# Extreme weather events and fertility differentials and trends in Bangladesh

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## Abstract

Bangladesh is highly vulnerable to extreme weather events. In this study, we examine whether there is an association between the types of flooding and fertility. We hypothesize that fertility may be higher for areas which are the most vulnerable to flood event and at high risk for the impacts of flood event than other areas which are less susceptible to flood event and at low risk for the impacts of flood events. DHS geospatial data are used to link women's fertility data (birth histories, fertility preferences, contraceptive use) and geocoded data on flood prone areas. Multivariate analyses show that marital fertility is consistently high in areas affected by severe flash floods, reflecting both higher ideal family size and lower contraceptive use.

**Keywords:** ***Bangladesh; Extreme weather events; Ideal family size, Types of flooding; Modern contraception; Total marital fertility***

## 1. Introduction and background

Bangladesh is one of the most populated countries on the globe and vulnerable to extreme weather events. The most common of which is flooding (Agrawala et al. 2003). Bangladesh is ranked sixth in the world for extreme weather activity (German Watch 2015). Bangladesh, as a natural disaster prone and highly densely populated country, suffers from extreme weather events, particularly floods. Climate change can cause an increase in the frequency of natural disasters, such as floods (Blanco 2006). When considering weather events as extreme or normal, social, economic and environmental factors also play a significant role (Tompkins 2002).

Studies on the relationship between the impacts of climate change/extreme weather events and population change are receiving much attention from academics and policy makers in recent days. But exploring the relationship between population dynamics and climate change is diverse and complex (Jiang and Hardee 2011). Since different forces such as socio-economic development, technological improvements, demographic changes, geographic locations, and culture influence human vulnerability to climate change/extreme weather events and its nexus with fertility dimensions (Jiang and Hardee 2011). Association between environmental shocks and fertility behavior differs based on the type of country and extreme weather events and uncertainty with the extreme events (e.g. earthquake in Italy and tsunami in Japan) (Lin 2010). Developing countries are vulnerable to extreme weather events in present day climatic variability. For instance, Bangladesh is located at the meeting of three

big rivers: the Ganges, Brahmaputra and Meghna. Magnitude and patterns of precipitation in the three river basins contribute extreme flooding (about 70 percent of Bangladesh) (Paul and Routray 2010; Mirza 2003). The severity, intensity and extension of flooding areas are more likely to increase in the future (Huq 2002; Agrawala et al. 2003; Dutta et al. 2004). The country will also face several feet sea level rise by 2100 and a higher proportion of low lying areas will be permanently underwater (Peter and Zunaid, 2008; Belt 2011).

Populations in Bangladesh are expected to increase to 220 million in the year of 2050, although Bangladesh has a rapid decline in fertility (Belt 2011). In Bangladesh, though fertility has declined but fertility differences exist for divisions. For instance, fertility is above than the country average (TFR=2.3) for Chittagong (TFR=2.5) and Sylhet division (TFR=2.9) and it is higher than other divisions (BDHS 2014). Bangladesh Bureau of Statistics (BBS) reveals that there is divisional and district level variations of fertility in Bangladesh. For instance, Khulna and Barisal division had an average TFR and it was below national average of Bangladesh. According to BBS (2012), Barisal district had TFR above the national level TFR (TFR=2.11) whereas Satkhira district (TFR=1.56) and Barguna district (TFR=1.59) had the lowest level fertility among the all districts in Khulna and Barisal division (Szabo et al. 2016).

## 2. Research gap and the study hypotheses

There have been many studies on the impacts of disasters on mortality and migration but few studies on the relationship between disasters and fertility dynamics (Davis 2017). Studies on the relationships between environmental disasters and fertility were conducted in the context of developed countries and the studies' results did not bring firm conclusions (Davis 2017). Fertility responses to different crisis events (e.g. war and extreme weather events) are also not well described in demographic theory (Hill 2004). Davis (2017) suggested that there is a need to conduct studies in the context of developing countries and those studies may bring important findings and conclusions for the fertility changes in response to different disasters such as floods. Studies should focus on how environmental changes/impacts of disaster events influence individual and household level fertility decisions (An and Liu 2010) and resulting change in national fertility needs to be studied in the context of developing countries like Bangladesh. This study aims to explore the relationship between the impacts of extreme weather events particularly types of flooding and fertility behavior and preferences in Bangladesh. Since the country is highly vulnerable to extreme weather events and climate change and majority people frequently face extreme flood events and live in rural areas. This study only considers floods as one of the extreme events and examines whether there is an association between the types of flooding and fertility or not. This study also aims to calculate total marital fertility for different vulnerable locations to extreme floods in terms of the intensity and severity of the flood events for different locations in the country. This study hypothesizes that fertility may be higher for areas which are the most vulnerable to flood event and at high risk for the impacts of flood event than other areas which are less susceptible to flood event and at low risk for the impacts of flood event (Cain 1978). Considering flood as an extreme weather event depends on the context of a country and its socio-economic dimensions (Zweiers et al. 2012). This study also hypothesizes that fertility in climate change vulnerable areas may vary in terms of types of flooding. This study testifies the aforementioned hypotheses by using DHS geospatial data and census data. This study can provide interesting findings and clues for further research since Bangladesh is in sixth position for occurrence of extreme weather events (Kreft et al. 2014).

