(169.9)	(78.0)	(411.0)	(268.6)	(447.5)	(133.8)

Notes: Standard errors in parentheses. Results are calculated using three rounds of the Bangladesh Integrated Household Survey (BIHS) data. Average savings and expenditures values are calculated for the households that reported to be exposed to disaster in the previous year. All monetary values are converted to US$ at the exchange rate of BDTk 1 = $0.012.

greater financial losses, in absolute terms, from disaster exposure, they also have higher adaptive capacity and better access to formal sources of finance. On the other hand, female-headed households and other socio-economically disadvantaged groups potentially experience greater relative losses (i.e. total loss as percentage of total assets) and are forced to allocate a greater share of their private funds in disaster recovery. Therefore, disadvantaged households who might

Table 4. Savings elasticity of disaster expenditures.

Variables	All regions	Barisal	Chittagong	Dhaka	Khulna	Rajshahi	Rangpur	Sylhet
A. *Precautionary Savings*								
PS_i	0.049***	0.100***	0.126***	0.032	0.034	0.005	0.063**	0.036
	(0.010)	(0.023)	(0.037)	(0.020)	(0.022)	(0.028)	(0.024)	(0.029)
Constant	6.711***	6.600***	7.131***	6.846***	6.303***	6.940***	6.545***	6.994***
	(0.027)	(0.064)	(0.130)	(0.049)	(0.062)	(0.069)	(0.087)	(0.077)
Observations	1636	267	86	443	314	161	176	189
R-squared	0.014	0.049	0.097	0.006	0.007	0.000	0.032	0.007
District FE	NO	NO	NO	NO	NO	NO	NO	NO
Year FE	NO	NO	NO	NO	NO	NO	NO	NO
B. *Precautionary Savings, with district and year fixed effects*								
PS_i	0.036***	0.062***	0.035	0.027	0.022	0.021	0.044*	0.042
	(0.009)	(0.023)	(0.046)	(0.019)	(0.024)	(0.026)	(0.024)	(0.030)
Constant	6.727***	6.637***	7.285***	6.851***	6.320***	6.917***	6.573***	6.987***
	(0.024)	(0.061)	(0.117)	(0.046)	(0.061)	(0.066)	(0.074)	(0.070)
Observations	1632	267	84	443	314	161	174	189
R-squared	0.251	0.150	0.378	0.162	0.170	0.169	0.371	0.188
District FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
C. *Total Savings*								
TS_i	0.065***	0.114***	0.067*	0.021	0.077***	0.038*	0.123***	0.085***
	(0.008)	(0.022)	(0.035)	(0.015)	(0.019)	(0.021)	(0.022)	(0.021)
Constant	6.568***	6.357***	7.107***	6.820***	6.107***	6.813***	6.173***	6.811***
	(0.038)	(0.095)	(0.186)	(0.067)	(0.084)	(0.096)	(0.120)	(0.094)
Observations	1636	267	86	443	314	161	176	189
R-squared	0.038	0.096	0.036	0.005	0.055	0.022	0.152	0.067
District FE	NO	NO	NO	NO	NO	NO	NO	NO
Year FE	NO	NO	NO	NO	NO	NO	NO	NO
D. *Total Savings, with district and year fixed effects*								
TS_i	0.051***	0.103***	0.053*	0.002	0.058***	0.041**	0.078***	0.082***
	(0.008)	(0.020)	(0.031)	(0.014)	(0.020)	(0.019)	(0.020)	(0.022)
Constant	6.611***	6.390***	7.162***	6.876***	6.168***	6.799***	6.344***	6.818***
	(0.034)	(0.089)	(0.141)	(0.063)	(0.085)	(0.091)	(0.099)	(0.089)
Observations	1632	267	84	443	314	161	174	189
R-squared	0.266	0.207	0.392	0.158	0.194	0.188	0.413	0.238
District FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses. ***, ** and * represent statistical significance at 1%, 5% and 10% levels, respectively. Dependent variable is the IHS transformation of disaster expenditures (DE_i), whereas the explanatory variables are the IHS transformation of precautionary savings (PS_i) in panels A and B and the IHS transformation of total savings (TS_i) in panels C and D. Estimating sample is restricted the households that reported to be exposed to disaster in the previous year. All monetary values are converted to US$ at the exchange rate of BDTk 1 = $0.012.

