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Formulation of a General Risk Assessment Framework for the Water Related Disasters of Bangladesh

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ABSTRACT

Bangladesh is a disaster prone area. Most of the disasters are water related such as flood, drought and water scarcity, cyclonic storm surge and river erosion. Almost every year the country faces severe catastrophic natural hazards. Risk assessment plays a vital role for planning proper risk reduction measures. Currently, the country has no risk assessment framework that provides a basic guideline for risk assessment to the planners and policy makers. In this study, a general risk assessment framework has been developed for the country. Various steps of risk assessment and options of risk reduction have also delineated in the paper.

Keywords: Disaster, risk assessment, framework, options.

INTRODUCTION

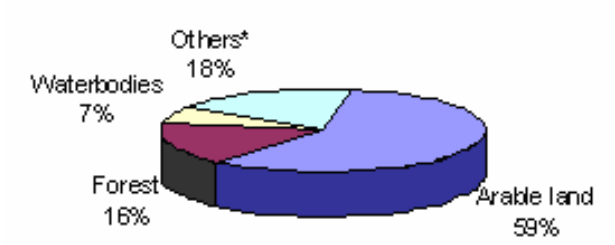
The Earth is a dynamic system and experiencing a lot of natural changes within the system. The natural changes often cause great havoc to human being. When a natural phenomena cause destruction of human life and property, we termed it as hazard. Various hazards are categorized according to the natural components related to it such as water, wind etc. Common water related hazards are flood, drought, storm-surge and riverbank erosion. Every year, peoples of the different regions of the world are affected by natural hazards. The effects depend on the socio-economic condition, geographical setting and technological base of the region (UN, 1991). Apparently it is observed that all of these disaster victims live in the poorer countries of the world. People are trying to save themselves from natural hazards from the ancient time. Recently researchers and development agencies have been engaged to investigate a comprehensive risk management plan to provide future safety of mankind.

Bangladesh is richly endowed with water resources on an annual basis, but the availability is characterized by wide seasonal as well as spatial variability (BWP, 2000). Flood, drought, storm surge and riverbank erosion are the common water related hazards of the country. The country's water management plan must consider the dual problem of flooding and water scarcity, along with the allocation of water to various water using sectors including agriculture, domestic, fisheries, industry, navigation and environment. The history of water management planning in Bangladesh dates back to 1964, when a 20-year master plan was prepared with emphasis on large scale flood control, drainage and/or irrigation projects. In 1972, World Bank conducted a land and water sector study with emphasis on small and medium scale projects through minor irrigation. In 1983, the Government of Bangladesh initiated a National Water Plan (NWP) preparation exercise, which was completed in 1986, and further updated in 1991. A five year (1990-1995) Flood Action Plan (FAP) was launched after the devastation floods of 1987 and 1988. All of these earlier water management plans focused mainly on agricultural development, neglecting the demands of other sectors. The comprehensive National Water Management Plan (NWMP) was initiated in 1998 and approved in 2004. Meanwhile, the government has formulated and approved the National Water Policy (NWPo) in 1999.

A risk assessment framework provides a guideline for risk assessment. It shows the ways in which risk assessment can be completed. The process of risk assessment is almost similar for each type of natural hazards and area affected by the hazard. Proper characterization of hazard and elements at risk is the prime requirement for risk assessment (UK, 1991). In this study, an attempt has been taken to formulate a general risk assessment framework for the water related issues of Bangladesh.

WATER STATUS OF BANGLADESH

The tributaries and distributaries of the three major river systems: the Ganges-Padma, the Brahmaputra-Jamuna, and the Meghna and numerous perennial and seasonal wetlands like *haors, baors* and *beels* are the water ecosystem of the country. The three major river systems of the country originate from outside countries. Out of 238 rivers, 57 are transboundary – 54 from India and 3 from Myanmar. The country has three broad types of landscapes: floodplain – 80%, terraces – 8% and hills – 12% (BWP, 2000). The total area of the country is 147, 570 sq. km and rivers and water bodies consist only 6.7%. The land-use pattern of the country has been shown in Figure-1.



* Others include settlement areas, physical infrastructure, urban areas etc.

Figure-1. Land-use pattern of Bangladesh (BBS, 1999)

The arable area constitutes about 8.76 million hectares. Out of them, 33.3 % is single cropped, 45 % is double cropped and only 11.5 % is triple cropped and 10.2 % is cultivable waste and currently fallow. The overall cropping intensity is 176%.

