Bangladesh Development Studies
Vol. XLV, March-June 2022, Nos. 1&2
DOI: https://doi.org/10.57138/VNEO7557

Climate Change and Child Marriage: Evidence from Bangladesh

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This paper examines the effects of environmental vulnerability on the risk of child marriage in Bangladesh. Community vulnerability measures are constructed for 240 rural communities in eight districts according to the presence of three indicators of environmental vulnerability—history of cyclones, flooding, and waterlogging. Community data are linked to individual-level adolescent survey data from a representative sample of 15,000 adolescent girls in those communities. Types of environmental vulnerability and the effect on adolescent girls' marriage outcomes have been explored using discrete time survival analysis. Results show that coastal communities with prolonged waterlogging and salinity have significantly higher child marriage rates, and there is no evidence of higher risks of child marriage in flood-affected areas. The paper concludes that slow and rapid onset events vary in their impact on child marriage. It is important to distinguish between rapid onset factors, such as floods and cyclones, and slow and less dramatically visible factors, such as waterlogging, that affect marriage through longer-term impacts on lives and livelihoods. Programs need to cast a wider net to safeguard girls living in the communities not only where immediate and sudden environmental emergencies have occurred but also in the areas where climate-induced disasters may not seem very visible but have slow, cascading effects and pose a risk for child marriage.

Keywords: Child Marriage, Environmental Vulnerability, Adolescent Girls, Bangladesh, Salinity, Waterlogging, Climate Change
JEL Classification: F63, J12

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This paper utilised data from projects funded by multiple grants received to generate evidence on child marriage over the years. The authors are grateful to the Embassy of the Kingdom of the Netherlands, and the UNFPA-UNICEF Global Programme to End Child Marriage- and UNICEF for their generous support and contribution to adolescent research interventions in Bangladesh.

I. INTRODUCTION

This paper explores the impact of environmental vulnerability on the probability of child marriage in a community. Bangladesh is characterised by several types of vulnerability to climate change—low-lying coastal communities on the Bay of Bengal are vulnerable to sea level rise, coastal flooding with associated salinity, and increased waterlogging and river erosion in south-western parts of Bangladesh. The countries surrounding the Bay of Bengal have historically been subject to extreme weather events, including several major devastating cyclones in the past several years. Communities in the path of cyclones were disproportionately affected because of characteristics of vegetation and land elevation. Northern and central districts are affected by riverine flooding and river erosion (Abrar & Azad, 2003).

Bangladesh is also characterised by high rates of child marriage overall and considerable local-level variability in marriage rates. Child marriage is defined as marriage below the age of 18 for girls. Regional variation in child marriage is well-established and suggests a role of poverty/wealth at an aggregate level. Regions that are the most prosperous within the country have a later age at marriage. In contrast, poorer regions have a higher prevalence of child marriage (National Institute of Population Research and Training [NIPORT], Mitra and Associates, & Macro International, 2017; Islam, Haque & Hossain, 2016). There is also variation within small communities and villages- girls from the poorest communities are significantly more likely to marry early (Amin et al., 2014). However, poverty is not the only reason and cannot fully explain variations in child marriage. We hypothesise differential environmental vulnerability explains a higher prevalence of child marriage risk among other social and cultural factors.

Bangladesh has already experienced environmental changes exacerbated by the intensity and frequency of events due to climate change. Coastal districts are affected by rising sea levels, leading to waterlogging, river erosion, and soil and water salinity. The entire country is affected by annual flooding and river erosion to varying degrees (Haque & Zaman, 1989; Elahi, 1989). The literature suggests that climate vulnerability puts adolescent girls at more risk of harmful practices as they are female and young (Gaag, 2013; Felten-Biermann, 2006; Mehta, 2007; Plan International, 2011). Several studies have suggested that for some settings, child marriage for adolescent girls is a coping strategy adopted by households in response to their increased vulnerability to environmental disasters (CCC, 2008; Azad, Hossain, & Nasreen, 2013; Nasreen, 2008; Deen, 2010; Alston, Whittenbury, Haynes, & Godden, 2015; Asadullah, Islam, & Wahhaj, 2020). Existing studies that have explored climate risk and child marriage have not differentiated between different types of environmental events and how they may

manifest differently for the people living in the communities. Climate change increases people's vulnerabilities by operating through varied intermediate factors.

This paper explores the environmental characteristics, differentiating between three types of vulnerability associated with waterlogging and salinity, cyclones and floods, and child marriage prevalence, as a way to understand the potential impacts of differential environmental factors on decisions about marriage. The paper is structured as follows. Section II defines different forms of environmental vulnerabilities that exist in Bangladesh and their manifestations and implications. Section III describes the socio-cultural context of child marriage and marriage practices in Bangladesh, and Section IV provides a conceptual framework to visualise the economic and social pathways by which environmental vulnerability links to child marriage. Section V describes the data sources and research methods adopted for this study. Results are presented in section VI, followed by a discussion and conclusion in section VII.

