Planning Green-Blue Infrastructure for Urban Climate Adaptation

A Study Related to Urban Flooding Issues in Dhaka

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ABSTRACT

To make the cities more resilient to climate change issues, there are opportunities for planners and designers to consciously deal with the green and blue spaces in the urban landscape. Environmental considerations in urban planning have been playing leading role in the development of planning theory and practice, but the Idea of applying green-blue infrastructure (GBI) is comparatively new. This study focuses on the role of GBI planning as a tool of this adaptation process, particularly in the context of urban flooding. Inland flooding is a common phenomenon in Dhaka during monsoon seasons and the continuous wetland encroachment, unplanned urbanization and several growth-oriented developments are worsening the situation. Climate change-risk has added new concern in the current flood-management regime. In that case, this study offers a comprehensive framework of GBI planning that aims to deal with the urban flooding phenomenon as well as the unplanned human-development in Dhaka by increasing its adaptive capacity. The proposed framework addresses the bio-physical and socio-political aspects of GBI and their relationship with relevant sectors such as urban planning and flood-risk management. A mixed method technique was applied to test the framework, including expert's interview, policy exploration and social survey. This cross-sectional study of the current planning system showed that, there are developments in institutional domains, but the development scenario is not balanced. Different technical approaches often lack social relevance which consequently lose efficiency. In the institutional environment, policies and programs related to climate change adaptation have been developed, but at local level, collaboration and multi actors' participation is not properly evident. In this situation, parallel development that interplays between technical and socio-political system is urgent to deal with flood adaptation. In this regard, some recent initiatives in the study area related to GBI development showed promising upgradation of the current system.

Key words: Green-blue infrastructure, Urban flooding, Climate change, Urban planning, Flood-risk management.

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Abbreviations

BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BUET	Bangladesh University of Engineering and Technology
CEGIS	Center for Environment and Geographic Information Service
DAP	Detail Area Plan
DMA	Dhaka Metropolitan Area
DMDP	Dhaka Metropolitan Development Plan
DNCC	Dhaka North City Corporation
DSCC	Dhaka South City corporation
DWASA	Dhaka Water and Sewage Authority
FAP	Flood Action Plan
GBI	Green-blue infrastructure
GBM	Ganges-Brahmaputra-Meghna
GHG	Green House Gas
IWM	Institute of Water Modelling
IWFM	Institute of Water and Flood Management
MoEF	Ministry of Environment and Forests
NAPA	National Adaptation Programme of Action
RAJUK	Rajdhani Unnayan Kortipokkho
SUDS	Sustainable Urban Drainage System
UHI	Urban Heat Island
WARPO	Water Resource Planning Organization

1.INTRODUCTION

1.1. BACKGROUND INFORMATION:

On one hand, climate changes around the world are stressing urban areas with increased number of heat waves, instance droughts and inland flooding, especially for the coastal regions threats are even devastating with frequent storm surges and sea level rise (Rosenzweig et al., 2011). On the other hand, it is largely argued that cities are majorly contributing to the global climate change with increasing consumption and waste generation (Roy, 2009). More than half of the world's population are living in urban areas (UN, 2014) and by the year 2025, the urban population will represent more than two-thirds of the global population including more than 90% of new population from developing countries (UNFPA, 2007). Thus, the higher concentration of people and built-infrastructure within the cities are also vulnerable to various locally induced climate change impacts (Bigio, 2002). Since cities are the major cause of anthropogenic warming and emission of greenhouse gases (IPCC, 2007) urban adaptation is an approach for minimizing the vulnerability against present and future impacts of climate change rather than the mitigation measures to minimize causes of climate change. Although synergies between mitigation and adaptation can take place in the urban mechanism, urban adaptation has wider prospect for comprehensive actions relating different sectors (Carmin et al., 2012). This adaptation can also take many forms (e.g. structural, non-structural) where structural urban adaptation involves novel techniques and implementations and non-structural adaptation involves communication and management plan.

To make the cities more resilient to climate change issues, there are opportunities for planners and designers to consciously deal with the green and blue spaces in the urban landscape (Demuzere et al., 2014). Environmental considerations in urban planning is not a new idea and have been playing a leading role in the development of planning theory and practice, but specifically the idea of green infrastructure is comparatively new (Benedict and McMahon, 2006; Kambites and Owen, 2006; Walmsley, 2006; Mell, 2008; Demuzere et al., 2014). Other similar approaches in the planning regime are sustainable development and eco-system services. The concept of sustainable development is quite broad and fuzzy (Phillis & Andriantiatsaholiniaina 2001) and an eco-system service approach is more focused on ecological functions for the human benefit (Haines-Young & Potschin, 2007). In this context, the green- blue infrastructural (GBI)[1] approach can be considered as tool for delivering eco-system services in environmental policies of planning (Demuzere et al., 2014).

There are several potentials of GBI to upgrade the quality of built environment by its eco-system services. For example, increasing bio-diversity, pluvial flood prevention, reduction of ambient temperature and urban heat island (UHI) effects, improvement of air-quality, increasing carbon storage, protection from storm surge, lowering energy demand and further (Foster et al, 2011). These are bio-physical performances of the GBI. There are socio-political factors that influence GBI's performance and this is relatively a less explored dimension of GBI planning (Matthews et al., 2015). Despite of the generalized global concern, it is argued that climate change adaptation can take place in different spatial and social scales and its success depends on how it is evaluated against different criteria of that different scales (Adger, Arnell, & Tompkins, 2005). So, depending on the different local circumstances the adaptation can be operated focusing on the significant environmental, social as well as economic factors. In this research,

[1] I'll use the term, 'Green-blue infrastructure (GBI)' throughout paper which is derived from the term 'Green Infrastructure (GI)' or 'Green Urban Infrastructure (GUI)' that have been widely applied in many articles.

the potentials of GBI for adaptation are targeted for specific local climate change impacts in urban flooding issues. In the following discussion, some relevant background study will provide the context of the research area with some focuses for urban climate adaptation.

1.2. BACKGROUND OF THE STUDY AREA:

The study area is Dhaka city, the capital of Bangladesh. Although the country is one of the lowest contributor to global GHG emissions, it is facing climate-related issues and is listed as one of the most vulnerable countries due to climate change (Haque, 2012). Situated in the world's largest delta (i.e. Ganges Delta) the country is exposed to adverse coastal hazards. The country has one of the most complex river system in the world with the three major rivers Ganges, Brahmaputra and Meghna (GBM) united within the geography (Khorshed, 2003) (see figure 01). Due to the country's geographical location in this GBM, it is most vulnerable to climate change risks; as studies showed, about 5% increase in precipitation over the GBM basins combined with approximately 1°C temperature increase could result in up to a 20% increase in the flood area in Bangladesh (Dasgupta et al., 2011). Climate change and consequent sea-level rise is evident which has altered the natural rivers flows and the vast low land of the river beds are more prone to flooding. Different modeling studies based on the IPCC scenario studies showed increase of average monsoon rain fall up to 20% and the sea level rise up to 100cm by 2050 (Ahmed, 2006). Apart from many natural impacts the major cities are becoming more vulnerable to climate-related effects because of the rapid urbanization that brings higher population density, encroachment of green and water retention areas and more built-up areas with solid surfaces. Among others, the capital city Dhaka has the highest population increase with migration from the rural areas and facing difficulties to cope with the increasing population (BBS, 2014).

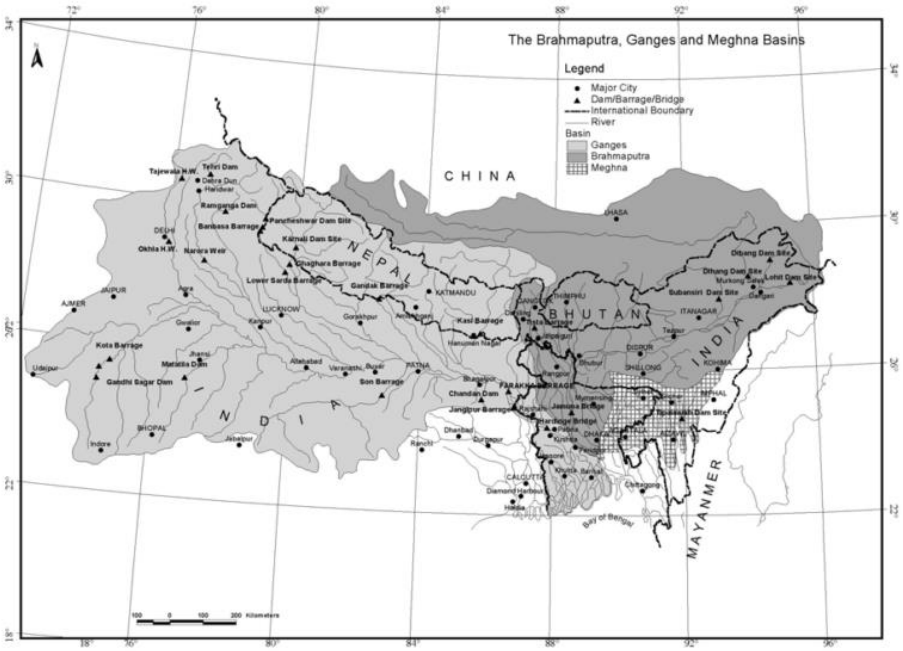

Figure 1:*Map of the GBM catchment areas and the lowest riparian Bangladesh. (Source:* Ahmed, 2006)

1.3. PROBLEM STATEMENT:

Dhaka city's environmental problems are mostly human induced but climate change is posing major threats in particularly flooding and heat stress (Alam et al. 2007). The rainfall patterns are erratic with higher intensity during the monsoon and less rainfall throughout the year (see figure 02), which is related to frequent pluvial flooding, and the city is also located in an active river tidal zone where low areas are often inundated by the surrounding rivers (Haque, 2012). The flooding problem in Dhaka damages the built-structures, roads and other transport infrastructures as well as hinders social activities that leads to huge economic and social loss. "The 1998 flood caused damage to more than 262,000 shelter units, or 30 per cent of the 860,552 units in the Dhaka Metropolitan Area, at a cost of Tk. 2.3 billion" (Alam & Rabbani, 2007, p-89). During that flood event, water from excessive rainfall got clogged inside the protected areas of the city and could not drain-out to the surrounding rivers since the river water-level was higher (Huq & Alam, 2003). This is quite a common phenomenon during monsoon seasons that the low laying areas suffers short term flooding and remain inundated until the surrounding river stage recedes. The drainage infrastructure is also not capable to handle the added pressure from excessive rainfall during extreme events. To worsen the situation, most of the existing canals and water-bodies are either being completely filled-up or losing depth due to heavy pollution. Alam & Rabbani (2007) discussed vulnerabilities of Dhaka due to climate change and argued for new adaptive techniques to deal with inland pluvial flooding where conventional dikes are failing. New measures can be taken for the comparatively underdeveloped eastern part of Dhaka (see figure 03) which is presently more vulnerable to river flooding but also could be at risk of pluvial flooding if same flood defensive measure is implemented. The rapid change of Land-use and land cover in Dhaka plays a major role in its flooding process (Dewan, & Yamaguchi, 2009). Land grabbing and illegal development on natural wetlands and river banks are causing obstruction to cities in-built natural drainage. The city is losing its wetland very rapidly (see figure 04). In the developing context of Dhaka, importance of GBI is being ignored since the continuous loss of greenery is also evident from several studies. Studies like Byomkesh et al, (2012) and Ansari, (2008) show the challenges of urban greening in relation to rapid urbanization. Studies showed that approximately 80% of areas of greater Dhaka had non-urban land-uses with open greenspaces and agriculture but the number has shrunk up to 40% by the year 2005 (Dewan & Yamaguchi, 2008; BCAS, 2006; Byomkesh et al, 2012).

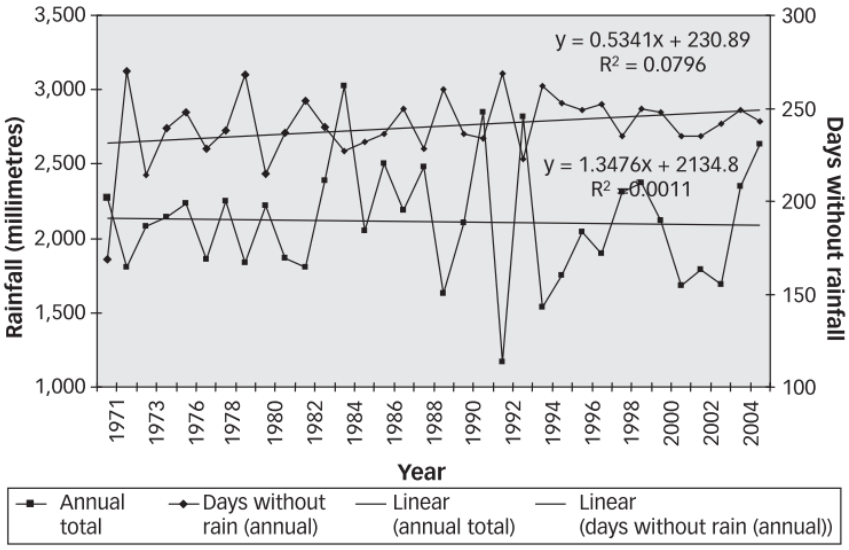

Figure 2:Trend of annual rainfall (1971-2004) showing the days without rainfall has increased with no significant decrease in annual rainfall. (Source: Alam & Rabbani, 2007)

Figure 3: Effected areas by the major flood event in 1998, mostly inundated eastern part of the city. (Source: Alam & Rabbani, 2007)

1.4. RESEARCH OBJECTIVE & RESEARCH QUESTION:

In this research, the focus is on the urban flooding issues of the study area. The main objective is to investigate the existing policy, planning and institutional structures in respect to GBI planning to assess its bio-physical and socio-political performance in the built-ecology at different levels (i.e. local and regional) in respect to the urban flooding issue. To overcome with the objective, this research aims to study the spatial planning oriented GBI concepts to develop a comprehensive framework for GBI adaptation to urban flood-risks. The environmental aspects of the GBI are strongly related to urban hydrology, as storm-water is one of the environmental performances of GBI (Gill et al. 2007;Mell 2008). Therefore, the urban hydrology sector is also a major field of interest for this research. Considering the research objective, the following main research question is formulated to conduct the research:

- How can planning for GBI create adaptation to urban flooding issues caused by climate change in the urban areas of Dhaka?

Under the main research question, the following specific research questions are formulated:

1. What are the climate change impacts that is causing urban flooding of the study area?
2. What is the existing situation of the GBI, drainage system and land-use pattern related to urban flooding in the study area?
3. What is the existing institutional capacity related to planning for adaptation to urban flooding in the study area?
4. What is the social attitude and interaction towards GBI in the study area?

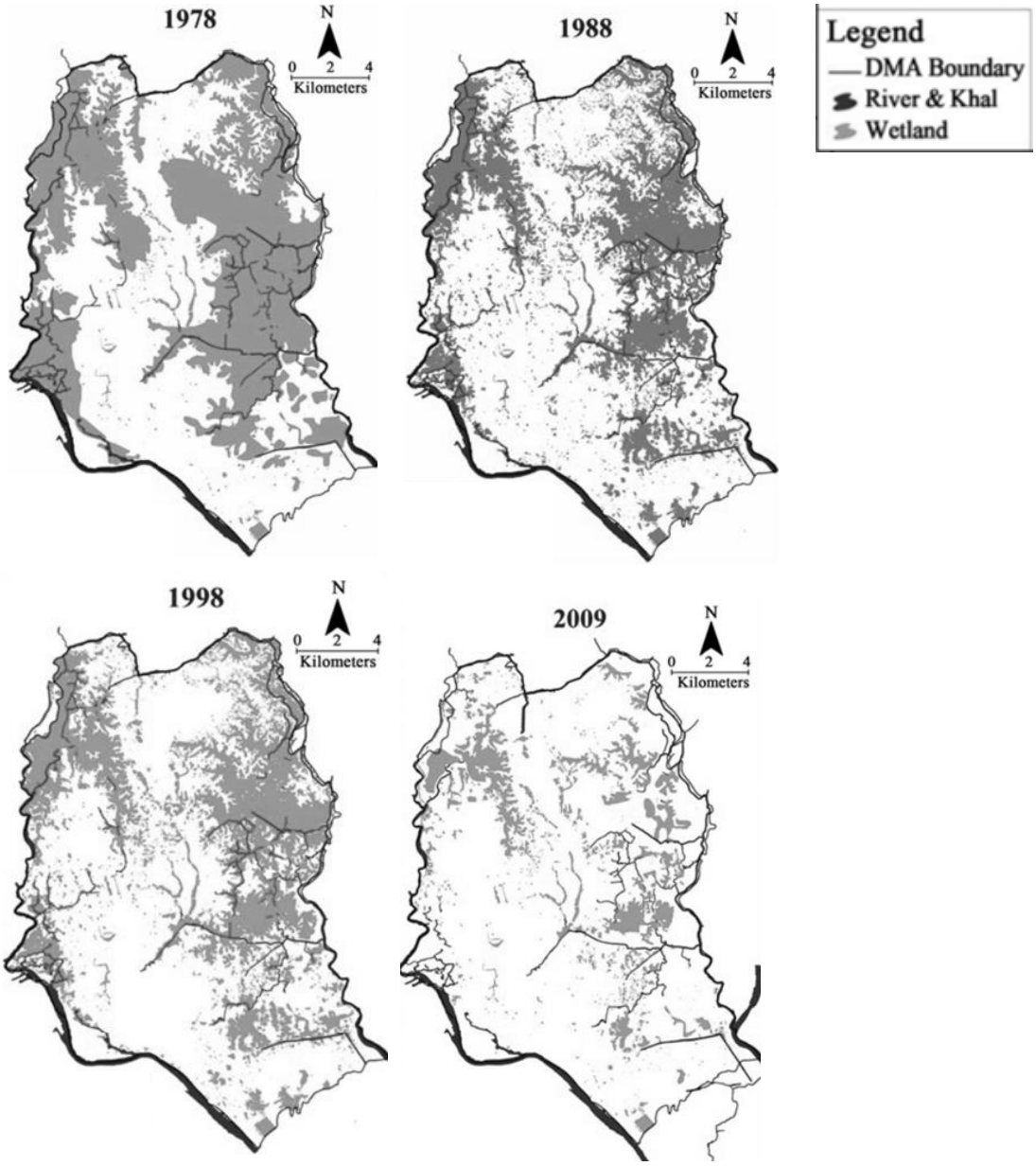

Figure 4: Chronological wetland loss of Dhaka. (Source: Mahmud et al., 2011) *(modified by Author)*

1.5. Scientific relevance of the research:

Applying GBI approach for climate change adaptation is a challenge for spatial planners (Matthews et al., 2015). Specially in the developing context of the study area, there is dominant socio-economic and political pressure in planning institutions. Results from this research provide guidelines for developing a strategic framework for future climate related risks. Research on the environmental service, specifically for climate change adaptation, is a very new and evolving approach of green infrastructure (Wright, 2011). This research can contribute in this new dimension. As a developing country, most of the researcher's attentions are towards community-based adaptation and policy-oriented development measures. Diverse environmental services form GBI as a part of urban eco-system can unfold new dimensions in climate adaptation for renewal of the built-up areas as well as strategic guidelines for future development of the city.

1.6. Social relevance of the research:

As this research relates the bio-physical functions with the socio-political aspects of GI planning, the investigation on institutional environmental of urban planning and flood-risk management have possibly revealed ways s for innovative institutional approach to tackle the growth-oriented planning process existing in the study area. A social survey for analyzing the cultural and behavioral relation with GBI and the users can contribute to the knowledge on the future participation in practice of GBI oriented design and planning. It has indicated the public appeal to new environmental development and can open-up new multi-functional uses related to business, recreation and health benefits. Climate change impacts in deltas is a very well addressed topic in the intellectual domain. Specially in the study area there are many researches on the affects and vulnerabilities of CC in urban and rural areas. Also, unplanned urbanization is another challenge which is well addressed in researches. But researches in adaptation methods, especially in the spatial planning policy domain are still inadequate. Long-term climate policy, integration of flood-risk management and spatial planning, mainstreaming CC are very recent questions in the local context. GBI is very recent concept in urban landscape ecology, and in other domains of urban studies. As the GBI concepts, have already gained popularity in the global cities for urban climate adaptation, it is very relevant to investigate for this research where the climate change issues are prominent. Bangladesh has become a lower-middle income country and starting to realize the importance of environmental issues over economic gain. So, this research will offer new knowledge on urban adaptation practices.

1.7. Structure of the report:

In this report, chapter 1 is the introductory part. It includes background of the study area, problem statement, research objective and questions and also scientific and social relevance of this research. Chapter 2 is the theoretical basis of this research and it contains the theoretical framework. The next chapter 3 is on research methodology. It describes the nature of this research and includes description and selection process of the study area, data collection and analysis methods. Chapter 4 includes the results from the data collection methods which are interview, document survey and questionnaire survey. Chapter 6 in the final chapter and answers the research questions in its discussions, reflects on the methods and theoretical frameworks and concludes the research.

2. THEORETICAL FRAMEWORK:

In this chapter, I'll explain my theoretical lens, which helped to analyze my research questions. I'll explain the concept of GBI theories associated with to understand and analyze the existing urban flood related environmental and spatial planning factors which are relevant for this research. This study will help to put the context of this research into perspective. In this chapter, my effort is on delineating the theoretical framework for this study, which has later shaped the empirical findings of this work.

2.1. THE CONCEPT OF GBI:

The GBI is a relatively new approach in the urban planning regime to address the leading concern of climate adaptation (or resilience). The research on GBI paradigm can be divided into two distinct categories; conceptualization and practical application (Mell, 2008). In this part, I briefly discuss the conceptual aspects of GBI to establish the under-laying rationales of planning implications of GBI. I also explain the development of this concept in brief. It will help to grasp the fundamental ideas and some theoretical orientations of this GBI approach.

Many scholars have defined this concept (e.g. Walmsley, 2006; Sandström, 2002; Benedict and McMahon, 2006; Turner, 2006; Ahern, 2007; Tzoulas et al., 2007; Madureira et al., 2011; Demuzere et al., 2014; Matthews et al., 2015) and the principal ideas of GBI has been evolved from landscape oriented disciplines such as landscape ecology, planning and human geography (Mell, 2008).

The importance of green-space within and around the city was realized in form of structuring urban development for recreational aspects and urban-aesthetics. The works of Ebenezer Howard and Frederick Law Olmsted laid the foundation of realizing green-space as a continuous space. Later in the 20th century the concept of 'continuity' was adopted widely in the landscape ecology principles and showed the importance of strategic spatial planning of green-blue spaces (Ahern, 2007). And growing attentions towards natural environment for eco-system services (e.g. restoring biodiversity, regulating pollutions) led the idea of multiple environmental functions and their valorizing of these green-blue spaces (Madureira et al., 2011).

Use of the term 'infrastructure' had significant impact on realizing urban green-blue spaces for public good as it promoted the concept towards large-scale, public infrastructural investment for human benefits (e.g. waste-water treatment, storm-water drainage, transportation, energy infrastructures) (Matthews et al., 2015). The quality of life has also become an important part of GBI concept. It is associated with social benefits such as health, physical activities and social interactions with outside environment, leisure and other social activities related with public satisfactions (Mansor, Said, & Mohamad, 2012)

The economic conceptualization of the GBI concept is another major turn for establishing the concept in practical field. Fiscal constrains dominate environmental ideals and uncertainty of climate-risk creates difficulties for strategic policy-making. The economic rational introduced the cost-benefits or trade-off between environmental imperatives and urban-growth in the GBI concept. Now, seeing GBI as a 'natural capital', the focus-shift has given more opportunities to the planners to use the multiple benefits of GBI and establish policy (Matthews et al., 2015).

2.2. Definitions of Green infrastructure (GI):

Now, in the following, I've introduced the definitions of GI to portray a concise sense of it. At the same time, it will show the varying focus of GI from previous researches.

Madureira et al. (2011, p.141) defined GI as,

"an integrated and coherent system of multifunctional green areas that links the city with the countryside through biophysical and social infrastructure".

Demuzere et al. (2014) and Ahern (2007) interpreted GI as a hybrid system of green-blue space and built structure which can contribute to environmental and social benefits through its ecosystem services. According to Ahern (2007, p. 267);

"Green infrastructure is an emerging planning and design concept that is principally structured by a hybrid hydrological/drainage network, complementing and linking relict green areas with built infrastructure that provides ecological functions".

In this definition, the blue (water) element is defined and considered as an inseparable part of GI concept. Authors e.g. Matthews et al. (2015), Kambites & Owen (2006), Tzoulas et al. (2007), Benedict and McMahon (2006), highlighted the need of strategic planning and systematic management of GI for an inter-connected and multifunctional network to provide ecological, social and economic benefits. Same policy focus by the Natural England (2009, p. 7);

"Green Infrastructure is a strategically planned and delivered network comprising the broadest range of high quality green spaces and other environmental features"

There are many definitions of GI by various scholars. Many of them has varying ideas (Wright, 2011). But, I've selectively mentioned the above definitions to show the core ecological basis and theory orientation of the GI and later the addition of blue and planning consents with it which made the concept more effective for practical interpretation. Wright (2011), analyzed different concepts of GI and identified the core consisting ideas. They are; connectivity, multi-functionality and green. Here, green implies not only the natural green-blue objects but also the infrastructural element which improves environmental quality (e.g. renewable energy structures).

In that aspect Mell et al. (2013, p. 297)'s derivation of GI in my opinion, is showing the planning control over the ecology and more specified for urban environment. They defined GI as;

"the biological resources in urban areas that are human-modified and primarily serve an overt ecological function' and which are 'intentionally designed and deployed primarily for widespread public use and benefit".

2.3. The study's conceptual focus of GBI:

From the above discussions on the conceptualization of GI, it is perceptible that the range of GBI approach is quite broad. In this research, I find it necessary to explain the wider-aspect of the GI and at the same time to focus on the flooding issue.

The GI concept has developed from ecological theories and has been evolving with diverse narratives from many disciplines (e.g. geography, spatial planning, development studies). This process of development has branched out to two different planning fields; conceptual and practical (Mell, 2008). It can be also divided into environmental theory and socio-economic policy (Wright, 2011). The practice-oriented

approach of GI includes the multifunctionality, the complex relationship between environment, society and economy and also sustainable development concepts. These ideas have been developed in the geography, development studies and planning disciplines. Whereas, the theory based rationales have been developed in the landscape ecology disciplines which are focused on ecological networking or connectivity (Mell, 2008). GI has no distinct theoretical foundation (Mell, 2008) but, the key ideas in GI are from landscape principles (Ahern, 2007). In that case, 'connectivity' is one of the key principles of GI which is often considered as ecological-networking. From the landscape-ecological perspective, the concept of 'connectivity' depends on the multi-scale approach with strong relationship of landscape pattern and its process. This approach is fundamentally grounded in 'hierarchical theory', realizing landscape as a hierarchical network-system that functions at multiple scales (Ahern, 2007). Multi-scale approach is well established in ecological science to understand the dynamic structure of nature. Also, social-structure must be understood at multiple scales to address the emerging institutional need in understanding the interactions between human and nature agency. In that aspect, the hierarchy theory can be used for conceptualizing both ecological and sociological system (Warren, 2005). So, it is imperative to understand the holistic manner of the GBI concept rather than interpreting theories for specific sectors.

Now referring to the practice-oriented part of GI approach, the multifunctionality and their complex relationships, policy and practice integration these ideas are in focus of the present advancement of GI research (Mell, 2008). The climate change issue also extended the functions of GI to climate change adaptation and mitigation (Ahern, 2007; Gill et al., 2007). The GI concept is relatively new in theory and this focus-shift has made it more likely to change, similar to planning theory (Wright, 2011). This is a transition towards practice. This transition refers to the integration of planning-policy, cooperation between organizations, multi-functionality and combinedly they can contribute to the development of planning policy (Mell, 2008). This can be justified under the larger socio-economic and environmental benefits, but the core principles of GI can be contested if interpreted into policy and practice (Wright, 2011).
But on the other hand, these diversified ideas and consequent functions will create more scope of integration and application. Ahern (2007, p. 282) therefore, provided some directions for GI practice;

"for green infrastructure to advance and to make legitimate contributions to urban sustainability, it must be practiced in a transdisciplinary manner – for it must meet the needs of stakeholders, benefit from the support of decision makers, engage scientists and engineers and challenge planners and designers to innovate. The proof of its success depends on the extent to which monitoring and systematic evaluations of long and short term results are made."

The climate change issue has created a more desirable platform for the GI adaptation especially, in the environmental policy and management sector. Now GI practice is more risk-based approach to cope with the uncertainty primarily from anthropogenic adversities and being realized as climate adaptation strategy (Matthews et al., 2015). GI has already reached high levels of policy-making (i.e. European Commission, 2010) and being deployed in planning policies at regional and city level (Wright, 2011).

In that context, the practical orientation of GI is important in planning and management related policy-making for climate adaptation, but these decisions are also dependent on the system's ecological and social capacity for resilience. Therefore, I'll keep the focus on planning for adaptation where both theoretical and policy aspects of GI will contribute through an integrated framework. Now in the following section I'll elaborate on GI's position in urban climate adaptation specially for urban-flooding (in respect to the main research objective) and later explain the significant components of theory-practice relationship of GI in the framework.

2.4. URBAN CLIMATE ADAPTATION:

In the previous discussion on GI conceptualization, I've explained the recent state of the GI approach which is more holistic in nature. To plan for urban areas, the synergies of existing landscape and urban system can be achieved by this GBI approach if it is adopted in an integrated manner. The arguments related to it was grounded by the 'theoretical and practice-oriented', 'technical and social' viewpoints of GBI planning. Now, in the following part, I would briefly explain the urban adaptation, especially from a planning perspective. Later, this discussion will lead to explaining the position the GBI planning as an urban adaptation from flooding issues due to climate change and anthropogenic causes.

Many scholars (Adger et al., 2005; Brooks, 2003; Carmin & Zhang, 2009; Huq et al., 2004) explained climate change adaptation based on the definition by IPCC (2001) which is, the system's (human or nature; ecological, social or economic) adjustment in response to present or expected climate change effects to regulate the adversities or to take advantage from new beneficial opportunities. Here, the adaptation can be individual or public, proactive or reactive, autonomous or planned.

So, from this definition it is understandable that, the process of adaptation has been distinguished between standalone action for a short-term goal and inter-related actions of managing multiple risks for a long-term goal. In relation to that, adaptation-planning is based on long-term objectives. The adaptation planning gives recommendations based on the current and future climate-risks and their interaction with other sustainable policy-objectives such as natural resource management, water management, disaster preparedness, urban planning, sustainable development, poverty reduction, etc. (Füssel, 2007). So, planning for climate-adaptation requires inclusive understanding of the current and future risks and non-climatic factors related with present climatic change effects. This planning approach is dependent on wider policy context and inclined to mainstreaming of climate adaption for multiple benefits. The policy domain of adaptation is not independent from other development sectors. Because, adaptation action is not an isolated process and decisions for adaptation actions or plans also depend on the other demographic, cultural and economic changes associated with climate change effects in local and global context (Adger et al., 2005). So, inclusiveness in the planning approach is imperative in a sense that it should include the necessary strategic changes in physical and social environment to cope with the future vulnerabilities as well as current variabilities of climate change.