The upstream inflow and runoff from rainfall within the country to the dense network of river systems is the natural surface water resources of the country. The cross border flows into the county amount to around 1010 billion cubic meter (BCM) and additional amount of 340 BCM is generated from local rainfall. Of this total yearly amount of surface water (1350 BCM), about 14% of water (190 BCM) is lost in the atmosphere through evaporation and evapo-transportation. The remaining 1160 BCM water is available for use and/or flows into the Bay of Bengal. 80% of this huge volume of water is concentrated in the monsoon period of June to October (BWP, 2000). The alluvial soil of Bangladesh constitutes a huge aquifer with reasonably good transmission and storage properties. Heavy rainfall (yearly 2300 mm in average) and annual inundation help the groundwater to be substantially recharged annually. Master Plan Organization (MPO), 1991 suggested the available recharge of groundwater is about 21 BCM.

WATER RELATED DISASTERS IN BANGLADESH

Geographically, Bangladesh is a disaster prone country. Most of the disasters are water related. According to the Ministry of Disaster Management and Relief of Bangladesh, about 13 thousand people are killed, 19 thousand injured and over a million of people affected by natural disasters every year. Mitigation measures undertaken to protect the people of the country from such disaster have been very inadequate so far (Khan, 2000). Most common water related disasters that hit the country almost every year are flood, drought, cyclonic storm surge and river erosion.

Floods

The geographical location and the intensive monsoon rainfall within and outside the country are the main cause of floods. As the country is the lowest riparian of the three major international rivers, the Ganges, the Brahmaputra and the Meghna, the country gives passage to the entire monsoon flood generated in the vast catchments of these rivers spread over parts of India, China, Nepal, Bhutan and Bangladesh. Of this total catchment area (1.75 sq. km), Bangladesh constitutes only 7%. The in-country rainfall floods, pre monsoon (April – May) flash floods, major river floods and the floods caused by tidal storm surges are the four types of floods in Bangladesh. The problem of floods is further exacerbated by upstream water resources projects in the transboundary rivers. Catastrophic floods of 1988 and 1998 inundated about 60% and 68% of the country's land area respectively. The 1988 floods took more than a month to recede.

Drought

Bangladesh often experiences droughts and water scarcity for prolonged periods during pre-monsoon and monsoon due to delayed rainfall. From January –June of 1999, the entire country faced severe water scarcity and drought conditions in absence of rainfall. During dry season (November – April), amount of rainfall is very small and the country depend largely on groundwater and surface water in major rivers. Dry season availability of surface water in transboundary rivers (Ganges, Teesta, Monu, Muhuri, Khowai, Gumti etc.) has been facing gradual reduction from historic flows due to upstream water diversion projects. India started large-scale diversion of the dry season flows of the Ganges by constructing the Farakka Barrage in 1975. Drought and water scarcity hamper the domestic and municipal water supply, agriculture, fisheries and navigation sectors of the country.

Cyclonic storm surge

The coast line of Bangladesh is vulnerable to cyclonic storm surges that occur when strong winds cause the sea level to rise locally due to development of low pressure, driving it into a confined area where a steep fronted wave develops, often moving as a tidal bore many kilometers up estuaries (Khan, 2000). The cyclone and accompanying tidal bores turn out to be catastrophic for the coastal people of the country. Bangladesh has some 700 km of coastline from the Sundarban to Teknaf. During the 1971 cyclone, about 30 thousands of people died on the shores of the country. In the decade of 1986 – 1996, an estimated 215 thousands of people were killed by floods and storm surges throughout the world. Of these deaths, about 140 thousands occurred in Bangladesh during the event of 1991 storm surge.

River erosion

River erosion has caused untold miseries to thousands of people living along the banks of rivers in Bangladesh. It has been reported that many of the slum dwellers in the metropolitan areas are the victims of river erosion. In the decade of 1982 – 1992, over 106 thousand hectares of land has been eroded in the three major rivers of Bangladesh (the Ganges, the Brahmaputra and the Meghna) against an accretion of only 19 thousand hectares. About 350 thousands of people were displaced

due to river erosion in that decade, who suffered severe economic and social consequences (Khan, 2000).

RISK ASSESSMENT

Risk assessment is a comprehensive task that includes assessment of elements at risk, probable risk to the element for a particular natural disaster and identification of possible mitigation measures to reduce the risk. It is an integrated process of determining the nature and scale of the losses that can be anticipated in particular areas during a specific time period. It involves an analysis and combination of both theoretical and empirical data concerning the probabilities of known natural hazards of particular intensities occurring in each area; and the losses expected to result to each element at risk in each area. There are some steps of risk assessment in an area for a particular natural hazard/disaster. The steps are illustrated below:

Identification and characterization of hazard

The natural water related hazards should be identified and characterized on the basis of their types, significance, frequency, magnitude and extent etc.