**3. Literature review and theoretical framework**

Davis (2017) argued that disaster can hamper reproductive activity due to its impacts on people's livelihood that can influence to reconsider reproductive decision by delaying childbearing in the short-term. It can lower fertility in the short-term but not a long term decline in fertility preference or actual number of children. On other hand people expect support, love and closeness during crisis period (Cohan and Cole 2002) and couples may increase coital frequency during disaster periods and it may impact to increase fertility (Davis 2017) due to unavailability of contraception (Evans et al. 2010). In a study in USA on the storm severity and its effects on fertility, Evans et al. (2010) found a positive relationship between fertility and low-severity storm warning and negative relationship with high-severity storm warning. In addition, several studies demonstrate those natural disasters such as earthquakes and tsunamis (e.g. Carta et al. 2012; Hamilton et al. 2009) and severe storm events (e.g. Tong et al. 2011) influence couples' fertility timing and fertility preference. Several post-hurricane fertility studies in the United States reveal that fertility both increases and decreases after strong storm events (Davis 2017; Cohan and Cole 2002; Evans et al. 2010). A case study of the Italian village of L'Aquila found a 27% jump in births 9 to 15 months after the earthquake in 2009 (Carta et al. 2012). Another earthquake study on the 2003 earthquake in Bam in south-central Iran found a decrease in the local fertility rate in

2004, followed by a rise in the fertility rate in 2006–2007 (Hosseini Chavoshi and Abbasi-Shavazi 2015).

People's beliefs of poor environmental conditions and effects of overpopulation on the environment may lower fertility preference (Ghimire and Mohai 2005). Conversely, people's beliefs about poor environmental conditions (crop production, ground water table and water quality decline) may increase fertility preference (Foster and Rosenzweig 2003). Since rural poor people depend on natural resources (Salam and Noguchi 1998) and their subsistence rely on women and children for collecting resources and consequently it increases the value of children's labor and a higher desire for more children as a cyclical relationship (Axinn and Barber 2005). Due to the scarcity of natural resources in developing countries, high fertility preference and demand for boys may be part of a vicious circle (O'Neill et al. 2001). The poor people who live closer to the river face/coastal area are at higher risks of climate change and extreme weather events (Brouwer et al. 2007; Jiang and Hardee 2011). Individual's beliefs about the immediate impacts of environmental degradation/climate change on fertility preference may be an important determinants of fertility dynamics for developing countries (Ghimire and Mohai 2005). Socio-demographic understanding of vulnerability (Marandola Jr. and Hogan 2006) and geospatial dimensions of climate change and its relationship with demographic change can be an effective preparation for the impacts of climate change/ extreme weather events (Curtis and Schneider 2011). Climate change is expected to cause an increase of natural hazards and poor rural households are likely to experience the burden of the effects of climate change (Olsson et al. 2014; Paul and Routray 2010).

When mortality shocks are location-specific, the local community is likely to be a salient group in which a broader replacement and rebuilding motive may operate. Bangladesh is highly populated and natural disaster prone country and socio-economic conditions of Bangladesh people are highly affected by extreme weather events. Impacts of extreme weather events may contribute to the demand for additional children when disaster shocks are location-specific and local community is a leading group for an intention to replace and rebuild family (Nobles et al. 2015). Parents may consider losing their any children and prefer to have more children as future security against the possible loss of children due to extreme events as replacement effects (Lutz et al. 2006; Finlay 2009). Fertility response to natural disasters has a positive response as one-for-one replacement against lost child (Finlay 2009). High risk of infant mortality is often associated with high fertility and parents usually aim to have a certain number of surviving children (Lutz et al. 2006; Yeatman et al. 2013; Sandberg 2006). Furthermore fertility, for any country, may be associated with different factors such as socio-economic conditions; culture and climate change (Collins et al., 2012). This study aims to compare fertility behavior between areas highly affected by floods and areas less affected areas by controlling socioeconomic determinants of fertility for Bangladesh.

## 4. Methodology

The latitude and longitude of Bangladesh are: 20°34’ to 26°38’ north and 88°01’ to 92°41’ east. Bangladesh, a humid low-lying alluvial region, is one of the largest deltas comprising delta of the Ganges-Brahmaputra-Meghna rivers. The geography of Bangladesh-the Bay of Bengal to the south and the Himalayas to the north-makes the country vulnerable to natural disasters, climate change and sea level rise (Ali, 1999). Bangladesh is highly vulnerable to climate change due to its geographical location and geomorphological conditions (Cash, 2013). Due to the exposure to extreme weather events, prolonged extreme events (Khan 2008) and a high population density (more than 1,209 persons per square kilometer), most of the country’s populations are vulnerable to climate change and many people are more likely to be exposed to climate change risks (Belal et al. 2010). This study includes Bangladesh as a case for vulnerable to extreme weather events and a dramatic change in fertility decline in the last two decades. However fertility is still in higher in rural areas than urban area and it is hypothesized that fertility in extreme weather prone areas where people face severe flooding is more likely to be higher than low risk areas to flooding.

Davis (2017) collected geographic and demographic data in Nicaragua immediate before and after extreme event such as Hurricane Mitch to examine its short and medium effects on fertility by using panel data and combining with municipality level mean precipitation data. This study also collects geospatial and fertility data from recently published DHS data archives. We used five demographic and health surveys of 1999, 2004, 2007, 2011 and 2014 for Bangladesh. A GIS map from Bangladesh Agricultural Research Council (BRAC) is used to identify flood prone areas, (see **Figure 1**). It shows three types of flooding riverine flooding, flash flooding and tidal flooding. BRAC (2000) classified each type of flooding into severe flooding, moderate flooding and low flooding. The clusters from DHS surveys are merged with the flood map in order to attach flood risks to each women (**Figure 2**), based on the GPS coordinates of here cluster.