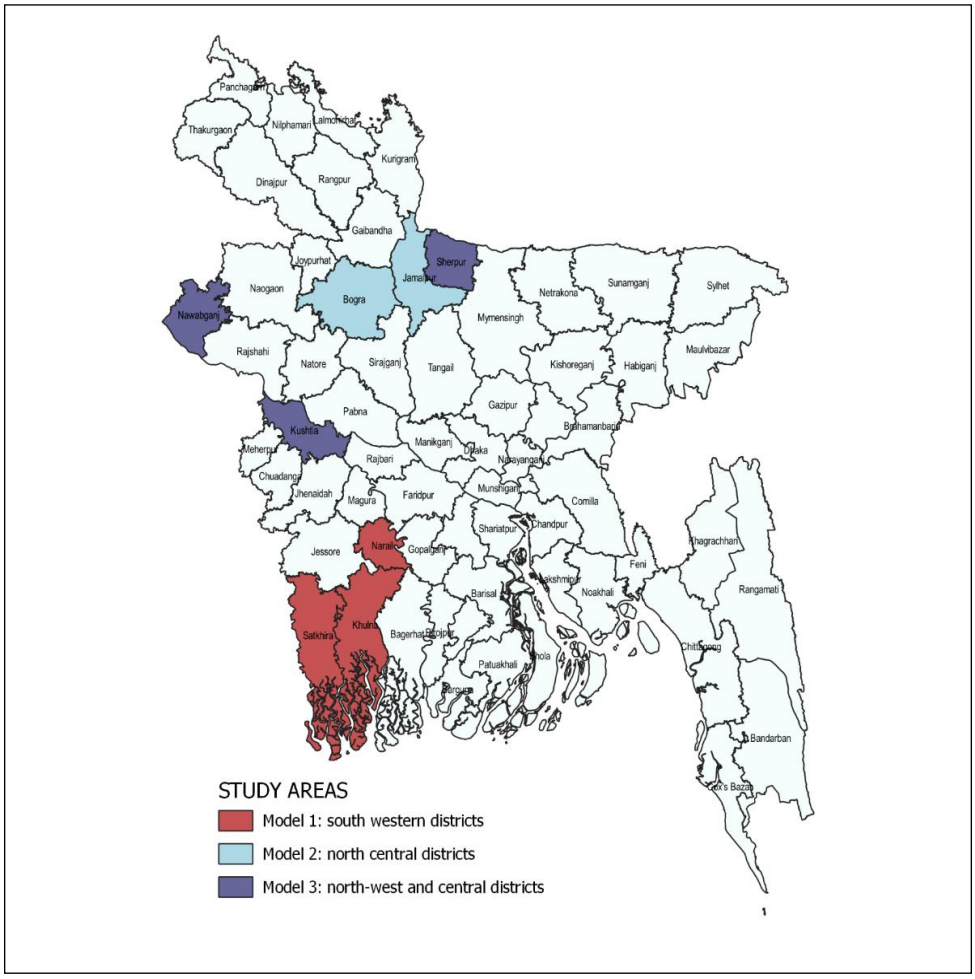
II. CLIMATE RISK AND VARIATION IN ENVIRONMENTAL VULNERABILITY IN BANGLADESH

Bangladesh is considered vulnerable to extreme weather events and ranks as the seventh most-extreme-weather-events-affected country. One hundred ninety-one events occurred from 1999 to 2018 (Eckstein, Kuznel, Schafer, & Winges, 2019). According to the special report on global warming of 1.5°C by the IPCC, the South Asia region- where Bangladesh is located- experiences hot extremes due to climate change. Heavy precipitation increased during the period 1991–2010 in comparison with 1960–1979 due to a 0.5°C temperature rise (Hoegh-Guldberg et al., 2018; Schleussner, Pfleiderer, & Fischer, 2017). Due to warming in the Bay of Bengal region, tropical cyclones and floods were also projected to increase in frequency and intensity (Hay & Mimura, 2010; Hirsch et al., 2015; Hoegh-Guldberg et al., 2018). Historical records from the last 100 years of global cyclone data show that Bangladesh experienced 50 per cent of all global casualties and damages (Alam, Momtaz, Bhuiyan, & Baby, 2018). Two devastating cyclones- Sidr in 2007 and Aila in 2009- displaced tens of thousands of people from their homes in the coastal communities (Akter, 2009; Dasgupta et al., 2010; Saha, 2016). Bangladesh continued to face several cyclonic storms in subsequent years- for example, Mohashen/Viyaru (2013), Roanu (2016), Mora (2017), Fani (2019), Bulbul (2019), and Amphan (2020). Flooding[1] is an annual occurrence and

[1] Flooding used in this paper refers to 'riverine flood' and study sites used in this research, have not encountered occurrence of flash flood or coastal flood. Hence, flood and riverine flood have been used interchangeably throughout the paper.

expected hazard in Bangladesh during the monsoon season. Flooding affects people's homes and livestock and may also cause temporary dislocation, and vulnerable households adopt a range of coping strategies, such as seeking relief or food aid and relying on social networks (Philip & Rayhan, 2004; Van der Geest & Warner, 2015). In 2020, flooding affected 5.4 million people in the northern, central, and northeastern parts of the country, and around 37 per cent of the country's total areas were flooded. In 2017, flooding inundated 42 per cent of the country, affecting 6.1 million people (Davis, 2017). In 2013, 2014, 2016, and 2018, 21, 28, 33, and 23 per cent of the country, respectively, were affected by flooding (Flood Forecasting and Warning Centre, n.d.).

FIGURE 1: **Study Sites**



Bangladesh is also facing climate change-induced accelerated sea-level rise, leading to increased inundation and saline contamination of soil (Mahmuduzzaman, Ahmed, Nuruzzaman, & Ahmed, 2014). Data for the period of 1977–1998 showed that the relative sea levels in the Bay of Bengal had increased by 4 mm per year, and the western and eastern coasts had increased by 7.8 mm per year (Alam et al., 2018). One model projects that by the end of the twenty-first century, 29 per cent of the total area of Bangladesh will be inundated by sea level rise (Hasan, Kumar, & Gopalkrishna, 2020). The number of people living in low-elevation coastal zones of Bangladesh and their exposure to coastal flooding is among the highest in Asia (McGranahan, Balk, & Anderson, 2007).

