Multilevel Governance for Climate Change Adaptation
A case study for climate induced flood in Bangladesh

Md. Mostafizur Rahman[1], Md. Mahbubur Rahman[2], Md. Tajminur Rahman[3]
[1]GIS Specialist, Institute of Water Modelling (IWM), Dhaka, Bangladesh,
[2]Assistant Engineer, Bangladesh Water Development Board, Dhaka, Bangladesh,
[3]Md. Tajminur Rahman, Assistant Director, Department of Environment, Bangladesh,

***Abstract*—Bangladesh is one of the most vulnerable countries in the world to climate changes. In Bangladesh, flood is one of the most natural hazards which is expected to be aggravated with future climate change scenario. Early adaptation research and practice to climate change was concerned with technical solutions. This trend gradually shifted to concerns with the institutional context of adaptation. More recently, the emphasis has been placed on governance followed by multilevel governance. This study aims to illustrate how governments at all level can act cooperatively to address climate change adaptation. To conduct the study climate induced flood for the year 2040 has been considered as climatic event. This study is based on a case study to show how climate change induced flood will affect infrastructure; under such condition what may be the adaptation strategies at local, regional and national level. Flood exposure analysis has been considered to examine the impact of climate induced flood on infrastructure. Flood exposure analysis shows that about 82.20% road, 91.43% educational infrastructure and 61.54% health facilities will be exposed to more the 1m inundation due to climate change induced flood in 2040. Adaptation strategy has been devised based on present practice across Asian countries, findings from other research and expert opinion. The study find that flood exposure analysis, flood hazard and proper landuse planning are needed at local level; regional level authority should focus on cross-border nature of flooding such as river basin management; national level authority should focus on policy level and financial matters to adapt with climate change.**

Keywords— Multi-level Governance; Climate change; Flood exposure analysis; Adaptation; landuse; Bangladesh

I. INTRODUCTION

Climate change is fast becoming one of the most significant challenges of the 21st century. Urban areas are heavily vulnerable to climate change; a large scale of people and infrastructure in urban areas across the world will be affected by climate change. Bangladesh is one of the most vulnerable courtiers in the world to climate changes and one of the most densely populated countries in the world.

In Bangladesh, flood is one of the most natural hazards which is expected to be aggravated with future climate change scenario [1, 2]. Approximately 20% to 25% of its territory is inundated during the monsoon season [3]. A number of research works have identified that the monsoon flood scenario will be aggravated with future climate change context [1, 4, 5, and 6].

The Fourth Assessment Report of the IPCC defines adaptation as "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" [7]. Early adaptation research and practice was overly concerned with knowledge and information needs on climate risks–and later on vulnerability–in order to identify technical solutions to adaptation issues. Research and practice gradually shifted to concerns with the institutional context of adaptation. More recently, the emphasis has been placed on governance and city government and the coordination of knowledge, actions and how knowledge among diverse actors emerges and influence decisions and interactions [8, 9, and 10]. It is argued that climate change adaptation can only be adequately addressed if action is taken at all levels of government: international, national, regional, and local [11].

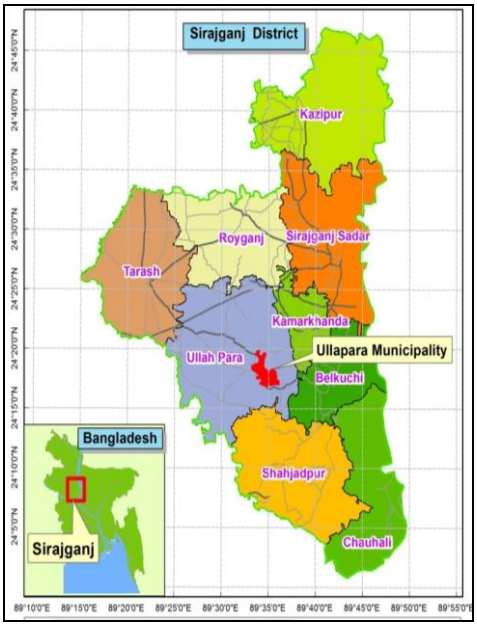
In Bangladesh there is no evidence of multilevel governance approach of climate change adaptation. This paper aims to demonstrate how governments at all level can act cooperatively to address climate change adaptation. Many sectors will be affected by climate change in many dimension and adaptation strategy will be different thereof. This study does not address all climatic events (hazards) and all sectors. This study has been conducted focusing climate change induced flood and infrastructure in Bangladesh.