**Figure 1: Types of flooding, Bangladesh**

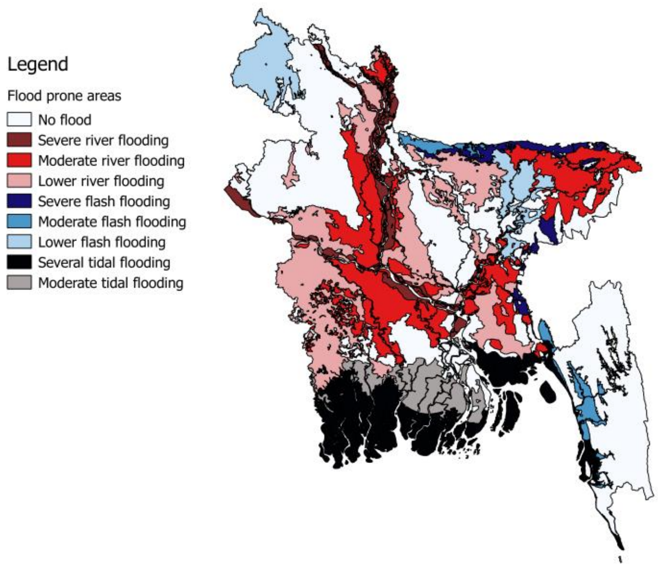
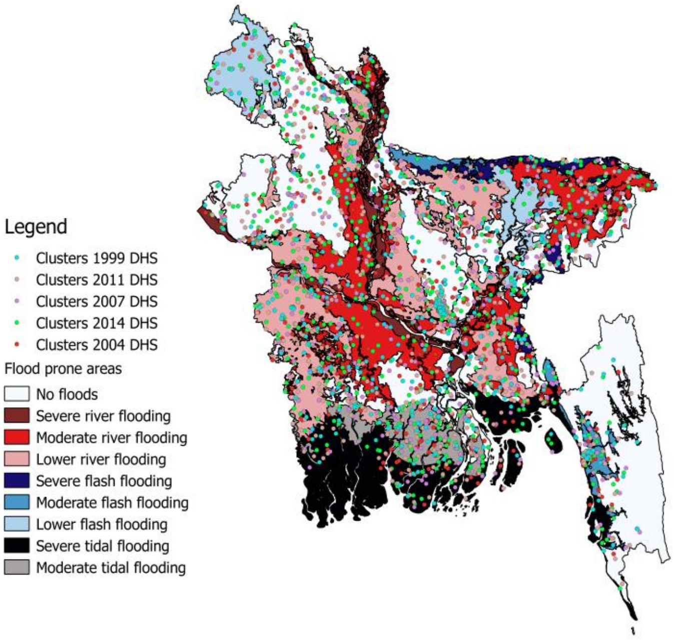


**Figure 2: DHS clusters and types of flooding, Bangladesh**



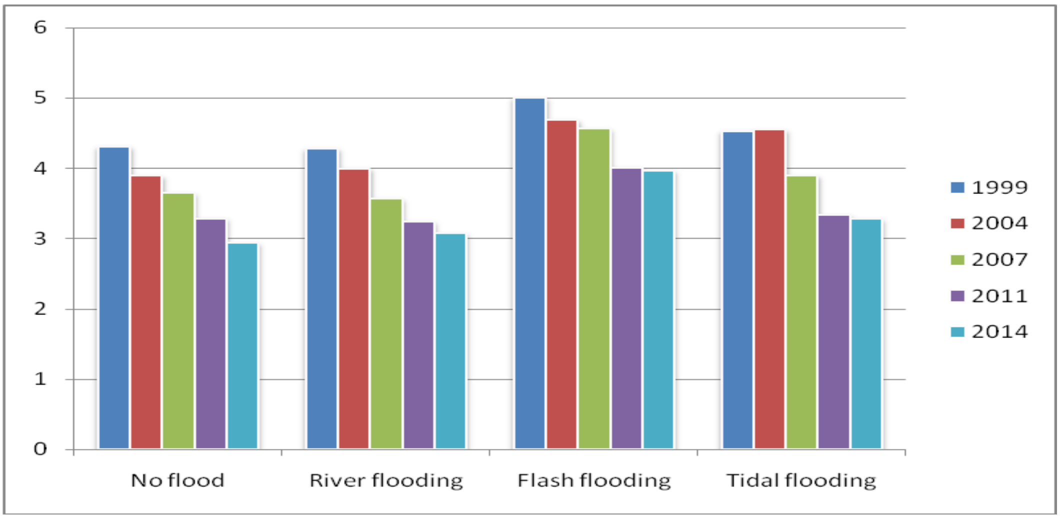

The study considers total marital fertility, ideal family size and modern contraception use as dependent variables (Islam et al., 2000) to look the influence of different flood types, controlling for age, education, wealth status and place of residence (urban-rural) as covariates. The study use multivariate analysis to look relationships between variables mentioned above not only by including socio-economic variables and also by controlling socio-economic variables to see whether variations in marital fertility are a response to climatic risks. The study calculated total marital fertility rates and rate ratios computed with tfr2 Stata command (Schoumaker, 2013). Linear and logistic regressions are used for ideal family size and contraceptive use.