South-western Bangladesh is affected by extended waterlogging and soil and water salinity associated with changes in the coastline and the rise of sea level. Waterlogging with salinity is a particular phenomenon of the south-western region, and unlike riverine floods, inundation continues for an extended period. The negative health effects of salinity in coastal regions are well documented (He & Macgregor, 2009; EPA, 2014; Pinchoff, Shamsudduha, Hossain, & Warren, 2019). South-west coastal communities inundated with prolonged waterlogging with salinity also suffered from other forms of vulnerability like lack of safe drinking water, access to school, etc. These coastal changes are also associated with reduced land productivity, loss of livelihood, and social vulnerability (Alam et al., 2018; Aryal et al., 2020; Andrei, Rabbani & Khan, 2015). Encroaching land salinity may result in reduced land productivity over some years, eventually pushing families off their land. Changes associated with waterlogging and salinity are slow onset and gradual and not as conspicuous as other climate disasters or emergencies, such as cyclones or floods; however, they may affect communities in larger magnitude but are often given less attention.

A study by Chen and Mueller (2018) made an important distinction between flooding in other parts of the country and flooding in the south-western region of Bangladesh. Salinity associated with coastal flooding and waterlogging was found to have distinctive effects on internal and international migration within Bangladesh, while no such migration effect was observed in riverine flood-affected areas otherwise (Chen & Mueller, 2018).

Riverine flood is a common and annual occurrence all over the country during monsoon season, and inundation continues for a couple of months and is expected, but there are occasional years that it is higher and longer than usual. Flooding is a sudden onset event that stands out in the news; people's sufferings are broadcasted with importance because people need an immediate response. Rescue teams are deployed, and affected people get aid, food, and safe drinking water. Heavy

monsoons and floods may also lead to temporary displacement, but farmers return to their farms with delayed benefits on yields (Banerjee, 2010; Gray & Mueller, 2012). Several recent studies echo the minimal migratory response to flooding (Gray & Mueller, 2012; Lu et al., 2016; Call, Gray, Yunus & Emch, 2017; Chen, Mueller, & Tseng, 2017).

The impact of riverine flood and waterlogging varies in terms of duration, acuteness, and effect on short-term loss and long-term loss and productivity. Though floods are conspicuous and sudden, waterlogging, in the longer term, has a more damaging effect on livelihood, land productivity, and social insecurity. Thus, while the discrete evidence of damage of assets and loss of home in sudden events such as cyclones and floods are clearly identifiable and hence easier and common to report, the other climate-induced environmental vulnerability, such as prolonged waterlogging with salinity in south-western districts, is a slow onset and have cascading and long-term reduction of land productivity and changing livelihoods may be equally pertinent but less likely to be identified as a factor for migration and on other kinds of scarcity and insecurity which have economic, social and psychological effects on lives of people and decision making for coping.

III. SOCIO-CULTURAL CONTEXT AND MARRIAGE PRACTICES IN BANGLADESH

Two in every three girls in Bangladesh are child brides, despite the fact that child marriage was prohibited by law for nearly nine decades (ICRW, 2011; Government of Bangladesh, Ministry of Law 2017, Child Marriage Restraint Act, 1929). Marriage is viewed as universal for girls and the optimal course of action for young girls in Bangladesh and believed to ensure socio-economic, social security and social status (Amin, 1998; Bates, Schuler, Islam, & Islam, 2004; Chowdhury, 2009; Kabeer, 2011; Jensen & Thornton, 2003; Zaman, 1999). Arranged marriage is the general practice where parents decide, and girls have little or no 'say' about whom, where, and when to marry, although increasing rates of love marriage are reported in recent studies (Amin et al., 2014; Ainul et al., 2020). The practice of dowry (payments by the bride's family to the groom's family) is a common and a major financial burden for the girls' family. It usually involves transaction of large amounts of money, jewellery, furniture, and other goods and other demands such as securing a job for the groom (Bhuiya, Chowdhury, Momen, & Khatun, 2005; Schuler, Bates, Islam, & Islam, 2006; Chowdhury, 2009; Amin et al., 2014). Dowry amounts increase with the girl's age, which makes child marriage a valued attribute and serves the economic interest of the girl's family (Amin et al., 2014).

Gender inequity and norms concerning girls' sexuality lead to the desirability of early marriage and childbearing because girls' sexual and reproductive roles dominate over their productive roles. In the context of Bangladesh, like many South Asian countries- child marriage is linked with the perceived protection of a girl's sexual purity, and it takes the form of preserving girls' marriageability, virginity, and family honour. Parents resort to early marriage to protect against the possibility that their daughters might engage in sexual activity and bring shame to the family. Threat and/or fear of sexual violence and to fall prey of predatory behaviour by men and boys is another major driver of child marriage in the context of Bangladesh (Amin et al., 2014; Azad et al., 2013; Nasreen, 2008; World Vision UK, 2013).

