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IMPACT OF CLIMATE CHANGE ON FLOODS OF BANGLADESH AND INTRODUCING FLOOD INTENSITY INDEX TO CHARACTERIZE THE FLOODING SCENARIO

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1. Introduction

In this paper, firstly the temporal changes of pattern of different disasters in Bangladesh are discussed based on their occurrence rate, number of people killed, and exposure to human and economic loss. The paper is mainly concentrated on temporal variation of floods in Bangladesh. The decadal change in return period and probability of low, moderate and high flood events are presented. The term 'Flood Intensity Index (FII)' is introduced to characterize the flood, which is considered as a function of inundation depth and duration. A heuristic approach is described to explain how the climate change will magnify the flood intensity index of this country.

2. Data

Three types of data were used in this study: i) the rainfall data, ii) the river discharge and flood hydrograph data and iii) time series of disasters in Bangladesh. The monthly rainfall records of 17 stations of Bangladesh for fifty years (1958–2007) are collected from Bangladesh Meteorological Department. The data on time series of historical floods in Bangladesh with inundation area are collected from Bangladesh flood forcasting and warning center (FFWC). The disaster related data were collected from EM-DAT (2011).

3. Analysis and Discussions

The main three disasters of Bangladesh are flood, cyclone and drought. Based on the Global Assessment Report of United Nations on Disaster Risk Reduction in 2009, it is observed that the flood is the mostly devastating disaster in Bangladesh compared to other disasters as it ranked 1st for the case of population exposed and 3rd in the case of economic exposure. Available disaster data from 1900 to 2011 was devided into two time spans 1900-1981 (1st span) and 1982-2011 (2nd span). It is observed that the number and pattern of disasters in the two time spans are varied significantly. In earlier time span, the number of disaster was about 1 number per year, and that number increased to about 6.7 in recent time span. In addition to that, new variety of disasters have been occured in recent past decades compared to that of before 1981. Although cyclone is the dominating disaster according to its number of yearly occurances with respect to others, its percent in 2nd span of time is reduced compared to 1st span of time. However, the percent of flood increased in recent years (1982-2011) compared to past decades. The yearly no of people killed by natural disasters is reduced by about 5 times in recent decades compared to 1st time span. That may be due to the improvement of management and communication facility of the country. In time span 1900-1981, the main cause of people killed was drought, whereas in the time span 1982-2011, the dominating disaster for people killed was storm (about 92%). Affected people per year was about 7 times higher in 1982-2011 than 1900-1981 span, and people mostly affected by flood in both spans, though the percentage is increasing day by day. It is found that the disaster nos., number of affected people and economic loss has been increasing with time in an alarming rate. 30 years average discharge curve of Ganges river is found to be similar pattern of rainfall (in Ganges Basin within Bangladesh) lagged by a month. Comparison of 50 years Monsoon rainfall anomaly with that of flooding area showed that, for more than 85% cases the flood anomaly is in phase with that of territorial rainfall. Although it is expected that the huge upstream flow has a high impact on floods of Bangladesh, such scenario is observed only for 15% cases; the 1998 flood shows such a case. The annual cycles of discharge in Brahmaputra river indicates significant phase differences with Ganges. The Brahmaputra flow increases rapidly in late spring and peak at mid of July, ahead of the Ganges by about two months. If the Brahmaputra does not discharge out its peak flow rapidly, its peak will coincide with the peak of Ganges and an extreme high flood will occur. The temporal variation of mean seasonal discharge at Bahadurabad point of Brahmaputra river for wet and dry seasons were analized seperately. It is found that in both the seasons, the discharge is in increasing trend with time. In wet season, the yearly increasing rate of Brahmaputra river discharge is about 54 cumec and that of dry season is about 114 cumec.

The discharge has been increased about 7.5% in last 50 years. The fluctuation in the variation of monsoon discharge is also increased. The variation of averaged monthly discharge for two averaging time spans 1956-1980 and 1981-2005 are also compared, and the averaged monthly Brahmaputra discharge in Bangladesh is found to be increased about 8% in 50 years.The historical time series of floods in Bangladesh shows that the top 5 floods in terms of inundation area are occurred in last 20 years in 60 years of history. It is observed that the number of moderate floods are decreased highly and they are converted to either extreme high floods or the extreme low floods. From the trend line for 50 years of rainfall data, it is found that the monsoon rainfall increases very gently as 2.65 mm/year. These changing phenomena in rainfall and flooding scenario in Bangladesh can be explain as the probable impact of climate change. To analyze the temporal change of return period and probability of floods, the floods were classified into three categories: low, moderate and high flood events. To show the temporal change, the data set was divided into two time spans: 1954-1981 and 1982-2008. From the two sets of data, it is observed that, in high flood events (Inundation > 29% area), the return period decreased and the probability increased by about 3 times in recent decades. In low flood events (Inundation <19% area), the return period decreased in recent decades and the probability increased by about 1.4 times. In Moderate Flood events (Inundation =19 - 29% area), the return period increased and the probability is reduced to about half (1/2). Considering a particular example of flood at Bahadurabad point of Brahmaputra river with discharge = 76,137 m^3/s, for data set of 1956 to 2007, it is found that the probability of occurrence of the characteristic flood is increased from 4% to 28% over the last 50 years.

IWM (2006) predicted that, by the year 2100, the temperature will be increased about 2.4^0C, the monsoon precipitation will be increased about 11.8% and the SLR will be 30cm ~ 1 m (9 cm ~ 88 cm by IPCC). They also predicted that, for 2^0C temperature rise and 10% increase in precipitation, the discharge in Ganges river will be increased about 19%, that of Brahmaputra will be increased about 13%, and about 11% discharge will be increased in Meghna river. That means, on an average, 10% to 20% discharge will be increased in all the three mighty rivers in Bangladesh by the year 2100 with a significant amount of SLR. To explain the long term effect of climate change on flooding scenario of Bangladesh, an index named *Flood Intensity Index* is introduced here to characterize the intensity of flood. Flood Intensity Index is defined as the product of the depth of flood above the danger level (m) and the duration of flood (days). A conceptual model to explain the impact of climate change on the flooding scenario of Bangladesh shows that due to increase of river discharge, the inundation depth will be increased; on the other hand, due to Sea Level Rise there will be drainage congestion to drain out the river water to the sea due to back water effect of higher elevated sea level. This will cause the slow down of rate of discharging river water to the Sea, which will actually influence to prolong the duration of flood. Since both the parameters of flood intensity index will be increased by the impact of climate change, the intensity of flood will also be increased significantly. As example, the flood intensity index is calculated for 1998 and 1988 floods and compared with a normal flooding year 2008. The water level above the danger level during flood is termed here as inundation depth. It is found that, although the depth of inundation among two floods does not differ too much, the duration of flood in 1998 was much (up to 4 times) higher than 1988 flood. The calculated Flood Intensity Index for different basins and their averages for years 1988, 1998 and 2008 showed that although the depth of inundation among two mega floods does not differ too much, the Flood Intensity Index in 1998 was much higher (about double) than 1988 flood, that is due to the prolong duration of flood in 1998 than 1988 flood.

4. Conclusions

The climate change induced increment in river discharge during monsoon will cause the increase of the inundation depth, and the increasing trend of Sea Level Rise causes in the increase the duration of flood due to back water effect of sea. Therefore, the Flood Intensity Index will significantly be increased due to climate change. Since, the 'Flood Intensity Index (FII)' is a measurable index to characterize a flood accounting all the impacts of climate change, this index can be used in expressing the change in flooding scenario due to climate change.

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