## 5. Results

### 5.1 Types of flooding and total marital fertility in Bangladesh

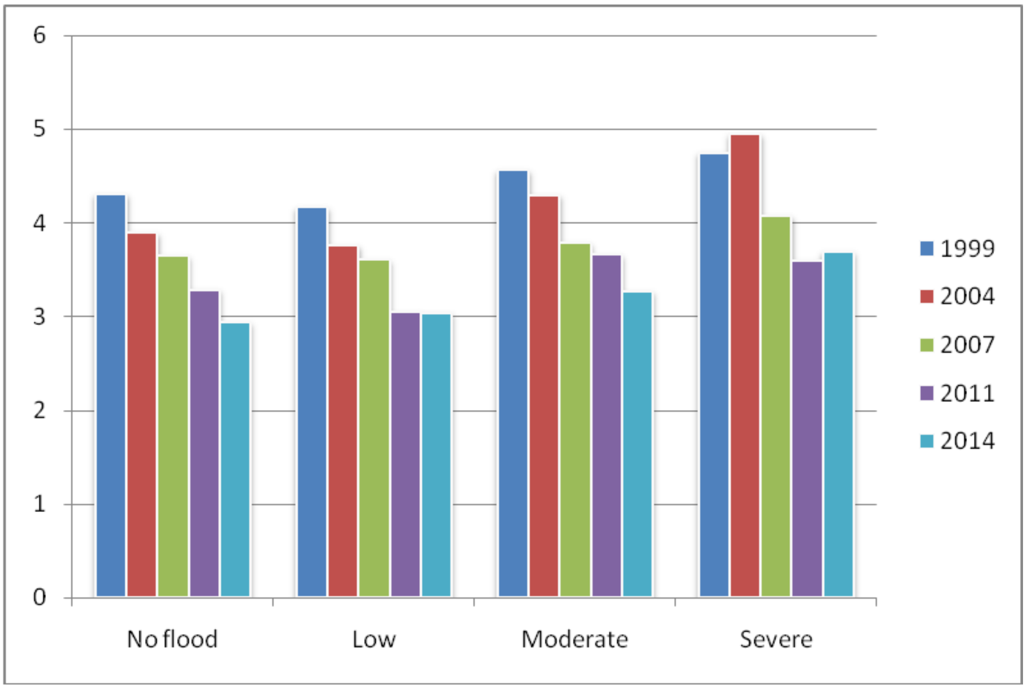
Findings show that total marital fertility (TMFR) is higher for all women in flash flooding affected areas than no flooding areas, river and tidal flooding affected areas in the all DHS survey year. Fertility is relatively closer for no flood prone areas and river flooding affected areas and it is about 4.3 per women in 1999 and about 3.0 per women in 2014. For flash flooding affected areas TMFR is about 5.0 per women in 1999 and about 4.0 per women in 2014. The TMFR decline is lower in flash flooding affected areas (about 1.0 per women) than no flooding areas (1.4 per women), river flooding (1.2 per women) and tidal flooding areas (1.2 per women) in terms of 2014 DHS survey and 1999 DHS survey. Fertility decline is relatively higher in no flood prone areas (**see Figure 3**).

**Figure 3: Types of flooding and total marital fertility**



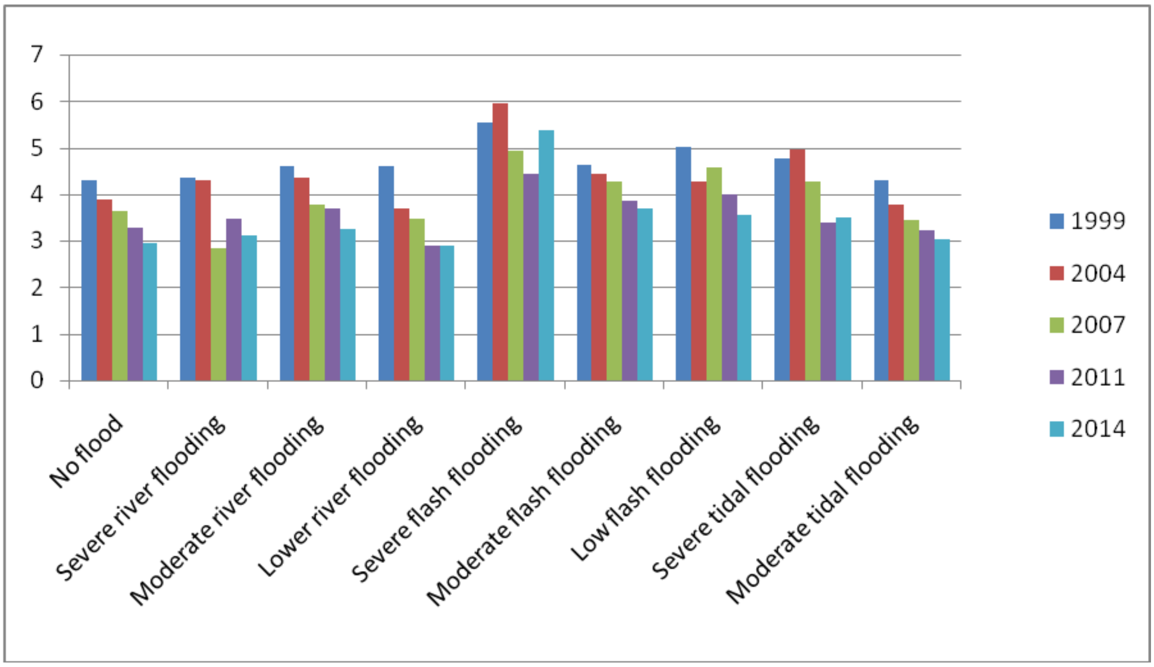

Findings also show that based on the types of severity TMFR is higher in severe flooding affected areas than no flooding areas, moderate flood areas and low flood affected areas for 1999 (4.7 per women), 2004 (4.9 per women), 2007 (4.0 per women) and 2014 (3.7 per women). In 2011, TMFR is slightly lower in severe flooding affected areas (3.6 per women) than moderately affected areas (3.7 per women). Interestingly, by comparing fertility decline between 1999 and 2014, TMFR decline is higher for no flood affected areas (1.4 per women) than severe flood affected areas (1.0 per women). This study also estimate TMFR for river flood areas, flash flood areas and tidal flood areas in terms of severity of flooding and categorized as severe, moderate and low (**see Figure 4**).