Identification of location

The location at risk should be specified as land use pattern. The pattern of land use of the selected area may include agricultural land, residential area, commercial area, industrial area, infrastructure and community services.

Classification of elements at risk

The structures affected by specific hazard should be categorized as agricultural land (crop field, poultry and livestock firms, ponds and wetlands for fish culture etc.), residential area (traditional and modern houses), commercial area (business center, market and shopping complexes, official buildings etc.), industrial area (small and large industrial plants), infrastructures (roads, railways, bridges, power grids, gas and telephone line etc.) and community services (hospital, educational institution, religious centers etc.).

Determination of specific risk for elements at risk

This is a three – steps task:

(i) Estimation of hazard from the data of geographical extent, probability of occurrence and magnitude for each locality.

(ii) Damage estimation for elements at risk. Damage of elements differs from location to location i.e. urban and rural area. For any area, damage estimation is a function of event (flood, drought, river erosion etc.), type and number of elements at risk (crop land, infrastructures etc.), area of elements (e.g. crop land area), duration and magnitude of hazard (e.g. depth and duration of flood). Damage must be estimated for each type of elements separately because specific risk of elements differs from each other. It is convenient to measure the damage in monetary value. However, all the damages will not be measured in monetary value e.g. life loss, injury etc.

(iii) Vulnerability analysis. Vulnerability of any element or set of elements at risk should be expressed in scale from 0 (no damage) to 1 (total damage). Vulnerability of each type of element can be estimated with the help of the following equation. Relative vulnerability, $V = D/D_{max}$. Where D is the damage of particular element for a particular hazard and D_{max} is the maximum damage that could occur for that element.

Estimation of specific risk

Specific risk of each type of element at risk can be estimated as, Specific Risk, $Rs = \sum (Vi * Pi)$, where Vi is the vulnerability for an event and Pi is the probability of occurrence of that event. In the case of class interval, specific risk can be estimated as $Rs = \sum [\{V (u\ i-1) + V (ui)\}/2] [P (u\ i-1) – P (ui)]$, where V (ui-1) and V (ui) are the vulnerability for event ui+1 and ui respectively, P (ui+1) and P (ui) are probability of occurrence of events ui+1 and ui respectively and ui+1 and ui are lower and upper limit of a class interval respectively.

Estimation of total risk

After estimation of specific risk, total or cumulative risk can be estimated by multiplying specific risk of an element i with the number of that element of type i. Mathematically it can be expressed as Risk, $Rt = \sum (Ei * Rs)$, where Ei is the number of elements at risk of type i and Rs is the specific risk.

Results of risk assessment

Results of risk assessment are usually represented in hazard map, table, graph and figure. Hazard maps are generally prepared as hydrological hazards (floods, cyclone etc.) or geological hazards (earthquake, landslide etc.) or in combination of hydrological and geological hazards.

Options of risk reduction

Common options for reducing water related hazard risk of Bangladesh could be categorized as:

(i) **Modifying hazard**: It includes the proactive measures of risk reduction such as construction of river and coastal embankment, dam across the river to control the flood at downstream, pumping station to withdraw water from drainage congestion, channel improvement to increase drainage capacity, river training works to prevent bank erosion, sea wall or dikes to prevent wave erosion, barrage across a river to

create reservoir for maintaining water supply during dry season or to divert water flow to a distributary etc. Changing the physical characteristics of the site such as ground improvements, drainage improvement or slope modification and dredging of riverbed can also be included as options for risk reduction.

(ii) **Reducing vulnerability**: Various options like raising plinth level of building, raising road and bridge level, strengthening of infrastructures (structural design improvement), proper maintenance of infrastructure, expansion of infrastructure systems (road, water supply line, gas line, power line, telephone line etc.) by increasing number of connections or loops within the system, construction of flood and cyclone shelter, disaster preparedness, disaster forecasting and warning system, setting safety standards and guidelines, post hazard harm alleviation by assistance and credit programme and post hazard rehabilitation and reconstruction etc. can be of good options for Bangladesh to reduce vulnerability.

(iii) **Loss sharing:** To provide disaster aid by community, government and non-government organizations, hazard insurance through individual or company, group insurance among the community, financial incentives to encourage adoption of vulnerability reduction measures are the options to share the losses.