Policy development for adaptation planning is an emerging field (IPCC, 2007) and there are diverse factors that can influence the adaptation activities (e.g. predictability of climate events, climate sensitive and non-climatic sectors, technical and institutional measures, spatial and temporal factors, wide range of actors) (Füssel, 2007). So, more knowledge input is necessary in this particular field by combining different theoretical and practical approaches. For that, Füssel (2007, p. 267) argued for a flexible approach of measuring and planning adaptation by combining different practices suitable for that particular decision context. He explained a 'complex integrative approach' for assessing and planning adaptation where mainstreaming of adaptation will happen in the planning and management context by integration of climate-based adaptation and other sustainable development goals. Countries are integrating mainstream adaptation to their national policies where major climate change threats are prominent (Huq et al., 2004) and there are guidelines for integrated adaptation plan such as the UNDP-GEF Adaptation Policy Framework which is internationally being applied in several adaptation projects (e.g. Mainstreaming Adaptation to Climate Change, MACC project) (Burton et al. 2005).

2.5. GBI FOR ADAPTATION PLANNING:

From the previous discussion, it is perceivable that planning for climate-change adaptation is an inclusive or comprehensive process. I've also explained the GI approach which has a similar perception. In both discussions, the commonality is the integrated approach that includes the social and technical aspects in GI and climatic and non-climatic factors in adaptation from planning perspective. In this part, I'll explain the role of GI approach as a tool of this adaptation process particularly, in the context of urban flooding.

Predicted future-risk of intensification of hydrological cycle and consequent increase in climate calamities due to climate change and future-risk regarding non-climatic reasons such as population increase and land-use change is creating conceptual challenges for the water managers (Hennessy et al., 2007; Kundzewicz et al., 2007; Short et al., 2012). Under this circumstance, adaptation in the water management sector refers to more innovative solutions which relate the conventional drainage-based system with more ecological techniques. Sustainable Drainage Systems (SUDS), Low Impact Development (LID), storm-water Best Management Practices (BMPs), Water Sensitive Urban Design (WSUD) all these approaches are based on the same principle under different labels which is initiating natural drainage process through GI (see figure 05); in general, they can be addressed as sustainable urban drainage system (SUDS) (Fryd, Dam, & Jensen, 2012). Water retention, infiltration, transpiration, evaporation, natural passage etc. are the natural processes that the hybrid hydrological techniques primarily aim to achieve by designed water infrastructures (e.g. constructed wetlands, swales, water-parks, retention ponds) into the system.

As a sustainable development, GI also addresses the social, economic dimensions along with its environmental functions. For example, a designed flood-plain can also be an aesthetical urban place which will increase health and nature restorative services. From the economic point of view it's a trade-off between development and maintenance costs and multiple ecological and social services (Demuzere et al., 2014). Therefore, the sustainable drainage infrastructures can be seen as a part of GI infrastructure which enhances the ecological and social functions by synergistic interventions within the system that connect and protect the built and natural areas (Ahern, 2007). From the climate change point of view, the role of water has major importance in the GI concept to research new means of managing and regulating thus promoting the value of the concept (Mell, 2008). As an adaptation and mitigations measure, the GI provides eco-system services that has multiple benefits to ecosystem and human-wellbeing (Demuzere et al., 2014) and along with these other benefits the GI approach can be a very appropriate adaptation strategy (Gill et al., 2007). Therefore, the Blue (water) component is essential in the GI concept and Green-blue infrastructure (GBI) is more appropriate term for my research.

Now, in the adaptation context managing GBI primarily is about managing risk from the challenging anthropogenic activities and present planning system has limited institutional capacity to realize large scale GBI initiatives through spatial planning (Matthews et al., 2015). The sustainable water-management sector also has the requirement of integrating spatial strategies with other technical and human aspects for inter-disciplinary decision making (Fryd et al., 2012). Whereas, the conventional water-resource planning is not so much aligned with the critical socio-economic domains as the urban planning is which is necessary for large-scale climate change adaptation (Short et al., 2012). Therefore, for governance and operationalization of GBI approach the institutional structure is also susceptible to change according to the climate change context.

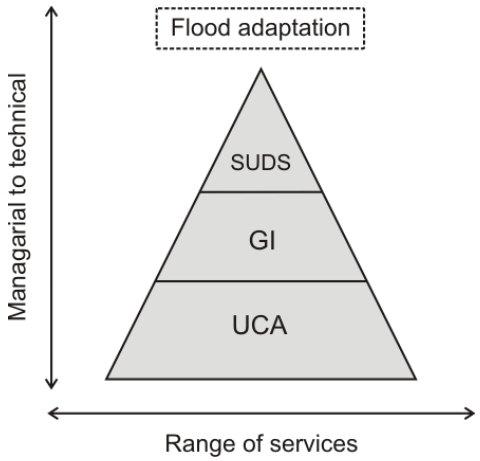

Figure 5:The focus of Sustainable urban drainage system (SUDS), Greene infrastructure (GI) and Urban climate adaptation (UCA) towards flood adaptation. (source: Author)

2.6. THE THEORETICAL FRAMEWORK:

Now, in this section I explain the framework with its relevant elements of GBI planning. This framework is derived from previously explained conceptualization of GBI approach, especially based on the scholarly work of authors who have conceptualized GBI from integrated socio-technical perspectives such as Byrne & Yang (2009), Matthews et al. (2015), Chappin & van der Lei (2014) and Fryd et al. (2012).

According to these studies, there are two poles of the GBI concept i.e. bio-physical and socio-political. The bio-physical and socio-political capacities are inter-dependent and successful adaptation of GBI depends on synergistic development on both sides. Byrne & Yang (2009, p. 38) have mentioned that four inter-connected factors are necessary for GBI adaptation; (1) biophysical characteristics of the built environment; (2) planning philosophy (3) governance structure and (4) residents' perceptions In GBI projects.

Later, Matthews et al. (2015) further developed this idea and re-conceptualized these four aspects into two major categories (i.e. bio-physical capacity and socio-political capacity which includes 2,3 and 4 from Byrne & Yang's model). They introduced the nature and climate agencies into the framework. The climate agency refers to the uncertainty of climate change impacts which will influence the decision-making process, such as vegetation suitability for future climatic conditions. The nature agency refers to the environmental effects from the GBI itself, such as health hazards through the inhalation of pollen. But, in general, their work is inclined towards institutional development for GBI with respect to 'risk-based' approach (i.e. considering uncertainty of climate agency) in the mainstreaming climate-adaptation debate rather than capital-based approach (i.e. multifunctionality and economic utilization of GBI). Chappin & van der Lei (2014) also showed these two inter-connected poles for infrastructural development for climate adaptations in the form of a socio-technical infrastructural system.

Therefore, different interconnected variables which are import for the efficacy of GBI in terms of urban flooding will be addressed in this framework as functional-domain considering these two major (i.e. bio-physical and socio-political) categories. But, another important aspect of GBI is its practice-orientation (previously mentioned in section 2.3). It is important to indicate a proper practice-approach and positions of the practitioners in the GBI planning process. In this regard, the previously mentioned models generally

indicate the factors which can determine or influence the capacity. Whereas, there are different disciplinary attitudes to interpret or utilize these factors and should be integrated in a mutually beneficiary way. For example, the hydrological thinking can determine the quantitative aspects of space for water whereas, the connectivity of water for multiple ecological and social benefit can be explained from landscape ecological study. For that, the planning framework developed by Fryd et al. (2012) (see figure 06) has a praiseworthy contribution. They explained three professional perceptions which are; (1) bio-physical process by engineers, (2) spatial strategies by architects and spatial planners and (3) adaptive strategies by management experts (see Fryd et al. 2012, p. 868). Integrating this practice aspect in the GBI framework will give useful indication on professional engagement and can help the decision-making process. But this practice-domain should be flexible and indicative rather than determinative. Because, it is explained earlier that the adaptation process of GBI is complex and dynamic and should be implemented in a transdisciplinary manner (Ahern, 2007). Particular approach can be adopted in an integrated manner depending on the factors which are constraining the capacity of the process and their severity. For example, if there is social resistance against environmental protection more managerial approach would be necessary to involve multiple actors to realize the project. In the following part, I've elaborated on the elements of the practice and functional domains and their interactivity in the GBI planning framework.

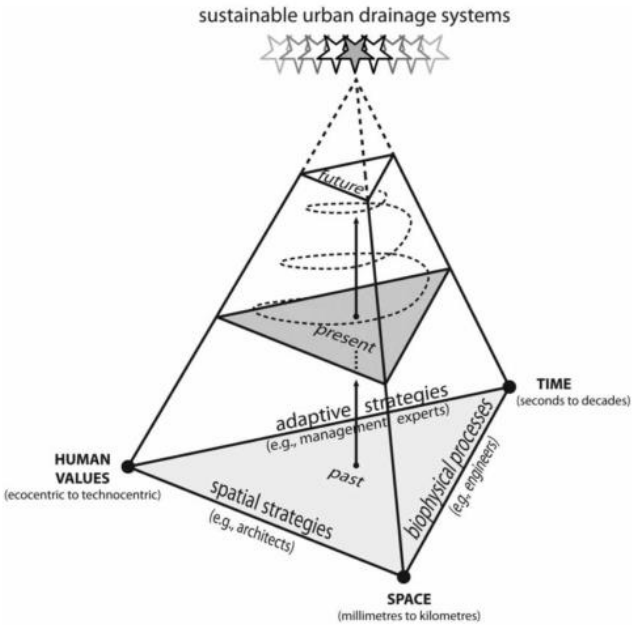

Figure 6: Planning and design framework of SUDS developed by Fryd et al., (2012). (source: Fryd et at., 2012)

2.6.1. THE PRACTICE-DOMAIN:

In this section, I explain the practical-domain mostly based on Fryd's framework. Other scholerly works i.e. (Ahern, 2007), (Mell, 2008) have provided conceptual support in this topic. Fryd et al. (2012) used the human value, space and time concepts from Agarwal et al. (2002) and aligned the three concepts with the practice approaches. The 'human decision-making' (or human-values) represents the values of actors involved in the decision-making process, the 'space' represents interconnected scale of the system (e.g. local to regional) and the 'time' represents the system's coping capacity per time-duration and past, present and future state.

2.6.1.1. URBAN HYDROLOGY:

Urban hydrology involves the quantitative and qualitative aspects of the bio-physical process of urban areas for GBI adaptation. It is a more technocentric approach and related to water-engineering disciplines. According to Fryd et al. (2012)'s model, the urban hydrology approach is situated in the 'time-space' domain. For example, the drainage system's design based on the return period of storm-event and their spatial limits. Fryd's framework argued for an inter-disciplinary manner where positions between human-values and time are important for decision-making process. In my opinion, this approach will also have strong influence by the 'human value' aspects depending on the socio-political conditions regarding the desired transdisciplinarity. For example, intervention of novel techniques can be challenged by the cultural-context in which it is designed for (Castro, Barrera, & Martinez, 2004).

2.6.1.2. SPATIAL STRATEGY:

Spatial strategies employ protective, defensive, offensive or opportunistic spatial strategies based on the adaptation goal and spatial context. Connectivity, pattern and scale are the most important terms in landscape to understand its ecological and human functions. Especially 'connectivity' is most relevant for water (blue) networks in the highly modified landscapes of urban areas (Ahern, 2007). The multi-scale adaptation of GBI is also another consideration in this discipline to harmonize the society and ecology (Warren, 2005). It deals with strategic decisions regarding land availability for GBI and applies spatial techniques such as greening of existing infrastructures, connecting and hybridizing built and natural networks etc. In Fryd's model, it is situated in the 'space-human value' domain but the temporal factor is also an important consideration for climate-change uncertainty.

2.6.1.3. ADAPTATION MANAGEMENT:

I've mentioned that, managing GBI for climate change effects is mostly about managing risks. Therefore, 'uncertainty' is the most challenging term for this approach. It is a more collaborative or communicative approach and deals with multiple actors, temporal issues and multiple governance level. Therefore, it is more tending towards mainstreaming of GBI or more generally climate-change policies to tackle the dynamic problems. Multi-functionality is one of the strategic aspect of GBI management, although it can be defined from a capital-based approach but also valorization of the associate social and ecological benefits makes it acceptable as trade-off. Multi-stakeholder platform is an participatory or democratic process of conflict management and it is emerging in the water-management sector (Warner, 2005). In Fryd's model it is situated in the 'human value-time' domain, but decision and implementation also depends on different institutional and governance levels. Because a successful adaptation strategy means it should meet its own individual goal along with improving others to reach their goals and consequently involving multiple scales for evaluating and implementation (Adger et al., 2005).

2.6.2. THE FUNCTIONAL DOMAIN:

The functional domain of the framework consists of bio-physical aspects and socio-political aspects of GBI in terms of adaptation planning. In the following sections, I'll elaborate on these aspects.

2.6.2.1. BIOPHYSICAL ASPECTS:

In this section, I've discussed the biophysical aspects of GBI planning from multi-disciplinary perspective (i.e. urban hydrology, spatial planning and management) to identify the important elements or indicators which are relevant for particular problem of urban flooding in the study context. Previously mention

concepts (i.e. GBI, SUDs, UCA) and relevant scholarly works (i.e. Fryd et al. 2012; Matthews et al. 2015; Byrne & Yang 2009) has provided the theoretical basis for this. The diagram of figure 07 is showing the conceptualization of GI for climate adaptation developed by Matthews et al., (2015).

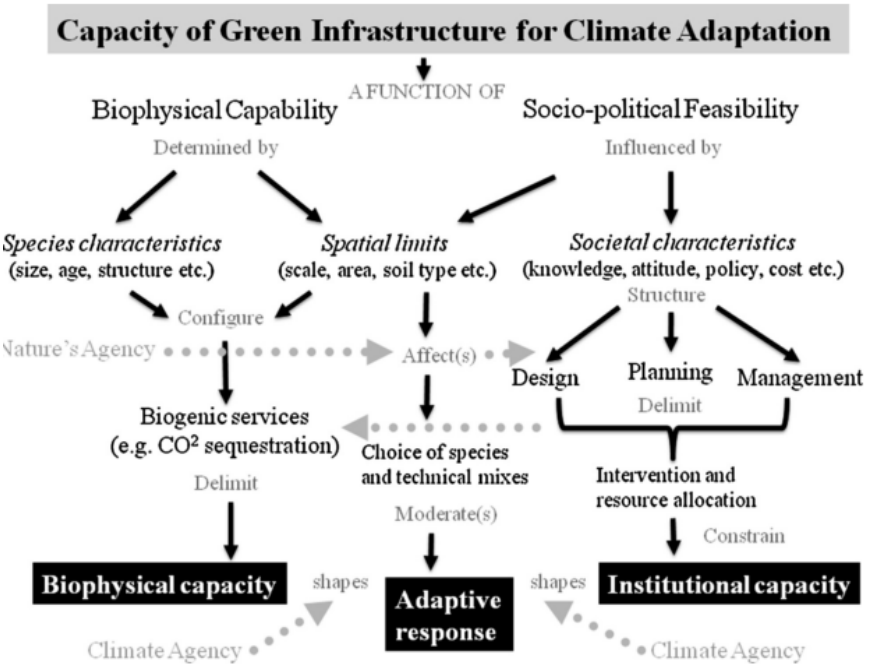

Figure 7: Conceptual model of GI for climate adaptation developed by Matthews et al., (2015) (Source: Matthews et al., 2015)

The bio-physical aspects of GBI primarily concern the ecological interactions of green-blue spaces with the built-up system. For vegetation purposes; plant characteristics and appropriateness for the specific location, soil-conditions, local macro and micro-climatic conditions (e.g. temperature, wind flow, precipitation), structural condition of the buildings for plantation etc. are the most important aspects which are recognized by empirical researches (Matthews et al., 2015). There is still need of empirical knowledges on the bio-physical capacity of greenspaces which can help the designers, residents or city managers to respond the greenspace requirements in the built conditions and their trade-offs (Byrne & Yang, 2009)

For urban flood adaptation, the storm-water management issues of GBI are important and can be understood as more technical environmental service of GBI (Wright, 2011). For storm-water management purposes; local precipitation pattern, surface cover and elevation of the terrain, dynamics of evaporation, transpiration, irrigation, interception etc. are the important quantitative measures that need to be addressed for controlling storm-water run-off. The quality control of this storm-water run-off is another emerging issue for GBI or SUDS approach because of the contamination problem if blended with other natural and built system (e.g. playing fields for temporary wetlands) (Fryd et al., 2012). These quantitative and qualitative aspects of storm-water runoff are related to urban hydrology disciplines and the hybrid drainage system can be designed according to the variable parameters of water flows. There are other aspects such as, scale, land-use and area available for GBI, networks of these structures etc. which are more related to spatial planning disciplines.

2.6.2.1.1. NATURAL FEATURES:

Selection of plants for urban greening is important depending on its physiology. The biogenic services from a plant (e.g. interception, evaporation, transpiration) depends on its physiology (Farrugia et al. 2013 cited in Matthews et al. 2015) and constraints for plantations in urban areas such as, interference with service lines, soil requirements, tolerance level from pollution are important factors that require careful section of plant species for GBI design (Matthews et al., 2015). Soil type is very important for storm-water runoff because of the infiltration capacity for example, sandy soil has faster infiltration and clay soil has slower infiltration (Fryd et al., 2012; Gill et al., 2007).

For climate change adaptation, risk associated with adverse climate effects is a prior concern in GBI planning. The uncertainty factor makes it difficult to measure accurately rather, it is understood in probabilistic terms (Matthews et al., 2015). Matthews et al. (2015) explained that, although it is difficult to determine the exact effects of the changing climate, the trend of this change and probable future effects should be an important actor for GBI adaptation. For example, the vegetation implemented in an urban area should also be able to sustain in its future climatic context. The local climatic conditions (e.g. precipitation pattern, temperature, wind flow) effect the quantitative aspects of water management need to be considered in the planning process to determine the service level of the system. For example, the drainage system can be designed targeting the 'return period'[2] and duration of a major rain event but also considering the variability of it as the climate change makes it uncertain (Fryd et al., 2012).

2.6.2.1.2. HUMAN-SETTLEMENT FEATURES:

The surface cover, surface elevation, land-uses and urban form these are relevant urban features for GBI and its performance in flood management. The rainwater run-off depends on the surface types and the slope of the area (Fryd et al., 2012; Gill et al., 2007). More permeable and vegetated surface decreases the storm-water runoff (Demuzere et al., 2014; Gill et al. 2007; Fryd et al., 2012).

The urban morphology is more appropriate for GBI if perceived as continuous element of different spatial scales (e.g. regional, local) and forms (corridor, patch, matrix) and very useful in spatial strategic thinking (see previous section 2.6.1.2). But, discretely it is a major physical element that allows green intervention in the settlement. For example, the green roofing, wall greening etc. depends on the structural condition (e.g. longevity and load barring capacity) of that built form. Compact and small-grain urban form can create more options for urban greening within the city and large open space in the periphery for more infiltration area and flood plains (Hamin & Gurran, 2009). In that sense, the sustainable urban form concept can be aligned with GBI development. The existing land-use will show a possible area for GBI and natural drainage provisions in the city.

The drainage infrastructural conditions such as; its drainage and storage capacity, sewage system (i.e. combined or separated) have effect on the quantity and quality of the water-flow. Various storm-events challenge the drainage system in various ways. For example, intensive storm events generate high flow rates and employ large pressure on the storm water drainage elements. Whereas, the rain events with lower intensity but long duration generate large run-off volumes which challenge the capacity of storm-

[2] Return period is the interval period of a rain event. For example, a 5-year rain-event means a similar rain-event will occur in every 5 years.

water storage elements. In terms of water quality, the combined system (sewage and storm water in a single pipe) collects household and industrial waste water with the storm water which need to be treated in waste water treatment plants. But, in separate system (individual pipes for household, industrial waste and storm water), storm water is generally discharged directly into the natural water bodies (Fryd et al., 2012). Therefore, implementation of GBI (or SUDS) measures need to deal with the existing drainage system to reach the environmental goals through optimal alterations.

2.6.2.2. SOCIO-POLITICAL ASPECTS:

The socio-political aspects of GBI are more related to management approach and depend on the institutional arrangements. According to Matthews et al. (2015, p. 161), "these factors are less readily resolved through technical planning and management approaches, and are less understood".

2.6.2.2.1. GOVERNANCE PRACTICE:

The political context in which the planning decisions are made influences the GBI planning (Young & McPherson, 2013 cited in Matthews et al. 2015) . In this case, the attitude of the government for climate adaptation and more specifically urban flood management is a concern. Alignment with the global plans and political agendas, local agendas, mainstreaming of climate change policy, planning philosophy of the leaders, administrative hierarchy etc. are the influential factors for GBI adaptation. The discrepancy between growth based development and climate mainstreaming can indicate the attitude towards GBI development (Füssel, 2007; Lim et al., 2004).

2.6.2.2.2. INSTITUTIONAL ASPECTS:

The institutional and operational capacity of the governing agencies are deciding factors of socio-political function of GBI. The complete realization of plans, maintenance and monitoring depend on this. For example, partial development of a highly technical solution can fail the complete system. Significant efforts in understanding the agency and institutional dimensions can lead to better understanding of the role of GBI in urban areas which are preparing for climate change (Matthews et al., 2015).

Policy instruments, strategic plans, environmental laws etc. are governance tools to regulate and control the settlement development (see also p. 19). To promote GBI, its regulatory barriers should be identified and requirement should be modified to facilitate the choice of GBI (Dunn, 2010). Land-use regulations and strategies can create scopes and can also constrain GBI planning. Mainstream policy discourse related to climate change is an important aspect for GBI realization (Matthews et al., 2015). There are internationally developed adaptation assessment programs such as the National Adaptation Programmes of Action (NAPA), the Climate Change Adaptation through Integrated Risk Reduction (CCAIRR) which are being adopted in the national policy by developing countries (e.g. Bangladesh) for alternative adaptation actions. Building codes and regulations can also include guidelines and rules to support GBI planning.

Budget allocation for implementing and maintaining GBI project is an important issue for the governing authorities. Other economic sectors will challenge the GBI planning such as property value increase, commercial growth etc. In this case, the wide range of social and economic benefits from a GBI project have been given priorities to GBI practice, by offering multiple socio-economic functions and also promoting other economic growths (Wright, 2011). So, financial capacity of the implementing agencies as well as their ability to involve other financial stakeholders play a significant role in GBI planning. Difficulties

in budget allocation and urgency can constrain municipal initiatives to change traditional approaches (Dunn, 2010).

2.6.2.2.3. SOCIAL ASPECTS:

Resident's perception and utilization of the green-blue spaces will influence the decision making of GBI planning. It is important to manage GBI developments in a social participatory system where people often take stewardship of their surrounding environment and contribute in improving the quality according to their suitability (Demuzere et al., 2014). The effectiveness of climate adaptation partly depends on the social acceptance of the strategic options (Anger, 2003).

Designing and planning GBI for an urban area is related to the demography of that area. Issues related to rapid population change such as urban densification and urban shrinkage are uncertain factors that challenge city's storm water management (Fryd et al., 2012). Compact growth can be good for the environment as it minimizes infrastructural requirements and frees more space for natural ecosystem, but rapid growth as in the developing cities poses enormous management challenges (Cohen, 2006). In this aspect, the time and scale of urbanization caused by population fluctuation is an important consideration in managing city's utility services. Uncontrolled population increase can challenge the capacity of the drainage system by increased waste water generation, transforming important natural features into settlements etc. Therefore, the risk of population fluctuation (in this case, population increase) is a significant management aspect of GBI development. The following diagram summarizes the several aspects related to GBI planning for urban climate change adaptation to flooding which have been discussed in the previous sections (see figure 08).

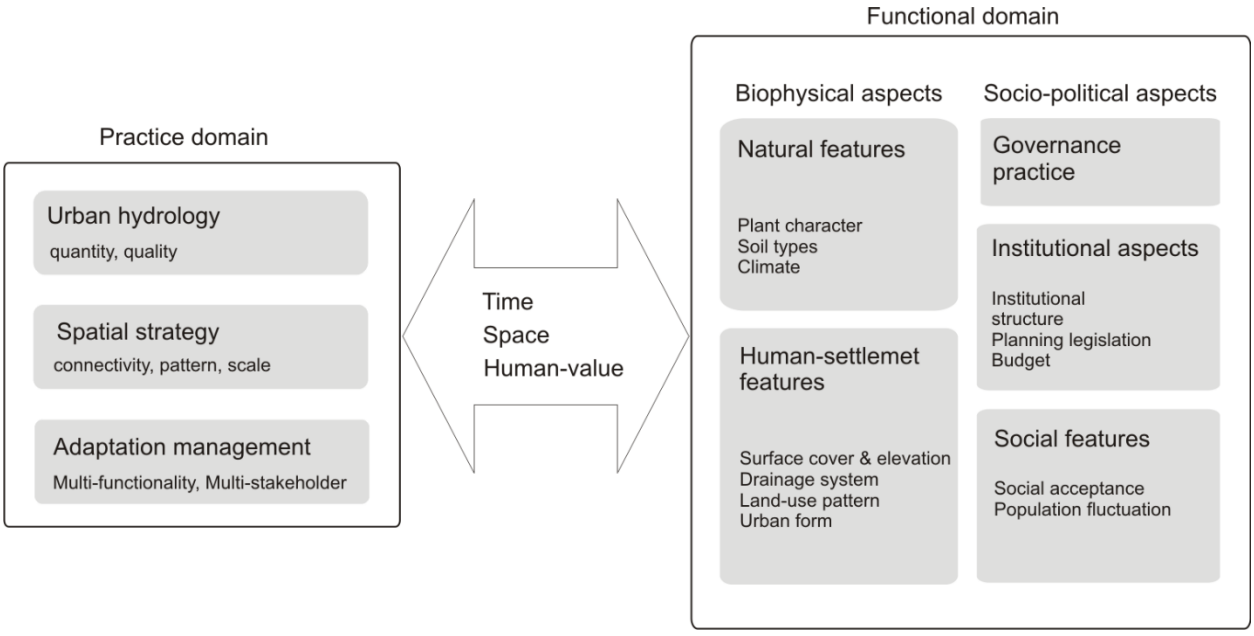

Figure 8:GBI planning framework for urban flood adaptation.

2.7. THE CONCEPTUAL FRAMEWORK:

In the previous sections, I've explained the key factors of GBI planning under the practice and functional domain. Different elements of GBI planning and the narratives of their inter-relations were perceivable. In this section, I've illustrated the inter-connectivity of these elements in a conceptual diagram (see figure 07). In this case, Fryd et al. (2012)'s work shows the relationship between the practical approaches of GBI where Matthews et al. (2015)'s work explains the inter-connectivity of different bio-physical and socio-political features.

In the practice domain (see previous section 2.6.1), I've mentioned the concept of time, space and human-value in the three disciplinary approaches i.e. urban hydrology, spatial planning and adaptation management. Although it is argued that the wide-ranging success of GBI adaptation depends on the transdisciplinary practice specially in the implementation phase (Ahern, 2007). But at the same time there are technicalities regarding hydrological designs (e.g. SUDS) that can be better realized by the inter-disciplinary relationships. In this regard, Fryd et al. (2012)'s model is used considering the influences of the three concepts (i.e. time, space and human-values) in each professional practice (i.e. urban hydrology, spatial planning and adaptation management). The positioning of the concepts in the diagram of figure 09 is followed by Fryd's model where they showed that the urban hydrology thus the quantitative and qualitative aspects are more related to city's bio-physical features especially, soil types, surface cover and elevation, and drainage infrastructures. The spatial strategies deal with connectivity, pattern and scale of bio-physical features of the urban environment. Plantation as a part of urban landscape, is related to spatial design, but as a GBI element its environmental services are more realized by landscape ecology along with its aesthetical purposes. In GBI, the drainage infrastructure is not only hidden drainage pipes and storage areas but also multipurpose spaces which are well integrated with human and natural systems. It is also dominant in urban environment designed by aesthetical principles. Therefore, in GBI planning the natural and built feature are strongly inter-depended. Climate is an important natural phenomenon in GBI planning which is explained as a natural feature in the previous discussion (see previous section 2.6.2.1.1). Matthews et al. (2015) emphasized that, GBI should consider climate actions more explicitly as it shapes biogenic services (e.g. evapotranspiration, absorption of particle matters) of GBI and also influences decision-making process due to its high impact (e.g. extreme weather events) on human settlements. So, it has an influence both in bio-physical process and socio-political sectors. The adaptation management on the other hand is more related to the socio-political aspects (see Fryd et al., 2012). It manages the wide range functions or services offered by the GBI through a multi-stakeholder environment and analyzes trade-offs for decision making. Within the socio-political factors, the governance (or political) practice influences the institutional measures, such as planning regulation for development options. But, the capacity of the institutions can be constrained by other social and financial issues as well as the spatial limits, such as budget and land availability for GBI development and social reactions to it. Here, climate change effect is an extraneous force that influences governance policies, such as mainstreaming climate adaptation.

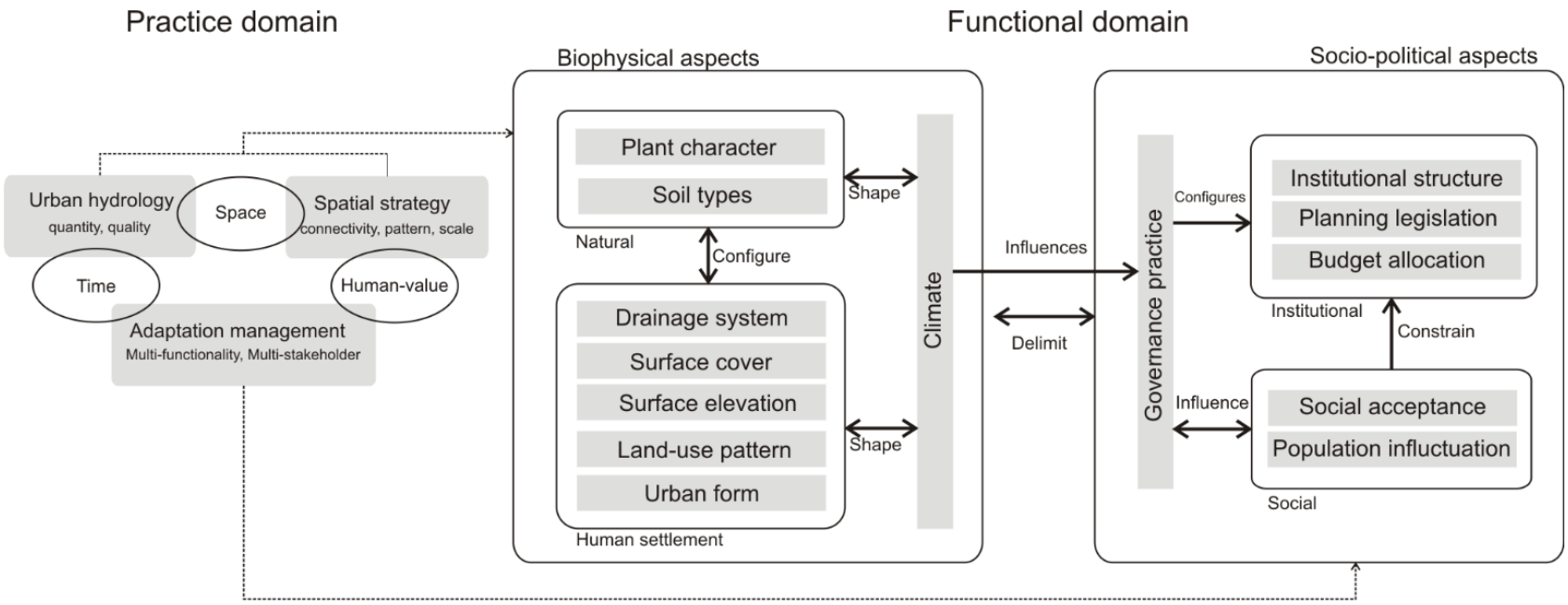

Figure 9:The conceptual diagram for GBI planning.