II. STUDY AREA

To conduct this study, Ullapara Municipality of Sirajganj District, Bangladesh has been taken as case study which, due to its geo-physical setting, urban character, important landuse and infrastructure, represents other climate change induced flood prone Municipalities (urban areas) in the country. Ullapara Municipality, being located in Sirajganj district, represents the impact of climate induced flood near the area of Jamuna River (Brahmmaputra), one of the rivers of GBM basin (Ganges-

Brahmmaputra-Meghna) through which the impact of climate induced flood will be observed across the country. This Municipality is located in eastern side of Ullapara Upazila under Sirajganj District and is bounded by 24016'47.83" N and 24020'02.11" N Latitude and 89032'57.01" E and 89036'01.61"E Longitude. Figure 1 shows the location of Ullapara Municipality. The mean elevation of Ullapara is about 10.78m. This low elevation and geo-physical settings of Ullapara Municipality make it most vulnerable to and the infrastructure within this Municipality will be at risk in climate change induced flood due to high level of exposure [12].

Figure 1: Location of study area



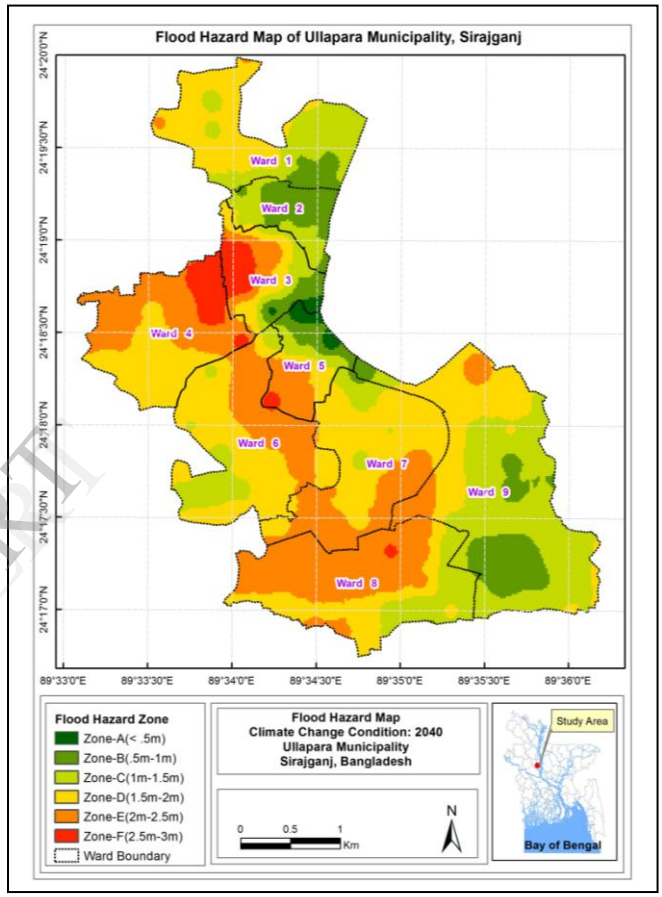
III. Data, Scope And Method

This study has been carried out mainly based on secondary data which includes climate change induced flood inundation data and infrastructure data. The flood inundation map has been prepared by collecting flood model result from Institute of Water Modelling (IWM). This Flood model has been developed for the year 2040. In this model, the 4th IPCC prediction of the global sea level rise for the IS92a scenario has been considered. This study is an empirical research and not includes all climate affected sectors. Mainly selected urban infrastructures have been considered for the study. These include transport infrastructure, educational infrastructure, health infrastructure, and other urban facilities including Community center, Fire Station, Police Station and Solid Waste Disposal Site. These data has been collected from LGED that has been prepared under UTIDP. ArcGIS 10.1 Software has been used for flood exposure analysis in the study.