**Figure 4: Types of severity and total marital fertility**




Results also show that TMFR is always higher in severe flash flooding affected areas than other all categories. TMFR for the areas is 5.6 in 1999 and 5.4 in 2014. TMFR is lower for no flood affected areas and low river flooding affected areas (about 2.9 per women) and moderate tidal flood affected areas (about 3.0 per women) in 2014 than other categories. TMFR decline is higher in low river flooding affected areas (1.7 per women) and lower in severe flash flooding affected areas (0.2 per women) by comparing TMFR for 1999 and 2014. Fertility decline in low-river flooding affected areas is even very higher than in no flood affected areas (1.4 per women) (**see Figure 5**).

**Figure 5: Types of severity and total marital fertility, Bangladesh**




### 5.2 Multivariate analysis between types of flooding and TMFR by including socio-economic determinants

This study conducted multivariate analysis between types of flooding and TMFR and looks the influences of socioeconomic determinants. This study found a higher TMFR in flash flooding affected areas than the reference group no flooding affected areas. 12 percent of higher TMFR was found in 1999 and 31 percent in 2014 than no flooding areas in flash flooding affected areas. Based on types of severity, 24 percent higher TMFR was found in 2004 and 25 percent higher in 2014 in severe flooding affected areas at p value<0.01. This study also found a higher percentage of TMFR in severe flash flooding affected areas. It was 30 percent higher in 1999, 40 percent higher in 2004, 33 percent in 2007 and 2011, and 78 percent higher in 2014 than reference group no flooding affected areas at p value<0.01 (**see Table 1**).

**Table 1: Multivariate analysis of marital fertility rates for types of flooding, not controlling for socio-economic factors (for all women). Rate ratios.**

| Survey year | 1999 | 2004 | 2007 | 2011 | 2014 |
|---|---|---|---|---|---|
| ***Flood type*** | | | | | |
| River flooding | 0.975 | 1.00 | 0.97 | .95* | 1.05 |
| **Flash flooding** | **1.12*** ** | **1.13*** ** | **1.25*** ** | **1.16*** ** | **1.31*** ** |
| Tidal flooding | 1.01 | 1.13*** | 1.05 | 0.96 | 1.11** |
| ***Flood intensity*** | | | | | |
| Low flooding | 0.97 | 0.97 | 0.99 | .92*** | 1.04 |
| Moderate flooding | 1.06** | 1.11*** | 1.04 | 1.12*** | 1.13*** |
| Severe flooding | **1.10** ** | **1.24*** ** | **1.11** ** | **1.07** | **1.25*** ** |
| ***Flood type and intensity*** | | | | | |
| Severe river flooding | 1.02 | 1.11 | .78** | 1.05 | 1.08 |
| Moderate river flooding | 1.07** | 1.12*** | 1.04 | 1.13*** | 1.12*** |
| Lower river flooding | .91** | 0.95 | 0.95 | .88*** | 0.99 |
| **Severe flash flooding** | **1.30*** ** | **1.40*** ** | **1.33*** ** | **1.33*** ** | **1.78*** ** |
| Moderate flash flooding | 1.10 | 1.14* | 1.20** | 1.19*** | 1.26*** |
| Low flash flooding | 1.18*** | 1.07 | 1.25*** | 1.19*** | 1.23*** |
| Severe tidal flooding | 1.10 | 1.25*** | 1.15** | 1.01 | 1.20*** |
| Moderate tidal flooding | 1.00 | 0.99 | 0.94 | 0.99 | 1.06 |
| For each survey, three models are fitted, with three different specifications for the flood variable.<br>Only age is controlled in the models.<br>Significance: * : p<0.10; **: p<0.05; ***: p<0.01. | | | | | |

This study also considered wealth status poor and non poor in the multivariate analysis and 26 percent higher TMFR in 2007 (p<0.01) and 42 percent higher in 2014 (p<0.01) in flash flooding affected areas. Based on the types of severity, TMFR was found 21 percent higher in 2004 and 25 percent higher in 2014 in severely affected flash flooding affected areas in poor people. In severe flash flooding areas, TMFR was found 36 percent higher in 2004, 58 percent higher in 20017 and 100 percent higher in 2014 in poor people compared with no flooding affected areas at p<0.01 (**Table 2**). For non-poor people, TMFR was also higher in 2007 (24 percent) and 2014 (21 percent) in flash flood areas. A higher percentage of TMFR was also found in 2014 (19 percent) in severely flood affected areas than no flooding areas at p<0.01 and 40 percent higher in 2014 in severe flash flooding affected areas at p<0.01 (see **Table 3**) than no flooding areas.