Table 5. Public budgets for climate and disaster.

Fiscal year	Total climate budget (Million $)	Climate budget as % of total national budget
2014–2015	1213.61	8.63
2015–2016	1311.01	6.90
2016–2017	1377.50	6.50
2017–2018	1719.48	7.10
2018–2019	2416.43	7.80
2019–2020	2735.27	7.60

Notes: Data on climate budget comes from Ministry of Finance (2020). All monetary values are converted to US$ at the exchange rate of BDTk 1 = $0.012.

experience increased inequality and marginalization after a disaster need to have access to affordable market-based financing instruments in addition to public supports.

6. Conclusions

This paper has established that rural households are bearing the burden of climate- and disaster-related expenditures in Bangladesh. There are considerable regional heterogeneities in household's disaster expenditure, which can be attributed to multiple factors such as frequency of disaster exposure, poverty, and proximity to major urban centres. Overall, household-level precautionary savings play an important role: this paper identifies that a 100% increase in precautionary savings can increase disaster expenditures by 5%.

Since affected households always spend for disaster-related repairs more than their precautionary savings, such expenditures must have been made at the expense of other important items. Therefore, the government of Bangladesh and its development partners need to increase financial contributions to climate and disaster risk reduction and management projects and need to ensure that the benefits of such projects reach the climate- and disaster-vulnerable poor households. Due to their apparent effectiveness in reducing the harms of climate change (Eskander & Fankhauser, 2020), it is essential to enact relevant climate laws and policies that will additionally ensure consistent flows of climate and disaster finances.

However, the government needs to develop a quality database on household's climate and disaster expenditures for this purpose. This paper provides the first quantification of household's contribution to disaster expenditure, something that was hitherto difficult to quantify given limited publicly available data. Carrying out a range of adaptation and coping strategies on limited incomes, rural Bangladeshi households need both public investments towards mitigating disaster risks, and coping and adaptation assistance (both cash and in-kind) from central and local government, donors, and NGOs. Moreover, microinsurance, social safety nets and devolved climate and disaster finance that is invested in ways that will meet their priorities – for example, raising house plinths and raising household compounds with earthen foundations – would help them prepare for disasters and future-proof their homes.

Notes

1. Due to frequent exposure to climate-induced disasters, most climate funds in Bangladesh are allocated to disaster risk reduction and management activities. Therefore, this paper uses the term 'disaster expenditure'.
2. This is an incomplete measure, which provides only conservative estimates of household contributions. Complete, robust accounting would require a survey focusing solely on households' climate and disaster related expenditures.
3. During the BIHS data collection, Mymensingh was still a part of Dhaka division.
4. According to the 2016 Bangladesh Household Income and Expenditure Survey, the incidence of poverty (lower poverty line) in Khulna, Rajshahi and Rangpur divisions were 12.4%, 14.2% and 30.5%, respectively, whereas Dhaka (7.2%) and Sylhet (11.5%) divisions have much lower incidences of poverty (Bangladesh Bureau of Statistics, 2016).
5. The Green Climate Fund (GCF) aims to help countries' transition towards low-emission (mitigating climate change) and climate-resilient (adapting to climate change) development. GCF Priority 1, i.e. shifting to low-emission sustainable development pathways, includes specific benefits of (1) low-emission energy access and power generation, (2) low-emission transport, (3) energy-efficient buildings, cities, and industries, and (4) sustainable land use and forest management. On the other hand, GCF Priority 2, i.e. increasing climate-resilient sustainable development for, includes (1) enhanced livelihoods of the most vulnerable people, communities, and regions, (2) increased health and well-being, and food and water security, (3) resilient infrastructure and built environment to climate change threats, and (4) resilient ecosystems.

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