The scope of study threefold: study area and climatic events and affected sector. As study area Ullapara Municipality has been selected to represent other flood prone areas of Bangladesh. As climatic event flood has been considered as it is the most destructive natural hazard in the country. As sector only urban infrastructure has been considered. Flood exposure analysis has been conducted to observe the impact of climate induced flood on infrastructure. To conduct exposure analysis, six categories of flood hazard zones have been identified based on extent of flood inundation depth. These hazard zones are Zone-A, Zone-B, Zone-C, Zone-D, Zone-E and Zone-F and these zones are characterized with 0-.5m, .5-1m, 1-1.5m, 1.5-2m and 2-2.5m and 2.5-3m inundation depth respectively (Figure-2).

This study is based on flood exposure analysis of infrastructure due to climate change induced flood as a prototype agent of climate change. Adaptation strategy has been devised based on present practice across Asian countries, findings from other research and expert opinion thereof.

Figure 2: Flood Hazard Map of Ullapara Municipality



IV. Climate Change Induced Flood And Exposed Ifrastructure

This section illustrates how climate change induced flood will affect the infrastructure in Ullapara Municipality and their consequences. To examine the climate change impact flood exposure analysis of various infrastructures has been conducted. Exposure is a measure describing the external stress brought about by climate change threats in relation to population, resources and property. It indicates the nature and degree to which a system is exposed to significant climatic variations. Exposed elements refer to the elements located in an area where hazard event is occurred.

A. Transport Infratsructure

In Ullapara Municipality there are about 64.36% Pucca and 33.22% Katcha road (Author own Calculation). The flood exposure analysis illustrates that about 20.41%, 33.99% and 26.35% Pucca road will be exposed to 1-1.5m, 1.5-2m and 2-2.5m inundation respectively. About 28.69%, 28.72% and 29.99% Katcha road will be exposed to 1-1.5m, 1.5-2m and 2-2.5m flood inundation respectively. Overall 23.07%, 31.97% and 27.16% road will be exposed to 1-1.5m, 1.5-2m and 2-2.5m inundation respectively indicating about 82.20% road will be exposed to more than 1m flood inundation depth.

Transport infrastructure, as a means of access to basic services, residence, workplace, and other urban facilities, is the key factor to accelerate economic growth and sustainable development. If this infrastructure does not perform properly economic growth and development will be hampered. In Ullapara Municipality, it is found that most of the road will be inundated in climate change induced flood resulting disruption of communication hampering access to all urban services.

B. Educational Infrastructure

Educational infrastructure is considered as one of the critical facilities that are supposed to be heavily affected by climate change induced flood in developing countries. In Bangladesh, there are already instances of very negative impact on educational infrastructure due to severe flood that had destroyed educational infrastructure all over the countries [13]. Exposure analysis shows that in Ullapara Municipality about 68.75% Primary School and 72.72% Secondary School will be exposed to more than 2m inundation; 87.50% College will be exposed to 1-2m inundation. Overall 91.43% educational institution will be exposed to more than 1m inundation due to climate change induced flood. Access to education has long been considered as an important vehicle for poverty [14]. Education empowers a person and it helps them to become more proactive, gain control over their lives, and to broaden the range of available options [15]. The findings of the study shows that most of the educational institution in Ullapara Municipality will be highly exposed to climate change induced flood resulting educational institution remain to be closed during this period which may lead to increase the children dropout rate.

C. Health Infrastructure

In climate change scenario it will be a great challenge to maintain the health services during flood because health infrastructures are supposed to be exposed in climate change induced flood. The study finds that about 15.38%, 30.77%, 23.08 and 15.38% Community Clinics will be exposed to 1-1.5m, 1.5-2.0m, 2-2.5 and 2.5-3m inundation respectively due to climate change induced flood. Bangladesh is vulnerable to outbreaks of infectious, waterborne and other types of diseases [16] and global warming would cause increase of vector borne and water borne diseases in the tropics [17]. The increase diseases rate would require more health facilities to meet the unavoidable situation. The inundation scenario indicates that it will be a great challenge to meet the increasing health care facilities in climate change induced flood in Bangladesh.