IV. ENVIRONMENTAL VULNERABILITY AND CHILD MARRIAGE

4.1 Economic Pathways for Child Marriage

The impact of climate on changing and limiting livelihood options is an important factor that influences scarcity and economic insecurity in several ways. Changing weather patterns lead to loss of biodiversity and changing land quality that forces agricultural adaptation. Coastal sea-level rise affects land productivity, which, in turn, leads to reduced livelihood options (Sarwar & Khan, 2007). Climate-induced changes have economic impacts through direct loss and damage of land and assets by climate events and by reduction in land productivity, thus contributing to poverty. In the socio-economic setting of Bangladesh and a variety of other settings, child marriage is associated with poverty (Bajracharya & Amin, 2012; Erulkar, 2006; Suran, Amin, Huq, & Chowdhury, 2004; Alston et al., 2015). Families that are financially constrained may use child marriage as a coping mechanism. By marrying off their daughters as early as possible, they save on dowry, reduce household expenses, and increase food security (Ahmed, Haq, & Bartiaux, 2019; Rezwana & Pain, 2020; Ferdous & Mallick, 2019).

Migration for livelihoods is often a response to changed livelihood options in communities that are dependent on natural resources. Seeking new work opportunities is generally an important adaptation strategy for those who are worst affected by climate change (Hunter, 2005), and lower socio-economic status is linked to a higher probability of relocation after a hazardous event (Hunter, 2005), suggesting that better-off households have the resources to rebuild (Hunter, Murray, & Riosmena, 2013).

Households that are impacted by climate change face economic insecurity and poverty, often leading them to seek opportunities for livelihood diversification.

Gradual increases in soil salinity also correspond to increasing livelihood diversification into aquaculture and migration of household members.

Migration causes the loss of familial and kin networks, which, in turn, leads to other social challenges and vulnerabilities that may not be possible to measure in economic terms.

4.2 Social Pathways for Child Marriage

An increasing frequency of climate-induced hazards is causing economic and non-economic loss and damage to communities living in disaster-prone areas (Formetta & Feyen, 2019; Preston, 2017; Serdeczny, Bauer, & Huq, 2018; Tschakert, Ellis, Anderson, Kelly, & Obeng, 2019). While the economic effects of climate disasters are well studied, non-economic and social impacts are often given less importance in the narratives of climate challenges. Climate-induced migration and displacement cost non-economic loss, which is often intangible, such as loss of cultural identity, personal safety, sense of loss of place or belongings, esteem, and sense of uncertainty of future (Hards, 2011; Heyward, 2014; Zellentin, 2015; Schwerdtle, Bowen, & McMichael, 2018; Ayeb-Karlsson, 2020a; Ayeb-Karlsson, 2020b; Hayes, Blashki, Wiseman, Burke, & Reifels, 2018). Such social and cultural losses are just as important as material losses in generating social resilience and enabling recovery. In contrast, non-economic loss and damage entail challenges of measurement, and the impact on non-material things is manifested through human cognition and culture and context-dependent (Morrissey & Oliver-Smith, 2013).

While there are several direct pathways of influence between climate change and livelihoods and economic insecurity, the social impact works in many indirect ways. Migration of family members and relocation of entire households both heightened insecurity for girls in the absence of community, familial, and kin networks, which are often perceived as protective resources. Women and children are likely to stay behind when men move from vulnerable locations to new places to find new work (Beddington, 2011). Women become socially and economically vulnerable to sexual and other forms of predatory behaviour when the main male household member migrates or when they themselves migrate in search of work (Massey, 2009; Nasreen, 2008; Poncelet, Gemenne, Martiniello, & Bousetta, 2010). Thus, marriage is also a strategy to protect girls from sexual violence during disasters (Alston et al., 2015; Ahmed et al., 2019). Increased incidents of sexual violence during environmental crises are not uncommon and well documented in previous research (Ballestores, 2010; Felten-Bierman, 2006). Environmental vulnerability-related displacement, even temporary dislocation to cyclones and

other shelter centers, increases the risk of sexual violence for girls (Ahmed, et al., 2019; APIT, 2009). Preserving girls' sexual *"purity" and related* marriageability often concerns girls' families, which promotes child marriage.

Gender roles and expectations may also play a part. In coastal communities with waterlogging and salinity, there is a scarcity of safe drinking water. Girls and women are responsible for fetching water and may have to travel further due to salinity intrusion, posing additional risks to girls' sexual safety and security. When prolonged waterlogging forces schools to close and girls stay at home, they are more likely to be married off. Girls from poor families are particularly vulnerable because their labour is fungible; hence, they are more likely to be pulled out of school and married off to reduce the costs associated with their upkeep (Bruce, 2015).

It is important to understand and consider both the economic and the non-economic loss of environmental shocks and associated vulnerabilities and their cascading effects and how they weaken community resilience. All these factors influence people's adaptative capacity and decision-making while dealing with environmental threats and vulnerability. Thus, climate shocks are best understood as operating to exacerbate the effect of poverty, scarcity, and insecurity on existing social and cultural practices such as dropping out of school, sexual violence, and its linkage with child marriage.

This paper explores possible roles of environmental vulnerability, in particular, as they manifest in local-level vulnerability to a range of climate-related phenomena to shed further light and understand the potential impact of environmental factors on decisions about marriage. Our main hypothesis is that girls living in communities with waterlogging associated with salinity are at higher risk of child marriage. Data from three child marriage intervention studies on adolescent girls conducted at three different points of time (2016[2], 2017[3], 2018[4]) have been used in this paper to explore this relationship. By linking survey data from adolescent girls with the community-level qualitative evidence from social risk mapping, the paper characterises communities according to three measures of environmental shocks—waterlogging with salinity (usually associated with coastal flooding and sea-level rise)/waterlogging with no salinity, weather events such as cyclones and frequent flooding associated with upstream glacial melt, to help us better understand adolescent lives under environmental vulnerabilities.