3. RESEARCH METHODOLOGY:

In this part, I discuss the methodological approach for this research and also explain the methods of data collection and analytical approach.

3.1. MIXED METHODS RESEARCH:

Mixed methods research is a synthesis of practical and intellectual knowledge. It is a pragmatic approach that imports useful logic from qualitative and quantitative researches. Fundamentally, qualitative research is based on a constructivist or post-structuralist principle whereas quantitative research is based on a (post-)positivist principle. Mixed methods research combines principles for conceptualizing a particular research problem as well as for data collection and analyzing. But, depending on the problem the position of the research could be qualitative-dominant, quantitative-dominant or equally balanced (Johnson et al., 2007). In this regard, my research is based on a mixed methods approach and can be positioned towards qualitative-dominant research. In the background literature study, I've found discourses based on the notion of transdisciplinarity and socio-technical integration of GBI planning specially when it is related to climate change adaptation. The studied articles commonly showed discourses between GBI theory and practice, and its bio-physical and socio-political factors. The adopted framework for GBI planning is also inclusive and requires critical investigation of both bio-physical and socio-political aspects. The bio-physical aspects of GBI are more technical and rely on a quantitative study and the socio-political aspects are more policy-oriented and rely on a qualitative study. According to the research objective, this study focuses on the planning of GBI for climate-change adaptation to urban flooding. In this research, qualitative analysis on political, institutional and social sectors were conducted from interviews, policy-planning documents and social survey. And related quantitative hydrological aspects were reviewed and discussed to delineate a comprehensive GBI adaptation scenario in the current context of flooding. As I mentioned, I've collected primary and secondary data from various sources (i.e. interviews, questionnaire and document study) so the data collection method is a triangulation method. This technique allowed me to accumulate multi-disciplinary information within the limited time and resources available. And information from various sources improved the validity of this research.

3.2. CROSS-SECTIONAL STUDY:

According to Kumar (2014), the cross-sectional study is suitable to develop an overall understanding of a phenomenon as it is designed to investigate the phenomenon by taking a cross-section of it at a single-time of the research. In this regard, my research is based on the cross-sectional design. It represents the present socio-infrastructural situation related to climate-change and urban flooding in the study area and evaluates the scopes for GBI implementation for adaptations purposes. Primary Data (specially questionnaire and interviews) were collected at a single time point in respect to the present situations but, secondary data (e.g. climate, flood, urban growth and population) were collected from different research works and policy-documents where historical development and future scenarios were discussed for better understanding of the existing planning issues in the relevant governance sectors.

3.3. CASE STUDY:

Case-study is a method to study, especially social phenomenon from an individual case and offers more scopes for intensive analysis of specific details from the case (Kumar, 2014). In this regard, I've studied two cases to gather case-specific information which strengthened my understanding of the problem and provided more information for my research objective. In the theoretical framework, multi-level planning and governance of GBI has been emphasized. The appropriate scales for analyzing urban landscape for GBI planning are city or regional-level, districts or neighborhood-level and household or individual-level (Ahern, 2007). Therefore, the biophysical and socio-political indicators from the adopted framework were applied on the specific cases to see the neighborhood-level capacities where the study area (i.e. Dhaka city) represents the city or regional-level. In this way, the variability between different spatial levels and their possible dependency has been realized in this study. The biophysical indicators and planning related (i.e. governance practice and institutional capacity) indicators were investigated from available research and planning documents and from interviews of involved experts. But the social acceptance of GBI planning requires resident's feedbacks on their perception and usage of the GBI projects. Therefore, questionnaire survey in the case study area and the neighboring residential areas were conducted to study the societal aspects of GBI planning within the context. These survey processes are explained later in the data collection methods (see section 3.5).

3.4. THE STUDY AREA AND SELECTION OF CASE STUDIES:

In the background information, I've already mentioned my research focus on Dhaka. I've selected this city based on the problem statement and also according to my convenience for field survey and communication. In this part, I'll delineate the study boundary and introduce my specific case studies for clear contextual understanding of the results.

3.4.1. STUDY AREA:

My objective was to conduct the study in both city (or regional) level and neighborhood level. For a city level study of Dhaka, I've decided to delineate the study extent according its political or administrative boundary. But the administrative boundary of this city had four (4) delineations in physical extents (see figure 10) depending on the different governmental agencies (Rabbani et al. 2011). Generally, Dhaka city referred to the Dhaka metropolitan area (DMA) which covers 306 sq.km (Mahmud et al. 2011)(see figure 10.2). Before 2011, this DMA area was mostly corresponding to the administrative boundary of former self-governing local agency named Dhaka city corporation (DCC) with some restricted areas under Airport and Cantonment authority. But presently there are two agencies called Dhaka south city corporation (DSCC) and Dhaka north city corporation (DNCC) divided from the DCC under the Local Government (City Corporation) Act 2009, (Amendment-2011) (Ahmed et al. 2014; DNCC website; BDNews24.com, 2011). Presently, at the time of this research the jurisdiction areas are 82 sq.km for DNCC and 45 sq.km for DSCC but there are governmental proposals by the National Implementation Committee for Administrative Reforms (NICAR) to expand their jurisdiction area by adding 114.58 sq.km to the DNCC and 64.17 sq.km to the DSCC (The Daily Star, 2016). So, there was ongoing development in the governing institutions regarding the administrative territory in respect to governance issue. There is also a strategic boundary delineated by the Dhaka's development authority or 'Capital Development Authority' (RAJUK) who are responsible for planning and implementing urban development plans. (SENES Consultants Ltd., 2007). It covers 1528 sq.km including the DMA (including DNCC & DSCC) area, the DND area, and the other urban

fringe areas namely, Savar, Gazipur, Tongi and Narayanganj (see figure 10.4. This broader area is defined as Dhaka metropolitan development plan (DMDP) area for long term strategic urban development. This area is also identified as the 'greater Dhaka' in many planning and policy reports.

In this case, I've decided to adopt the Dhaka metropolitan development plan (DMDP) area boundary as an extent of my study area (see figure 11). This is because, the research focuses on the urban flooding issue with underpinning GBI adaptation, so a broader research boundary will help to generate strategic understanding of this topic. Specially, when the larger strategic context can reveal alternative options for long-term and higher adaptation goals (Fryd et al., 2012). So, the term 'Dhaka city' refers to the DMDP area as study area in this research.

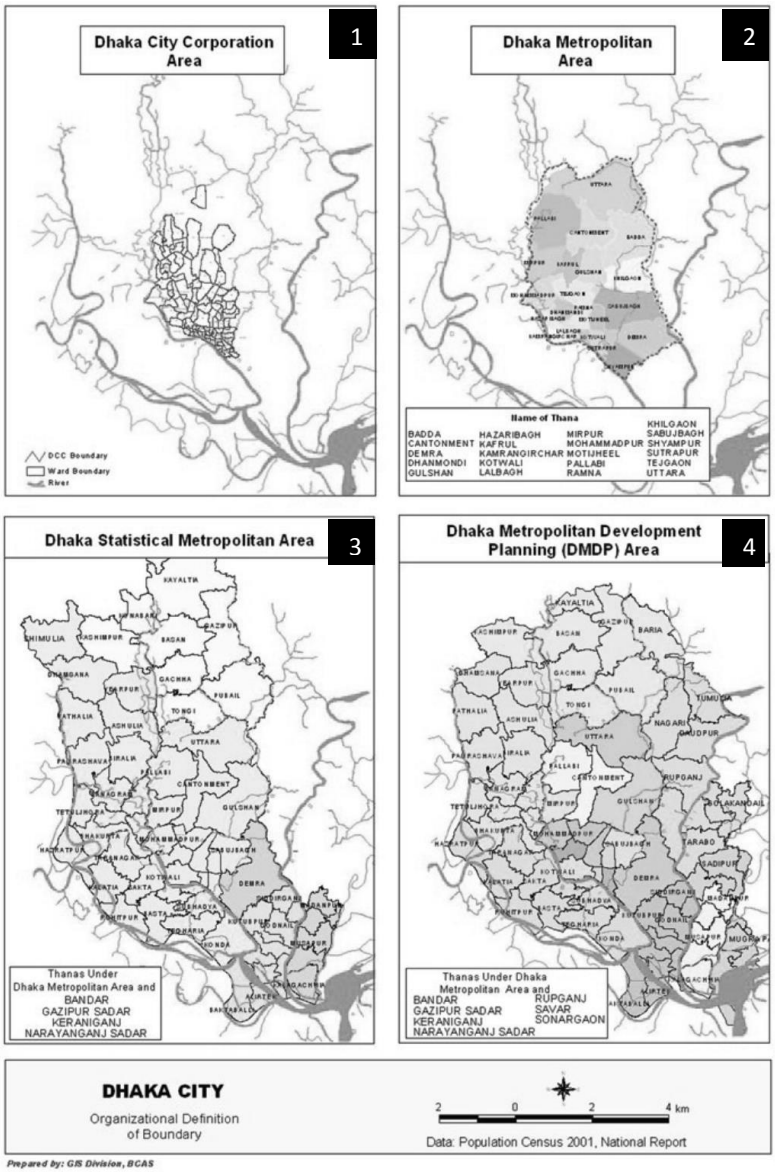

Figure 10:the image shows the different administrative boundaries (1) Dhaka City Corporation (DCC), old boundaries before 2011 (2) Dhaka Metropolitan area (DMA) (3) Dhaka statistical metropolitan area (DSMA) and (4) Dhaka metropolitan development planning (DMDP) area. (Source: Rabbani et al. 2011)

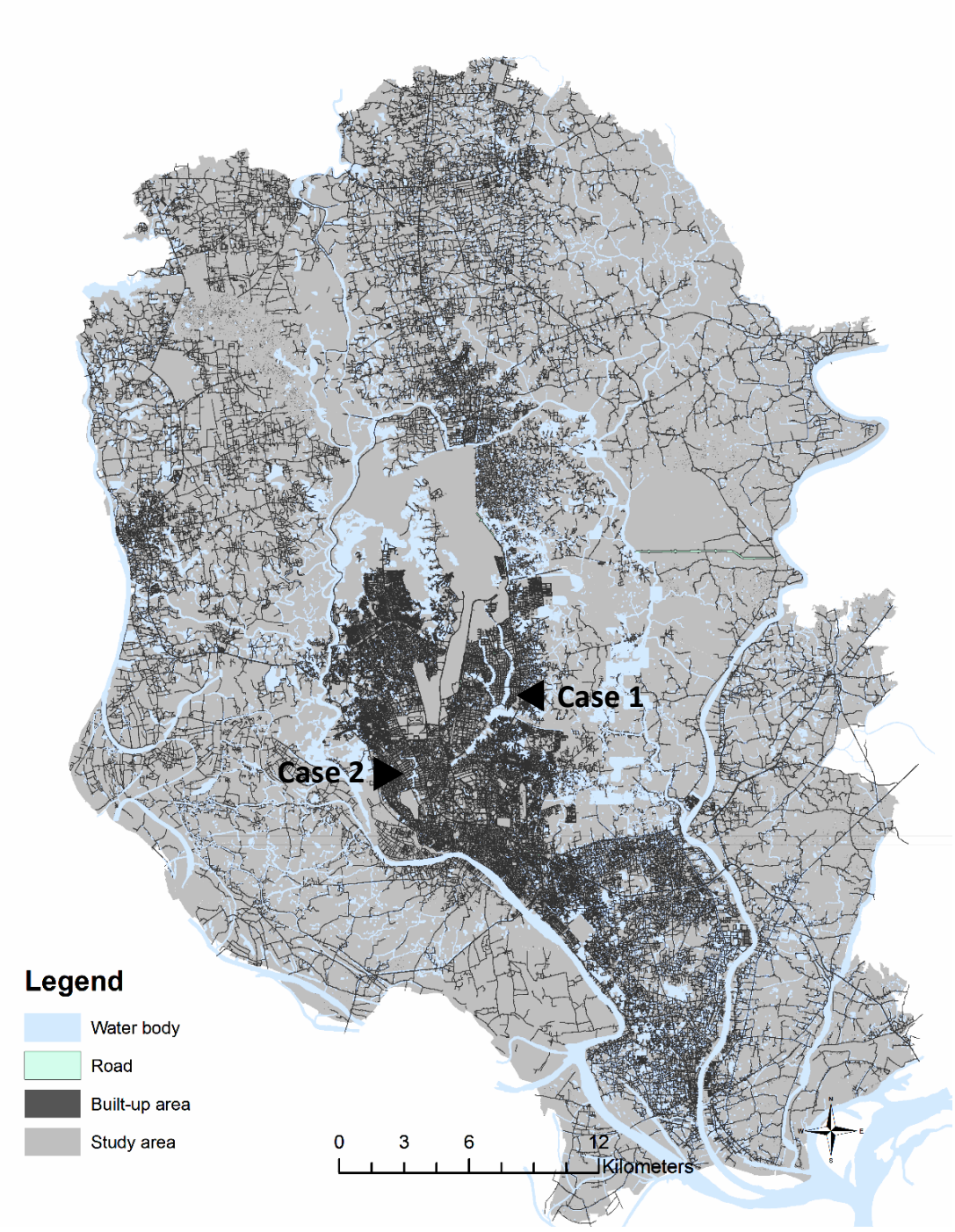

Figure 11: The study area, corresponding to the DMDP area (Greater Dhaka) and locations of case study areas. Source: RAJUK, Dhaka 2016 (modified by the Author)

3.4.2. Selection of the case studies:

"The assignment of projects at neighborhood and city level are expected to have particular importance, as this is where sustainable urban development is given its spatial and visible shape" (Fryd et al. 2012, page 878). In this study, I've selected two cases which have shown such importance not only as environmental projects but also as breathing space for the city. These projects have multiple objectives other than environment restoration and water retentions such as storm-water drainage, circulation, recreations and can be identified as GBIs (or SUDS) within the study area. They are situated in the central location (see figure 11) and serve the core population of the city.

These projects are- Case 1: Integrated development of Hatirjheel lake and surrounding area (including Gulshan and Banani lake) and Case 2: Dhanmondi lake and lakeside area development.

3.4.2.1. Background of the case studies: Case 1:

During the research, there were several ongoing projects in Dhaka which can be defined as GBI (or SUDS) projects due to their environmental objectives (specially water retentions and urban greening). In the RAJUK website, I've found list of current projects titled as 'Lake improvement/ Beautification'. From that list, I've selected the 'Integrated Development of Hatirjheel Area Including Begun Bari Khal Project' and 'Gulshan-Banani-Baridhara Lake Improvement & Beautification Project' as a combined case study area as they are situated in the same area. These projects are generally wetland restoration projects but also integrated with other public place-making, landscaping and transportation goals. Among the two project (i.e. Hatirjheel, Gulshan-Banani), the project on Hatirjheel lake is more significant for its many social issues and city-scale development goals. It started in 2007 and opened in 2013 after completing most of its goals (The Daily Star, 2013) but, the project was undergoing with new architectural integration during the time of this research. Whereas, the project on Ghulshan-Banani lake was started in 2010 with less development goals (i.e improving water quality and surrounding landscape environment) (Sultana R, 2013). It was at its initial stage during the time of this research. The extent of this combined case study area includes the lakes (wetlands) and surrounding residential areas (i.e. Baridhara, Gulshan, Banani, Korail, Begunbari, Merul Badda, West Rampura, Ullan, Nayatola) under Ward[3] no. 18, 19, 20, 21, 22, 24, 35 and 36 (of DNCC).

3.4.2.2. Background of the case studies: Case 2:

Compared to the first case study, this case study is a more neighborhood oriented development. It was a landscape project of the Dhanmondi lake and lake-side area in an important residential zone (i.e. Dhanmondi R/A) undertaken by the DCC (former city corporation) in 1998 (Hakim A, 2014) and completed in 2000 (VITTI Ltd. website). Its objective was restoration and conservation of the existing lake and improving lakeside environment through water-body management and design interventions (VITTI Ltd. website). Since this project was realized in a different time-period and being experienced by the users for more than a decade, I've selected this project as a case study to get variant feedbacks from the residents as well from its planning processes. The extent of this case study area is the Dhanmondi lake and lakeside residential area under Ward no. 15 (of DSCC).

In this research, these two cases will represent the GBI (more specifically, SUDS) development in the study area and will give in-depth understanding of the GBI planning. The extents of the case-study areas were

[3] 'Ward' is the smallest electoral unit of the city.

selected to accommodate the large urban wetlands (i.e. Hatirjheel, Gulhan-Banani and Dhanmondi lake) situated at the core city that have neighborhood-level and city-level environmental and spatial impacts. But in this research, my major objective is to investigate the user's or resident's responses on the on-going development along with its other biophysical and planning aspects discussed in the framework.

3.5. DATA COLLECTION AND ANALYSIS METHODS:

The data collection method is a mixed methods approach. In this research, I've conducted expert's interviews, document studies and a questionnaire survey. Each of the methods are focused at a particular aspect of the GBI planning framework but also have overlaps in subject matters to triangulate the data (see figure 12). In the following part, I'll briefly explain each method.

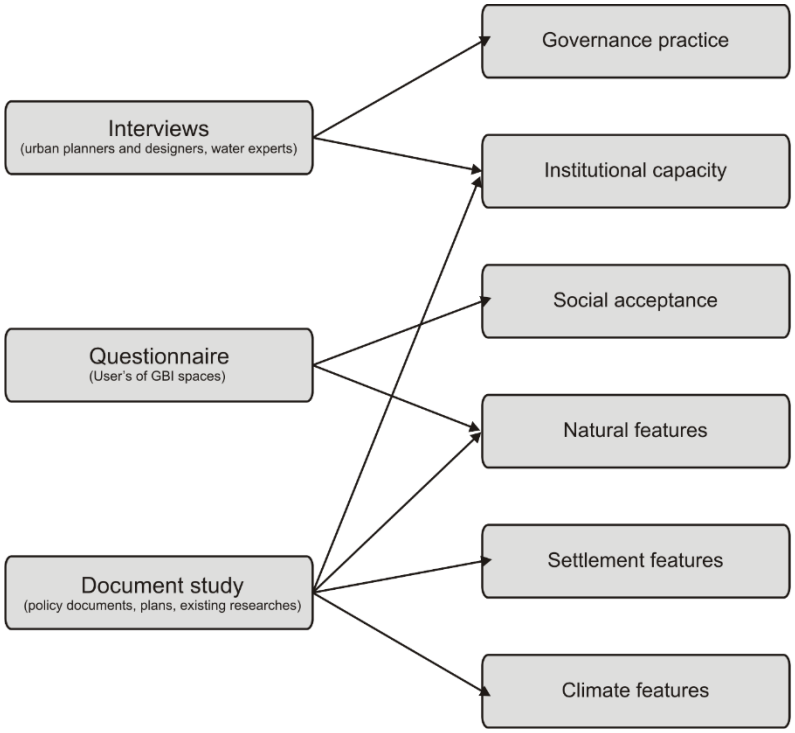

Figure 12: Data collection method of this study.

3.5.1. INTERVIEWS:

In the GBI planning framework I've discussed three disciplinary approaches (i.e. urban hydrology, spatial planning and adaptation management) in the practice domain and I've portrayed the significance of transdisciplinary knowledges for the flood adaptation context. Therefore, my target groups were experts from these three disciplinary backgrounds. I've selected eight (8) experts for interviews through snow-ball sampling techniques. It is a useful technique to study knowledge distribution within a group (Kumar, 2014). In this research, this approach also showed the communications among the agencies and institutions. Most importantly, I had little knowledge about present organizations in the flood-management sector, therefore it helped me to establish fast connection between experts. I've started my snow-balling from Wageningen University, Dhaka office as an initial contact and eventually communicated with experts from governmental agencies i.e. Dhaka Water Supply and Sewage Authority (DWASA), Water

Resources Planning Organization (WARPO), Capital Development Authority (RAJUK), local consulting institutes i.e. Institute of Water Modelling (IWM), Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET) and private firms involved with selected cases and relevant works i.e. VITTI Ltd, JPZ Consulting Ltd. (see figure 13). Finally, I've categorized the experts in two disciplines (i.e. spatial planning and hydrology engineering) depending on their disciplinary backgrounds (see Annex I).

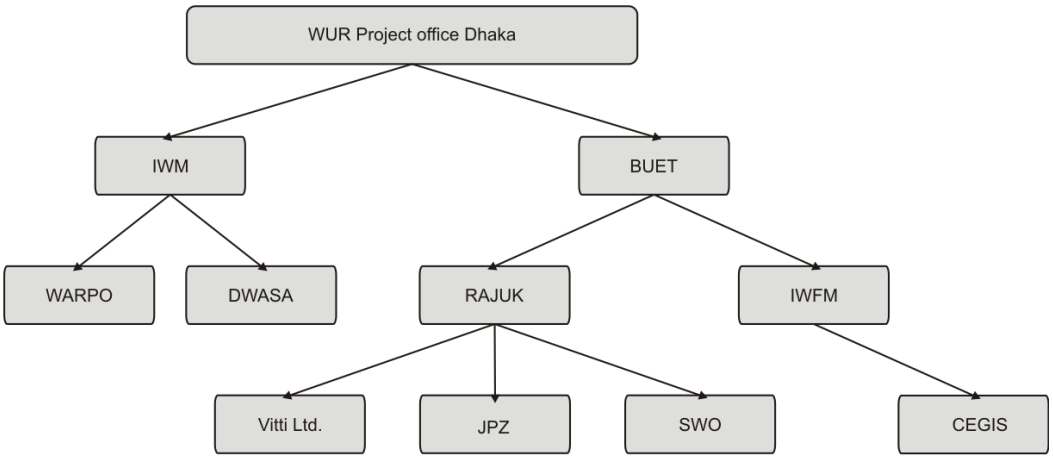

Figure 13: The snow-balling network of the sampling process of interviewees.

I've conducted face to face interview with a semi-structured questionnaire. The interview questions had two major segments (i.e. institutional aspects of urban planning and flood management and technical information about inland water management) in respect to the GBI adaptation. These questions correspond with my specific research questions and was guided by the GBI planning framework. I combined questions from each disciplinary topic for all the interviewees. For example, drainage management issues are more relevant to urban hydrologist and land-use strategies are related to urban planners but I've presented both issues to the planner and hydrologist to understand the interdisciplinary attitude among experts and their organizations. There were also some specific questions on the selected case studies depending on the expert's insolvency in the project.

3.5.2. Document study:

Along with the interviews, I've gathered information from secondary sources mostly through government publications, existing researches and consultancy reports. Main reason for this document study was to explore the existing knowledge development in the parallel scientific and policy-domains within the study context. Due to data limitations, empirical research on the existing bio-physical condition was not considered, rather results from previous hydrological studies showed the bio-physical aspects of the realized GBI projects and the whole drainage condition of the study area. In the interview sessions, the scientific aspects were also explored, but factual data on climate condition, performance of existing drainage system and invested GBI project (i.e. Hatirjheel lake) were reviewed from scientific researches

and consultancy reports mentioned and recommended during the interviews. For institutional capacity, experts also mentioned existing political goals, policy instruments and drainage and urban development master-plans on the topic of urban flood adaptation. In this research, policy and strategic plans from the local governmental agencies specially, DWASA's (for drainage) and RAJUK's (for urban development) developmental proposals were reviewed to support the overall investigation of this research. I should mention that, during this research there were ongoing master-plan developments by both RAJUK and DWASA. RAJUK was working on a new detail area plan (DAP) for 2016-35 (only the draft structure plan had been released). DWASA had been preparing the new storm water drainage master-plan. But, I didn't consider these documents in this research, because they were not released as public documents and the previous documents were legally applicable for the concurring period.

3.5.3. Questionnaire survey:

The questionnaire survey was conducted in the two specific case study areas. In this survey, my major objective was to investigate the social responses on the realized projects, which is one of the socio-political indicators of my framework. For that, my study population were the residents from the near vicinity of the lake projects (i.e. Hatirjheel, Gulshan-Banani and Dhanmondi) who have experienced the pre- development and post-development conditions of these projects. I've selected six (6) key locations in the case study areas; four (4) locations from the Case 1 and two (2) locations from the Case 2 depending on a preliminary observation on their urban morphological pattern, land-uses and accessibility to the project (see figure 14). A sample of 60 residents combining 10 from each zone was given with standardized questionnaire. The selection was random and upon willingness to respond. In the questionnaire, the experience of flooding, preferred functions and activities of GBI, adaptation options etc. were measured in respect to pre-development and post-development situation. To measure respondent's perception about environmental situation and services, both close-ended and open-ended questions were used. Open-ended questions were coded for further analysis and functional preferences were measured with simple Likert-scale. The questions were formulated in generalized and simple form to investigate the common attitude from the respondents as the target population were diverse and not classified by social or educational background.

3.5.4. Description of the selected locations and their spatial configuration:

Location-1 is situated in the south-west side (i.e. Gabtola and Nayatola) of the lake and location-2 is situated in the south-east side (i.e. Ulon and Mahanagar housing). The location-3 and location-4 represents the large informal settlements (i.e. Karail slum area) within a newly planned higher class residential area (i.e. Gulshan and Banani). The location-5 and location-6 are situated in the north-west side (i.e. Dhanmondi 12A, 7A) of the Dhanmondi lake (see figure 14). I should also mention that, in Case 1 the residential environment on the either sides of Banani lake are distinct. At the western side of the lake has the large slum area whereas the opposite eastern side has upper-class housing areas of Gulshan and Banani. So, another key location on the Gulshan or Banani residential area would be necessary for this case but, due to an on-going security issue there was limitations for field survey.

3.5.4.1. THE SPATIAL CONDITION OF THE LOCATIONS:

It is important to integrate the concepts of spatial configurations, scale and connectivity to understand the ecological or bio-physical process of GBI (Ahern, 2007). I've mentioned the important relationship

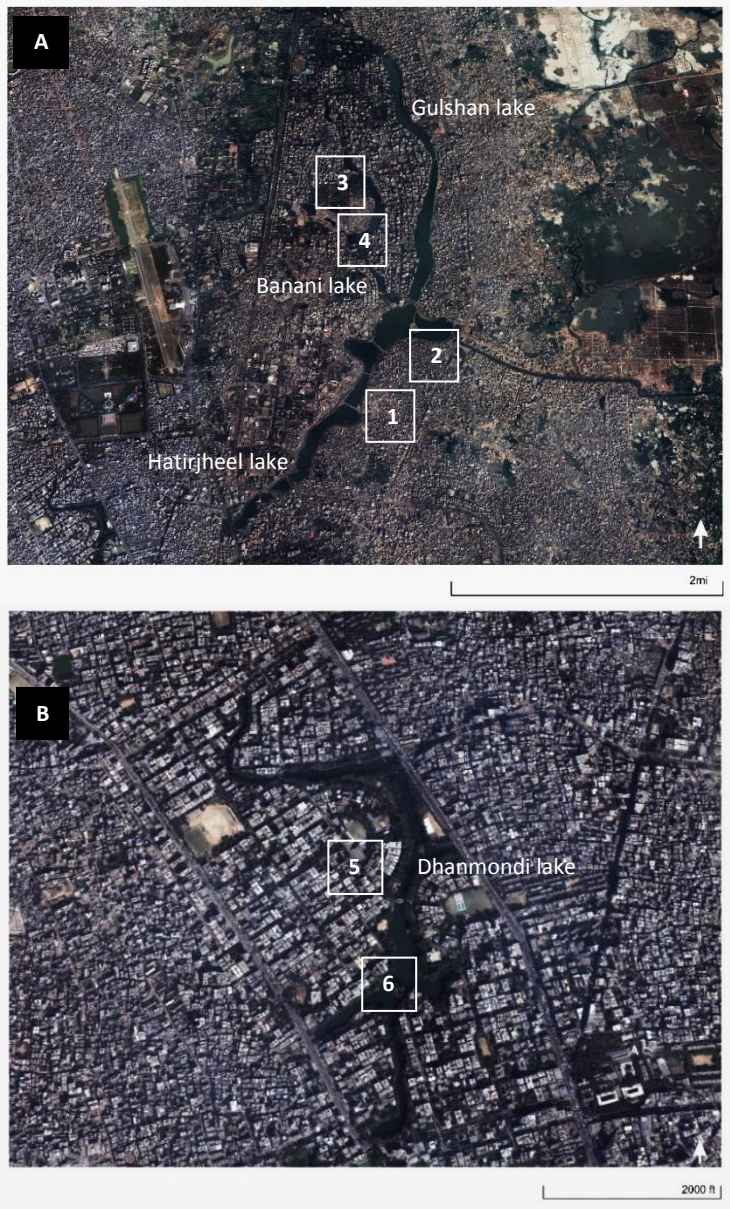

Figure 14: Arial images of Case 1 (A) and Case 2 (B) including the survey locations. (Source: Google maps 2017) (modified by the Author).

between urban forms and GBI in the bio-physical part of the framework (previously discussed in section 2.6.2.1.2). To quantification the biophysical performances (e.g. storm water runoff estimation), it is very important to characterize the urban morphology (Gill et al., 2007). Quantification of such biophysical functions was not the objective of the questionnaire survey, but to understand the user's responses on GBI projects. Therefore, it is important to identify the spatial conditions of the selected locations to relate the resident's responses according to their livelihood conditions. Here, I've presented the spatial

categories of the selected key locations. This is not an outcome of an in-depth physical survey. Only satellite images and on-site visual observations were used for a general orientation.

3.5.4.1.1. UNPLANNED RESIDENTIAL AREA:

The locations near the Hatirjheel lake area (i.e. Location-1,2) are unplanned residential areas (see figure 15). These areas are organically developed with different sized plots, narrow streets, and mid-rise settlements. For location 1, the major connection with the lake area is the Mahanagar housing road and for location 2 is Modhubag road. But pedestrian and hand-pull vehicles (i.e. rickshaws) are restricted on the major vehicular roads around the Hatirjheel lake project. The area (i.e. Ward-22) that the locations are situated has about 20,205 households per square kilometer (BBS, 2014).

3.5.4.1.2. SLUM AREA:

The locations besides Banani lake (i.e. Location-3,4) are situated in the largest slum area (i.e. Karail) in the study area. Most of the households are either temporary or semi-permanent settlements (in local terms 'kacha' and 'semi-pakka'). The internal roads are only pedestrians and no formal arrangements for public infrastructures (i.e. municipal drainage, water and electricity supply) are there. The area is surrounded by government or privately owned buildings allowing a very limited access to the internal areas. Before, boat-crossing was an important means for the community to access the surrounding areas but it was restricted due to the Gulshan-Banani lake project. The overall area (i.e. Ward -19, including Gulshan-Banani housing) has about 7132 households per square kilometer (BBS, 2014).