D. Urban Facilities

Some of the important urban facilities are included in this study for flood exposure analysis. These are Community center, Fire Station, Police station and Solid Waste Disposal Site. The study finds that Community Center, Water Pump Station, Fire Service Station will be exposed to about 2-2.5m; Solid Waste Disposal Site and Police station will be exposed to 1.5-2m and 1-1.5m inundation respectively. Community centers are public locations where members of a community tend to gather for group activities, social support, public information, and other purposes. Fire station and Police station are also known as critical facilities because of their function, size, service area, or uniqueness. They have the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed, damaged, or if their functionality is impaired. These facilities are essential for the delivery of vital services and for the protection of the community. The study indicates that facilities will be highly exposed to flood resulting disruption in their services which may lead to further loss of lives and properties. Solid waste disposal site is an important urban facility which is much more related to environmental pollution. The proposed waste disposal site in Ullapara Municipality is supposed to be exposed to 1.5-2m inundation which will pose a threat to surrounding areas and surface/groundwater bodies of Ullapara Municipality due to waste emissions and subsequent pollution. The social impact and damage in this area would be worse if the flood waters transport waste to residential areas. The high level of exposure of water pump station will lead to decrease the access to pure water supply which may cause diseases.

V. Concept Of Multilevel Governance

Governance is a concept and a process linking political system with its institutional environment. It is about how to steer society and the environment through social coordination. The choice of governance structure for adaptation and disaster risk management is politically contested and not obvious [18]. A multi-level governance framework provides a useful entry point for understanding the relationships between cities, regions and national governments – including also international institutions - across relevant policy issues as well as across a range of non-state and civil society actors [11]. It also provides a starting point for understanding how central governments and other public and private actors interface to design and implement policies from international to national and local levels of action [19].

Any multilevel governance framework will encompass at least two different dimensions of action and influence: the first is the vertical dimension across scales or levels of governance and the second is the horizontal dimension of governance [19, 20, and 21].

The vertical dimension of multilevel governance recognizes that national governments cannot effectively implement national climate strategies without working closely with regional and local governments as agents of change. On the other hand, to take action, cities cannot be effective and do not operate in isolation from other parts of government. Local governmental authority to act in areas related to climate change

is often "nested" in legal and institutional frameworks at higher scales [18, 22].

On the horizontal axis, there is increasing evidence of multi-level patterns of governance and transnational networks on climate change and other global environmental issues where actors work across organizational boundaries to influence outcomes. Within the multilevel regulatory framework, learning, information transmission and cooperation also occurs horizontally with linkages increasingly being forged between cities, regions and national governments [23].

Forms of governance at multi-levels have taken off increasingly at the local scale, building upon the notion of 'think global, act local', in cities in particular [20]. Climate change becomes an increasingly important policy driver for regional and urban economic development policies that leads to require sound public policy development and implementation. A multi-level governance framework is now being used in several areas of work related to multi-level governance including on cities and climate change, regulatory governance, sub-national finance and water governance

VI. Multilevel Governance And Climate Change Adaptation

In relation to climate change, it is widely assumed that the response to the impacts of climate extremes such as floods, raise complex development issues that are best addressed at the local level with substantive community involvement. It is however also recognized that local and city level actors require firm linkage and support from higher levels of government, including also from international agencies, if the aim is to further adaptive capacity and resilience on a broad city-wide scale [24]. Thus adaptation to climate-related disaster risks is a concern of multiple actors, working across scales from international, national, and sub-national and community levels, and often in partnership, to ultimately help individuals, households, communities, and societies to reduce their risks [25, 26, and 27]. Recent studies on climate change adaptation strategies underscore the need for attention to multilevel governance, i.e. governance across all levels of government and active engagement with stakeholders within a particular level for successful adaptation with climate extremes (28, 29, 30, 31, 32, 33]. It is now understood that climate change adaptation can be best addressed under multilevel governance framework each having different level of contribution and coordination. Now this chapter will discusses how different level of government can play their role to adapt with climate change induced flood in Ullapara Pourashava.