**Table 2: Multivariate analysis of marital fertility for types of flooding and poor people, controlling for socio-economic factors (lowest 2 Quintiles). Rate ratios.**

| **Survey year** | **1999** | **2004** | **2007** | **2011** | **2014** |
|---|---|---|---|---|---|
| ***Flood type*** | | | | | |
| River flooding | 0.95 | 1.03 | 0.98 | .91** | 1.06 |
| **Flash flooding** | **1.10** | **1.13*** | **1.26***** | **1.12*** | **1.42***** |
| Tidal flooding | 1.01 | 1.22*** | 1.05 | 0.95 | 1.17** |
| ***Flood intensity*** | | | | | |
| Low flooding | 0.94 | 0.98 | 1.00 | .84*** | 1.09* |
| Moderate flooding | 1.02 | 1.10* | 1.03 | 1.05 | 1.14*** |
| Severe flooding | 1.02 | **1.21***** | 1.10 | 0.98 | **1.26***** |
| ***Flood type and intensity*** | | | | | |
| Severe river flooding | 0.90 | 1.08 | 0.82 | 0.98 | 0.93 |
| Moderate river flooding | 1.04 | 1.08 | 1.03 | 1.04 | 1.14** |
| Lower river flooding | .88** | 0.98 | 0.96 | .79*** | 1.03 |
| **Severe flash flooding** | **1.24*** | **1.37***** | **1.58***** | 1.17 | **2.08***** |
| Moderate flash flooding | 1.00 | 1.19 | 0.85 | 1.24* | 1.41*** |
| Low flash flooding | 1.10 | 0.99 | 1.21** | 1.06 | 1.22*** |
| Severe tidal flooding | 1.05 | 1.25*** | 1.06 | 0.93 | 1.25*** |
| Moderate tidal flooding | 0.94 | 1.16 | 1.04 | 0.98 | 1.06 |

For each survey, three models are fitted, with three different specifications for the flood variable.
Age, education, wealth index and place of residence (urban-rural) are controlled in all the models.
Significance: * : p<0.10; **: p<0.05; ***: p<0.01.

**Table 3: Multivariate analysis for types of flooding and TMFR for non-poor people by including socio-economic factors (Quintiles 3 to 5). Rate ratios.**

| Survey year | 1999 | 2004 | 2007 | 2011 | 2014 |
|---|---|---|---|---|---|
| ***Flood type*** | | | | | |
| River flooding | 0.98 | 0.99 | 0.96 | 0.98 | 1.04 |
| **Flash flooding** | **1.14**** | **1.14*** | **1.25***** | **1.19***** | **1.22***** |
| Tidal flooding | 1.01 | 1.07 | 1.04 | 0.95 | 1.04 |
| ***Flood intensity*** | | | | | |
| Low flooding | 0.93 | 0.93* | 0.96 | .94* | 0.99 |
| Moderate flooding | 1.06 | 1.08* | 1.04 | 1.10** | 1.11** |
| Severe flooding | 1.08 | 1.15** | 1.10 | 1.02 | **1.19***** |
| ***Flood type and intensity*** | | | | | |
| Severe river flooding | 1.05 | 0.97 | .71** | 0.83 | 1.20** |
| Moderate river flooding | 1.04 | 1.11** | 1.0 | 1.11** | 1.10** |
| Lower river flooding | .91** | .92** | 0.94 | 0.91** | 0.96 |
| **Severe flash flooding** | **1.29*** | **1.27**** | **1.20** | **1.35**** | **1.41***** |
| Moderate flash flooding | 1.19* | 1.13 | 1.30*** | 1.19** | 1.18** |
| Low flash flooding | 1.05 | 1.05 | 1.22* | 1.15* | 1.15* |
| Severe tidal flooding | 1.02 | 1.18** | 1.20** | 0.98 | 1.06 |
| Moderate tidal flooding | 1.01 | 0.90 | .82* | 0.92 | 1.02 |

For each survey, three models are fitted, with three different specifications for the flood variable.
Age, education, wealth index and place of residence (urban-rural) are controlled in all the models.
Significance: * : $p<0.10$; **: $p<0.05$; ***: $p<0.01$.

### 5.3 Multivariate analysis for types of flooding by controlling socio-economic factors (for all women)

This study also controlled the influence of socio-economic determinants and conducted multivariate analysis and found a higher percentage of TMFR in 2007 (26 percent) and in 2014 (42 percent) in flash flooding affected areas than no flooding areas. Results also shows a higher percent of TMFR in severe flooding areas in 2004 (21 percent) and 25 percent in 2014. TMFR was higher in all DHS year 2004 (32 percent), 2007 (34 percent), 2011 (26 percent) and 2014 (74 percent) in sever flash flooding affected areas than no flooding areas at p<0.01).

That indicates that fertility is higher in severe flash flood areas than other areas, even controlling the socio-economic determinants (see **Table 4**).

**Table 4: Multivariate analysis of marital fertility for types of flooding, controlling for socio-economic factors (for all women). Rate ratios.**

| **Survey year** | **1999** | **2004** | **2007** | **2011** | **2014** |
|---|---|---|---|---|---|
| River flooding | 0.95 | 1.03 | 0.98 | .91** | 1.06 |
| **Flash flooding** | **1.10** | **1.13*** | **1.26***** | **1.12*** | **1.42***** |
| Tidal flooding | 1.01 | 1.22*** | 1.05 | 0.95 | 1.17** |
| Low flooding | 0.94 | 0.98 | 1.00 | .84*** | 1.09* |
| Moderate flooding | 1.02 | 1.10* | 1.03 | 1.05 | 1.14*** |
| **Severe flooding** | **1.02** | **1.21***** | **1.10** | **0.98** | **1.26***** |
| Severe river flooding | 0.96 | 1.04 | .77** | 0.95 | 1.04 |
| Moderate river flooding | 1.04 | 1.09** | 1.03 | 1.08** | 1.11*** |
| Lower river flooding | .90*** | .95* | 0.95 | .86*** | 0.98 |
| **Severe flash flooding** | **1.26**** | **1.32***** | **1.34***** | **1.26***** | **1.74***** |
| Moderate flash flooding | 1.11 | 1.15* | 1.26*** | 1.20*** | 1.24*** |
| Low flash flooding | 1.09 | 1.00 | 1.21*** | 1.11* | 1.18*** |
| Severe tidal flooding | 1.04 | 1.21*** | 1.14** | 0.96 | 1.17*** |
| Moderate tidal flooding | 0.98 | 0.99 | 0.93 | 0.95 | 1.03 |

For each survey, three models are fitted, with three different specifications for the flood variable.
Age, education, wealth index and place of residence (urban-rural) are controlled in all the models.
Significance: * : p<0.10; **: p<0.05; ***: p<0.01.