3.5.4.1.3. PLANED RESIDENTIAL AREA:

The Dhanmondi lake adjacent areas (i.e. Location-5,6) are part of the Dhanmondi housing area which is a planned residential area from 60s. This area is planned in grid-iron pattern with regular sized plots. There are different height restrictions according to the master-plan but in general the settlements are midrise apartments. The area has many access to the lake project including peripheral walkways. The Dhanmondi area (i.e. Ward- 19) has the lowest household density among the study areas with about 6297 households per square kilometer (BBS, 2014).

House hold: 20,205/km^2 House hold: 7132/km^2 House hold: 6297/km^2

Figure 15:Unplanned residential areas of location-1,2 (A); urban slum areas of location-3,4 (B) and planned residential areas of location-5,6 (C). (source: Google maps 2017) (modified by the Author)

3.5.5. METHODS OF ANALYSIS:

In the following section, I explain the methods of analysis which include content analysis of the expert's interviews and analysis of the questionnaire survey.

3.5.5.1. INTERVIEW:

For the expert's interview, a qualitative analysis was conducted. For the interviews, open questions were developed related to the specific research questions of this study which guided the interview sessions (see Annex III). During the interview sessions discussions were recorded and later typed for written transcript (see Annex I). Most of the interviews were in the local language (i.e. Bangla) which were later translated into English. The content of the interviews was analyzed with the support of a qualitative data analysis software namely, Atlas.ti (version: 7.0.70). The analysis was conducted in a deductive approach. Topics from the theoretical framework were adopted as initial codes for the content analysis. The analysis process was iterative and new codes were formulated along the process. Sub-codes were also given to specify certain narratives (see Annex II). From the interview transcripts, narratives were identified and categorized according to the codes. The importance given by the interviewees and number of counts were considered to rank certain codes for importance. Important narratives (as quotes) were deducted from the discussions. The conceptual framework was considered to compare inter-relationship between certain narratives. Finally, the outcomes were discussed in the following result chapter under related topics from the GBI planning framework.

3.5.5.2. QUESTIONNAIRE SURVEY:

The questionnaire for the case study mostly had close ended questions (see Annex III). For some questions (i.e. question no: 3,5,8,9), the respondent had to choose from given options and some questions (i.e. question no: 1,2,4,6,7) the respondent replied with specific answers. The specific answers were coded (see Annex II) for simplification and were indexed using the spreadsheet software tool Microsoft Excel (version: 2016 MSO, 16.0.7830.1018). The responses were categorized according to locations under case-study areas. Most of the responses were analyzed using the command (=countif) to check the count of each response. For the question 5, a Likert scale was used in the questionnaire which was analyzed by Microsoft Excel to construct bar graphs.

4. RESULTS

In the previous chapter, I've explained the methods of this research. In the data collection method, I've mentioned that I've conducted interviews, document study and questionnaire survey to investigate the different GBI planning aspects from the framework and to answer my research questions. In the following sections, I present the results from different data collection methods. I've organized the results according to the data collection methods that I've explained in section 3.5 and later I've combined them for an overall understanding. As I've explained in section 3.5, the interview and document study were focused on the overall study area including the case study areas (local and neighborhood level) and the questionnaire survey was focused on the cases (neighborhood level). Therefore, I'll also try to explain the different GBI planning aspects in relation to these different levels.

4.1. INTERVIEWS:

The interviews were focused on the socio-political aspect of the GBI planning for climate adaptation from urban flooding (previously explained in section 3.5.1). During the interview sessions, the governance and institutional aspects were given importance. But, the experts also explained relevant bio-physical aspects in respect to the potential GBI adaptation for the study area. Therefore, I'll also present those bio-physical aspects in a way that it will give a holistic view of the existing situation through the lens of the experts. In the interviews, there was a section for the case studies and most of the experts gave their critical observations on the cases depending on their inviolacy with the projects on which the case studies are based.

4.1.1. SOCIO-POLITICAL ASPECTS:

As the interviews were conducted for gathering the socio-political knowledge of GBI planning prospect in the study area, the sessions started with the general study area level discussions on the topics which are related to socio-political section of the framework. Therefore, I will present those topics first followed by the bio-physical aspects which are also mentioned by the experts.

4.1.1.1. GOVERNANCE PRACTICE:

Realization of the GBI in a metropolitan context needs appropriate governance and an institutional environment in which multiple stakeholders can participate in a strategic manner for advancement of the GBI adaptation process (Young & McPherson, 2013). It was important to understand the political context and its alignment with climate change agendas, attitude of governing bodies, thus the existing situation of governance practice in the study area. In the GBI planning framework of this study, I described governance practice as a significant element which gets influenced by the climate features (climate risks and existing climate) and interrelated with institutional and social features to configure the socio-political aspect for GBI adaptation. It is difficult to define the state of the governance in respect to GBI because it is related to a higher level of climate-governance. The global nature of climate change issues challenges organization of governance across the temporal and spatial scales (Adger, 2001).There are global governance mechanisms (e.g. UN framework Convention on Climate Change) for legalizing international actions, and agreement with such policies would enforce the governments to adopt certain climate change mitigation and adaptation goals in their national agendas. But the adaptation can also occur as a

spontaneous response to changing social, economic and environmental circumstances (Adger, 2001). To realize the appropriate governance situation for GBI adaptation in the metropolitan area, the concept of urban environmental governance can give some insights. This environmental governance involves of institutional reformation to create new platforms for public, private, scientific and community sectors to act jointly in resolving complex environmental problems (Young & McPherson, 2013). From the expert's interviews, necessity of such governance practice emerged in respect to the GBI adaptation in the study context.

From the background of this research, the country's (i.e. Bangladesh) general situation of climate change stress should be understood. Recently, the government is aiming to reach MIC (Middle Income Country) status from LMIC (Lower Middle Income Country) by 2021 and major advancements are envisioned in infrastructural and export-oriented industrial sectors (Chakraborty & Vasanthagopal 2015). New initiatives in infrastructural sectors are consequent to its recent strive for economic growth. As the capital city Dhaka has the government's prior attention. The possible positive outcome of such attentions can be related to recent city-beautification and environmental restorations initiatives, but economic actors are also stressing urbanization by housing and industrial development within the city. On the other hand, from expert's () explanations it is understandable that, the national level policy reformation for climate change reflects the government's alignment with global climate change governance. So, there is a tension between climate-stress and economic-growth influencing the current governance practice. The following discussion will stretch this dichotomy of governance for GBI adaptation in the local level[4] (Dhaka city).

ECONOMIC AND CLIMATE CHANGE ACTOR IN EXISTING GOVERNANCE:

In the study area, I find basically traditional governance practice where most of the public developments are planned and implemented by the governmental agencies. The political environment plays a strong role in the development process. The private sectors are not formally associated in the planning of climate adaptation such as GBI. In the decision-making process, economic benefit plays an important role but the benefits are not carefully planned and most of the cases are controlled by the market or private sectors. The land-use planning experts UP-03 explained the land development situation and how the development activities eventually transfer to the private real estate sectors. As critic to this situation, the hydrology expert UH-02 argued for a more cautious governance approach where equity should be ensued in the GBI adaptation process. To describe the situation, he said;

"There is a political-economy behind our developments…There are things which are more political than pure public benefits. There are external and internal benefits of infra-structural investments"

In the current situations, the focus is on a growth-based development. Land development for accommodating urbanization is major concern in the land-use governance. The flood control and flood protection attitude is dominant in the water and flood management regime. In this regard, UP-01 said;

"in Dhaka response to climate change issues are more infrastructural… Till today Dhaka is mostly relaying on the 'gravity-based' drainage, but the water management sector (mostly WASA) are going towards full pump based system, which I think is not a good approach to deal with the historic problem of flooding and logging (river flood) and also climate change issues."

[4] The governance of the study area defines Dhaka as local-level, it is per governmental documents.

In that context, the governance is more reactive, specially to the flooding issues. Major initiatives were taken in the past after major flooding incidents. And the initiatives were isolated flood control and protection measures taken by designated agencies, rather than a joint approach by multiple agencies. UH-03 mentioned;

"These approaches were taken as a reaction to the big flood events in 80s (1988). At that time, the strategy was to separate the urban areas from the river through embankments and use pumps to evacuate water. That mentality is still there. The mentality to live with the flood or adapting to it hasn't reach Dhaka."

As I've mentioned that the flooding issue is an important consideration in governance, now the climate-risks are adding more stress to the current situation. Therefore, now the climate change effects have influence on the decision-making process and government agencies are shifting towards a long-term approach such as adaptation. But, there is a struggle to this shift. UP-03 explained this situation;

"Traditionally, Planners didn't consider the data regarding hazards or vulnerability aspects. Before it was more based on demographic status but now there is a shift towards resilience. Now it is a part of governmental goals or visions. So, climate change is playing an important role in the policy domain."

At the national level governance, the climate policies are adopted but the local level governance is yet to establish coherent strategies for implementation. This is a challenge for comprehensive GBI practice. Up-03 explained the lack of concerns on the interconnected issues and mentioned;

"If we talk about heat-stress, there are no specific policies or that, but there are policies for urban greening or plantation. In the city corporation mandate, there are plantation goals, but generally they are not given priorities in implementation. But, for flood issue there is much concern, the climate change effects are a recent addition to it…"

Now, traditionally the private sectors are not involved in the environmental development. It was sole responsibility of the government. But the recent initiatives showed multi actors involvement and also private-public partnerships which is indicative to a governance shift. Mostly in the Hatirjheel project (it will be explained as one of the cases, later in the result section). In this regard, UH-01 stated,

"Now, there are not many examples of public-private partnerships for environmental restoration works. Mostly the governmental agencies are working in this sector. But now that the Hatirjheel project is a good example for private investors to see the economic benefit from environmental restoration it will have good impact on the public-private collaboration practice. If the wetlands are developed with multiple development objective, there will be more scope for economic growth and the private agencies will be interested to share the costs and benefits".

So, there are political, economic and environmental actors influencing the traditional governance situation to undergo with changes. Growth based development and climate-risk are two major drivers in this governance shift.

Another issue which was repetitively mentioned as a governance challenge is the implementation issue. Most of the experts stated that the Dhaka's governing agencies are lacking implementation of the strategies. The reason behind this problem is somewhat unclear. It can be related to institutional coordination, funding, social cohesion or other management issues within the governance structure.

During the discussions, the anthropogenic activities are given importance by the experts for urban flooding. There are other issues such as encroachment of the dedicated wetlands and channels which indicate lack of sincerity to the adaptation strategies by the governing agencies. UH-03 stated that;

"the weaknesses are in terms of implementations and enforcement. Before financing was a big problem but now-a-days, I think we have enough finances to implement some of these flood-management projects (GOB funding, not from donors). The weakness is in terms of delays of formulating the projects and implementing the plans. Day by day more people are coming in the city and less case is available to put in green-blue infrastructures and costs will also go up".

From urban hydrologist and GIS expert UH-04's explanation, another dimension was revealed. UH-04 said;

"Actually, partial implementation is the problem…Funding doesn't appear in proper time, or there are overlaps in the work. Sometimes, there are repetitive works due to lack of coordination. I would say time is a very important factor, because lot of the flood management issues requires timely development but delayed work eventually lose the functionality of the whole system"

From the experts comments it appears that the temporal and spatial factors are not under proper consideration within the governance practice for adaptation works. The global climate change phenomenon poses challenge to governance structure at all spatial and temporal levels (Adger, 2001). The successful adaptation decisions depend on the scale of implementation and the principles of defining it (Adger et al., 2005). Therefore, the distinct goal for each governance level and their inter-connectivity, timeframe for implementations are important considerations for adaptation.

4.1.1.2. Institutional aspects:

Institutional structure, planning legislations and budget allocation are important institutional aspects in the GBI planning framework. In the following sections I'll discuss the issues which were found related to the institutional aspects.

4.1.1.2.1. Institutional Structure:

The desired governance practice for GBI adaptation requires its institutionalization (Young & McPherson, 2013). GBI planning in Dhaka operate through the existing institutional structure and understanding the applicability of GBI depends on understanding the role of its agencies and institutions. From the previous discussion, it appeared that the adaptation is a new trend to the current system. So, effective operation of adaptation initiatives will require new institutionalization or a reformation of existing structure.

The local governments basically facilitate implementation of climate policies through institutionalization of the works translated from the climate policies (Anguelovski & Carmin 2011). In this research, the exploration on institutional structures is specified as local level governance structures operational in the study area specifically for planning, budgeting, implementing and monitoring climate adaptation action plans attained from the national and local level policies and regulations. In this part, I will explain the expert's observations and opinions on the questions for institutionalization of GBI adaptation in the study area.

In the context, governmental agencies are dominant in governing GBI works. Therefore, the experts exerted to comment mainly on the organizational situation of the current governing institutions. Apart from the governmental institutions, there are non-governmental and private institutions working on local

adaptation programs. Generally, their efforts are more on the community level adaptation for vulnerability reduction.

CAPACITY AND COORDINATION CHALLENGE AT THE LOCAL LEVEL:

Responsibility of local level institutions in climate adaptation is high and with increasing climate risks it is necessary to increase institutional capacity and institutional coordination (Agrawal et al. 2008). But for the study area, based on the interviews the situation seems stagnant.There are capacity limitations and inter department coordination problems. The experts commonly admitted on the lack of resources, capacityand coordination problem. But demand for institutional change specially for new implementation authority is mentioned. There is a major organization (i.e. RAJUK) for developing strategic plans for Dhaka but no separate organization for operationalizing the plans. Most of the experts put their concern in this respect due to the issue of dominant single governing body and credibility of the execution of strategic plans. Experienced practitioner UP-02 mentioned in that aspect;

"*I believe, planning is a continuous process, we should keep updating and refining it but until the plan is implemented it has no value. I'm very much upset about that, still from 2010 we are waiting to have an implementing authority. Our planning authority (RAJUK) is playing as the mother-organization for doing all the implementation where it was not entitled to it. There should be a separate independent implementation authority, that is how the law was passed."*

Enforcing the legislations and monitoring is also difficult due to the lack of capacity of the existing institutions. For example, there are legalized adaptation tools for individual development within the administrative area but practically less effective due to proper monitoring. The planning expert UP-01 explained this situation with an example;

"In every plot, there must be a certain percentage of open surface, but in reality, people are paving because there is lack of monitoring. These are only small examples of our institutional lacking".

Institutional coordination is a challenge for GBI adaptation works within the institutional structure of the study area. The structure should clearly establish jurisdictions of activities in order to maintain efficiency (Ivey et al.,2004). Whereas, in the existing situation, the experts highlighted the jurisdiction and communication problems between governmental agencies and argued for coordination for implementing adaptation plans. Expert UH-04 mentioned;

"particularly in governing agencies, there are gaps between inter-agency coordination. They have overlaps in works, funding delay etc. These issues happen because of inter-agency communication gap. At the city-level it is a problem. But at secondary town level (Pouroshova) it is well refined. At the secondary town level, there is 'coordination committee'…which organize a coordination meeting and exchange plans. But, in Dhaka corporations are independent and have lengthy communication".

Another experienced urban hydrologist UH-02 stated the lack of planning attitude and coordination result in conflicts between organizations;

"Planning integration is also absent in our water sectors. The water and flood-risk management regime was more inclined towards flood-control. We still have conflicts over such issues. There are conflicts between organizations. The conflict mitigation is absent in our system. Adaptation is more like a co-operation approach. But there are so many different agencies in related field that do not have integration between them. They are under different ministries and it makes it more difficult".

4.1.1.2.2. PLANNING LEGISLATIONS:

In many cities, GBI adaptation depends on the suitability to comply with the regulatory environment (Bosselmann 2006). So, if there are existing legislations which are appropriate for GBI then the applicability become easier in that system. In this case, the research is focused towards storm-water management functions of GBI. So, for example, the wetland preservation and drainage related legislations can support GBI to be adopted as a part of the land-use strategic plan for climate adaptation within the jurisdiction level of those legislations. In that sense, the experts mentioned some legislations or acts which can correspond with GBI planning, although there is no specific policy for GBI. Another aspect is the national level climate policy and its integration in the strategic plan. It is possible that, as the policies have some level of definitional deficit, it can be misinterpreted at the implementation stage (Urwin & Jordan, 2008). These types of complexities are also discussed by the experts when explaining the prospect of policy and legislation in term of GBI in the study area.

STRATEGIC PLAN CRISIS AT LOCAL LEVEL:

Translating the national level climate policies into a local level adaptation plan is a challenge for the existing planning sectors. The local institutions are struggling to develop robust action plans which will strengthen the legislation process of climate adaptation, thus GBI practice. It is possible that policies, adopted for a larger scale can have different effects when adopted in local situations (Brooks & Adger 2005). In this case, there are national level climate policies but a translation of those policies into a strategic plan is still under development. Two reasons are mentioned by the experts, one is about the interpretation of a general overall climate policy into a specific strategic plan for Dhaka and the other is about a delayed planning and legislation process in deploying the strategic plans and legislative tools. Describing the difficulties to adopt the climate policy into local level strategic plan expert UP-03 mentioned;

"*Particularly, climate change policy is more general, it says we should adopt to climate change. So, for implementation it requires more supporting policies specific to flooding problem. Now, policies or laws are there, we have also strategic plans but the development authorities are failing in implementation. I think they could've taken stronger role…"*

Expert UH-04 also mentioned;

"In terms of climate change, there are mostly national level policies and plans, such as the national adaptation program for action (NAPA), final report 2005, Bangladesh Climate change strategy and action plan (BCCSAP) 2009. I think in any strategy, its translation towards local level is difficult. In our cases, policies are open-ended and difficult to transfer in a detailed spatial plan. I think it is now necessary to transfer the BCCSAP'S plans to DAP for Dhaka".

Most of the experts expressed their concern on the climate adaptation specially the flood safety aspect of Dhaka's strategic plan (In that case DAP). The fact that is, there are constant changes in the strategic plan while shifting from one period to other and delays in delivering plans consequently reduces the implementation period. The climate policies are newer documents than the strategic plan, so there are ongoing discourses regarding adaptation of climate policies in the plans. In light of this situation, the professor of urban planning UP-03 explained the public debates and legislation process of the current detail area plan (DAP). Another expert UH-01 also explained the delaying process and stated;

"the strategies for Dhaka are developed before the climate adaptation plans and I don't think the DAP considered detailed climate adaptation studies, they included some options based on the available documents during that time…we took long time to develop polices and plans and even though, after adopting the strategies, the implementation starts late and between that period most of the land-uses changes in unplanned manner".

4.1.1.2.3. BUDGET ALLOCATION:

In this topic, generally the experts didn't discuss much. Some experts (i.e. UH-03, UH-04) mentioned that development agencies are mostly relaying on government budgets and there is less dependency on donor agencies than in previous terms. In terms for budget allocation, there are some delays which they described as coordination lacking rather than fund shortage. In this aspect, the expert UH-04 said;

"Before, funding was a major issue but now only about 5-10% of our development fund are international funds (according to gov.). So, the challenge is more a coordination gap than funding. But we do have inadequate resources and lack of capacity in the technical sectors".

4.1.1.3. SOCIAL ASPECTS:

In the research methodology I've explained that the social acceptance of GBI in the study area were studied by the social survey, conducted on the case study areas where the residents represented their opinion in this issue. Therefore, in the interview questions this topic was not stated. But during the sessions the experts strongly mentioned some social issues related to large-scale development projects and in this case environmental projects. These are given a new code (i.e. urban renewal and displacement) in my content analysis of the interviews and I'll present these in the following section.

4.1.1.3.1. URBAN RENEWAL AND DISPLACEMENT ISSUES:

Adaptation decisions are taken by representatives of the society, but the decisions rest on a set of interests which eventually create winners and losers during the adaptation process (Anger, 2003). In this case, the experts explained that in the adaptation process potential 'losers' could be the most vulnerable groups. In the study area, low-income communities are living in the marginal areas of urban settlements and areas most vulnerable to flooding. In many cases, urban-poor or low-income communities have their households are on the low lands or wetlands and restoration of these areas will possibly displace them. In the recent projects, experts mentioned many setbacks in the realization process and displacement was a major social challenge for those projects. On the other hand, creating public spaces from the inaccessible and encroached wetlands are related to collective benefits where those places can be commonly accessed and utilized. But migration or relocation is arguably the last choice among the various adaptation measurements (Johnson & Krishnamurthy 2010) and the social equity should be a concern due to social causes of vulnerability (individual or social groups lacking the capacity to adopt) in adaptation from future risks (Adger, 2001). This social displacement issue and concerns for equity in the GBI adaptation process were highlighted by the experts. Expert UH-01 mentioned;

"there is concern for the low-income population. From my experience from Hatirjheel and similar projects, I've realized that there is not much inclusive practice regarding the low-income communities. Most of the cases they don't have legal rights over the land and get evicted or the economic pressure influence them to move out. In such conditions, the authorities should include that affected population and accommodate them within the area".

Another expert, UP-02 said;

"As an Architect and urban designer here we have to face that your development always wipe out the scope of people who are originally there in the underdeveloped areas. I'm not sure, this is may be one common phenomenon embedded in any development within our system. There are social issues…, economic issues and many other dynamics".

So, in this case the displacement issue is much more complex in nature and not only related to future adaptation measures, and rather depends on the social, political and economic factors.

4.1.1.3.2. Population fluctuation

In general, urbanization and rapid population growth is a significant threat to many of the urban sectors. The experts expressed their concern in this aspect but more as a general under-laying driver for urban flooding issues. Some experts (i.e. UP-03, UH-03) did mention the uncertainty of population size due to constant in-migration that makes it difficult to design any infrastructure, but the issue is too obvious in the study area that most of the experts defined it as a general problem for urban flooding.

4.1.2. Bio-physical aspects:

Quantification of GBI requirements in the study area and performance of adopted GBI depends on the definitive values of bio-physical aspects (e.g. plantation character, soil type, drainage system, surface cover and surface elevation, land use and urban form). And the objective of the interviews was not to gather bio-physical information on GBI on the study area, but rather unfold the overall situation which will explain the socio-political conditions related to GBI. Therefore, the experts spontaneously mentioned some cases which were relevant to describe the situation. In the following discussions, I'll present the results which appeared as bio-physical aspects of GBI and were given priorities by the experts.

4.1.2.1. Climate change effects on urban flooding:

Climate is an important consideration in the bio-physical aspects of the GBI framework of this research which includes the future prediction of climate change as well as the current micro-climatic environment for the GBI's sustenance. From the interviews, the impact of climate change was discussed previously under the governance practice which showed how the climate change impact influences the decision-making process at national and local level. As much as the experts explained the politics behind the climate change related governance, there were less discussions on the causes of urban or pluvial flooding by the observable climate change effects. Although all of the experts mentioned climate change as one of the major actors of the flooding issue of Dhaka, most of the interviewees elaborated on the development issues for the existing flood-vulnerable condition of the city. Among the interviewees, mainly two (2) experts (i.e. UH-3, UH-4) explained the effects of climate change on flooding from a hydrological point of view. From their discussions it was understandable that the drainage system of this city is not at its optimal condition due to infrastructural lacking and other management oriented issues (e.g. encroachment of natural drainage, waste disposal). And climate change phenomenon such as prolonged monsoon, increased river level, shorter return period of intense storm-event has added more challenges to the system. The urban hydrologist UH-3 explained that the city's drainage system is dependent on the surrounding river system. The existing drainage system works based on gravity and pumping. During the monsoon, the drainage system relies on pumping when the surrounding river-level is higher. Based on

modelling studies he mentioned, the water level of the peripheral rivers has a trend to go up which means the existing drainage system will have to depend on pumping for a longer period if other measures were not taken.

4.1.2.2. EXISTING URBAN MORPHOLOGY AND CHALLENGES IN GBI ADAPTATION:

With GBIs, specially for flood-risk management, the idea is to create new systems and also create synergy with existing drainage system by retrofitting (Fryd et al., 2012). In the study area, the experts have put their concerns on the issue of rapidly changing urban environment and increasing challenges in the adaptation approach by incorporating the natural system. The lack of foresightedness in the earlier designs have brought more environmental problems. The water and flood management sectors are moving towards pumping and dams which might cater more built-up areas and less natural drainages. Describing the situation, expert Up-01 said;

"42 khals (canals) were filled up by the urbanization from British rule till now. There are few remaining canals which are either disconnected or covered by roads and 'box culverts'… In Arshad's regime lot of engineering measures were introduced such as these 'box culverts', dams, pumping stations etc. was introduced. These developments didn't consider the social and natural context of our city".

Hydrology expert UH-03 said;

"They are also increasing the pump capacities in response to the loss of retention ponds. In some areas, they have doubled it and yet again they are thinking of increasing the capacity more because they are expecting that there will be lesser areas for retention from the present trend of development. But these are still traditional thinking in terms of flood managing. So, again it's not an optimal situation when you are putting all your eggs in one basket".

Generally, the experts stated the traditional reactionist attitude of flood-risk management which results in more dams, culverts and high roads that disconnects the natural drainages with the urban environment and could make things difficult in future flood-events. Because, the traditional flood-risk management approach ignores the pro-active, local level bottom-up initiatives which are necessary for building resilience for future impacts (Tippett & Griffiths, 2007).

4.1.2.3. URBAN HYDROLOGICAL APPROACH AND PRACTICAL BARRIERS:

Another important remark from the experts is the suitability of hydrological infrastructures in the social context and their practicalities. In the past, some measures were taken by the engineers which in practice didn't work due to the social-behavioral and managerial issues of the context. For example, engineers implemented box-culverts over natural canals for creating roads but didn't consider issues like waste dumping and sludge accumulation. Those actions rather invented new environmental and management problems. Expert UP-03 mentioned;

"The 'box-culvert' type engineering solutions are not suitable for our context. For say, we can stop house hold waste dumping…but what about the natural waste, (e.g. dusts, plant leaves), construction waste etc.? Our municipalities do not have that much-sophisticated management".

Throwing waste into the drainage structures is a major problem for water and flood-risk management sectors. It makes it very difficult for the experts to model the system and develop adaptation scenarios. Also, water quality is a major problem due to waste dumping. With such polluted water, it will be difficult

to allow the multipurpose uses of GBI structures (e.g. playground as temporary wetlands). Hydrology expert UH-03 mentioned;

"one of the biggest challenge for us is to keep the water clean. As a megacity, we only have one water treatment plant. And it is not functioning optimally. It is not getting enough waste water because of the problems of the sewer collection system. So, with a separated system we can have lots of options with storm water (e.g. recycling, reusing for irrigation and other uses)".

Different hydrological techniques became irrelevant because of lack of civic sense and social awareness and failed to cope with the practical context. UH-03 shares;

"What happened few years ago, some pillars were put to demarcate the navigation route of the river for the dry season. So, people started to fill up the river up to that boundary for more lands without knowing the actual reason behind it. So, very unfortunately what was initially a good idea, had a bad impact".

As a summary, at the city level the role of the governance and institutional set backs were signified by the experts. Specially, lack of implementation and enforcing planning instruments were given importance as constrains for city's adaptation process. Two important poles of climate-risks and growth-based economic pressure were dominant on the governance-discussions. In terms of environmental regulation and legislation, the experts mentioned about the existing planning legislations which are aligned with GBI approaches but also mentioned their practice-gaps. Need for a robust strategic land-use plan that incorporates the water-based adaptation concepts supportive to the national-level climate policies was recommended by most of the experts. Urban management issues such as inter-agency coordination and timely deployment of services are addressed at the local level governance. They also reflect on the social challenges (e.g. social displacement) of GBI implementation and place it as one of the fundamental considerations for GBI implementation. The bio-physical aspects were also explained focusing on the traditional flood-management attitude and its impacts on the morphology of landscape. Practical barriers of technical hydrological or GBI designs were indicated and the complexity of hydrological modeling was explained. With all these aspects, the discussions indicate the existing inter-relations between the bio-physical and socio-political aspects of the study area.

4.1.3. Interview results per case studies:

In the previous sections, I've presented the experts responses on the overall study area. Now, according to the previous mention (see section 4.1), I'll present the case specific comments in the following sections. There were topics which were only mentioned during case-level discussions and I find it important for this research to mention these neighborhood or project-level discussion as there are elements which are unique to the previous city-level responses. Most of the cases, the experts gave references to the projects (specially, Hatirjheel lake) which are part of the case-studies to give detailed examples respect to the GBI planning issues in the study area.

4.1.3.1. Case 01:

This case study is based on the Hatirjheel lake and Gulshan-Banani lake projects (see section 3.4.2). The Gulshan-Banani lake is situated next to the Hatirjheel lake and was realized following the foot-steps of the Hatirjheel project during this research. The environmental concerns for the lakes around the selected case-study area raised in the institutional and public domains, started with the Hatirjheel-lake project due

to its strategic importance and deteriorating conditions. It was also the most recent large-scale GBI realization during this study. Therefore, in the interviews, experts mainly mentioned this particular project (i.e. Hatirjheel-lake) as reference-point to their discussions. So, for the following section, the planning process related to Hatirjheel-lake is presented.

According to the experts, the problems of the Hatirjheel lake project were diversified and extremely complex. On the other hand, the potentiality was very high for the urban environment. The large wetland at the center of the city had significant environmental potentialities including inland flood-risk management for the city by storm-water detention. The economic value of the area and its strategic location for urban transportation made it more desirable for development. Therefore, there were different development proposals from the governmental agencies. But, according to the experts, those proposals vastly ignored the environmental services that the area could offer and didn't materialize from any strategic plan rather it was grounded with growth-oriented rationales. Besides that, there were ongoing researches in the academia and scientific communities that were concerned about the environmental issues of this lake area. The experts advocated for its drainage values over transportation and other developments that might promote built-up areas. Initially, the economic drivers were the main priority of the planning authority and the environmental knowledge had less influence on the planning process. But in 2004, there were extreme rain events and water logging situations. Reaction to that the local government decided a more participatory approach between agencies and experts for decision-making about this area. Among the different actors, the experts could negotiate the environmental function (in that case water detention and drainage) based on the academic researches and the focus was shifted towards GBI development instead of road and housing development.

Multifunctionality was a major consideration for realization of this project. This project initiated with two major rationales (i.e. rain water detention and east-west road connection). The major objectives were developed through negotiation between actors (e.g. transport authority, development planning authority, experts) and the design was formulated by a team of multi-disciplinary experts. Before the detail design, the proposal was modified several times for political and budgetary issues and the experts facilitated the trade-off between environmental and transportation goals. Later, recreational and public amenities were added to the design to make it more for financially viable. The multi-functional approach speeded up the decision making and administrative process for realization of project. The concept of this multiple rationales became so acceptable in the administrations that even after the official completion in 2013, new spatial developments are being integrated with this project for its optimal utilization. One of the lead designer of this project said;

"There were many "dreams" around this project which cannot be realized in this context, we had to realize the integrality or multifunctionality of this project. Otherwise, with only environmental rationales it would never be realized".

In the implementation phase, experts specially mentioned the social distress from the equity perspective of the project. Most of the development areas including the lake were government-owned public land. But the area was under encroachment threats with lot of illegal developments. To restore the area and implement the plan, the authority evicted illegal settlements and acquired land from private owners. This process created winner-loser situations and there were lot of arguments over the land rights. Some compensation mechanisms were adopted but the experts specially expressed their concern on the social

displacement as many low-income households were forced to leave the area due to legal issues. So, in this case in-site social issue was a major implementation challenge.