A. The Local Level

Local authorities are in a unique position to develop tailored responses to the impacts of climate change. They have first-hand knowledge of local conditions and can develop proactive strategies in response to climate change, experimenting with local solutions and committing to ambitious targets. Local authorities can work together with voluntary efforts such as city networks, the private sector and community organizations to develop new institutional models for local adaptation [34]. There are many adaptation strategies at local level. Many studies suggest that spatial planning or structural measures should be considered as indispensible part and be given as utmost priority to adapt with climate change induced flood [35, 36, 37, 38, and 39]. Among others, this study focuses mainly on spatial planning and/or structural measures as adaptation strategies in response to climate change induced flood in Ullapara Pourashava. The following sections discuss adaptation strategies for selected infrastructures in Ullapara Pourashava in climate change induced flood scenario.

I) Transport Infrastructure

A number of international studies including studies conducted in Asian countries regarding climate resilient road infrastructure suggest that raising road elevation or height above the anticipated highest flood level may be one of the strategies to adapt with climate change [40, 41, and 42]. Several studies suggest that construction of culvert along the road may be one option to protect road infrastructure that may be vulnerable due to heavy load and pressure to be incurred by extreme flow of water due to climate change induced flood [38, 41, and 42]. If there is not sufficient number of culverts along the roads, the flood water may overtop and thereby causing destruction to the roads. So, sufficient number of culvert may be constructed along different roads of Ullapara Pourashava to allow free flow of water. Priority should be given to those roads that benefit the highest number of people and connect village markets with each other and growth centers. Design specifications of culverts should be such that water flows in canals, small rivers and heavily flooded area are not obstructed. The location, size and number of culverts are related to existing canals and the main flow pattern during floods. To quantify the location, size and number of culverts a hydrological study is required. It will assess the number, location and width of culverts needed. The period of inundation by floodwater affects the load bearing capacity and strength of pavement layers significantly. According to [43] in case of inundation for 30-days, the stability of road materials reduces by 26 percent. So climate change induced flood should be considered as a design parameter for designing roads in Ullapara Pourashava and other flood prone area of Bangladesh. Several studies [38, 41, and 42] suggest that selection of material for construction of road is one of the design considerations for climate proofing infrastructure. There is no much study in Bangladesh regarding climate proofing construction material. However, a recent project by LGED with financial assistance from IFAD suggests that Bituminous Carpet (BC) and/or Reinforced Concrete Cement (RCC) can be used as surface material for road construction to cope with climate change induced flood [6].

II) Educational Infrastructure

Several studies have been conducted on "climate change and education" especially in developing countries and these studies suggests several structural and non-structural adaptations measures for education in response to climate change induced flood [12, 44]. However, three types of alternative structural solutions can be devised from these studies to face the challenge of climate change induced flood. These are Relocation, Height Enhancement and Floodwall Construction.

III) Health Infrastructure

Flooding is one of the most widespread of climatic hazards and poses multiple risks to human health, yet there has been little systematic research work on health outcomes and the means by which vulnerable populations and health systems respond to those risks. According to IPCC global warming would cause increase of vector borne and water borne diseases in the tropics [17]. Given the prospect that flood hazards may increase as a result of climate change, it is high time now to make a strategic assessment of the existing knowledge base on health and flood risk. Thus, the planning, design and construction of health infrastructure needs to take into account the likely physical threat from flood events. Anticipated disruption in access to health care infrastructure during flood in Ullapara Pourashava emphasize the need for guidelines to ensure as far as possible that health care infrastructure is built outside flood zones or designed to function effectively in a flooded environment. For this, existing codes and regulations on the design and construction of facilities should need to be revised and adapted to local requirements, and mitigation objectives should be integrated into every step of new health infrastructure construction.