## 5.4 Multivariate analysis between types of flooding and ideal family size (including socio-economic determinants)

This study also looks at the influence of flooding on ideal family size to check whether total marital fertility is related with ideal family size in terms of wealth status poor and non-poor by including the influence of socio-economic determinants. This study found 16 percent higher in 2004 and 24 percent higher ideal family size in 2014 in severe flash flooding affected areas (p<0.01) for poor people. For non poor, it was 11 percent higher in 2004 and 2007 in severe flash flooding areas than no flooding areas (see **Table 5**). The results indicates that fertility preference is not strongly influenced based on the types of flooding, types of severity and, in terms of wealth status poor and non-poor.

**Table 5: Types of flooding and ideal family size for poor and no-poor people. Rate ratios.**

| For poor people (lowest 2 Quintiles) | | | | | |
|---|---|---|---|---|---|
| **Survey year** | **1999** | **2004** | **2007** | **2011** | **2014** |
| Severe river flooding | 1.00 | 1.00 | 1.08 | 1.09*** | 0.96 |
| Moderate river flooding | 1.01 | 0.99 | 1.03 | 1.00 | 1.03** |
| Lower river flooding | 0.92*** | 1.01 | 0.97** | 0.94*** | 0.98 |
| **Severe flash flooding** | **1.12**** | **1.17***** | **1.08**** | 1.03 | **1.25***** |
| Moderate flash flooding | 1.05 | 1.10*** | 1.01 | 1.06 | 1.06 |
| Low flash flooding | 1.04 | 1.00 | 1.03 | 1.05** | 1.07*** |
| Severe tidal flooding | 1.07** | 1.10*** | 1.13*** | 1.02 | 1.06*** |
| Moderate tidal flooding | 0.97 | 1.02 | 1.01 | 0.96*** | 1.02 |
| **For Non-poor people (Quintiles 3 to 5)** | | | | | |
| **Survey year** | **1999** | **2004** | **2007** | **2011** | **2014** |
| Severe river flooding | 0.97 | 0.99 | 1.04 | 1.05* | 0.95* |
| Moderate river flooding | 1.01 | 1.01 | 1.04*** | 1.04*** | 1.05*** |
| Lower river flooding | 0.95*** | 0.98 | 0.99** | 0.98** | 0.99 |
| **Severe flash flooding** | 1.06* | **1.11***** | **1.11***** | **1.05*** | **1.10***** |
| Moderate flash flooding | 1.08*** | 1.09*** | 1.10*** | 1.10*** | 1.05*** |
| Low flash flooding | 1.04 | 1.01 | 1.01 | 1.06*** | 1.08** |
| Severe tidal flooding | 1.00 | 1.07*** | 1.10*** | 0.99 | 0.99 |
| Moderate tidal flooding | 0.98 | 0.98 | 0.98 | 0.98 | 0.96*** |
| Age, education, wealth index and place of residence (urban-rural) are controlled in all the models.<br>Significance: * : p<0.10; **: p<0.05; ***: p<0.01. | | | | | |

### 5.5 Multivariate analysis between types of flooding and modern contraception use (including socioeconomic determinants)

This study also looks at the relationship between modern contraception and types of flooding by including socio-economic determinants. Results show a lower percentage of the use of modern contraception in severely flash flood affected areas in all DHS survey year than no flooding areas by including all women. It was about 44 percent lower in the all year 1999, 2004, 2007, 2011 and 2014. For poor women, the percentage of using modern contraception was found very low, only 25 percent in 1999 and 2004. 40 percent and 45 percent of using modern contraception was found in 2007 and 2011. It was also dropped to 36 percent in 2014 in severely flash affected areas than no flooding affected areas for poor people. For non poor people, use of modern contraception was higher in all DHS survey year than poor people. It was 55 percent in 2011 and 59 percent in 2014 (see **Table 6**).