4.1.3.2. CASE 02:

This second case is based on another lake project i.e. Dhanmondi lake (see section 3.4.2.2). Unlike the Hatirjheel project, it is smaller in scale and situated in a residential neighborhood. It was one of the first lake restoration projects and became a popular meeting spot for people. It was planned as a neighborhood park for the nearby residents including environmental restoration objectives but became a cultural attraction for the whole city. About this case, the hydrology experts didn't responsed much because when the project was realized, there were no extensive water-modeling or detention design. But the spatial planners mentioned its strategic importance as it was historically interlinked with the Hatirjheel lake. The urban design expert UP-02 explained the planning and realization process of this project. Within the area, there were local communities organized (e.g. landowner's associations) and had common interest on upgradation of their residential area. So, they were influential actors and had active participation in the development process. There was not debate about its objective between the agencies and due to it neighborhood-scale the interest group was small and manageable. The multi-functionality played an important role in this project. Place-making was an important consideration in the design and small businesses and activities were introduced. But in this case the functions which were designed per local demands became insufficient due to the increasing pressure from outside visitors. The expert UP-02 specifically mentioned that this project was an important example for planning experts to realize that the environmental development can promote economic growth. It also showed the importance of vitalizing environmental sites with public activities.

As a summary, the discussions on the case studies were more like an exploration of the actual situation at the project-level. The experts mentioned these cases as examples to support their arguments directed to the multi-actor and multi-stakeholder involvement, the role of expert knowledge and multi-functionality of the GBI adaptation. And they gave lot of background on the planning process of the projects. Therefore, I've presented the case-results in an explorative manner. These cases showed different decision-making and implementation challenges and their practical resolutions. The differences in the site-specific governance and planning issues reveals the spatial factors GBI adaptation in different spatial scales.

4.1.4. INTERVIEW CONCLUSION:

Analyzing the interviews different issues were surfaced under the socio-political and biophysical aspects of GBI planning in the study area. Those aspects have temporal and spatial effects and they were presented during the discussions. For example, the rapidly changing urban landscape and implementation delay of the GBI adaptation process increase climate vulnerability of the study area. The general discussion on the aspects indicated the city-level issues and the case studies showed their practical effects in the adaptation process. Discussion on these different spatial scales also indicates the increasing complexity in governance and environmental sectors with increasing spatial limits. Basically, the overall discussion raised issues which need normative interpretations such as environmental governance, concept of equity in environmental practices and the case-level discussions provided ground for their application with real-life examples. In general, the city-level discussions identified challenges on local governance level which

have consequential effects on implementation of GBI. The under-laying economic and climate change drivers were discussed and conditional gaps agencies were given priorities in the governance practices. In this regard, the case studies showed significant possibilities by explaining the multi-actors and multi-functional approaches of the selected projects. Other than that, different priorities in the two important disciplinary sectors (i.e. spatial planning and urban hydrology) is also visible. The spatial planning experts mostly argued for a robust strategic plan given the importance on spatial adaptation whereas the hydrology experts mentioned the technical complexity of storm-water management in the existing social context and argued for better municipal management of drainage-infrastructures.

4.2. Document survey:

In the document survey, I've reviewed national and local level policy and planning documents including policies, strategic plans, environmental and building legislations from governmental agencies for climate change adaptation, flood-risk management, spatial planning and technical papers in the field of and urban hydrology to relate adopted GBI framework with the planning context (see table 01). The effort is to triangulate with the interview results according to the mixed method approach I've explained earlier. Most of the reviewed articles are selected via recommendation from the experts. Other than I've also mentioned relevant documents which will help further elaborate research in this field. It is important to mention that; the objective is not to develop a complete policy review, but rather an inspection of the selected policy documents. The technical paper which I've reviewed in this research was an outcome of an extensive study on hydrological modeling of the study area according to their individual methods. I've discussed on their methods and results to comprehend some of the bio-physical conditions of the study area as per the GBI framework.

Table 1: List of documents recommended by the experts and selected for review.

Type	Governance level	Tittle	Ministry/Agency	Authors	Research area	Status
Policy & planning	National	Bangladesh climate change strategy and action plan (BCCSAP)	Ministry of Environment and Forest (MoEF) of Gov. of Bangladesh	Consultant team of MoEF	Climate Change Adaptation	Final Report, 2009-2018
Policy & planning	National	National Adaptation Programmes of Action (NAPA) for Bangladesh	Ministry of Environment and Forest (MoEF) of Gov. of Bangladesh	Consultant team of MoEF	Climate Change Adaptation	Final Report, November 2005 till present
Strategic Development plan	Local	Greater Dhaka Flood Protection Project FAP 8A	Flood Plan Coordination Organization, Gov. of Bangladesh	Consultant team JAICA	Drainage and Flood-risk management	Adopted in 1991, yet to realize
Strategic Development plan	Local	Dhaka Integrated Flood Protection Project. FAP 8B	Flood Plan Coordination Organization, Gov. of Bangladesh	Louis Berger International, Inc. & Associates	Drainage and Flood-risk management	Adopted in 1991, partially realized
Strategic Development plan	Local	Dhaka Metropolitan Development Plan (DMDP) Detail Area Plan (DAP)	RAJUK	RAJUK	Urban Land-Use Planning	Developed for 1995-2015, ongoing
Strategic Development plan	Local	Detail Area Plan (DAP) of DMPD Area	RAJUK	RAJUK	Urban Land-Use Planning	Developed for 2010-2015, ongoing
Gov. Legislations		Wetland Conservation Act 2000, Water Act 2013, Local Government Act 2009, Dhaka Metropolitan Building Construction Rules 2008	Local Government, RAJUK, DWDB	Gov. of Bangladesh	Water and Flood-risk management, Housing	Applicable for the study area
Hydrological Model	Local	Urban Flooding of Greater Dhaka in a Changing Climate Building Local Resilience to Disaster Risk	The World Bank, IWM, BCCRF	Authors from various organizations	Flood-risk Management, Urban Hydrology	Published 2014

4.2.1. NATIONAL LEVEL POLICY AND PLANS:

In the following section, I've reviewed the national level policies focusing on the climate adaptation issues. Previously mentioned two policy documents (i.e. BCCSAP and NAPA) were briefly presented and also, relevant policies were mentioned to explain the policy domain around the topic of this research.

4.2.1.1. BANGLADESH CLIMATE CHANGE STRATEGY AND ACTION PLAN (BCCSAP):

This is a national level climate -policy document adopted as per the government's commitment to the Bali action plan launched in the 13th conference of parties to the UN framework convention of Climate Change (UNFCCC) in 2007. The goal is to integrate the climate change adaptation and mitigation strategies with the overall development strategies to meet country's vision of economic development and eradicate poverty by 2021 without environmental degradation.

The BCCSAP has six pillars (i.e. Food security, social protection and health; Comprehensive disaster management; Infrastructure; Research and knowledge management; Mitigation and low carbon development; Capacity building and institutional) and there are 44 programs under those pillars. Among those pillars 'infrastructure' and 'capacity building and institutional' are mostly relevant for this research.

The following strategies are mentioned in different sections which are important for GBI planning for climate adaptation;

- Improvement of urban drainage capacity
- adaptation of flood by implementing flood management infrastructures, flood plain zoning and non-structural flood proofing measures
- Adaptation of existing and under construction building for rain-water collection and storage
- mainstreaming climate change in all national, sectoral policies and strategies for planning and spatial development with appropriate involvement of relevant stakeholders
- Improving institutional capacity for climate change management through inter-ministerial and inter-institutional coordination, organizational reform and strengthening key governmental and other agencies

For implementing the plans for improving urban drainage and flood adaptation the BCCSAP proposed medium to long term actions and for revising policies for climate resilience the BCCSAP indicated immediate actions in its program details. According to the plan, relevant ministries (e.g. Ministry of Local Government, Ministry of Water Resource, Planning Commission), their agencies, private sectors and NGOs shall take the responsibilities of such actions. There are other strategies in BCCSAP which are important of GBI adaptation but not directly. For example, modeling climate change in sub-national level, flood forecasting and signaling, waste management, monitoring external and internal migration and support for resettlements.

4.2.1.2. National Adaptation Programme of Action (NAPA)

This policy document was adopted as a response to the 7th session of the Conference of the Parties of the on United Nations Framework Convention Climate Change (UNFCCC). In NAPA, actions are divided into two major types (i.e. intervention type measure and facilitating type measure). The activities within these types were prioritized by poverty reduction and livelihood security with gender perspective. 15 projects were developed from the prioritized activities. The following strategies are important for this research;

- Capacity building and conflict management for integrating climate change in planning and designing of infrastructure
- Mainstreaming climate change adaptation into policies and programs in different sectors (mainly disaster management, water, agriculture, health and industry)
- Enhancing urban resilience to climate change

According to this document the implementing agencies are the department of environment (DoE), Water Resource Planning Organization (WARPO), Local governments and NGOs for the mentioned strategies. This policy document is also focusing on adaptation measures but suggested community-based or social adaptation more than infrastructural adaptation.

At the national level, there are many other policies relevant (e.g. flood-risk management and spatial planning) sectors which are not fully committed to mainstreaming of climate change but covered several aspects regarding environmental preservation and flood safety. For example, the National Wetland Policy (draft) gives main attention to wetland preservation and their sustainable use, integration of wetland functions in resource management etc. but the policy-set is mostly focused towards sustainable resource management related to farming (e.g. fisheries, agriculture) of the natural wetlands and rather on urban

drainage and flood-risk management. The National Water Policy (1999) similarly prescribed for preservation of natural water bodies, maintaining their environmental quality and facilitate natural drainage. It also mentioned decentralizing and involving private-sectors in water resource development and management. Jolmohal Management Policy (2009) addressed the management of closed water bodies and their regulatory scales. There is a National Water Management Plan (2001) which sets a comprehensive framework for operationalize the National Water policy. This plan included water management programs for towns or urban areas to anticipate future water supplies and infrastructure requirement rather than responding to demand. The Flood Action Plan (1989-1995) was a nation-wide elaborate flood-risk management study which developed flood-control measures and improved drainage-system for urban centers. In the national level their objective was to enhance agricultural production and livelihood protection through flood-control. This plan had particular studies for Dhaka (the study area) which is later explained in section 4.2.2.1.

In the urban spatial planning sector, there is the National Housing policy (1993 and 2001) which stated housing affordability for all social groups specially for low-income people, reducing standard for improving existing slums, financial mechanisms for affordability and rehabilitation. The National Urban Sector Policy (2011) has the objective to ensure regionally balanced urbanization by decentralizing development and has a policy for protection of urban environment specially water bodies and optimum utilization of land-resources. The Sixth Five-Year Plan (2011-2015) which follows the government's Outline Perspective Plan (OPP) 2021 as well as the goals of the Millennium Development Goals (MDGs) has strategies and plans for managing spatial growth, ensuring social protection, ensuring environmental sustainability, institutional reform for governance improvement, realistic scale for climate change assessment etc. For proper utilization of land-resources the government has the Land-use Policy (2001). Particularly for environmental protection, there is the National Environmental Policy and Implementation plan (1992).

From the above exploration, it was clear that in the policy-domain there are sufficient policies which indicate environmental governance through institutional reformation, decentralization for strengthening local governments, environmental protection specially for water bodies, flood-risk management for urban areas, social protection for low-income community and rehabilitation facilities, proper land-use for compact growth etc. The initially described two policy-set (i.e. BCCSAP and NAPA) mentioned by the experts particularly stated climate change mainstreaming and its immediate application in institutionalization. So, the policy environment at the national level appears ideal but their implementation in the local-level is a matter of concern for climate adaptation through GBI implementation.

During this research, there was another policy work in development, namely, the Bangladesh Delta Plan 2100. It is a major policy and plan reformulation study grounded by the objective of integrating all policy and planning from delta related sectors to develop a holistic long-term plan for the whole country. The inspiration of this plan came from the delta planning process as used in the Netherlands but rooted in the Bangladesh context. The aim was to finalize and approve this plan in September 2016, but the process was ongoing and yet to appear as public document during this research. The study process developed and published baseline reports where Dhaka (the study area) is one of the hotspots for a strategic plan. In those reports several policies were reviewed and evaluated which gave an indication for the implementation-gap in the study area regarding adaptation strategies.

4.2.2. LOCAL LEVEL STRATEGIC PLAN:

In the interview sessions, experts mentioned particular strategic plans in the flood-risk management and urban spatial planning sectors which are local level spatial plans for the study area. Most of the experts mentioned the issue of proper policy-interpretation and implementation of these spatial plans. Also, integration of flood-risk management and land-use planning was a part of their discussions. In the following section, I've reviewed those plans to relate with those previous responses.

4.2.2.1. FLOOD ACTION PLAN, FAP 8A AND 8B:

In reaction to the 1988s-flood events, the government adopted the Flood Action Plan (FAP) in 1989. There were 26 components in that national level plan. FAP-8 is one the component with two sub-components (i.e. FAP-8A, FAP-8B). The FAP 8A study developed a master plan for drainage and flood-control for eastern side of Dhaka (i.e. Dhaka east, DND, west Narayanganj) (see figure 16). That plan divided the area with drainage zones for storm-water drainage and a proposed embankment at the eastern border, retention ponds, improve and construct canals for drainage and new pump stations. The FAP 8B under Dhaka integrated flood protection project had developed plans for flood protection, drainage, implementation assistance and environmental improvement for the western side of the city. It proposed rehabilitation and improving 21 major Khals (natural canals), three (3) major retention ponds with pump stations and proposed land acquisitions for those areas.

These reports show structural and non-structural measures for flood protection of the study area. But both projects have not been realized completely. Mostly, the structural part of FAP 8B was realized and the designated retention areas were not properly maintained and got encroached over the time. FAP-8B proposed around 4.5% land area as retention but in 2007 this area was reduced to 1.79% at the western part (Das & Islam, 2010). The FAP 8A has not being realized yet. After 1998s and 2004s major flood events, these studies were revised and the government approved this as priority project but for some reason suspended in 2003. The 1998s flood event showed that only structural measures were not sufficient for flood protection and the non-structural features significantly reduced flood damage (Faisal, Kabir, & Nishat, 1999).

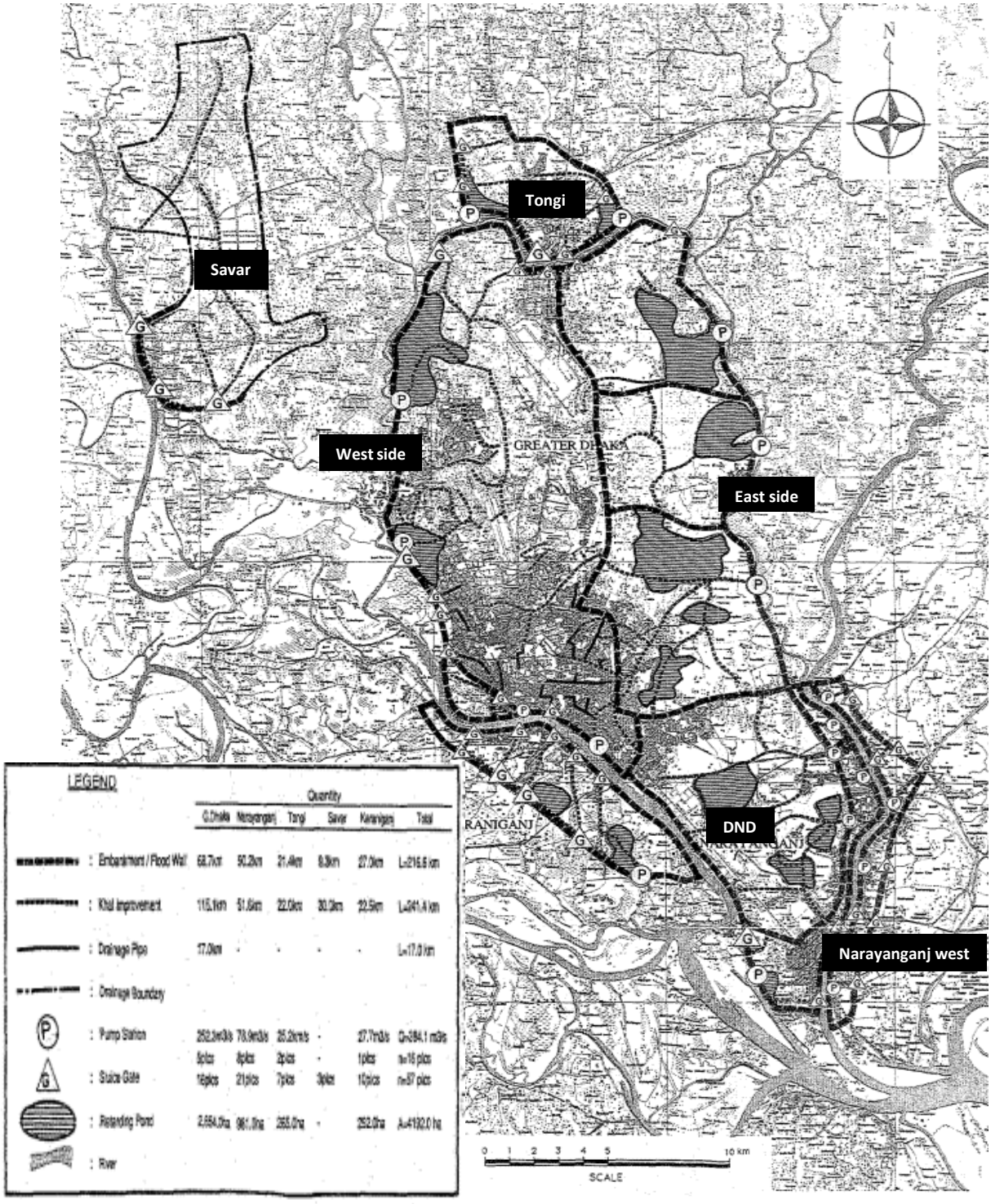

Figure 16:Proposed master plan for Dhaka East and West area from FAP 8.A (Source JAICA, 1991)

4.2.2.2. Dhaka Metropolitan Development Plan, DMDP and Detail Area Plan, DAP:

Dhaka Metropolitan Development Plan (DMDP) is a long term (1995-2015) strategic plan for the greater Dhaka area. It consists of three (3) plans (i.e. Structure Plan, Urban Area Plan and Detail Area Plan). The DMDP has sectoral policies and strategies for urban development of the metropolitan development area. DMDP defined set of policies and developed strategies for the city's future growth. It designated green belts, retention ponds, preservation of wetlands, agricultural low lands and flood flow zones, circular waterways (see figure 17) to sustain healthy urban environment and protection from urban and river flooding. This plan was published in 1997. Its structure plan identified 26 strategic planning zones (SPZ) as sub-areas and later in 2010 the DAP was published. DAP proposed detail land-use plan (see figure 18) with implementation guidelines.

Flood safety was one of the primary component of DAP but it didn't properly adopt the flood-control measures from DMDP or FAP-8B (BanDuDeltAS, 2015). In fact, DAP has proposed built infrastructures (e.g. road, land development) over the designated retention ponds (e.g. Goranchatbari, Kallyanpur) shown in FAP 8B (Das & Islam, 2010). Many local experts have criticized DAP for contradicting the development guidelines from its strategic plan (i.e. DMDP) (Mowla, 2011, 2013). During this research, this DAP was the regulatory land-use plan for the study area.

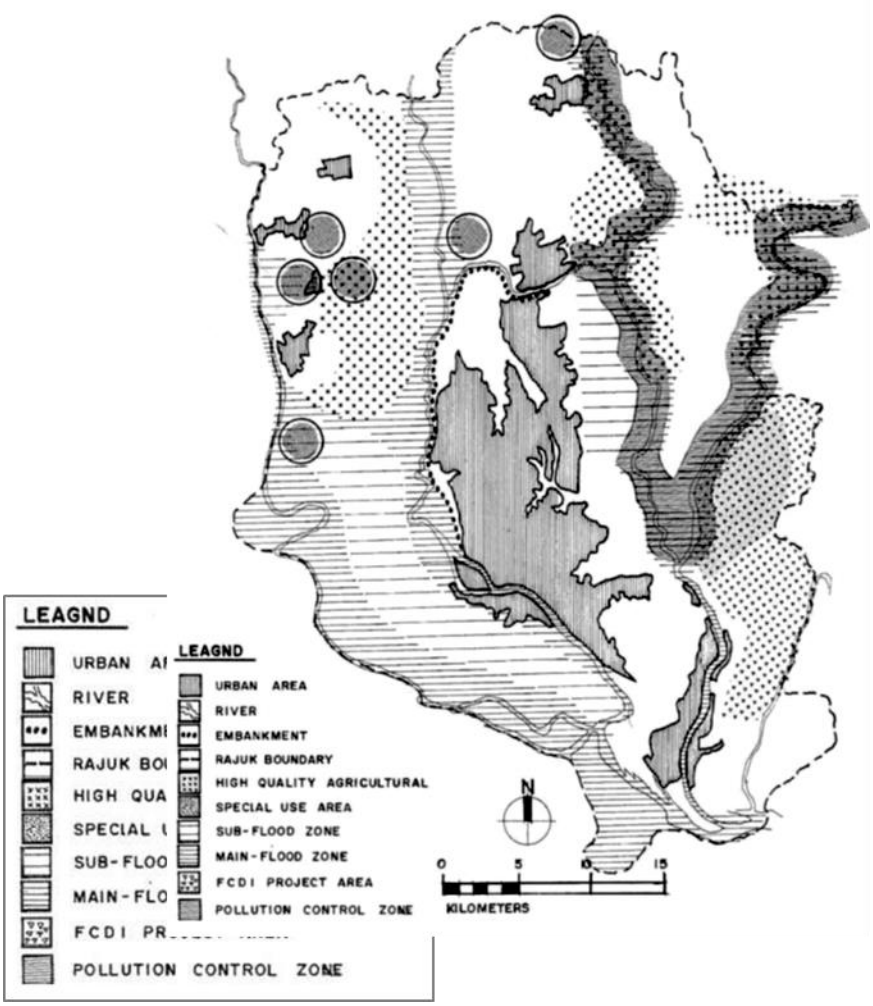

Figure 17: Strategic plan of DMDP (Source: RAJUK, 1995)

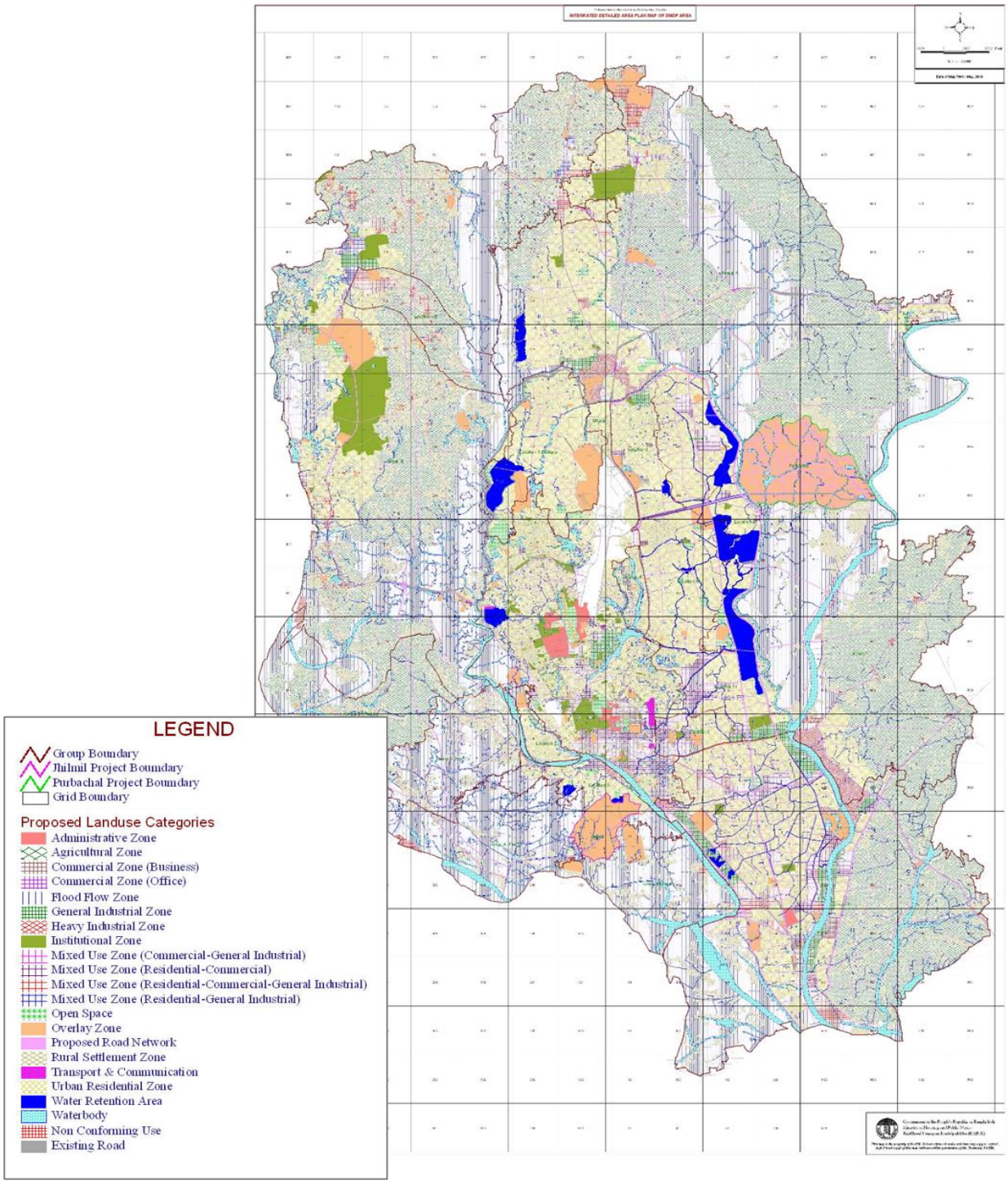

Figure 18: Proposed land-uses of DAP (2010-2015) (Source: RAJUK, 2010)

4.2.3. WATER AND URBANIZATION RELATED ACTS:

The government of Bangladesh has a large number of water related Acts. By law public open spaces and wetlands are protected and privately own wetlands are also defined by these laws and need authority's permission for any development. Different agencies are assigned for implementing these legislations at a specific governance level. For example, the Department of Environment is responsible for implementing the Natural water reservoir Conservation Act 2000 and it is under the jurisdiction of the District Commissioner; the Local Government Act 2009 is deployed by the authorities of specific levels (i.e. City corporation, Municipal, Union Council). In the urban areas, all open spaces, play grounds and natural water bodies are protected by the law of "Playgrounds, Open Area, Park and Natural Water Reservoir in Municipal Area of City, Divisional Town & District Town Conservation Act 2000". The government announced the Bangladesh Water Act 2013 to implement the National Water Policy. Large set of water bodies and important land areas (e.g. 'foreshore') for water and flood-risk management is marked through this legislation.

Some other water related Acts are National River Protection Commission Act 2013, Bangladesh Water Development Board Act 2000, Water Supply and Drainage Authority Act 1996, Bangladesh Environment Conservation Act 1995, Water Resource Planning Act 1992, Ground Water Management Ordinance 1985, The Embankment & Drainage Act 1952, The Tanks Improvement Act 1939, The Public Parks Act 1904, The Irrigation Act 1876, The Canal Act 1864 etc. There are constructions rules and regulations for example, Bangladesh National Building Codes 2010, Dhaka Metropolitan Building Construction Rules 2008, Private Housing Project Land Development Rule 2004 which include mandatory open space in private housing, regulation for water storage and drainages etc. which are good instruments for implementing GBI in built environment.

As a summary, this exploration in the policy, strategic planning and legislations explains the policy environment, governance and implementation process of GBI in the study area. The climate change policies gave presidency to climate mainstreaming for institutional reform where different agencies will align their sectoral policies with national level policies and plan the implementation process in collaboration with actors from private sectors, NGOs and experts from the civic society. According to the policies, it appears as an ideal situation but in practice it needs to ensure strong leadership for coordinating. The BCCSAP and NAPA is developed by the Ministry of Environment and Forests (MoEF) and it is central to formulate adaptation related tasks. But other ministries and organizations such as Water resource, Local governments, Planning Commission, Water Resource Planning Organization (WARPO) are designated in relevant programs for flood-risk management for climate adaptation. Agencies under these ministries will be important governmental actors in implementing strategic plans in their jurisdiction areas. For the study area, primarily the Local Government and its agencies such as RAJUK, DWASA, LGED and DCCs are responsible for planning and spatial development of adaptation works. In most of the policy frameworks, relevant ministries are identified but inter-ministerial and inter-agency coordination for policy adaptation in local level is a challenge. For example, the National Wetland policy identified five (5) ministries and 12 agencies but didn't identify any central coordination body to coordinate the adopted programs (BanDuDeltAS, 2015).

This has effects in decision-making for the strategic plan. For Dhaka, RAJUK is responsible for planning and implementing development works and has the constitutive power to coordinate between different sectors and their plans. But in structure plan formulation from DMDP, this coordination was lacking and eventually the final plan raised many inconsistencies (SENES Consultants Ltd., 2007). In a sense,

coordination is a problem. But in this case, the driver for proper initiation and implementation is lacking specially when it comes to environmental development. From that perspective, experts criticize the RAJUK's combined role of execution and monitoring as a conflicting practice (Mowla, 2011). Competition between actors becomes challenging in such monopolistic environment.

In terms of legislative support for GBI adaptation, such as utilizing open spaces and natural water bodies, there are sufficient laws specially, in preserving wetlands. But using those regulatory instruments for strategic purposes is rare. The ongoing encroachment in the urban area is an unmistakable evidence of that. In this regard, developing institutional capacity for monitoring illegal development as well as the tasks of responsible agencies is essential (BanDuDeltAS, 2015). In respect to the social displacement concern raised by the experts during interviews, the National Housing Policy gives precedence to slum-improvement and discourage relocation. Whereas, from the case study it was clear that the real situation is no pro-poor and in infrastructural development slum-dwellers are the most vulnerable community for force-relocation.

From the national level policy making to local level strategic plan, the planning process for climate adaptation indicates a top down approach. The following diagram will show the standard planning process of climate change adaptation idealized in the reviewed policies in respect to the urban flooding issue. In this case, the outcome of such process is GBI implementation as an adaptation measure.