IV) Land Use Planning and Flood Zoning

Where exposure to events is unavoidable, land use planning and location decisions can be accompanied by structural or non-structural methods for preventing or mitigating risk [35, 45]. River engineering and land use may have altered flood probability. In growing and expanding urban settlements, flood hazard may be seen to be of lesser importance than other land management concerns, such as providing land for existing or new businesses or housing. Ongoing development and encroachment of floodplains and other flood-prone areas is a consistent problem throughout the urbanized world. The need to integrate flood risk management into land use planning is vital in order to minimize the rise in exposure to hazard, and to seek to manage the consequences of flooding. Land use planning provides a policy and regulatory mechanism that enables diverse and often conflicting objectives to be integrated and addressed in a development framework – with this process and its output, is referred to as 'integrated land use planning'. Integrating flood risk management objectives and principles into land use planning is an essential component of contemporary flood risk management.

V) Storm water storage pond and drainage system

In many study it has been reported that due to climate change rainfall will increase in this region. It has been reported that monsoon rainfall may increase by 10-15% by the year 2030 and by 15-20% by the year 2050 [46]; 11% and 28% increases over Bangladesh by the year 2030 and 2075, respectively [47]. The increase in precipitation may lead to rianfed flood in urban area. To tackle this type of rainfed flood researcher and practitioners suggest to concentrate on storm water retention pond and improved drainage system in urban area [48, 49]. This storage pond and improved drainage system will manage storm water runoff to prevent sudden flooding in urban area that may be caused by heavy rainfall due to climate change. The depth and design of pond and drainage system should be based on specific hydrological characteristics of the locality.

B. Regional Level

Local authorities face different obstacles in their efforts to design and implement adaptation policies. Such obstacles to local policy design can be of a variety of natures including jurisdictional and institutional and economic and budgetary [50, 51]. Important limitations of local level authority relate to the scale of intervention. For example, local level authority can raise road elevation to safe road infrastructure from inundation but municipalities cannot solve the problems of climate change induced river flooding of their own; they are not able to operate at the basin level management of river. This requires up-stream interventions of regional approach [52]. Moreover, the cross-border nature of flooding requires a regional approach in which local measures should embedded. Under changing climate scenario, flood risk management plans should involve a region much larger than the city itself [53]. Thus effective climate change adaptation requires consideration of cross-scale management concerns and at the same way any action that crosses jurisdictions from local to regional to national can be best planned using a perspective that takes into account all levels of management [54].

It has already been stated that Sirajganj district is located in the bank of Jamuna River which is one of the rivers of GBM basin (Ganges-Brahmmaputra-Meghna) through which the impact of climate change induced flood will be observed across the country [4, 12, 13]. So increase in water level in Jamuna River due to climate change will cause flooding in the surrounding area. Solutions to flooding problems under climate change conditions can be achieved by adopting and exercising watershed-scale best management practices that include: floodplain zoning, planned urbanization, restoration of abundant channels and lakes, dredging rivers and streams, efficient storm sewer systems, establishing buffer zones along rivers, and improvement on flood warning/preparedness systems [55, 56]. But Ullapara Pourashava, as a local level authority, is not capable to address river management and even they are not responsible for river basin management. It requires regional approach of river basin management from upper level authority. In Bangladesh, BWDB, RRI and WARPO are responsible for such course of actions. Most importantly, BWDB is responsible to develop and manage water resources in the country. So these organizations can take initiative for flood management strategies in Jamuna River to adapt with climate change induced flood.

Experts from various organizations suggested the following adaptation strategies at regional level in response to climate change

a) Dredging of major rivers, tributaries and distributaries for mitigation of flood and erosion and to improve navigability.

b) Floodplain policy and act can be formulated. Under this provision floodplain zoning should be introduced to reduce flood plain development; to reserve space for water. Landowners who wish to develop in these areas should require permission from the concerned authority prior to any development. In such case, if permitted, the authority should

determine site specific design criteria e.g elevation, drainage etc.

c) Planned urbanization should be ensured; flood risk management should be incorporated in regular urban planning practice that can cope with a changing climate and uncertainties.

d) Restoration of abundant channels, lakes and khals to allow free flow of water during flood

e) Construction of embankment with adequate sluice gates for controlled water flow.

f) Controlling flood through structural measures is impossible in Bangladesh. As part of non-structural measures, flood forecasting and effective and organized early warning system should be introduced to reduce the flood risks. People-centered early warning systems will empower communities to prepare for and confront the destructive nature of flood.