**Table 6: Types of flooding and using modern contraception for all women, poor and non-poor. Odds ratios.**

| For all women | | | | | |
|---|---|---|---|---|---|
| **Survey year** | **1999** | **2004** | **2007** | **2011** | **2014** |
| Severe river flooding | 1.01 | 1.04 | 0.56*** | 0.94 | 0.82 |
| Moderate river flooding | 0.73*** | 0.83*** | 0.71*** | 0.71*** | 0.80*** |
| Lower river flooding | 1.11* | 1.09 | 0.94 | 0.97 | 0.96 |
| **Severe flash flooding** | **0.45*****| **0.43***** | **0.46***** | **0.51***** | **0.47***** |
| Moderate flash flooding | 0.68*** | 0.60*** | 0.75** | 0.73*** | 0.68*** |
| Low flash flooding | 0.59*** | 1.22 | 1.05 | 0.93 | 0.79** |
| Severe tidal flooding | 0.96 | 0.75*** | 0.68*** | 0.92 | 0.86* |
| Moderate tidal flooding | 0.81** | 0.81** | 1.00 | 0.89 | 0.87* |
| **For poor people** | | | | | |
| **Survey year** | **1999** | **2004** | **2007** | **2011** | **2014** |
| Severe river flooding | 1.11 | 0.98 | 0.70 | 0.82 | 0.73 |
| Moderate river flooding | 0.62*** | 0.80** | 0.73*** | 0.69*** | 0.82** |
| Lower river flooding | 1.03 | 1.15 | 1.02 | 0.98 | 0.98 |
| **Severe flash flooding** | **0.25***** | **0.25***** | **0.41***** | **0.46***** | **0.37***** |
| Moderate flash flooding | 0.61** | 0.44*** | 0.73 | 0.73 | 0.93 |
| Low flash flooding | 0.62*** | 1.31* | 1.07 | 1.02 | 0.75** |
| Severe tidal flooding | 0.89 | 0.69*** | 0.68*** | 0.86 | 0.95 |
| Moderate tidal flooding | 0.95 | 0.81 | 1.00 | 0.89 | 0.93 |
| **For non-poor people** | | | | | |
| **Survey year** | **1999** | **2004** | **2007** | **2011** | **2014** |
| Severe river flooding | 0.90 | 1.14 | 0.47*** | 1.18 | 0.93 |
| Moderate river flooding | 0.81** | 0.86* | 0.70*** | 0.72*** | 0.78584*** |
| Lower river flooding | 1.17** | 1.07 | 0.90 | 0.97 | 0.94 |
| **Severe flash flooding** | 0.63** | 0.67* | 0.48*** | 0.55*** | 0.60*** |
| Moderate flash flooding | 0.73** | 0.71** | 0.74* | 0.73*** | 0.61*** |
| Low flash flooding | 0.53*** | 1.01 | 1.04 | 0.84 | 0.86 |
| Severe tidal flooding | 1.02 | 0.80* | 0.69*** | 0.99 | 0.07** |
| Moderate tidal flooding | 0.74** | 0.73** | 0.91 | 0.90 | 0.82** |
| Age, education, wealth index and place of residence (urban-rural) are controlled in all the models.<br>Significance: * : p<0.10; **: p<0.05; ***: p<0.01. | | | | | |

## 6. Discussion and Conclusions

The study included multivariate models comparing fertility in river flooding areas, tidal flooding areas and flash flooding areas. This study also considered severe, moderate and low flooding affected areas to compare fertility, ideal family size and use of modern contraception. This study included multivariate models all types of flooding in terms of severity. The study included socioeconomic determinants of fertility (e.g. education, place of residence and wealth status) to calculate total marital fertility. Different social, economic, cultural and environmental factors affect fertility (Collins et al., 2012; Bongaarts and Potter 1983). Education, preferred ideal number of children affects higher or lower level of fertility (Caplescu 2014; Abbawa et al. 2015; Adhikari 2010; Debral and Malik 2005). The study finds a higher level of fertility in flash flood affected areas than no flooding areas for all women. This study also found a higher level of fertility in severely affected flooding areas than moderate and low flooding affected areas. This study also found a higher level of fertility in severe flash flooding affected areas. Fertility was found higher not only for severely flood affected areas but also for people living in severely flood affected areas for poor and non poor women. Finding indicates that types of flooding can accelerate fertility decision-making process (Lindell and Perry 2004).

The study also conducted multivariate analysis and found a low percentage of use of modern contraception in flash flooding areas, severely affected areas and severely affected flash flooding areas at $p<0.01$ and the use of modern contraception was low among poor women than non poor women. However, results do not show a slight influence of types of flooding on ideal family size in terms of socio-economic determinants. Results show that fertility is consistently higher in severely affected flood-prone areas in all DHS year, even after controlling socioeconomic covariates of fertility. Lin (2010) considered earthquakes (Italy) and tsunamis (Japan) as natural disasters and shows differences in fertility in terms of the type of disaster. The study also finds fertility differentials in terms of severity and effects of flooding, socio-economic status. Therefore, differentials between flood-prone areas and no flooding affected areas are much stronger among poor women in the all DHS survey considered in the study. People of low socio-economic conditions are at high climatic risk (Paul and Routray 2010; Jiang and Hardee 2011). Climate change is expected to cause an increase of natural hazards (Blanco 2006). Poor people are dependent on natural resources and are more likely to experience the burden of climate change (Agrawal and Perrin 2008; Olsson et al. 2014; Paul and Routray 2010).

Results of the study also indicate that higher fertility in severely flash flood prone areas among poor women may be a response to greater climatic risks and unmet need for modern contraception. Haq (2013) in a study on a flood affected area in Bangladesh also argued that fertility among rural poor people may be higher due to respond to extreme weather events such as having more sons to repair damages and earn more money to repay loan received during crisis. Finlay (2009) mentions that fertility is a response to natural disasters (de Sherbinin et al. 2008; Ellis 2000).

In conclusion, we can say that Bangladesh fertility is declining in general. But in terms of extreme weather events such as types of flooding and types of severity, fertility can vary and even be higher in certain types of flood affected areas. There is still high fertility in flash flooding areas, severely flooding affected areas and severe flash flooding affected areas area of Bangladesh. However the study did not find a significant presence of ideal family size in terms of flooding types. But the study found low use of modern contraception even below 50 percent among poor people living in severely flash flooding affected areas. That indicates of low access and availability of modern contraception and importantly an unmet need for modern contraception among poor women. Doing studies on fertility differentials in terms of the types of extreme weather events such flooding in the study may contribute to decline fertility in all regions of flooding affected areas particularly in severe flash flooding affected areas.

***Acknowledgements***

Fonds National de la Recherche Scientifique (FNRS)

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