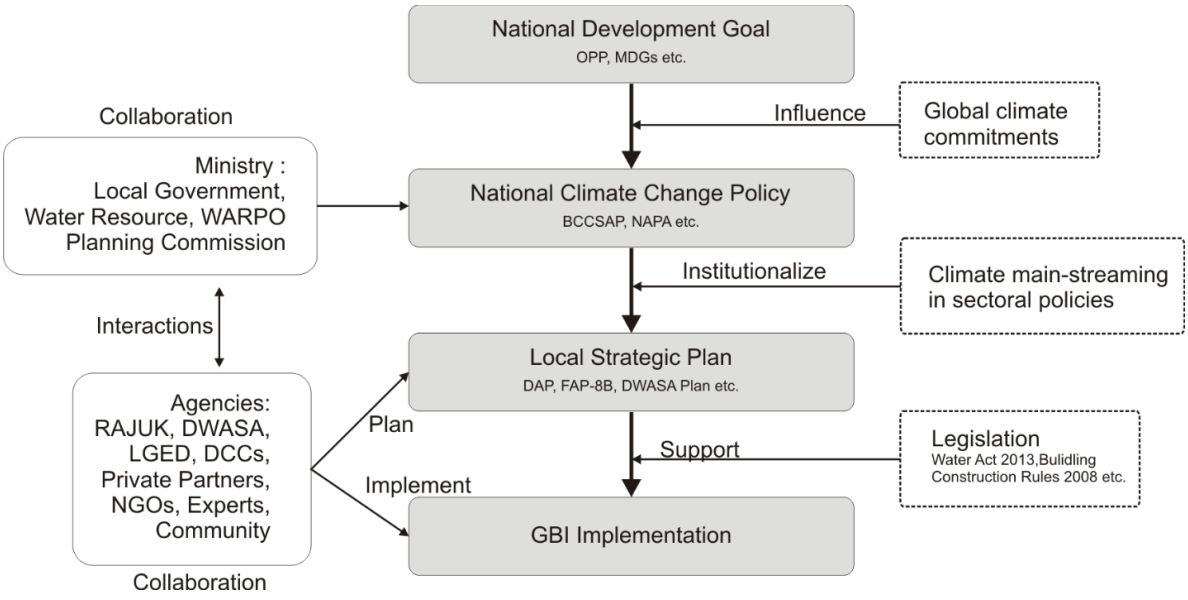

Figure 19: Standard planning process of GBI adaptation according to adopted policies

4.2.4. Study on urban Hydrology of the study area:

Understanding the biophysical functions of GBI of the study area will require extensive technical research. I've previously explained that (see previous section 2.5), SUDS are more relevant to GBI adaptation methods for flood-risk management. To implement GBI (or SUDS) for a flood-proof urban landscape, it is imperative to have knowledge about local hydrology and modern technologies. In the international context, there are profound scientific knowledge and planning guidelines on the biophysical aspects of GBI (Matthews et al., 2015) specially in UK and North America (Mell, 2008). But, for Dhaka, GBI (or SUDS) adaptation for urban flooding is a new concept. There are several hydrological researches mainly on existing hydrological processes and the flooding issue of the study area, but future requirement of drainage in respect to climate change risks is comparatively a new area for research. During the interviews, the hydrology experts mentioned the modeling complexity and lack of current data for local urban hydrological study and advocated for more research based knowledge to promote the water-based adaptation in decision-making. Now, for this research, it is also necessary to explore the biophysical aspects of the GBI within the study context. In this regard, this research relied on secondary sources and expert's responses. Based on the experts recommendation, I've reviewed the Dasgupta et al. (2015)'s work which includes a hydrology model study on the study area regarding climate change and urban flooding issues.

4.2.4.1. Hydrology modeling of Greater Dhaka:

4.2.4.1.1. Regional level finding:

The Dasgupta et al.(2015) study was conducted to support the local agency (i.e. DWASA) for developing Dhaka's drainage capacity for flood mitigation. For this, a hydrological model was developed considering climate change scenario. The extent of their modeled area (i.e. DMDP area or greater Dhaka) corresponds with the study area of this research. Although, due to the lack of proper drainage infrastructural data, it excluded some underdeveloped areas (e.g. peri-urban, rural) from the initially adopted area, the overall result of that model will represent my research's city-level hydrological condition. Their research also has 7 sub-models for detail study and one of those areas (namely 'central Dhaka') represents the Hatirjheel lake surrounding area thus corresponds with the neighborhood-level hydrological situation of case 1.

The Dasgupta et al.(2015) study considered two (2) climate change scenarios (i.e. B1[5] for 25 years , A1FI[6] for 50 years). They included external river-flooding and used IWM's North Central Regional Hydrodynamic (NCRHD) Model for regional flood modeling of the Greater Dhaka area. NCRHD provided water level and water flow from the surrounding river. Data about surface cover change, meteorology (i.e. rain fall, temperature), topography using digital elevation model (DEM), drainage infrastructure (based on DWASA's master plan), and external drainage (i.e. river stage, river flow, river sections, slope and alignment), evapotranspiration were used. But the model did not consider urban vegetation or plant character for either scales (i.e. greater Dhaka, detail area). Other information such as wastewater inflows, Subsidence, Sea level rise (SLR) was considered negligible for this 50 years' model. They have analyzed time series data of daily rainfall from different BWDB (Bangladesh Water Development Board) stations around Dhaka, and selected 2004s rain event (in 13th September 2004, 341mm/day) for simulation. However, there were another recorded extreme event (in 28th July 2009 448mm/day) but the 2004s

[5] IPPC scenario with future based on a high level of environmental and social consciousness with global coherence for sustainable development

[6] IPPC scenario with future based on fossil fuel–intensive development

event was of interest for their study as it caused major flooding in Dhaka and corresponds well with the availability of other datasets (such as land-use data). The selected 2004s rain event was 100yrs[7] event and simulated with the increase (16%) from A1F1 scenario of 2050, so in 50yrs 396m/day.

It is worth mentioning that their analysis of extreme precipitation data shows a clear trend of increasing frequency of intense rainfall events. It showed that return periods are decreasing, meaning larger events are occurring more frequently.

One of the major consideration in hydrological model is surface cover change and elevation (Gill et al., 2007). For existing elevation, the experts used DEM (25m x 25m grid) from IWM of the year 2004 and the surface cover was used from to the DAP study. For the future scenarios, they considered the land-use proposal from DAP assuming that the city will develop according to it. They used the population increase and land-development trend which shifted the main land-level category (in terms of height) from 3-4m to 7-8m in 2050[8]. This is a major decision where most of the areas at eastern part of the city is a low-laying area and susceptible to river flooding. The following figure (see figure 20) shows their results on flooding in existing and future situations.

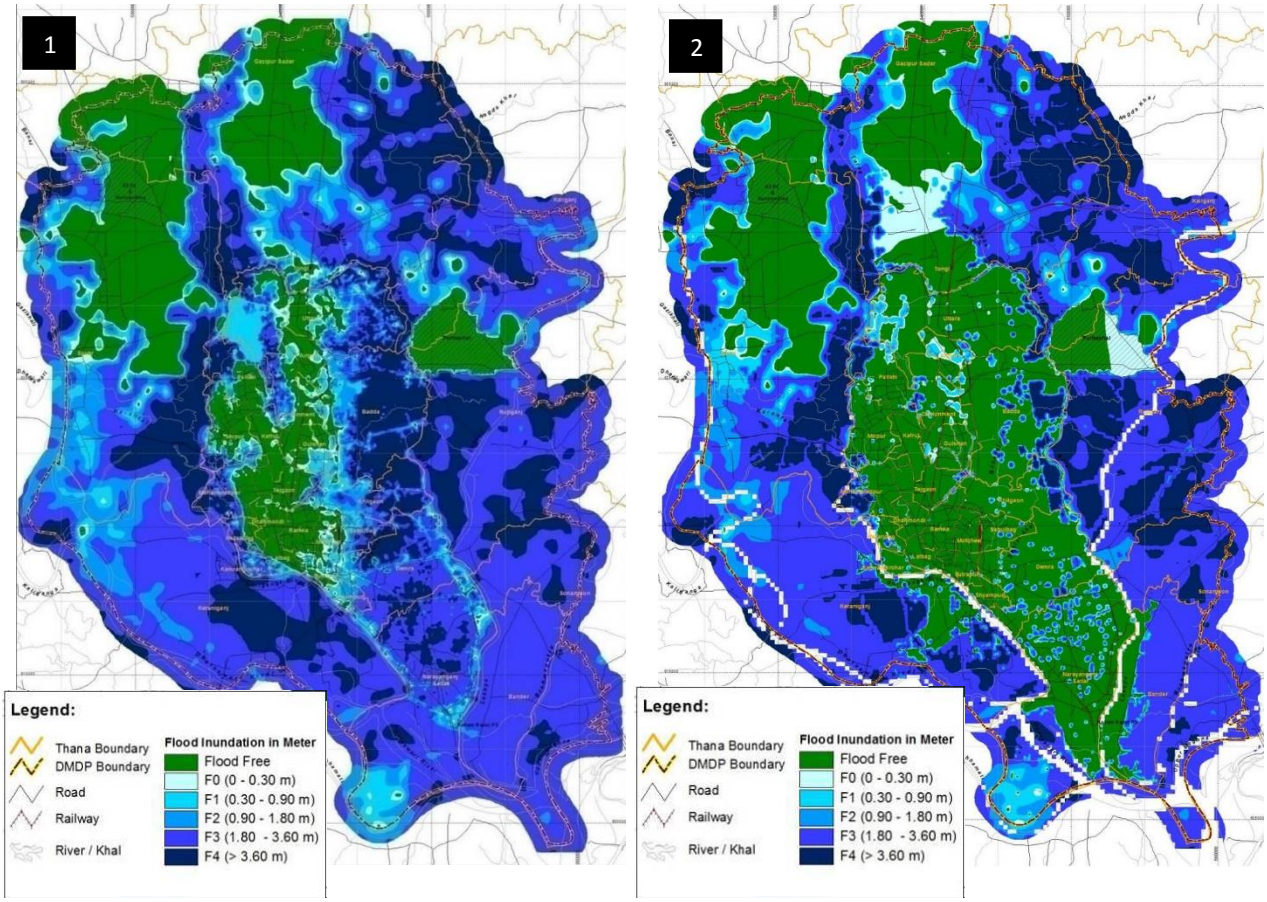

Figure 20: Flooding situation in existing situation including climate change (1) and in A1F1-2050 scenario (2) (Source: IWM, 2014)

[7] classified by IWFM, JAICA classified it as 1000yrs or more

[8] Expecting that existing unurbanized low areas will be raised up per proposed land-uses

4.2.4.1.2. CASE-LEVEL FINDINGS:

For detail area modeling, the Dasgupta et al.(2015) study considered more local scenarios. In this case 4 scenarios were sequentially investigated the situation. Along with the earlier climate change (CC) (i.e. B1-2025, A1F1-2050) and future socio-economic changes (SE) (which represents surface cover change due to future developments), two scenarios i.e. planned drainage developments (PDIs) and additional improvements (AIs) were added to simulate the areas performance to achieve the predefined criteria (i.e. 90% of the administrative area must have less than 0.25m flooding and no inundation more than 12 hours). The planned improvements refer to the future developments in drainage per RAJUK's and DWASA's plan. In the site-specific situation, their study proposed some additional adaptation options. But the adaptations are mostly and engineered approach such as new pumps with increased capacity, sluice gates etc. In the central Dhaka area (which represents case 1), despite of having the largest existing water retention area (i.e. Hatirjheel and Gulshan-Banani lake), there is more chance of flooding with longer duration with actual rain events (100yrs event) even if the model includes planned improvement for the future scenario (see figure 21). This is due to the increase of impervious land cover change according to the proposed urbanization.

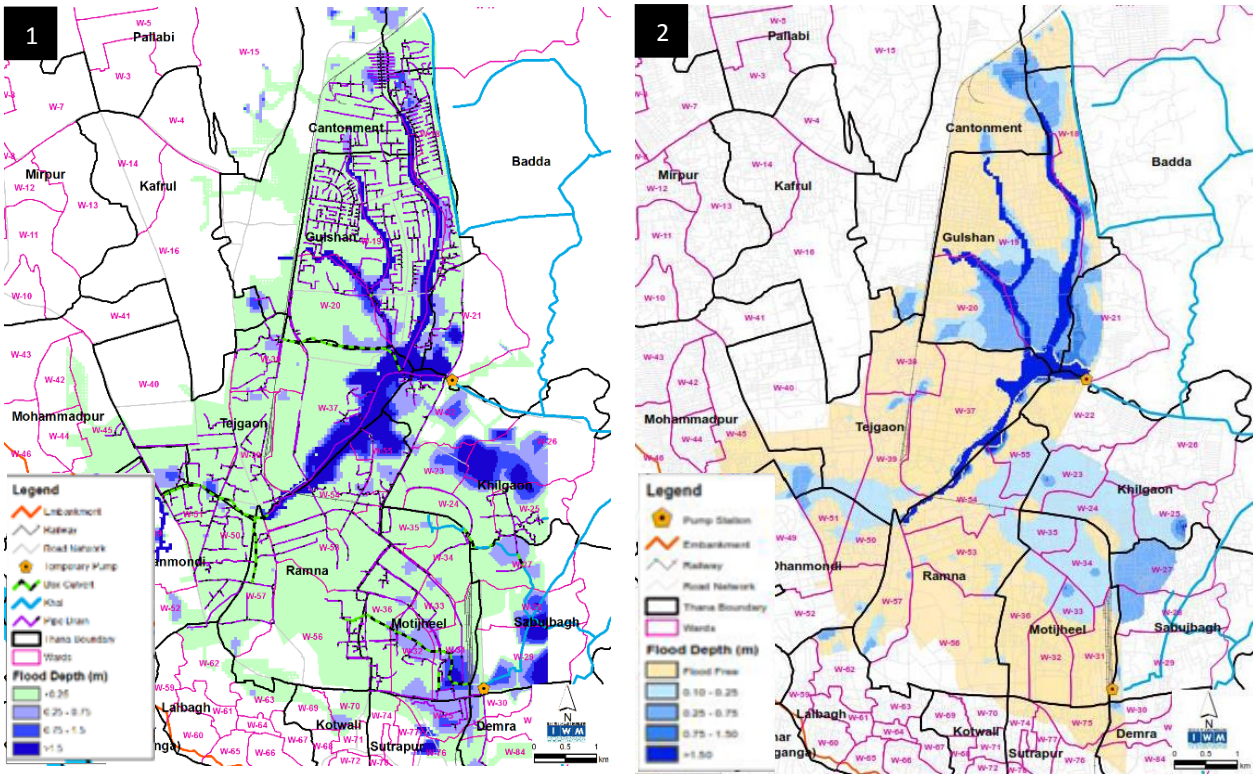

Figure 21: the flooding situation in the existing land-use with 2004s (100yrs) rain event (1) and flooding situation of same rain events in 2025 with changed land-uses and improved drainage condition (2). (Source: IWM, 2014)

For this area the experts proposed new pipelines and pumps, and a sluice gate to divert the excess water to another lake (i.e. Dhanmondi lake). Another case study in a more densely populated area with less

water sheds (i.e. the old Dhaka) showed interesting results in this regard. The experts sugested a playground to design as 'dry-ponds' (see figure 22)as there were less chances of fututure development. The result showed sucessesful outcome in reducing shallow flooding after adopting to this measure. In some areas (e.g. Gulshan, Banani) where there are chances for future drainage developments, the experts suggested separate sewerage and storm-water drainage for better efficiency.

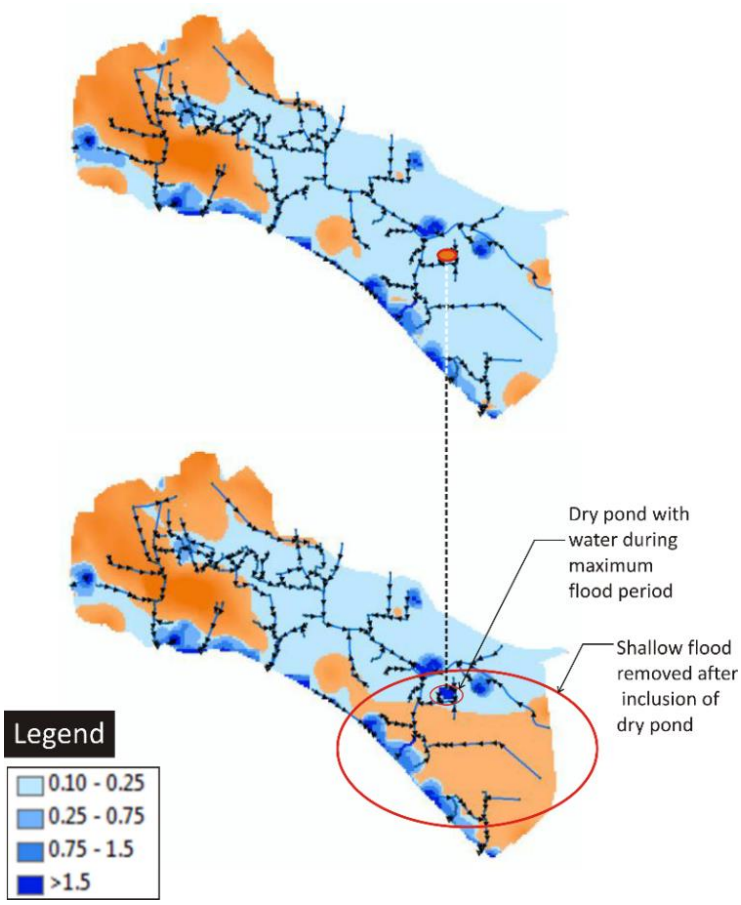

Figure 22: Adaptation option 'dry pond' in a part of the study area for flood reduction (Source: IWM, 2014) (modified by Author)

In summary, the study suggested lot of adaptation measures, but mostly from engineering perspective. Though, it showed some interesting results such as 'dry-ponds' which indicate the potentiality of GBI adaptation in the specific settings. An important aspect of this study is that the experts made lots of assumptions (e.g. all storm waters are properly draining out through the system, no waste accumulation in future) which are idealistic as per the study context. As the land level rise (from future senarios of population increase and land-development) played an important role in reducing flooding, their study highlights the importance of local-level changes in land development for adaptation to future-risks of flooding.

4.3. Questionnaire survey:

In the GBI planning framework of this research, the social aspect is one of the major elements of socio-political aspects of GBI which was studied by questionnaire surveys in the case study areas. The objective, survey locations and analysis methods were explained in the methodology part (see sections 3.5.3 & 3.5.5). In the following section, I'll present the findings of the survey per cases. According to the questionnaire, the respondent's comments on flooding effects, preferences on GBI functions and adaptation options are presented here.

4.3.1. Case 1:

In case 1, there were four (4) locations, the location-1,2 represent the unplanned residential areas adjacent to the Hatirjheel lake project (area showing at the right side of figure 23). The resident's responses from the location-1,2 are therefore reflect their experiences regarding the Hatirjheel lake project. Location-3,4 represent the urban slum areas next to the on-going Gulshan-Banani lake project and the dwellers expressed their comments regarding the ongoing development.

Figure 23: Hatirjheel lake area. (Source: SWO, Bangladesh Army 2017)

4.3.1.1. Location 1,2:

Within these locations, the majority respondents confirmed that the recent developments have significantly reduced the water logging due to rainfall. Before realization of the project (i.e. Hatirjheel lake), the area was susceptible to urban flooding and with regular rain-events during monsoon period (i.e. mostly June-July). The main reason was insufficient drainage. After the development, the drainage system around the project area is much more efficient. Most of the residents stated that the area namely, Ulon was less effected by flooding due to its higher elevation. But, other areas such as Mahanagar housing,

West Rampura, Wapda road, Amtola were regularly suffering from flooding. Still there are some areas (e.g. East Noyatola, TNT & Gabtola, Majar road to Staff area, Chairmangoli) where the storm water accumulates due to intense rain event. In the previous situation, roads and settlements below the road level were mostly effected by flooding and the water used to stay there up to months depending on the weather. There were other environmental issues (e.g. household and industrial waste, mosquito) in this area which have significantly reduced by the restoration of the existing lake. After the realization of the project there are more socio-economic activities in this area regarding housing development, higher house-rent, outside visitors, food shops etc. Transport connection to distant areas are much better due to new high speed link-roads around the lake. The residents mentioned some negative impacts of this new development. Among those negative comments, a newly implemented boundary wall is mostly addressed. The boundary wall enclosed the residential areas leaving selected access points to the main road. Now, there are restrictions on pedestrian activity in the link-roads to maintain the desired traffic flow. Some users mentioned that, due to these restrictions there is less pedestrian access to their areas. Some local businesses (e.g. restaurants, shops) were developed because of the public attraction to this place but these regulations are hindering such business environment. Three (3) inhabitants strongly mentioned that, there are more traffic incidents because of this new high-speed traffic next to the residential areas. There are some complains about the water quality of the detention lake that the water is deteriorating rapidly and spreading odor in particular areas. The respondent's comments varied in same topic based on the existing spatial situation. For example, most of the residents from Mahanagar housing area (which has easy access to lake side area) accepted the existing situation whereas, the residents from Ulon area (which has less access) complained about the wall and traffic regulations. As a response to the question on multi-functionality of GBI, the respondents from these locations were more aware of the benefits of GBI (or SUDS) from their present situation and appeared as pro-environment compared to the other locations (see table 2, p. 64). They preferred developments related to environment, connectivity, health and recreations in GBI projects (see figure 24). In terms for adaptation options, the residents mostly preferred community-based waste management, more play-grounds and individual adaptation such as elevating property area which are categorized as 'other' in graphs (see figure 25). Many users also mentioned urban forestry as a suitable adaptation option for their area.

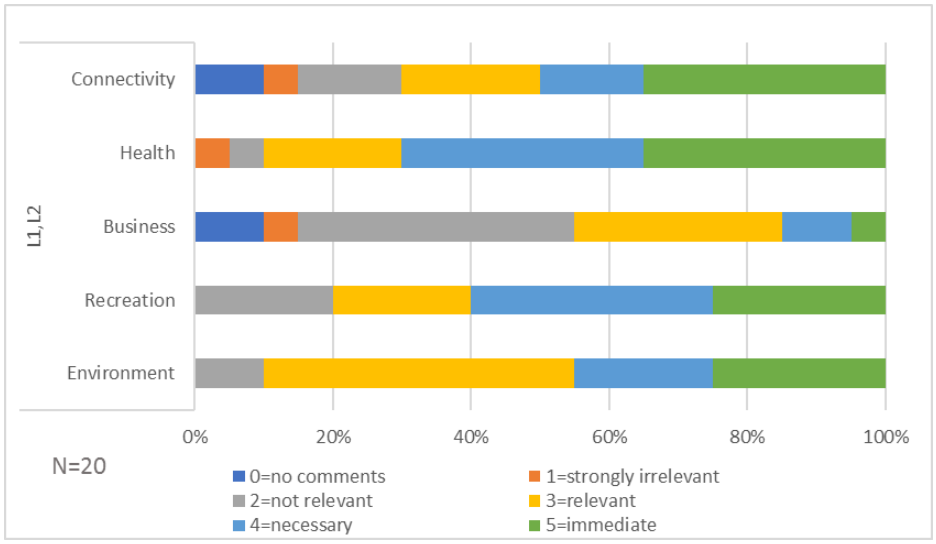

Figure 24: Multifunctional preferences in the existing area (response form location-1,2).

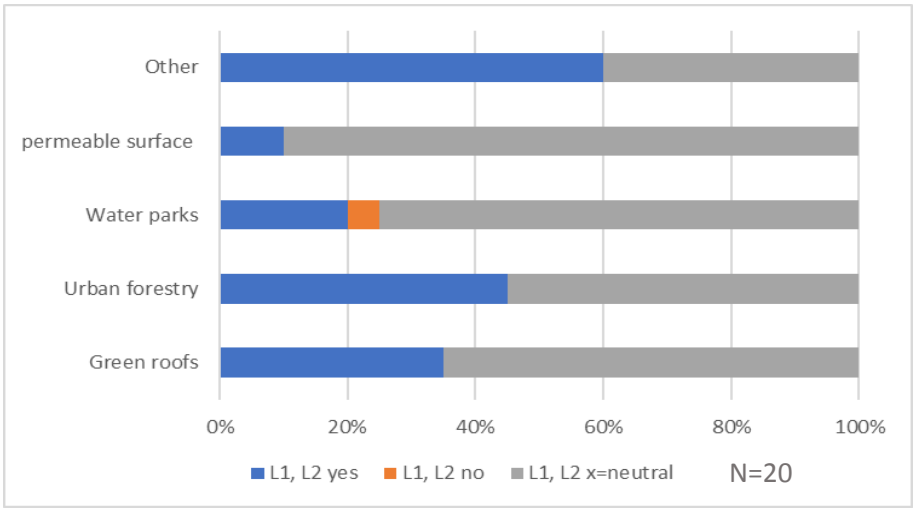

Figure 25: Preference on the types of adaptation measures (response form location-1,2).

Figure 26: Ongoing work of Gulshan-Banani lake project and Korail slum area. (Source: Author, 2016)

4.3.1.2. LOCATION 3,4:

In these locations, the Gulshan-Banani lake project were on-going (area showing at the upper right side of figure 26) therefore, the post development scenario was not available. But, from the respondent's expectations and recent experiences a probable future scenario was realized. According to the residents, many parts of the slum area are vulnerable to flooding by regular rain-event. The lake side area, namely Jhilpar is most prone to flooding. At the inner parts of the slum area some NGOs had improved the internal pathways by elevating the surface and adding drains. Individual house owners elevated their houses up

to the pathways so houses bellow the pathway level were demarked as more vulnerable to flooding by the inhabitants. During intense rain-events the area gets inundated and usually the water takes about 2-3hr to drain out. In the lake-side area, the situation is much aggravated. The area stays inundated for months during monsoon depending on the water level of the lake. During the flood period, the inhabitants have to move to houses on the higher ground with higher expenses. There is no governmental initiative to improve their livelihood condition because the community has no legal right over the land. In this situation, the ongoing Gulshan-Banani lake project does not have any direct effect on the community yet but, the people from the lakeside area are worried about possible eviction. As the surrounding area is being developed, there are new restrictions on peddling business, rickshaw garages and other small businesses on which the community depends on. The authority had put boundary walls surrounding the slum areas and restricted boat use for crossing the lake. The pedestrian accessibility is much limited due to the boundary walls and transport expenses are higher (because the boat cost was much cheaper than other transports). As a response to the preferred functionality, most of the respondents had chosen business and connectivity from the environmental projects such as Gulshan-Banani lake project (see figure 27). In terms of adaptation options, the respondents mentioned local management for cleaning drainage blocks, good leadership, less living expenses which are categorized as other measures in the result (see figure 28).

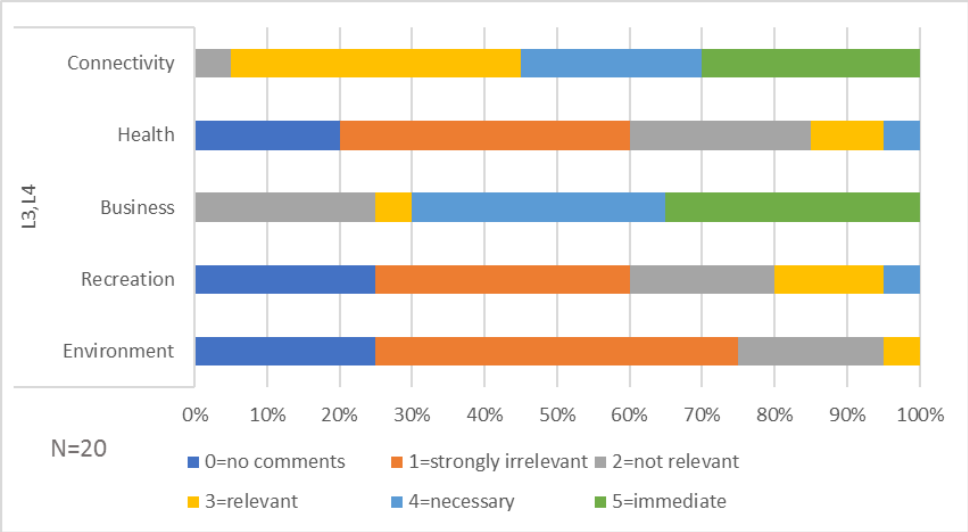

Figure 27: Multifunctional preferences in the existing area (response form location-3,4).

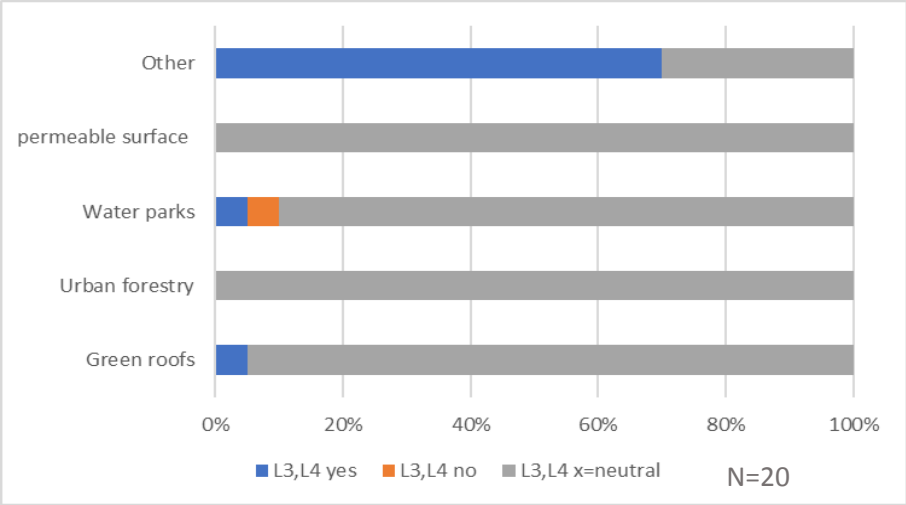

Figure 28: Preference on the types of adaptation measures (response form location-3,4).

4.3.2. CASE 2:

The case-2 had two (2) locations (i.e. location-5,6) and those locations represent planned residential area in this research. The locations are next to the Dhanmondi lake (see figure 29) which is a historic lake and had been restored in 2000 under the 'Dhanmondi lake and lakeside area development' project. The respondents replied on this project as a GBI development. As the project had been realized for long time, the residents have experienced its impact in their neighborhood.

Figure 29: Dhanmondi lake area. (Source: Author, 2016)

4.3.2.1. LOCATION-5,6:

Compared to the other locations in case-2, the area of these locations is well planned and had less experience of flooding. Only in the significant flood events (i.e. in 1988 and 1998) the area was inundated. But before the lake project, there were environmental issues regarding the lake. The water was polluted by household waste disposal. Some flooding issues within the lake area was reported by the respondents. Due to extreme rain-event some part of the lake area gets inundated and the water usually takes 5-6 hours to drain out depending on the weather. After the project had been realized, there were significant changes in the neighborhood. The respondents mentioned that the lake project had generated socio-economic activities mainly in real estate development, cultural activities, health and recreational activities, food business. There are some negative feedbacks from the users. Most the residents mentioned that the detention capacity is not enough as the water level gets very high during monsoon. The lake area gets lots of visitors in evening hours and in special occasions it gets over crowded. The respondents also mention that, there are much commercial activities within this residential area that generates outside traffic and cause traffic jams specially during school hours. This area is greener than many other neighborhoods in Dhaka. Responding to the multifunctionality question, the residents mainly mentioned health and recreation from GBI projects (see figure 30). For the adaptation options, there are already some good examples (e.g. green roofing) in the vicinity and many of the respondents were aware of their benefits and preferred green integration to their individual households for environmental and aesthetics reasons (see figure 31).