C. National Level

Another level in climate change adaptation strategies is the National Level. Cities do not act in a vacuum. They are embedded in a legal and institutional context set by national governments [57]. Although regional level authority is significant in climate change adaptation, Regional level authority has limitations in national policy level action in terms of their scope, mandate and institutional backing. The specific role that regional governments can take depends on the dynamics of national structures [58, 59]. This leads to need for national level authority to be strongly engaged in climate change adaptation. National governments can provide a strategic framework. They can set the framework by developing national legislation and creating a variety of standards and incentives [60]. National governments can formulate climate-proof national legislation and policy and mainstream adaptation into different areas whilst ensuring that national policies are also coherent and supportive for local adaptation [11]. Many countries including Japan, Finland, Denmark, Sweden, Germany and Norway have their own national adaptation strategies and policy in response to climate change [60].

Likewise other countries, Bangladesh has also national adaptation strategies and policy in response to climate change. There are mainly two national level strategies and policy exist in Bangladesh namely National Adaptation Programme of Action (NAPA) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP).

Now the challenge is to translate the national policy into local level planning and implementation. As the magnitude and long-term nature of the climate change threat is increasingly better understood, it is becoming clear that simply implementing a set of adaptation projects, although useful, is not going to be sufficient. If long-term resilience to climate change impacts is to be built into the economy and society of the country, then climate change adaptation (as well as mitigation) needs to be embedded (or mainstreamed) into regular national development planning and actions. Moreover, mainstreaming climate change into planning needs to be done at every level, not just national plans. Thus sectoral ministries such as local government, water management, agriculture, health and others also need to mainstream climate change into their respective sectoral plans.

Experts from various institutions suggest the national level recommendations for infrastructure planning in response to climate change induced flood:

a) Climate change adaptation needs to be mainstreamed into national development planning including policy-making, budgeting and implementation processes.

b) Priority activities as outlined in NAPA should be implemented. There are four types of activities viz intervention, research, capacity building and Awareness Building. In NAPA, about 15 projects have been identified as priority activities following iterative process as adaptation strategies. Among them project no 3 and 8 are most important for the current research (in respect of infrastructure). These two projects are as follows:

- *Capacity building for integrating Climate Change in planning, designing of infrastructure, conflict management and land-water zoning for water management institutions. Responsible agencies are WARPO, DoE (Climate Cell) CEGIS, IWM and BWDB, LGED,RHD, MoL, MoWR, MoEF, DAE, DoF.(Project No-3)*

- *Enhancing resilience of urban infrastructure and industries to impacts of climate change. Responsible agencies are DoE and LGED, UDD (project No-8)*

c) There should be interdisciplinary co-operation at all level of government for a co-ordination of sectoral policies regarding environmental protection, physical planning, landuse planning, agriculture, transport and urban development, and a co-ordination regarding all phases of risk management: risk assessment, mitigation planning and implementation of measures.

d) International cooperation on climate risk adaptation and flood risk management is necessary to strengthen the knowledge and information base as well as financial assistance.

In case of infrastructure (urban) planning in Bangladesh, concerned ministries are Ministry of Local Government, Rural Development & Cooperatives and Ministry of Housing and Public Works. Different departments including UDD, LGED, Municipalities, City Corporations and Development Authorities (e.g. RAJUK, CDA, KDA, RDA etc) are engaged in urban planning of Bangladesh. These ministries along with Ministry of Environment and Forest can prepare national adaptation policy for urban and/or infrastructure planning. Once adaptation policy is prepared it has to be circulated among concerned departments to be followed while preparing urban plan and thus the adaptation strategies should be mainstreamed and translated into local level planning.

VII. CONCLUSION

In this study it has been tried to illustrate how multilevel governance at local, regional and national level can work in response to climate change adaptation. Climate induced flood has been considered as climatic event and adaptation strategies

have been devised from this point of view. This study concludes that climate change adaptation cannot be successful without strong participation of all level of government: local, regional and national. This study recommends that there should be effective coordination among all level of government and effort should be made as a whole ensuring implementation of desired plan of action.

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