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[2] https://www.popcouncil.org/uploads/pdfs/2016PGY_BALIKA_EndlineReport.pdf
[3]https://www.popcouncil.org/uploads/pdfs/2018PGY_BangladeshChildMarriageBaseline.pdf
[4] https://knowledgecommons.popcouncil.org/departments_sbsr-pgy/967/

V. DATA AND METHODS

The data sources include (1) individual-level data from three comparative large adolescent surveys conducted in 2016, 2017, and 2018 in 240 communities/ unions (lowest administrative unit) in eight districts of Bangladesh and (2) environmental vulnerability data at each of these 240 unions recorded from community mapping. Adolescent surveys were administered to adolescent girls 12-19 years of age. Similar survey instruments were used in all three of the surveys. Survey instruments included questions about their socio-economic profile, parents' education, occupation, their own education, marriage-related knowledge, and practices. Environmental vulnerability data were collected in a structured community mapping form consisting of indicators on extreme weather events and environmental vulnerability. The team sent to the field visited each union, observed and took notes, talked with randomly selected community members, and used this information to characterise the environmental vulnerabilities of these study unions. Table I shows environmental vulnerability recorded in each of the unions under eight study districts.

TABLE I

ENVIRONMENTAL VULNERABILITY IN STUDY UNIONS

	Flooding (reported in last 3 years in no. of unions)	Waterlogging (reported in last years in no. of unions)	Cyclone
Model 1: South-western districts: Khulna, Satkhira, Narail (72 unions)	12	43 (with salinity)	6
Model 2: Northern-central districts: Jamalpur, Bogura (96 unions)	44	14 (without salinity)	35
Model 3: North-west-central districts: Chapainawabganj, Kushtia, Sherpur (24 unions)	9	1 (without salinity)	2

Variables

Table II shows the variables included in the analysis and their distribution according to major categories of interest. The outcome measure for the present analysis is married before age 18 (child marriage). The dependent variable is the estimated time to first marriage calculated from data on marital status and age at first marriage in exact years. For the analysis, independent variables considered were indicators of environmental vulnerability collected—flood, waterlogging (with or without salinity in the land), and history of cyclones. While waterlogging with salinity is a relatively common event in the southern districts, waterlogging

recorded in northern and central districts is without salinity, and flooding is a more common phenomenon in the northern districts. Additional explanatory variables included as control variables in the analysis are 'respondents' educational status' and 'parents' educational status.'

TABLE II

COMPARISON OF DEMOGRAPHIC AND COMMUNITY CHARACTERISTICS OF RESPONDENTS BY CHILD MARRIAGE OUTCOME FROM THREE ADOLESCENT SURVEY

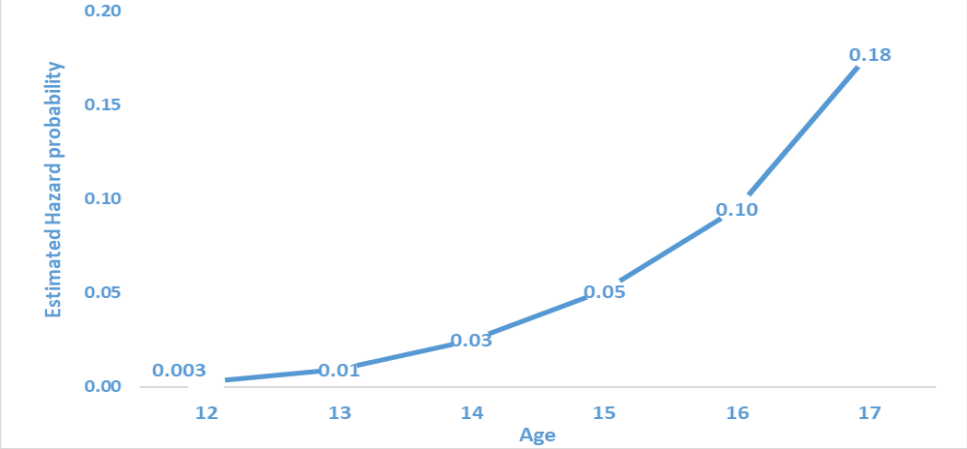
Characteristics	**Model 1-south western districts BALIKA (2016)**		**Model 2-north central districts UNFPA/CM (2017)**		**Model 3-north-west and central districts UNICEF/CM (2018)**	
	Never married/Married after 17	Married before 18	Never married/Married after 17	Married before 18	Never married/Married after 17	Married before 18
Age (mean)	16.8	17.9***	14.4	17.0***	14.5	17.0***
Religion						
Muslim	71.5	81.7***	96.5	95.8	98.4	98.6
Respondents' Educational Status						
Years of schooling (mean)	8.7	7.5***	7.5	7.3***	7.1	6.9
Primary or less	8.0	19.3	21.5	33.1	25.4	24.7
Secondary incomplete	50.8	57.6	60.3	47.9	47.5	49.3
Secondary complete or higher	41.2	23.1	18.2	19.0	27.1	26.0
Mother's Educational Status						
Years of schooling (mean)	4.3	2.8***	3.7	2.2***	4.4	2.4*
Primary or less	64.0	80.1	70.9	85.4	62.2	85.6
Secondary incomplete	27.6	17.3	22.1	11.9	26.9	13.4
Secondary complete or higher	8.4	2.6	7.0	2.7	10.9	1.0
Father's Educational Status						
Years of schooling (mean)	5.1	3.8***	4.2	2.8***	4.3	2.6***
Primary or less	56.1	69.7	67.3	81.0	67.1	83.6
Secondary incomplete	24.8	20.6	18.1	10.3	15.2	11.0
Secondary complete or higher	19.1	9.7	14.6	8.7	17.7	5.4
Environmental Indicators						
History of waterlogging	44.9	46.7	14.5	15.1	4.1	3.8***
History of cyclone	7.6	4.0***	34.7	45.0	8.5	8.6
History of flood	6.1	6.7	46.5	43.2	36.4	44.2
N	**7,612**	**3,997**	**2,395**	**595**	**1,287**	**292**

Notes: *** p<0.001; ** p<0.01; * p<0.05; P-values are reported from an independent sample t-test for continuous variables & chi-square test of independence for categorical variables. All values are percentages unless otherwise indicated.