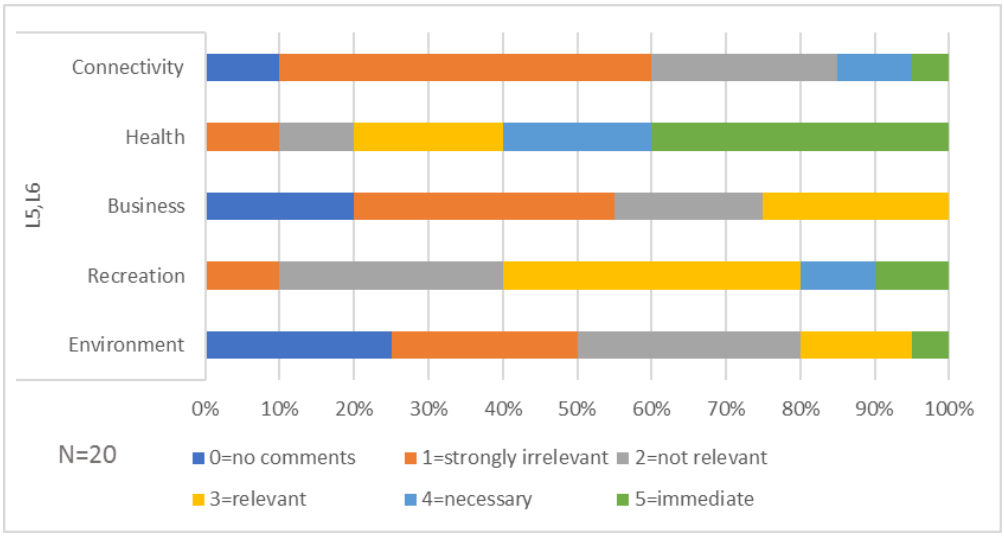

Figure 30: Multifunctional preferences in the existing area (response form location-5,6).

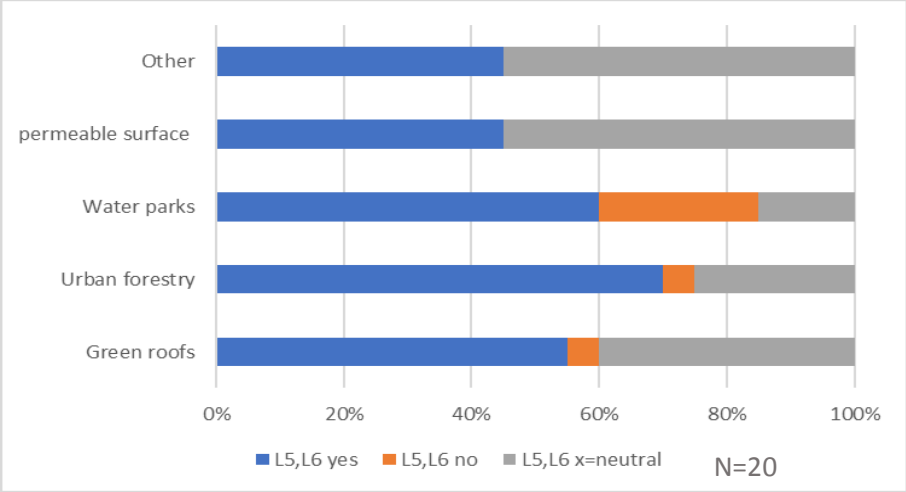

Figure 31: Preference on the types of adaptation measures (response form location-5,6).

In the following table, functional preference of GBI projects from all the surveyed locations were summarized based on the maximum mentions by the respondents. For example, in location 'L5, L6' 'health' is considered as 'immediate' by the maximum number of respondents.

Table 2: Maximum responses on multiple functionality from the surveyed areas

	Locations		
Functions	**L1, L2**	**L3, L4**	**L5, L6**
Connectivity	(++)	(-+)	(--)
Health	(+),(++)	(--)	(++)
Business	(-)	(+),(++)	(--)
Recreation	(+)	(--)	(-+)
Environment	(-+)	(--)	(-)

(--) = strongly irrelevant, (-) =irrelevant, (-+) = relevant, (+) = necessary, (++) = immediate

Similarly, the following map is showing the preferences on different types of adaptation measures were maximum mentions were summarized from the previous graphs.

Table 3:Maximum responses on preferred types of adaptation measures from the surveyed areas

	Locations		
Adaptation options	**L1, L2**	**L3, L4**	**L5, L6**
Other	(+)	(+)	( )
Permeable surface	( )	( )	( )
Water parks	( )	( )	(+)
Urban forestry	( )	( )	(+)
Green roofs	( )	( )	(+)

(+) = Yes, (-) = No, ( ) = Neutral

5. DISCUSSION & CONCLUSION:

In the previous chapter, results were presented from different data collection methods. In this chapter, I answer the research questions based on the results. I'll also reflect on the adopted methods and the theoretical framework of this research. Finally, the main findings of this research are presented related to the framework.

The key objective of this research was to understand the current situation in the study area related to urban planning that deals with climate change adaptation to urban flooding issues. According to the objective, the main research question (RQ) was- how planning for GBI can create adaptation to urban flooding issues caused by climate change in the urban areas of Dhaka? In respect to this main objective, GBI-planning was conceptualized with the focus of adaptation to urban flooding and a framework was formulated. That GBI planning framework provided the theoretical basis of this research. To deal with the main objective, the main research question was divided into four (4) specific research questions (SRQ). In the following section, I'll present the answers to SRQs based on the results.

5.1 THE ROLE OF CLIMATE CHANGE IN URBAN FLOODING IN THE STUDY AREA:

In this section, I discuss on the first SRQ, which is: What are the climate change impacts that is causing urban flooding of the study area?

To plan for climate adaptation, it is a prerequisite to understand the complexity associated with the increasing risk caused by climate change (Wamsler, Brink, & Rivera, 2013). Understanding urban flood-risk requires assessment of the impacts of floods and their spatial and temporal distribution where impacts are tend to be more complex with climate change uncertainty (Zevenbergen, Veerbeek, Gersonius, & Van Herk, 2008). In this research, the objective for this SQR was to understand the nature of such complexity of urban flooding issue raised by the climate change phenomenon and relevant actors in relationship with its scale and time. To deal with this, I relied on expert's observation and document survey. I've analyzed the responses from the professionals in the field of urban hydrology and spatial planning. The scientific hydrological explanations were triangulated with a hydrological model study conducted by Dasgupta et al. (2015). To study urban flooding and its relationship with climate change, it is imperative to predict the average rain fall, stream flows, extreme flows and storms, changes in groundwater yields in future situations (Muller, 2007). Such prediction of climate change are often realized by probabilistic terms (Matthews et al., 2015). The country is also susceptible to sea-level rise and subsidence besides the increase in precipitation and river flow (A. U. Ahmed, 2006). The Dasgupta et al. (2015) study used a regional model (i.e. North Central Region Hydrodynamic or NCRHD) considering the relevant climate and physical data. Their climatic prediction of 2050, showed that the return period of intense rain fall event is decreasing, the internal rainfall is increasing and the river level is increasing around the study area. Despite all these climate change stresses the result showed decrease in the area of flooding of the study area. In their baseline study, total flood free area (<0.25m depth) was 22% and in 2050 with climate change scenario the area increased up to 39%. This surprising result can be related to a significant assumption for their model. In their study, they assumed that in future Dhaka will develop according to the current land-use proposal (i.e. DAP) and the low laying area will be raised and developed up to the flood free level. This is, in my opinion, a very idealistic assumption regarding the current progress of DAP's implementation. The Dasgupta et al. (2015) study also assumed other planned infrastructural

improvements (e.g. new pumps, clean drainage pipes, sluice gates) including the eastern dam (i.e. Eastern Dhaka Bypass Project) at the unprotected low laying part of the study area. With all these assumed interventions, the model promoted an optimistic future situation which can influence the decision-making environment where dependency on socio-economic actors (such as land-development) is high. They suggested many technological interventions which may indicate that climate change protections cost is high. In this regard, models using large set of assumptions and mean values to predict future-risks can hardly represent the actual diversity of the spatial environment and related flood impacts on multilevel economic networks (Zevenbergen et al., 2008). Despite being a contemporary tool for determining the normative principles for possible climate change, the complexity of the models cannot represent the actual complexity of climate in nature and its wide-ranging future impacts in the bio-physical and social environment (Zhang, Yang, & Singh, 2014). From the hydrological perspective, the interviewees commonly stated that increase in monsoon rainfall and surrounding river water level rise are the major climate change threats for the study area. The city depends on the surrounding river system for its drainage and the eastern part of the city has no flood protection dam. Therefore, in the regional level river-system climate change risks pose a significant threat of river flooding to the city and consequently more dependency on dams and pumping. The regional dynamics play a significant role in the flood risk management and with the climate change risks it will be difficult to quantify the impacts and costs for the measures (Muller, 2007). Due the country's geographical location in the GMB river basin, slight increase in precipitation in the upstream will consequently inundate large areas of the country (S. Dasgupta et al., 2011). In terms of inland or pluvial flooding, it was realized that the responses depend on location specific measures and local level management. In such situation, planning for climate adaptation to urban flooding should consider the complexity of scale, time and social effects of the vulnerability. To manage responses, understanding of cross-scale interactions of adaptation measures and how they will affect flood vulnerability is similarly important (Zevenbergen et al., 2008). Apart from the negative environmental effects, the experts mentioned the political impact of the climate change vulnerability which has influenced a governance shift towards mainstreaming adaptation approaches. The government is aligned with global climate change agreements (i.e. United Nations Framework Convention Climate Change or UNFCCC) and in the national level policies, the government has adopted climate change risks in future development goals. Climate change has become an important driver in the paradigm-shift towards flood resilience (Zevenbergen et al., 2008). In the context of the study area, it is prominent, especially at the national level, that there is significant interests in adaptation to flooding associated with climate change risks.

5.2 The existing bio-physical situation and its relationship with urban flooding:

In this section, I discuss on the second SRQ, which is related to the bio-physical part of the adopted framework. The question is: What is the existing situation of the GBI, drainage system and land-use pattern related to urban flooding in the study area?

The bio-physical aspects of GBI includes the plantation or green characteristics, natural and built drainage networks, urban morphology, surface cover and elevation etc. Related to urban flooding issues, the quantity and quality of storm water are considerable aspects of urban hydrological aspects but, for GBI (or SUDS), the sustainable development means the interplay between quantitative and qualitative aspects of hydrological designs and spatial strategies (Fryd et al., 2012). For comprehensiveness, this research

acknowledges both aspects of the bio-physical situation, but despite climate change risks, the results showed that, the drainage system is already under current risks of failing due to human induced causes. For example, sludge accumulation in the drainage pipes due waste dumping casing overflow during regular rain-events. The encroachment of river and canals prevent water from natural drainage. The rapid urbanization and population increase are major drivers for such anthropogenic activities. However, the existing drainage system is dependent on the natural blue-networks for most part of the year. The western part of the city is highly urbanized and the natural watershed is almost lost but the eastern part of the city is still environmentally rich but also a low laying area and vulnerable to river-flooding. The city had adopted some flood protection measures and shifted from gravity to pump-based drainage as a reaction to major flood events. Now, there is an apparent dichotomy on the feasible approach of flood management for the eastern part. From the socio-economic perspective, flood-protection approach will complement the expected urbanization of the eastern part whereas more GBI incorporated ecologically oriented approach would require land compensation for retention areas for water. In the strategic plan (i.e. DAP) there is a proposal for drainage for the eastern part, which is more or less based on the flood protection principle including a dam and retention areas. This proposal reflects the alignment of the existing flood management regime towards a centralized and technocentric approach. This approach would potentially increase the adaptation cost for the city. Increasing dependency on a centralized system develops greater technical complexity and reduces the system's adaptability as it exhibits large impact form failure (Zevenbergen et al., 2008). Whereas the ecologically oriented or GBI approach refers to built-natural hybrid system comprising interconnected smaller systems. This approach is new to the current flood-management regime and would take longer in implementation. The GBI adaptation involves an incremental implementation as the knowledge advances (Fryd et al., 2012). The storm-water management works at multiple spatial levels (Tjallingii, 1996) and the efficiency of GBI depends on ecological networks, spatial configuration (i.e. corridor, patch and matrix) and other bio-physical conditions (i.e. soil types) (Gill et al., 2007). Therefore, the GBI adaptation is more site specific and decision making is difficult without scientific observations. In this case, the studied model developed by Dasgupta et al. (2015) did not offer much knowledge as it adopted the DAP land use as the spatial data which doesn't represent the existing landscape. But, for the western part, the land-use is mostly built-up and therefore their results of the baseline study can be discussed to indicate an apparent flooding situation. In such built-up areas, there is not much options for GBI rather than opportunistic strategies (Ahern, 1995) to retrofit existing buildings or small scale green spaces in individual or neighborhood level. In this regard, the Dasgupta et al. (2015)'s study showed an innovative adaptation option (i.e. dry-pond) to reduce the flood impacts in the old Dhaka area (see previous section 4.2.4.1.2). Regarding existing drainage infrastructure in the study area, infrastructural domination hindered its natural drainage area. For example, to build new roads, engineers adopted 'box-culverts' over natural canals which eventually failed to operate in the socio-cultural context. As the climate change risk is a major concern and the city has lost lot of its historic watersheds, these box-culverts should be removed to restore the original drainage areas. With the increasing uncertainty of climate change, the hydrological systems should be reconsidered to overcome future-risks (Muller, 2007). Also, roads are strategically planned to disconnect the water channels to prevent flooding, which is also a reason that the western parts and the eastern parts are hydrologically disconnected. Roads are the greatest contributor to fragmentation of urban environment (Forman et al., 2003). However, Dhaka has legislation for greening public spaces such as roadside, river banks and railway lines. For adapting GBI, the roads, railways and canal-banks might be good opportunities for green corridors within the city depending on the specific contexts. The recent draft

DMDP structure plan (2016-2035) conceptualized green corridor by proposing greening the inter-city railway line across the city. According to legislation it is fair, but in Dhaka, a large number of people live in slums situated alongside the railway lines. So, in reality, such social issues might constrain GBI implementations. Hatirjheel project is a great example of social displacement; although the survey of this study showed that, after realization the surrounding residents have reported significant environmental improvement of their neighborhood. Effects of the adaptive responses depends on different level, adaptation for an individual might not be helpful for the large system and the effect is vice-versa (Adger et al., 2005). It is also important to consider how the effects of the responses are interconnected in different spatial and economic environment (Zevenbergen et al., 2008). Urbanization is a vital issue in transforming the ecological characteristics of the study area and economic drivers are powerful. Adaptation to non-climatic drivers can elevate climate change vulnerability (Adger et al. 2005). In that respect, land-development issue was strongly mentioned by the experts which stresses the environmental principles for climate change adaptation. For example, the housing development proposals (indicated as overlay-zone in DAP) on the designated flood-flow zones reflect that the socio-economic benefit often supersede environmental benefit in the governance environment.

5.3. Institutional capacity for GBI planning:

This part discusses the SRQ that states: What is the existing institutional capacity related to planning for adaptation to urban flooding in the study area?

In this discussion, the institutional capacity refers to the existing governance structure, its planning instruments, knowledge and public-private partnerships. On the socio-political topic, the interview responses and planning-documents summaries are compared in this discussion. In the policy discussions, the respondents (and policy documents) mentioned different levels of governance namely, national level and local level. For this particular aspect, the local level represents the study area according to the governmental definition. In the interview results, I've mentioned some governance challenges brought up by the experts in general and per case-studies. In this research, these responses represent the existing institutional situation and the policy documents represent desired institutional environment according to the governance system. The existing governance practice can be described as traditional system with central or top-down governing structure. The relevant sectors studied in this research are flood-risk management and urban planning. Dhaka is governed by the city corporations (DNCC, DSCC) under the ministry of Local Government. There are several local governmental agencies which operate in the study area such as RAJUK, DWASA, LGED, RHD, WARPO, BWDB and are centrally governed by relevant ministries. Ministries are the national level governing body and have their individual policies. This research did not however had the objective to evaluate the general urban planning or flood-management governance structure. Rather, relevant agencies and institutions were identified related to GBI planning by the adopted methods (i.e. interview, case-study and document survey). The key local agency responsible for planning and implementing spatial development is RAJUK; and DWASA develops city's drainage infrastructure. At national level climate change policies (i.e. NAPA, BCCSAP) and relevant programs were developed by the Ministry of Environment and Forests (MoEF); other ministries such as Ministry of Water Resource, Local Government, Planning Commission are involved in climate change and flood-risk management issues. Now, in terms of decision making the political hierarchy play a very important role. Although, according to the policies (i.e. NAPA, BCCSAP) adaptation related decision should

be taken in an integrated manner, considering the related sectoral policies, and involving different local agencies and private actors (i.e. experts, society representatives, NGOs). But, according to the experts, major challenge of the institutionalizing adaptation is inter-ministerial and inter-agency cooperation or coordination. Several studies showed that, cooperation between urban actors is one of the strategies to incorporate climate change adaptation into urban planning (Wamsler et al., 2013). Moreover, in Dhaka, separate agencies are independent in terms of implementation,and coordination is lackingand jurisdictional conflicts are more prominent than progressive competition.

The functionality of GBI, especially when it's comes to flood-risk management, depends onits technical design (Fryd et al., 2012). In this case, conflict mitigation is a primary need for the governmental agencies as the experts noted partial implementation or implementation bottlenecks often challenge realization of immediate adaptation needs. However, shifting towards environmental governance with higher level of private participation is an option to speed-up the adaptation initiatives, but without compromising of public accountability (Young & McPherson, 2013). Climate change impacts and future risks have been a dominant factor in the governance practice, at least at the national level, but as the most prominent urban center for business and administration, in Dhaka, the political economy plays a dominant role in the development. Organizational mainstreaming by modification of institutional structures for local level adaptation programs is one of the mainstreaming strategies to integrate climate change into urban sectors (Wamsler et al., 2013). In the national policies, climate change mainstreaming and decentralization of actions for adaptation are present but its realization at the local level authorities is still a major concern. Distribution of the adaptation action across scale and legitimacy of decision-making is important, so that the authorities cannot rule out the action as "somebody else's problem" (Adger et al., 2005). In Dhaka, most of the establishments for flood-safety are reaction to major flood events and result of pragmatic actions. Bottom-up management is one of the prerequisites for increasing adaptability to urban flooding (Zevenbergen et al., 2008) whereas, in Dhaka's case it was evident that, many top-down initiatives had failed to acknowledge the diverse complexity of the urban areas. For example, road development over a natural canal was instant traffic solution for Dhaka, but eventually it is being realized as a major reason for environmental loss. In this regard, experts mentioned (i.e. UH-2 strongly stated), deviation form authoritarian practice towards democratization and public empowerment of the adaptation process is essential to deal with comprehensive development process. Complexity in strategy formulation for local spatial-implication was evident in this study. The experts have mentioned that, there are sufficient policy framework in climate adaptation and in this study, I've identified several strategies which are related to adaptation planning for the study area (see previous section 4.2.1). But at the local level, the struggle for a robust strategic plan is explained by the experts. In the document study, I've given some observations on the strategic land-use plan which indicates gaps between initial policy and adopted plan. Legislations to support GBI implementation are also identified and discussed, but a major concern for deploying these legal instruments were noted from the interviews. In that respect, the experts (i.e. UP-1, UP-2, UH-4) identified the combined jurisdiction of RAJUK in implementation and monitoring as problematic.

Storm water management for flood adaptation requires specific scientific knowledges on the bio-physical conditions of the built-environment (Fryd et al., 2012). The government agencies often depend on local consultancy institutes such as IWM, IWFM, BUET, CEGIS and also international organizations. Interviewees from those institutes shared their experience in light of the existing knowledge and information available

on climate change, flood adaptation and GBI. During this research, two aspects were mostly realized. Firstly, there are several researches ongoing in the different agencies, but between the two sectors (i.e. urban planning and flood-risk management) no formal integration is present. There is no central database for flood-risk or spatial planning at the local level. Different governmental agencies have individual databases which are often developed and maintained by external agencies. There is some form of dependency between governing and consultancy agencies, but it depends on the individual agencies. Secondly, application of novel techniques is challenging due to inadequate governmental initiatives and social awareness to cope with it. However, the result from the case studies offered deeper understanding on the previously discussed aspects, particularly from case 1. The realization process of the Hatirjheel lake project described by the involved experts explained the socio-political challenges that the project had to overcome with as an environmental development. In that case, the existing knowledge and intellectual's advocacy offered a key role in the decision-making process. Another notable and very promising aspect is the benefit of multi-functionality and its role in the planning and decision making process regrading GBI adaptation. Studies showed that multifunctionality is an important aspect of GBI from management and environmental perspectives (Demuzere et al., 2014; Hansen & Pauleit, 2014; Matthews et al., 2015). In the Hatirjheel case, it played a significant role and also showed that, flexibility in planning is necessary for continuous and incremental development of the GBI. The complexity of the GBI project was also addressed by stakeholder's engagement and public-private partnership in the Hatirjheel project and most of the experts referred it as a model. But, the downside was the equality issues raised by obvious winner-loser situation and social displacement due to the project.

5.4. Social attitude and interaction towards GBI:

The last SRQ is: What is the social attitude and interaction towards GBI in the study area? Here, elaborate the outcomes on the social acceptance of the concurrent GBI developments from the user's perspective, their preferences and interactions with those developments.

In the adopted GBI planning framework, this topic is part of socio-political factors of GBI. It is important for the planning process as the contextuality and usefulness of GBI in future depends on it. And also important in implementation as there may be possible constrains or supports by the inhabitants from the location where the adaptation is needed. To investigate such aspects, the questionnaire survey on the selected cases were primarily considered. Experts also mentioned social issues regarding the GBI projects which are also compared to give a comprehensive scenario. Survey outcomes on the different GBI projects indicated that the preferences depend on site-specific situations. In this study, selected locations were categorized under different spatial conditions. Although I did not conduct an in-depth demographic survey on socio-economic aspects, the spatial categories were distinct and represented communities from different classes. The results showed that, the communities are well-aware of the environmental benefits of the water-bodies mostly related to water logging issues because of their continuous association with flooding, and people from the areas where GBI developments had already realized are experiencing drastic changes. But yet the preferences are gravitated towards local needs such as communications, health or business opportunities from the environmental projects. Therefore, the multifunctionality becomes an essential quality of GBI to cope with existing socio-physical situations.

A Participatory process can encourage self-regulation and sustainable use of the environmental resources (Anger, 2003). In some cases, such as Dhanmondi lake project, community's participations in the design

process indicated that public involvement in the planning and design process can generate a form of stewardship for the new developments where locals will take the responsibility to protect and maintain the system. Community management for drainage and waste as adaptation measure preferred by most of the study population indicates their willingness to take initiatives to deal with the individual or communal risks. In Dhaka, a major concern from the social perspective is the displacement issue due to infrastructural developments. The low-income communities who live on the urban edges are most vulnerable to flooding; in the DAP those areas are designated as flood flow zones. Within the core urban area, informal settlements occupying wetland areas are also vulnerable to inland flooding. In this situation, eviction or force displacement is a substantial issue for spatial development for flood adaptation. From the case studies, it was also evident that many local inhabitants had to leave their properties for water retention area. To avoid force displacement, studies showed that some local governments adopted the way to directly engage the climate change vulnerable community in the development program (Anguelovski & Carmin, 2011). In the study area, the displacement is happening due to economic stress from the urban renewal by GBI, rather than direct climate risks. It is specific per case, not in all GBI like roadside greening, mostly in the encroached water shed. In that case, social protection for displacement issues by focusing on economic migration (Johnson & Krishnamurthy, 2010) can offer equitable development for the society.

5.5. Reflection on the methods:

This research was conducted by a mix method approach where interview, document study and questionnaire were the three data collection methods. For the interview, I've explained the snow balling in the research methodology part (see previous section 3.5.1). Related to my theoretical framework, my initial intention was to gather information from urban managers along with the hydrology and planning experts. In the snow-balling there are governing agencies such as WARPO, RAJUK and DWASA. Representatives from those agencies helped me with gathering public documents, reports and news-letters of updates about ongoing and upcoming projects, but no formal interview was conducted with their experts. One practical reason was to avoid official authorization process as the survey period was limited, another theoretical reason was that the managerial posts are represented by either planner or hydrology engineers. In that case, I preferred planning and hydrology experts from the technical institutes such as BUET, IWFM, IWM to represent the two sectors (i.e. urban planning and urban hydrology) in this research. In my opinion, their observations were scientific and critical on the current situation. The SWO is a military based organization assigned for the construction of the Hatirjheel Lake project. Their representative discussed their experiences during the implementation phases, but those comments were not quoted in this research due to security reasons. In the questionnaire survey, there were also some setbacks in collecting social information. More study locations under planned residential areas at the eastern side Gulshan-Banani lake were initially selected to compare feedbacks from location 3,4 (urban slum area), as there were contrasting urban characters on the either sides of the lake. But the housing societies disapproved household survey due to a concurrent security crisis. Data availability was an issue for the quantitative approach for the biophysical part of this research. Specially in the land-use planning, no recent existing land-use data were available on the overall study area, only available land-use data was from RAJUK, 2004. The hydrological model study adopted in this research also used that land-use information as they simulated the major rain-event in 2004 for baseline scenario.

5.6. Reflection on the GBI framework:

In this section, I briefly reflect on the adopted framework and its relationship with the main research objective of this research which helped this discussion to summarize the SRQ's answers.

In the framework, Fryd et al.(2012)'s work was followed. In their work, they've described the adaptation concepts from a planning and designing point of view. According to them, the mentioned approaches were not exhaustive in the current theoretical and practical domains, mainly the socio-economic aspects were not made explicit. My research is also planning-oriented, but it is also important to address the GBI from social and economic perspectives. In that case, the functional domain of the framework offered much directions in the socio-political aspects, but the economic factors were not explicitly investigated in this research. For the functional domain, Matthews et al. (2015)'s work was followed. Their conceptual model was adopted and modified according to the flood-adaptation (thus SUDS) and its contextual focus for my research. For example, the population growth and urban in-migration is important in my study context and was incorporated in the framework, and the biophysical factors were described from urban drainage perspective. However, the Matthews et al. (2015)'s model had provided a comprehensive guideline for this research. The bio-physical aspects included several elements under the natural and physical categories, this categorization is based on mere physical nature and doesn't represent that they are separate elements. In urban areas, both natural and man-made elements formulate a complex ecological environment (Ahern, 2007). Under the socio-economic aspects, the framework considers budgetary aspects for GBI planning and implementation and the research also showed that, the economic driver is a key factor in urban climate adaptation in the study area. Therefore, economic conceptualization of GBI is important in current planning sectors. Now, from the given discussions on the specific questions, the following summary can be developed in reference to the adopted GBI framework.

Related to the practice domain, there is a lack of integration in planning and flood-risk management both in governance and research fields. Experts interviews and study on current governing system indicated such outcome. Multifunctionality appeared as an important prospect of GBI for adaptation management. The research also indicates that strategic spatial measures are lacking in historic and recent practices in flood-risk management in the study area. Climatic factors, especially due to climate change, have significant impact on the bio-physical environment. The climate change issues have substantial impact on socio-political aspects as well, especially on governance practice. In terms of institutional capacity, the coordination between agencies and proper implementation are lacking depending on various governance levels. Social issues are much more complex in the study area than social acceptance on the GBI approach. There are underlaying challenges regarding social exclusion and rapid population increase. Therefore, possible improvements in the following aspects can address the existing lacking:

1. Integration of urban planning and flood-risk management for comprehensive adaptation planning
2. Prioritize Local responses and social participation for efficient adaptation avoiding, system failure.
3. Adopting to multifunctional GBI development through negotiation between actors and stakeholders.
4. Mainstreaming climate change in the local level through institutionalization and coordination.
5. Incorporating GBI adaptation measures in the local strategic plan.
6. Finding trade-off between environmental and socio-economic actors such as; Compact development vs land-development.

7. Create opportunities for rehabilitation of the affected communities from environmental development works.

5.7. CONCLUSION:

This chapter concludes the research. Limitations of this research are mentioned and thoughts are provided for further researches in similar topic at the end of this chapter.

I've explained the conceptual focus of the GBI which guided this study towards a holistic GBI planning that considers different sectors related to urban climate change adaptation. Different theoretical narratives related to landscape ecology and human geography were discussed to express the theory-practice dichotomy of GBI and the necessity of a comprehensive approach of GBI planning in this research. In terms of urban flood adaptation, the character of GBI was narrowed downed to SUDS as an integral part of GBI concept. This research deals with the two major urban sectors (i.e. urban planning and flood-risk management) for investigating GBI planning aspects in the study area related to its urban flooding issues. To overcome with the objective, I've developed a conceptual framework based on theoretical studies such as Fryd et al.(2012) and Matthews et al. (2015). The framework has provided the theoretical guidelines for conveying the investigation. With the help of the framework, this research strived for understating the relationship between the bio-physical and socio-political aspects of GBI and the practitioner's (i.e. urban planner, hydrologist) role in those aspects. During the course of this research, several factors were identified; among them, the socio-political issues constraining the adaptation process were prominent. The Matthews et al. (2015)'s study mentioned that a primary objective of their GBI model was to find out the institutional issues created by GBI adaption initiatives. In this case, my research also indicates several gaps in the institutional environment for GBI planning and implementation. In the study area, rapid urbanization is a paramount problem which relates to many environmental and social problems. Therefore, the primary goal of investigating the climate change issues for urban flooding often contested by the overwhelming human-induced causes such as water body encroachment, waste dumping, increasing built-surface areas. In that case, dealing with urbanization problems and uncertainties generated by anthropogenic activities is an inherent goal of GBI. This principle of GBI can promote the climate change related adaptation in such developing circumstances of the study area.

In the existing situation, there are developments in technical and socio-political (or institutional) fields, but the development scenario is not balanced. Different technical approaches often lack social relevance which consequently lose efficiency in real life situations. In the institutional environment, policies and programs related to climate change adaptation have been developed, but at local level their application is not properly evident. In this situation, parallel development that interplays between technical and socio-political system is urgent to deal with the adaptation. The factors that decide over adaptation initiatives depend on the fact that, how the specific system is being defined for adaptation (Brooks, 2003). And in Dhaka's case it is a primary requirement that the authorities and experts have to decide how they will tackle the present and future flood situation. The socio-economic drivers are strong in Dhaka which pressing the development dilemma related to eastern part of the city. Under this circumstance, finding a trade-off between spatial and hydrology infrastructural approach is very important due to the socio-economic and climate change actors.

Due to the global concern and the country's vulnerable position, the climate change risks have created a suitable platform for the GBI adaptation, especially in the national environmental policy and management sectors. Now, at the local level, mainstreaming is required as a driver for power-shift and institutional reformations towards a multi-actor governance practice. Incorporation of knowledge and multipurpose rationales of GBI should be given priority to tackle the growth-oriented development practice such as expanding the city into flood flow zones, covering canals for roads, land development for urban expansions etc. Planning agencies often justify these developments by theoretical rationales, but the social context should be considered too. Previous experiences showed that, encroachment and lack of law enforcement threaten the watershed. This tendency of illegal occupation of natural spaces is still present. The western dam offered flood-safety which allowed fast urbanization of the western river banks. So, taking the same initiative in the eastern part of the city will possibly create less options for natural integration for adaptation. Natural and municipal storm-water drainage areas are considered as waste dumping areas within the communities. Infrastructural developments such as box-culverts have created spatial disconnection with the natural drainage and those spaces eventually became less attractive to public. So, multiple uses of the drainage areas as per GBI principles can ensure their appeal through social interactions. From the case studies it was evident that, due to economic responses to GBI implementation, the multi-purpose functions invite new developments. This multi-functionality notion is argued as promising feature of GBI for popularizing its demand. But it should also be considered that, such developments should not contribute to more environmental problems such as inviting more traffic thus more exhaustions, heat and pollution.

Transformation of the existing water and flood management regime towards GBI (or SUDS) adaptation will require time. Incremental knowledge development and social awareness will be necessary for the bio-physically and socio-politically balanced adaptation process. Integration of GBI into the existing drainage system is a starting point of this process where achieving climate change resiliency with intergenerational equity is a distant goal for Dhaka.