RISK ASSESSMENT FRAMEWORK

A risk assessment framework provides a guideline for risk assessment. It generally shows the ways in which risk assessment can be completed. The process of risk assessment is almost same for each type of natural hazards and area affected by the hazard. Proper characterization of hazards and elements at risk are the prime requirement for risk assessment. A general framework has been developed for the country and shown in Figure-2.

CONCLUSION

Bangladesh has no risk assessment framework for water related hazards. Natural, social, economic and environmental settings of a particular area are affected by many global, regional and local factors. Risk of any element for a particular hazard varies depending on the factors. Proper determination of risk is very important for planning risk mitigation measures of the country. Risk assessment helps to find out a suitable solution for hazard mitigation.

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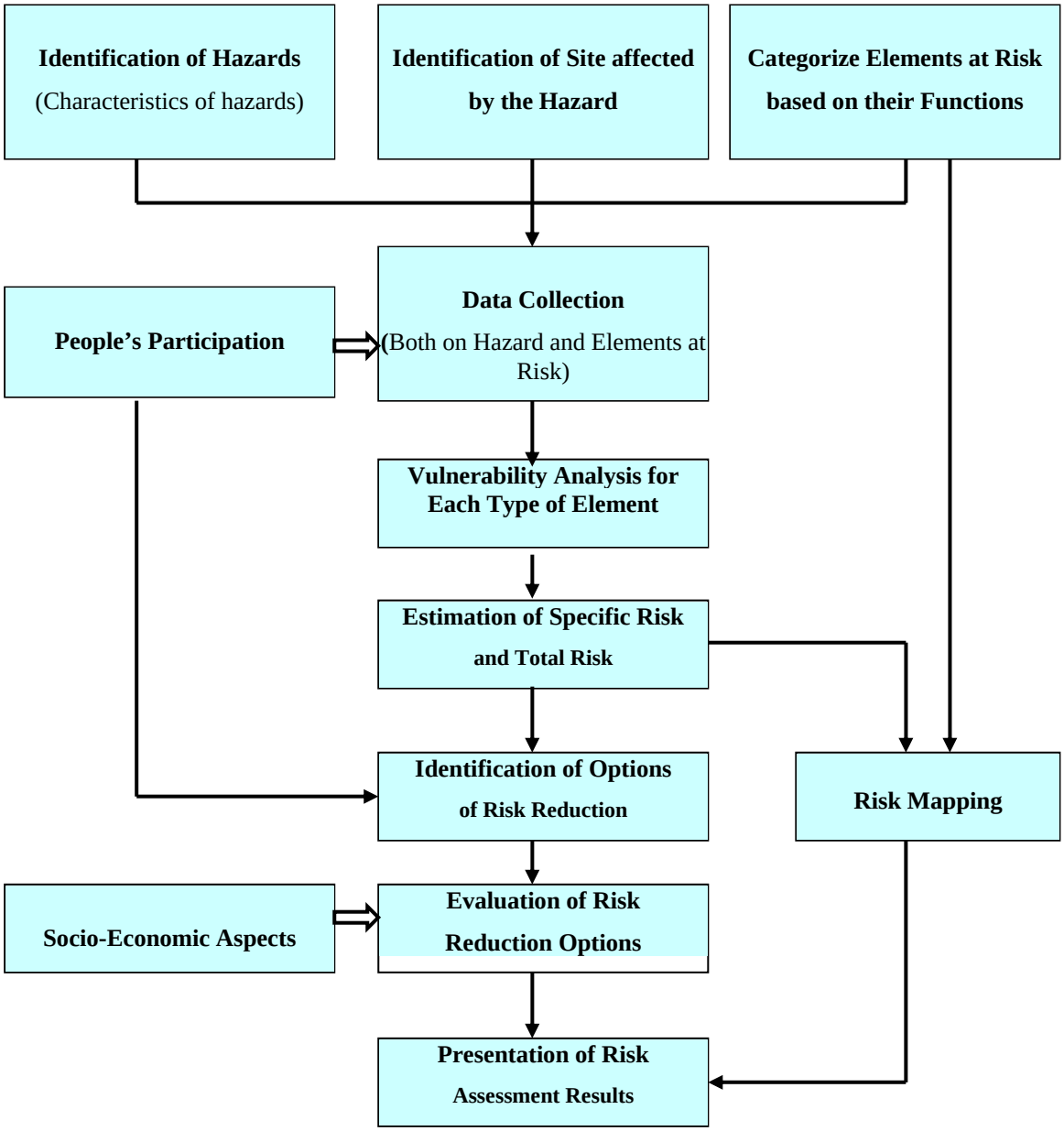

Figure-2. A general risk assessment framework.