Statistical methods

The analysis aims to explore the impact of environmental change on the risk of child marriage (under the legal age of 18 years). Since the risk of marriage during adolescence is highly dependent on age (shown in Figure 2), and the distribution of risk cannot be fit using standard parametric options, a non-parametric discrete survival model with Generalised Estimating Equation (GEE) was used. Discrete-time survival analysis (DTSA) was used to relate multiple characteristics to the hazard function of child marriage across the adolescent age range. There are several reasons for using DTSA over traditional multivariate analysis in this scenario. The first reason is that DTSA can control for each respondent's risk of marriage over the age range. The second reason to prefer hazard models is that they incorporate time-varying covariates, or explanatory variables that change with time. Also, censored observations can be handled with discrete-time survival analysis.

FIGURE 2: **Risk of Marriage Expressed as Smoothed Hazard Rate by Age (Three Models Combined)**



In the DTSA model, the dependent variable is the time to first marriage calculated from data on marital status and age at first marriage in exact years. In the survey, all respondents were asked questions about marital status and timing of first marriage in exact years.

In order to fit a discrete-time hazard model, individual observation files were converted so that each individual contributed multiple observations corresponding to her time to event (marriage). For example, a 17-year-old respondent who remains unmarried throughout the study would provide six rows of ‘at risk’ time (12-17). For each respondent, the event indicator is coded 0 for all time periods

except the interval when the event of marriage took place. Thus, the outcome indicator is coded as zero if the respondent is censored and one if the respondent got married in that period. Censoring can occur if a respondent remains unmarried until age 17, which results in right censoring. Six dummy variables were created to capture the hazard for each time period starting from 12 to 17.

After transforming a person-oriented data structure into a person-period data structure, we fit the discrete discrete-time hazards model by employing the Generalied Estimation Equation (GEE) method so that within cluster correlation can be adjusted (Liang & Zege, 1986; Hayes RJ & Moulton, 2009).

In discrete time survival methods, the hazard is a conditional probability (*Pi,j)* that a person i will experience the target event at time period j, conditioned on the fact that the person has not experienced the event in a previous time period. We have used the complementary log–log link function instead of logit to transform the hazard probability onto a new scale with no upper or lower bound. The complementary log-log transformation is preferable to the logit transformation because the Clog-log link function yields a proportional hazards model; in contrast, the logistic function provides a proportional odds model. The hazard can vary across the study period in the clog-log model, but the hazard ratio remains constant. In the clog-log model, coefficients are directly comparable across time intervals of different durations (Singer & Willett, 2003).

Discrete-time model using complementary log-log link function can be written as:

$$Log[-Log(1 - P_{ij})] = D_j\alpha_j + X_i^T\beta$$

where, j=12, …, 17

D_j Denotes dummy variable for each time period and X_i^T represents covariates program exposure, religion, parental education, and respondent education. The set of α's is the complementary log-log transformation of the baseline hazard and $X_i^T\beta$ is the effect of each covariate on the hazard (Singer & Willett, 2003). The antilog of a coefficient from this model provides an estimator of a hazard ratio. GEE models have been estimated using the STATA command XTGEE (StataCorp LP, 2013).

VI. RESULTS

Table II presents the distribution of key variables from the three adolescent surveys. Bivariate analysis shows that three of the environmental variables- history of floods, history of cyclones, and history of waterlogging - are significantly correlated with having a child marriage. Bivariate distributions (Table II) also

show that ‘girl’s educational status,’ ‘parent's educational status,' and ‘religion' are significantly correlated with having an early marriage.

Table III shows adjusted hazard ratios (AHR) estimated from discrete-time analysis estimating the association of child marriage with community and demographic characteristics. We have estimated three models using three different adolescent datasets. Demographic variables, such as ‘adolescents' education' and 'parents’ education,' have been included in these models as 'control' to adjust for compounding factors.

Model-1 also shows that girls residing in waterlogged communities (with salinity) are at 1.16 times higher risk of child marriage (AHR=1.16, 95% CI=1.04-1.29, P-value=0.01), whereas waterlogging with no salinity (model 2 and model 3) does not pose a higher risk of child marriage.[5] All three models show that flooding has no significant impact on child marriage. The effect of 'history of cyclone' remains significant with marriage outcome but works in a different direction (in model-1)- adolescent girls living in a community with 'history of cyclones' are less likely to get married (AHR= 0.61, 95% CI=0.43-0.86, P-value=0.01) compared to adolescents who live in communities without a history of cyclones. In model-2 (Northern- central districts), adolescent girls living in communities with 'history of cyclones' are found to be more likely to get married (AHR=1.45, CI=1.12-1.89, P-value=0.01).

TABLE III

ADJUSTED HAZARD RATIO ESTIMATED FROM DISCRETE TIME SURVIVAL ANALYSIS ASSESSING RELATIONSHIP BETWEEN CHILD MARRIAGE AND SELECTED INDICATORS

Variables	Model 1-south western districts BALIKA (2016) Adjusted Hazard Ratio (95% CI)	Model 2-north central districts UNFPA/CM (2017) Adjusted Hazard Ratio (95% CI)	Model 3-north-west and central districts UNICEF/CM (2018) Adjusted Hazard Ratio (95% CI)
History of waterlogging			
No (ref.)	1.0	1.0	1.0
Yes	1.16 (1.04-1.29)**	1.06 (0.73-1.54)	0.72 (0.52-2.29)*
History of cyclone			
No (ref.)	1.0	1.0	1.0
Yes	0.61 (0.43-0.86)**	1.45 (1.12-1.89)**	0.82 (0.65-1.04)
History of flood			
No (ref.)	1.0	1.0	1.0
Yes	1.01 (0.88-1.16)	0.88 (0.67-1.14)	1.04 (0.74-1.47)

(Contd. Table III)

[5] In model 3 (North-west and central districts), there is only one observation with waterlogging.

Variables	Model 1-south western districts BALIKA (2016) Adjusted Hazard Ratio (95% CI)	Model 2-north central districts UNFPA/CM (2017) Adjusted Hazard Ratio (95% CI)	Model 3-north-west and central districts UNICEF/CM (2018) Adjusted Hazard Ratio (95% CI)
Control Variables			
Religion			
Non-Muslim (ref.)	1.0	1.0	1.0
Muslim	1.20 (1.07-1.34)**	0.98 (0.71-1.36)	1.10 (0.52-2.29)
Respondents' Educational Status			
Primary or less (ref.)	1.0	1.0	1.0
Secondary incomplete	0.78 (0.72-0.84)***	0.34 (0.27-0.42)***	0.64 (0.45-0.89)**
Secondary complete or higher	0.23 (0.21-0.26)***	0.16 (0.12-0.21)***	0.21 (0.15-0.31)***
Mother's Educational Status			
Less than secondary (ref.)	1.0	1.0	1.0
Secondary incomplete	0.81 (0.74-0.89)***	0.74 (0.54-1.02)	0.68 (0.48-0.96)*
Secondary complete or higher	0.55 (0.44-0.68)***	0.71 (0.39-1.29)	0.17 (0.05-0.51)**
Father's Educational Status			
Less than secondary (ref.)	1.0	1.0	1.0
Secondary incomplete	0.95 (0.87-1.05)	0.70 (0.57-0.87)**	0.92 (0.64-1.34)
Secondary complete or higher	0.82 (0.73-0.92)**	0.64 (0.45-0.91)*	0.72 (0.43-1.22)
Age			
12	0.02 (0.01-0.02)***	0.03 (0.02-0.05)***	0.02 (0.01-0.05)***
13	0.05 (0.04-0.06)***	0.10 (0.07-0.15)***	0.05 (0.02-0.11)***
14	0.11 (0.09-0.13)***	0.23 (0.16-0.35)***	0.15 (0.06-0.37)***
15	0.21 (0.18-0.24)***	0.39 (0.26-0.59)***	0.27 (0.12-0.60)***
16	0.36 (0.30-0.41)***	0.52 (0.34-0.79)**	0.52 (0.24-1.10)
17	0.48 (0.41-0.56)***	0.77 (0.48-1.24)	0.35 (0.15-0.85)*
Wald Chi-square	12793.43***	2028.99***	106546.84***
N	**11,609**	**2,990**	**1,579**

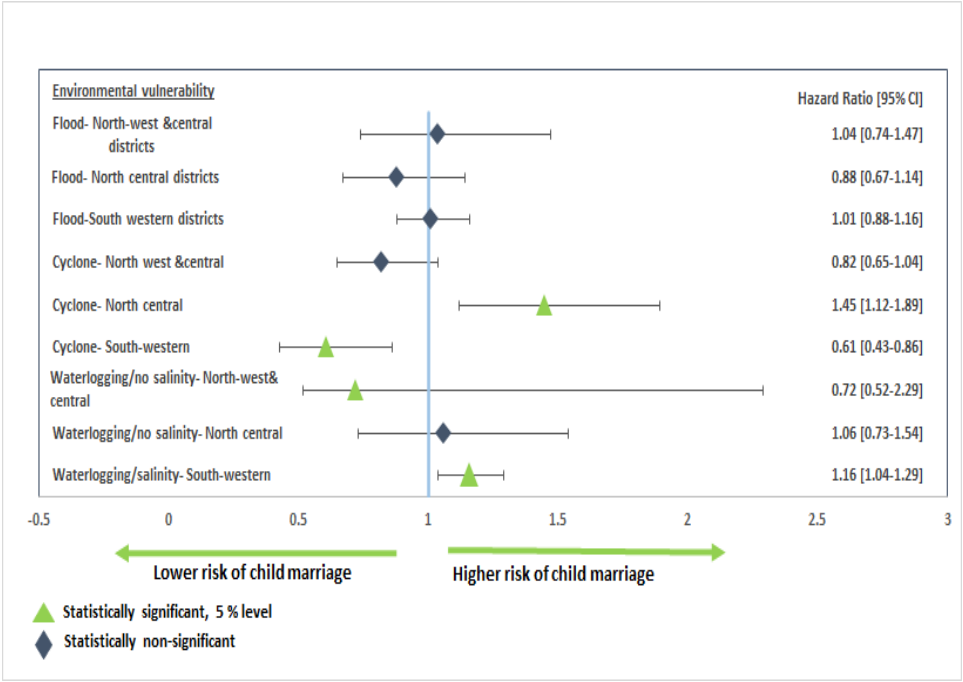
Notes: *** p<0.001; ** p<0.01; * p<0.05, † p<0.10. Standard errors are adjusted at the union level, where randomisation takes place.

VII. DISCUSSION AND CONCLUSION

Findings show that there are important variations in child marriage outcomes with different types of environmental vulnerability. In this paper, we have examined three forms of environmental vulnerability to see whether there is any relationship between environmental vulnerability and child marriage levels in the community. The summarised results presented in Figure 3 suggest that climate shocks vary in their impact on adolescents' lives in varied ways. Our analysis shows that adolescent girls living in waterlogged areas with salinity were significantly more likely to be married as children compared to areas not similarly waterlogged. The community assessment report documented that prolonged waterlogging with increased salinity in south-western districts affected the

community in terms of biodiversity, livelihood, and social disruption such as schooling, housing, and sanitation. There are fewer opportunities for paid work due to reduced cropping, disrupted transport, and reduction in non-farm activities. Communities that suffer from prolonged waterlogging also have converted croplands to shrimp farming in that region. In shrimp farming communities, alongside the environmental impact of waterlogging, there are also changes in landlessness and tenancy arrangements, leading to socio-political conflict in some instances.

FIGURE 3: **Environmental Factors Associated with Child Marriage (Adjusted Hazard Ratio)**



By contrast, we found no significant positive relationship between child marriage and riverine flood. Floods occur every year in Bangladesh during monsoon and usually die down in a month or two with much less impact than prolonged waterlogging with salinity in coastal regions where land fertility and crop production have been changed.

Findings show mixed results for cyclone-affected communities. In model 1 (south-western districts), communities with cyclones are less likely to have a child marriage –another finding of interest but also one to be interpreted with caution. It perhaps indicates a residual effect of out-migration of more vulnerable populations.

Cyclones Sidr and Aila happened several years before the survey in 2016-*Sidr* in 2007 and *Aila* in 2009, and it is also likely that the impact of cyclones is not observed in the places hit directly due to the adaptation strategies and movement of more vulnerable households away from the areas that are worse-affected.

There may also be an explanation associated with the selectivity of who migrates and who is able to stay behind. People who can remain in an area after devastating events such as these cyclones may be more privileged. The fact that child marriage rates are lower in these areas may have two interpretations—first, it is possible that post-disaster humanitarian aid and development programs caused the resources to flow to the community, resulting in these positive effects on the communities. The contrasts may also be due to the selective retention of populations in these areas that are better off. Also, it depends on whether the population is in the direct pathway of cyclones (south-western region) and whether the effect of cyclones is much weaker in the northern part. In the Northern and central districts, we have found child marriage rates are higher in communities with 'history of cyclone' as that part is further from the cyclone pathways and may not have had a harsh impact as it does for the south-western districts and vulnerable may not have moved away.

In all three models, we found no significant positive relationship between child marriage and flood. Floods occur every year in Bangladesh during monsoon and usually die down in a month or two, which have a much lesser impact than prolonged waterlogging with salinity in the coastal south-western region where land fertility and crop production have been changed.

Sudden onset events like cyclones or floods put immediate stress on livelihood as well as the loss of assets of the affected people. Flood-affected people usually return to regular life and yield delayed benefits from sediment deposited by floodwaters, which, in turn, fertilises fields. Increased water logging with saline intrusion in south-western districts has rather a slow and cascading effect, which might not have the unexpectedness of sudden events like cyclones and thus do not

have visibility and required attention, but it may have an enduring and lasting impact if it leads to crop failure and puts chronic and long-term stress on the livelihood of the family along with other social impact concerning women and girls' safety and protection discussed earlier in this paper. The high rates of child marriage in waterlogged communities with salinity in the south-western districts highlight the vulnerabilities of young girls living there.

Our analysis shows that adolescent girls living in waterlogged areas with salinity were significantly more likely to be married as children compared to areas not similarly waterlogged.

We want to note several limitations of the study. While the survey attempted to record the exact date of marriage and used multiple ways of verifying age at marriage, we cannot rule out the issue of recall error leading to some level of misreporting about the age at marriage. However, given that the age group is young, and all of the marriages took place in the relatively recent past, we think such an error is likely to be minimal.

The environmental indicators were based on local conditions gleaned during short visits to the area by the study team to conduct community assessment forms filled in by talking with the community. The unit of analysis is the community, but reports may reflect some level of subjectivity of those informing the community assessment. In addition to subjectivity, the salience of events at the time of data collection, as in the case of waterlogging, may be more likely to be reported than events or ones that have occurred in the distant past, such as a flood. It also varies in terms of assessing the severity of events and reporting of people; for example, cyclones reported in North and Central districts might just be annual storms that community people have reported as cyclones if it is in the recent past, and that brings out the subjectivity. Moreover, as we have been careful to highlight in our discussion of results, these risk factors may overlap, and subjective perceptions or salience may be biased towards reporting some types of vulnerability over others.

Nevertheless, our documentation of the association of child marriage levels in the community with environmental characteristics should be of interest to programs and policies designed to prevent child marriage. It is important to address local community, household, and individual level variation in the practice of child marriage, even as wider societal and cultural factors are at play. The results highlight that child marriage is a part of household strategies in response to crises

and suggest the importance of programs to safeguard against child marriage not only in the communities where immediate and sudden environmental emergencies have occurred but also in the areas where these climate-induced disasters may not seem very conspicuous but which has slow but cascading (such as waterlogging) and long term impact on households in terms of livelihood and social aspects to guard against the irremediable damages of child marriage.

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