5.7.1 Limitations

The following limitations in this research were:

1. In the bio-physical part, some aspects were less addressed in this research, such as plant characters and climate suitability for GBI planning.
2. In this research, no quantitative study was formulated to identify the required amount of GBI in the current bio-physical condition to deal with pluvial flooding in the study area.
3. During this research, latest land-use data (e.g. GIS) was not available to investigate the exact land-use condition, in this case this research had to rely on previous reports and satellite images.
4. during the time of this research, there were two major public documents (i.e. DAP for 2016-2035 and Dhaka city storm-water masterplan) were under preparation stage. So, in further research it is important to evaluate those plans for Dhaka's climate adaptation aspects.

5.7.2. Recommendation for further research:

The following recommendations will help further studies in this research topic:

1. The role of economic actors and economic feasibility including possible development cost and benefits of GBI to help the decision-making process to find possible trade-off.
2. Quantitative study on the capacity of the existing GBI and future requirement will be necessary for upcoming strategic plans.
3. A synthesized framework was developed with a specific focus on urban flooding issue. This framework can be tested for other GBI related developments.

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ANNEXES I:

INDEX OF INTERVIEWEES:

In the following Table, I've listed details of the final interviewees whose feedbacks I've officially documented and analyzed in this study as per their consent.

Table: List of interviewees

No.	Interview respondents	Positions	Field of expertise:
1.	UP-01	Professor, Dept. of Architecture, BUET	Urban Design and Built-Environment Design
2.	UP-02	Architect of the Hatirjheel and Dhanmondi lake projects. Architect, VITTI Sthapati Brindo Ltd.	Architecture, Urban design, landscape design
3.	UP-03	Expert in HatirJheel Lake project. Professor, Dept. Urban and Regional Planning, BUET	Land-use planning, Urban design
4.	UH-01	Expert in HatirJheel Lake project Professor, Dept. of Civil Engineering, BUET	Urban storm drainage, Environmental management system
5.	UH-02	Expert in HatirJheel Lake project Professor, Institute of Water and Flood Management, BUET	Urban water systems, Hydro-climatic vulnerability and adaptation
6.	UH-03	Water resource planning, DSS Specialist Institute of Water Modelling (IWM), Bangladesh	Urban hydrology
7.	UH-04	Senior Professional, Climate Change and Disaster Management Division CEGIS, Bangladesh	Climate change and urban flooding, GIS specialist

INTERVIEW TRANSCRIPTS:

UP-01: (translated from Bangla)

Q: What policies are present for climate adaptation of Dhaka city? Are there any new policies being adopted specially on flooding issue?

Now in Dhaka response to climate change issues are more infrastructural. For the flooding issue Dhaka is planning for 'Dam' construction. Now, only western part is enclosed by dam but there is a new plant to construct dam on the eastern side as well, which is mostly low laying areas and agricultural fields. Till today Dhaka is mostly relaying on the 'gravity-based' drainage, but the water management sector (mostly WASA) are going towards full pump based system, which I think is not a good approach to deal with the historic problem of flooding and logging (river flood) and also climate change issues. I also think, it is not an energy efficient approach too where Dhaka also suffers from lacked on electricity, gas etc. With the dam enclosing the hole city we are building a 'backed and only pumping will be our resolution?

Now, planning for-climate change in our country is motley about adaptation, epically I community level management sectors (NGOS, local Gov.) are building community resilience in the climate-vulnerable areas, (coastal, river bank areas). We are not focusing on mitigation.

Now, in the national level experts are working on a climate change policy. It will help the government to get more international attentions which is Ok. But only focusing on climate change or main streaming climate change shouldn't ignore our traditional development problem of our urban areas where there is lack of good governance and planning-practice.

For Dhaka, we had previous master plans. Those were well-thought out plans. For example, in 1917 Sir Patrick Geddes (Scottish planner) planed for Dhaka. That is the earliest modern plan we have. In his plan) even though it was centuries ago) he particularly focused of the natural canal-system and small water bodies which were existing throughout the city. Historically, Dhaka's growth started from the Buriganga river mainly from the area around 'Dholaikhal'. In his plan, Geddes argued for the water front character there and planned the city respecting the wands (canals, lakes and even small ponds). He not only planned for a beautiful water front for the urbanized Burignanga river side's but also realized environmental importance for all the water bodies, especially for drainage issue. The mentioned in his report to keep those are preserved for public use.

In, 1982 we had DMIUDP (Dhaka metropolitan integrated urban development plan) which contained some of these concerns that Geddes showed for the natural drainage. It was later followed by the DMDP (Dhaka Metropolitan development plan) for a long –term period from, 1995-2015. In that plan, the natural detention/retention areas were fixed. But to implement it the DAP (Detail area plan) was not there. The work for DAP started very late and eventually lots of natural areas were urbanized Now, there is situation like past, the new DAP for 2016-35 is already due and RAJUK only prepared a draft structure plan which is from my point of view a worth less plan. My observation about the land is it has no reflections on the previous lands and most importantly significance of the water-retention has lost.

Q: Why there is such inconsistency in the plans? Are there not enough supporting policies?

Actually, we have such policies that defend our natural water bodies. For example, we have water-act 2000; we have laws for 'fore-shore protection'. The 'Physical planning division' of the planning commission is responsible for preparing our national goals for land-uses.

There is a land-fixation policy for agricultural lands yet, from a study (in 2003) I saw 1% of agricultural land is lost each year. To accommodate the urbanization, we are expanding our cities towards suburbs and pillages, even building on flood plains. We are filling up rivers and erecting building on it! Now that the river camels are narrow or closed, it is affecting the down streams. So, does, the encroachment have anything to do with the 'climate-change'?

Our 'wetland act 2000' says natural or historical water bodies cannot be filled up without authority's permission. But in a sense our development authority is filling up natural areas in the name of development. RAJUK is developing housing (ex: Purbachal, Jhilmil) on the designate flood plain areas. So, they are promoting expansion rather making policies for compact planning.

Even if the land development is a dire necessity (From their point of view) they must compensate the nature by constructing more wetlands and canals. These wetlands, water-retentions are new concepts for our cities. But in our rural culture, we have long tradition of such adaptation. In our vernacular house-

holds there is a system that we first dig ponds and build our houses with the mud, higher the plinth we need the deeper the pond we cut, that is our traditional way of adaptation from river flooding.

Now you can see our governing agencies have management problem and lacks vision for this city. There is classic example of cities planned with canals, like Amsterdam. Where, Dhaka was naturally geographical character, but due to bad planning it is lost. 42 khals (canals) were filled up by the urbanization from British rule till now. There are few remaining canals which are either disconnected or covered by roads and 'box culverts'. Not very long before, in 80's the Dhanmondi lake but now there is that 'Panthapath Road' over the connection and you want find any trace of the existing channel. In Arshad's (autonomous president of that time) regime lot of engineering measures were introduced such as these 'box culverts', dams, pumping stations etc. was introduced. These developments didn't consider the social and natural context of our city.

In national level, we have issues due to wrong water management. Our country is an 'active delta's our low-laying areas are prone to get flooded. At one side, we get flood but on the other side we have 'Chars' (fertile land from sedimentations). But in 60's, our national objective was 'green-revolution' in agriculture. For that we made dams and polders. We managed to stop flooding of our agricultural lands but eventfully we've lost land fertility and damaged the natural river system.

That is one example of our lack of vision and expert knowledge. In Dhaka, there are plenty of examples. For Dhaka, it is more management problem than lack of expertise. In adaption, only the land use regulation and proper governance could've played big role. But as I've told you earlier, we are still struggling to develop a (honest) land use for the city. I've spoken in many public forums ad published several researches advocating the 'water urbanism' for the city, but it barley has any effect on the attitude of the authorities.

Q: What is your comment on the recent environmental projects (such as Hatirjheel lake project)?

I will explain the back ground of this project first. As I was saying, in the academic research there are plenty of studies on Dhaka (in urban- inaction related issue) at least in the local institutions. But the governing agencies do not usually incorporate these studies. In BUET we design many projects but the RAJUK or planning ministry or LGED do not show much interest. But the Hatirjheel project was an exception in that case. Before the actual project, there was a Bachelor thesis on the area, for urban place-making and transport development. In that presentation, we (BUET, Architecture department) the planning minister during that period, the was so amazed by the ideas presented in the thesis. Later when the project was initiated the LGED contacted BUET for expert opinion. Then BUET (through BRTC) formed a consultancy committee including planer, engineers, and designers, in the initial proposal they (BRTC) considered the student's research for the spatial design part. In the original research, more wet and areas managed with minimum intervention, the main connection road was proposed elevated and the ground area was left open detentions and green corridor.

The encroachment issue (tendency to fill up illegally) was considered and only light pedestrian road was proposed on the edge of the like. But all of these considerations were ignored in the latter phases of the project. Instead of focusing the environmental goals (greenery and detention) the transportation and beautification gained more importance. I think it is not the economic problem for such deviation (as there are more build structures now). Rather lack of sensitivity, lake of interdisciplinary communication (especially designer and hydrology experts) and main influence from different private actors hindered the

environmental rationales. Now there is too much roads, very close to the neighborhoods, concrete pane areas. All of these might increase the UHI effect instead of cooling it. The Karwanbazar area (same area that Hatirjheel is situated in) has a heat island issue and there is an ongoing research on that area. After the realization of this project present data indicates such issue, now there is increased mobility in that area which might be a reason but after all it should not contrib. Ute to the UHI problem.

Instead of soloing the problem with a single elevated road, now there are multiple bridges and roads with lot of intersections. It is not an ideal situation for the surrounding residential area, mostly when they are designed for high speed traffic. Never the les, a large member of households had to be demolished to introduce these connections which will eventually change the existing urban fabric and the social environment. For example, if you to genre no, you'll sees only the community mosques are there, the community have been evicted. I, think the hydrological design of that lake is also not functioning well. The lake was not supposed to collect ante water from surroundings but recently there are bad order coming from the lake, may be the drainage system is mal functioning. In overall sense, due to the project now we have the lake projected from encroaching but there is lot of drawbacks.

Q: In Your opinion, what re major challenges for adaptation of green- blue infrastructure in Dhaka?

In my opinion, adaption is the best way for our city, as I've always argued for that. And for that our governing institutions are not prepared. They, lacked capacity. Implementing the policies (also proper translation of policies into strategies) and then involving experts and stakeholders in the process could a solution. There is no set base-line or goal for compact land uses, even though, before proposing new urban land-use no prior studies are conducted. So, the policy instruments are not being deployed properly by the authority itself! Dhaka has FAR, building construction rule, BNBC etc. In every plot, there must be a certain percentage of open surface but in reality, people are paving because there is lack of monitoring. These are only small examples of our institutional lacking.

UP-02: (conducted in English)

Q: What are the prospects of environmental projects as an urban space? Are there any conflicts?

Every city has its own identity, a unique physical configuration. This configuration has influence in functionality, growth and also in sustainability. It also explains the relationship between natural green and blue networks. In that sense, Dhaka has its own character which is not like Melbourne or not like Amsterdam. So, context is important. I think, this nature of identity is deeply rooted with its historical relationship with green and water. This is one aspect. Another aspect is the human relationship with green and water. This relationship is perceived differently in urban and rural environment and in different cultures. So, these ideas were considered in both Dhanmondi and Hatirjheel urban projects. They are unique in their set-up and part of our water-urbanism.

In Dhaka, there was large natural blue-networks consist of water bodies like Dhanmondi and Hatirjheel lake. Land was fragmented in smaller islands by those streams. But unplanned and uncontrolled urbanization disconnected these natural networks and few isolated lakes remain. After liberation, political centralization made Dhaka more attractive as a capital and from than it has grown 26 times in terms of population. In terms of spatial size, grown 18 times larger. This high-density development has influence over nature and in Dhaka, the existing natural spaces (green and blue) became relief points.

Until the lake projects were in place, these areas were negative urban spaces of unplanned settlements. As a consequence, those spaces had lost their desirability to the city. In Dhanmondi area, very few houses were approached by the lake. Lake was their backyard and the housing area grew facing towards roads blocking city's connection with the lake. During that period, housing development was more depended on transportation and electricity. In the design, we wanted to interpret the lake as green-blue refuge space for neighboring housing area, beside its environmental function of storm-water retention. The existing green belt surrounding the lake was also under encroachment threat and lake water was polluted by household waste dumping. So, ecological restoration was also one of the objectives. We have made practiced couple of interventions in the existing Dhanmondi lake. First, an encircling pathway was designed to stop the encroachment tendency, combinations of spatial sequences of green, pathways and resting spaces and housing were developed to create dynamic landscape. Secondly, all the waste from sewers, households etc. had been diverted as a separate drainage system and only the storm water runoff was allowed into the lake. And thirdly, we introduced crossing bridges and new connections to integrate the lake within the existing space matrix where previously it was segregating the area into different blocks. Apart from that, we carefully introduced pocket-like spaces for businesses to generate income for this project. We have observed in Dhaka, it is suffering from lack of public spaces. Saying public spaces, I strongly mean 'democratic space' (literally translated from Bangla 'Gonotantric porishor'). Our public spaces do not comply with the ideal meaning of 'public space'. Due to lack of governing policies and capitalist attitude, this city ignores many special groups for example, elderlies, women, physically challenged and financially weaker communities. So, existing public places were failing to serve as all-inclusive spaces. So, for Dhanmondi lake another concern was to make it all inclusive space. Now whether you call the Dhanmondi lake a democratic space or democratization of space that is another argument but that was one of the issue which was a design consideration of ours. From that idea, we proposed new activities in the area which can make this project economically self-sustainable. For example, boat club, coffee shops, floating restaurants (which was initially a swimming pool and health facility but wasn't commercially successful) etc. Apart from these, cultural space like amphitheater (Rabindra shorobor) were designed so that local people can use it for recreation. Although, due to lack of such environment in this city these spaces are overcrowded and became an 'urban lake' from a 'community lake'. That is another issue, we often fail to understand that development is not an isolated process. Now there is an argue for such development around the city to reduce pressure to one. It was obvious that being an initial design it will have visitors pressure unless there are more similar developments. So, from a simple water detention new issues such as connectivity, integration, environmental restoration and regeneration, inclusive public space etc. became part of this project. And the Dhanmondi lake finally got its own image converging those issues. Now from 5am to 10pm people from any occupation, any ages or any classes can access this area for public uses. And due to that, the development attitude of this Dhanmondi area has also changed drastically. The previously mentioned lake-blocking housings development have been redeveloping to lake-facing development. For example, lake-view, lake-side, lake shore these are the common title for real-estate developments. That means this lake project had influence over the surrounding spatial development. This doesn't mean that there is no miss-use of it but at the same time the attitude of water front or reviving water urbanism became very important for the city. As in 1917, Sir Patrick Geddes envisioned water front development of Dhaka through the 'Dholai khal' (a lake at old Dhaka) which has been forgotten during the course of Dhaka's urban development, has restarted by this project. The Dhanmondi lake has become the successor of the old Dholai Khal area started the water front culture. Its continuation is the Hatirjheel retention pond realized as a consequence of 5-6 years' active

environmental movements. Instead of following the specific plan for the Hatirjheel lake area in the 1997's the strategic transport plan for Dhaka and urban area plan for Dhaka there were attempts for making housing or CBDs in that area which we protested for almost 6 years (he played an active role in BAPA; an environmental movement group who protested against new proposals and speaking as a part of that movement) and finally it has become a project. But as project, initially there were ideas of water retention and connections for missing-link between 'Kazi Nazrul Islam road', 'Taj Uddin Ahmed road' and 'Progoti Sharani road'. Later on, when many experts were engaged (as masterplan was developed by BUET, VITTI was commissioned by LGED for architectural and landscape design etc.) we tried to turn the project again into a place for water urbanism. So, according that concept we introduced water transportation, surrounding walkways, cantilevered viewing decks so that people can closely experience the water. Connection (vehicular and pedestrian) was a major issue and we created lot of new streets to bridge the old and new developing part of the city. A finally it became a successful integrated development and at the same time it brought back the image of water based growth as the historical development of Dhaka from Buriganga river. I think it's a new attitude of bringing back the water front character within the city. It was started with Buriganga river to Dhulai Khal lake and then the Dhanmondi lake and finally the Hatirjheel lake and should be an ongoing process. It is more of a legacy of reviving our originality, the unique configuration of this city. Actually, this is how I conceive these projects.

You mentioned about the inclusiveness of these projects, can you please elaborate on that? How inclusive were the planning and design process for these cases? And from your experience, how is the practice of involving people in such spatial development in the context?

As you mentioned spatial or urban planning and design, it is not only shaped by the external forces but also the people. Keeping that in mind we undertook some collaborative initiatives. In Dhanmondi lake project we didn't plan the design in computers, it was hand drawn. In that process, we wanted feedbacks from the communities. Several times we sit with 6 or 7 public heads in community centers around the lake area for public hearing. It was a bitter experience for us, but was an important experience which shaped our inner understanding of the whole project. The problem is that, initially people couldn't understand what public hearing is about. Most of them thought it is a session for complaining. But it wasn't, it was more about finding the dream or scoping session for the project. But, as you know it is not a common practice in our context so, initially we got 20 feedbacks and of half of them were complains or mistrusts based on assumptions. They protested this initiative thinking that we are going to destroy this natural area. From the other half, we got like 6 good and rational ideas and about 4 of them were completely unrealistic. That was one picture. But, I can still remember the inauguration day of the Dhanmondi lake where all these public heads were there such as ex-ministers, secretaries. The leaders and peoples who were involved in the process such as representative from Dhanmondi walkers' association, Abahoni club, Dhanmondi club, lake viewers club, women walkers' association. Most important guardianship was played by the Dhanmondi walkers' associations where most of the members were ex-bureaucratic people living in the area. Although the participatory sessions were not very pleasant and we didn't get expected feedback during the process, on that very day at the opening ceremony all of these representatives claimed that it is for them and their guidance the design is so beautifully realized. On that moment, I was very proud, instead of getting sad because I saw that people have taken the stewardship of the lake and realizing it as one of their own creation. This is what we wanted. We were advocating for these stakeholders and finally they toke the guardianship of this project. This project later gave us courage to make efforts in urban spatial intervention projects participatory.

In Gulshan lake project we are also making such efforts. We have communicated with at least 6 parties from different layers. For example, we invited the surrounding societies such as Baridhara society, Gulshan society, Banani society, the combined Gulshan club and Gov. ministries for participation sessions. We have already got some feedbacks for the design. So yes, along with your own investigative ideas the public participations give you people's purview of integration, which we did. In our Facebook page and website, we've also published these summaries of our analysis on Hatirjheel and other projects. So also, try to share it in the public domain. It is true that this process is not common and in case of Hatirjheel project the public incorporation was difficult due to many circumstances. But we took efforts, for example, there were 2 public sessions (jonotar moncho) on 2 sites. I was an activist on the streets for 6 years and together with many groups we made many demonstrations for Hatirjheel. So, we knew some of the peoples demands. For that, we organized the sessions where two MP's including the present Home minister were elected members from the 2 sites. And with the deep participation from our honorable Prime minister we tried to make this process more co-public. But you have to understand the different scale of this Hatirjheel project compare to the Dhanmondi lake. In Hatirjheel, there were more diverse multi-community participation where in Dhanmondi it was more like one single community which is Dhanmondi. For Hatirjheel, there were Gulshan, Mogbazar, Malibugh, Rampura, Badda, Baridhara and Begunbari communities. In all of these, there were not many organized groups and associations. So, this was one of the issues. But we've got many feedbacks diverse feedbacks. There were reports and articles on the hatirjheel area which also helped us prepare the design. It is true for any designer, architect or planner to open his or her eyes and ears first to be able to observe and listen beyond the lines. When we were involved in such projects that have large spatial interventions we were also motivated in such way to deal with people's interest.

Q: But there are many criticism about the process and also set backs from the locals. What are the challenges for planning and designing such projects?

This planning and design processes get much easier if there are consensus among the people regarding environment. We need greater preparations for that. We need the city dwellers to understand what is good for them and what to ask for. It was interesting to see that there was much public awareness for the Hatirjheel area. Formally, do we have any institutions that are motivating people, making aware of their own resources? Is there any public platform for discussing sustainable urbanism? No, we are lacking such platforms and when we talk about development, we always talk about urbanization, urban development. But where is the urbanism in our development context? We couldn't even plan or design for any urban development plans until today (he means until the Hatirjheel project as an urban project). We had the Detail area plan (DAP) which is the first ever detailed development plan of DMDP. But unfortunately, from 2010 we couldn't even carefully implement it. The city with such expansions in terms of population, in terms of volume yet to going into the process of planned development making it very difficult and unique situations to solve! Look at the density we have in our city now! It is unbelievable that we have more than 40,000 people per square kilometer is too much comparison to any city you may. More than the city-based countries like Singapore, or high density city like Tokyo. Our current stage is; without plan, with unbearable density, without any urban philosophy. So, what we can do in such chaos! It is a very difficult job my friend! And I can tell you, we (as planners) should take all the blames. Still I can tell you in my 25 years of career these 3 projects (Dhanmondi, Hatirjheel and Gulshan-Banani lakes) are the toughest jobs ever. Because, this was my dream too (as a citizen of Dhaka)! When I was in the design table with all the multi figures people, I was thinking of myself too. It's contagious, you cannot be oblivious when you are

designing! I'm sorry, I'm saying it very harshly but it is the fact…this is a city only for the powerful people, physically and financially…only for the able and powerful people. This city denies the very existence of 44 to 46th percent of the poor people because they are economically weak, it denies around 11 to 12th percentage of physically challenged people who are there but not 'there', this city denies around 10th percentage of adolescent female, can you see them playing around the city freely! This is what it is! And you are working in that perspective thinking that you will manage every bodies inclusiveness? But can challenge you that, if you go to the Dhanmondi lake now will see all of those people owning that place. And go to Hatirjheel see if there is any foot over bridge, any footpath which is not accessible by physically challenge people. We tried to make it all accessible. But do you think that was easy to establish as most of the 'people' (authorities) doesn't feel like that. I'm clamming that, you go and observe the Hatirjheel site and you will see at the Begunbari area those people who are very poor, they are all using the lake side as a living room (they are personalizing that place as if their own backyard). Some people stood up and blamed me! Are you stupid? Look what you've done! I said why? This place is not yours, it is everybody's. I couldn't restrict a place by design, it was designed such a way that everybody can use it. I'm bot craving that this project is a big success but at least these issues were in my mind, not only mine but in the minds of our whole design team. We debated on such issues, we fought for these issues days after days.

It was after the Dhanmondi lake project in 1999, I've decided that I have to become an activist. And till 1999 I'm working as an urban activist. But I don't know when I've become an activist. And I took this role not for pleasure. After that I've faced many threats on my life, even got threats like they will abduct by kids. I've went through such time. When I was fighting against Bashundhara housing nobody was with me, no architects were there. I was almost in the jail standing in front of the magistrate to hear the verdict whether I will go to jail or not because I was fighting for Dhanmondi 8 play field. Do you think my children are that small? I wasn't for my kids but for all the rights for all. It is not the architect who was crying, it was the father, the fatherhood within myself, the ownership of the city within myself, the stewardship of the city within myself, the city I dream within myself! It is every bodies right, some of us takes responsibility and some of us don't. The bottom line is, it should be responsible and responsive act of any professionals not only for the architects. That is how city grows.

Q: Now, you might have already mentioned many of these on the Dhanmondi and Hatirjheel projects, but I would like to ask you some detail questions about functions. You talked about urban place-making of these areas, but how did you incorporate the environmental objectives? Were there any contradictions with spatial design?

Three things were very important. The Hatirjheel was not meant to be an urban space. Its objective was mainly restoration of water retention area and creating some communications. But we felt it could be an opportunity for creating some breathing spaces where were not so many initiatives taken after the Sorwardi Uddan (one of the large city park in Dhaka) since the British period. The place making was mostly to find out some pockets out of it. Not having any extravaganza, we tried to create something which is more induced within the resources. For example, we made water works (which is presently withheld by the army but will restart someday), cantilevered viewing decks. These are some small elements but the decks would allow people to see their reflections on water. In a sense its self-reflection. It is about celebrating our water culture. We Bangladeshis have intrigue relationship with water and its reflections. We wanted to make 'Ghats' (traditional docks for boats), that is how the Bangladeshi people like to see the water-edge. We made green-edge instead of concrete edges, and the landscape will change, the local plants were selected. The green will fell off during dry seasons and look ugly but that was part of the plan

to make it more natural and local. We didn't want it to look like Vienna, Vancouver or Paris (as developers' pitch) we wanted the landscape to look like Bangladeshi water edge. We added couple of things off course. We designed an amphitheater which is floating (not occupying water) and has capacity for 1000 people just to create a place-making situation. But for that we also had to propose a multi-storied car parking connected to the that place with over bridge because there was not enough space to accommodate the parking that the function will generate. We considered the traffic impacts from the places we tried to make. We designed parking lots for the Boating stations, parking building for the amphitheater along with a children park. Initially there was not such activities. We are promoting a new modality which is water bus and will add extra connectivity to this area. One interesting thing we are thinking now which is not in the master plan, that is a bio-diversity island isolated to people as a bio-diversity compensation area for the project. This is a minor symbolic initiative to promote environment responsive attitude.

Q: What about generating businesses like Dhanmondi lake in Hatirjheel project? It is much larger in scale, what is developing situation in the surrounding? Was is considered in the master plan?

You should understand one thing that, we have only worked on the edge of the lake area where all the surrounding areas are vigorously waiting for to develop. We rather made some macro level action plans by-laws to ensure that the sun never get blocked by the surrounding development. By that, we are trying to control that development, the control is mostly in terms of building height and floor area ratio. If I could show the pictures before Dhanmondi lake project, you could've understood. There, before the project was only 1-2 or sometimes 3 storey buildings, but now 6-12 storey buildings are surrounding the lake. Those developments were not planned. They automatically grew for the lake, more like instantaneous response actions by the real-estate sector. Now in Hatirjheel these types of developments are coming, like hotels, condominiums, restaurants, luxurious housing. But let them be growing out of private investments. I'm pretty sure all these up-coming private developments will take advantage of the lake project.

Q: But will this area be permeable from far neighborhoods, as you talked about large developments adjacent to lake? I've seen some restrictions on accessing the lake area and the situation is difficult for some of the surrounding neighborhood.

The thing is, the plan was developed to have new road accesses. But if you allow everybody to access, this road will be unbearable. But the developments which are coming up, have other alternative connections on the other side of their plots. We've given 26 connections for the plots who had no other alternatives to access their houses, other than those 26, all have alternative roads. Bu given that, those who had lost their direct connections will always have the visual and environmental benefit from the lake. Detail plan for the surrounding developments is being done by a different consultant namely, JPZ Ltd. Initially, I was involved in their study phase and wanted to work jointly buy I became frustrated. I think that study was lacking in-depth research. I wasn't persuasive to getting the action-plan project. Professionals were thinking of I'm after the project and money, but I didn't do injustice to the whole plan. Whatever the circumstances are, I together with Dr. Ishrat and lot of other experts as an advisory committee we tried to guide the plan.

Q: Do you think there are chances that out-side investors or real-estates will benefit from that surrounding plan rather than the local who are more effected during the project?

It is true. Let me tell you one thing! The people who were living here for long time had the right to take the full advantages from the project. Out of this project there was 256 families who were compensated financially for their land. But they were legal owners of those lands with houses on it. So, there were always claims from those effected families that, "you gave us money but we've lost our chance to be here!". In our first presentation to the Honorable PM we raised this issue. We proposed to acquire more land and accommodate the displaced families in a cost-effective way. She took this seriously and showed precedence to this matter. She asked, "Is there any example?" I showed the Khilgoan-Malibugh rehabilitation housing for the Komolapur Rail project and other rehabilitation housings such as in Gulshan, Bhatara or Badda. She replied, "this isn't the question of money, it is the question of right." And she agreed for this proposal. Now there are two apartments for those families. although someone else have designed those very unimpressively.

Now I know 90% of the people who were living around cannot live here anymore. They are selling their lands to developer. This transformation of land tenure-ship is beyond my control. That is something which has always sadden me. As an Architect and urban designer here we have to face that, your development always wipe out the scope of people who are originally there in the underdeveloped areas. I'm not sure, this is may be one common phenomenon embedded in any development within our system. There are social issues (sometimes son pressurize their parents to sell for profits), economic issues and many other dynamics.

Q: Was it a part of your design consideration? And how was it considered in the planning process?

It was bothering me, but to be honest I couldn't do anything. What can I do? They (LGED) didn't give me that opportunity. My working territory was limited, the wall you see? That was my limit. I didn't even want that wall. That is a stupid solution. It was done in overnights. At least, I could've designed a better fence to allow light and more accessibility.

Q: Do you think the project could be designed with less built-up areas (e.g. concrete surfaces, roads)? Some experts have mentioned critics about that and also the roads are still not enough for particularly the locals because there is not enough pedestrian accessibility allowed.

I think most of the people do not understand the positivism of this project. Some think it is another project like the Dhanmondi lake, unfortunately. I'm telling you very frankly, it was more likely a city level connectivity project (road development) with a retention pond. It is not a park project, it is not a lake project. We had to deal with the functionalities of this project. There were many "dreams" around this project which cannot be realized in this context, we had to realize the integrality or multifunctionality of this project. Otherwise, with only environmental rationales it would never be realized. I can assure you, there are adequate trees planted, may be at this initial stage it is not appearing but, we have planted thousands of trees and they this shade this area within another 3-5 years. Another thing is, since we've to design roads on the ground we avoided intersections with different layers which reduced travel time. Now the circular bus services have already been started. This a local business generated by our designed bus route. This project need 75 million tk. Per year to maintenance and we had to develop some earning sources out of it. We have managed to create opportunities to earn about 80 million tk. from circular bus, water bus, parking, mobile food carts, amphitheater and children's park. So, it is a self-sustainable project like the Dhanmondi Lake. It was not an easy job to incorporate all these without hampering the objectives. No government agencies would not be interested if they realize they have to pay 75 million tk. each year.

Our governing agencies face difficulties because they ignore the maintenance costs of the infrastructure and after realizing the maintenance cost became a burden.

Q: In this aspect, what institutional lacking do we have? Are there lack of planning and governing tools?

Firstly, I think integration between agencies is most important. Secondly, for implementation, having comprehensive and holistic perspective is very difficult area. And last but not the least, ensuring public participation to generate appropriateness is another most difficult area in our practice. Where now involved in another project which is in Narayangonj, it is riverside and canal development project where our design approach will be very similar with the previous ones but in this case, we are hoping to integrate the public insolvency under the leadership from Mayor. The demand for developing those important public areas came from the people, so in that sense it is bottom up. But from the moment, she (the mayor) has taken the initiative the issue became more important. So, we need strong leadership also, when it is committed, it should be implemented. I believe, planning is a continuous process, we should keep updating and refining it but, until the plan is implemented it has no value. I'm very much upset about that, still from 2010 we are waiting to have an implementing authority. Our planning authority (RAJUK) is playing as the mother-organization for doing all the implementation where it was not entitled to it. There should be a separate independent implementation authority, that is how the law was passed.

Thank you for your generous support. I'm thankful to you and your office for managing such elaborate session within your very busy schedule.

UP-03: (translated from Bangla)

Q: What Policies are there for Urban Climate adaptation in Dhaka City?

If we see what are the climate change risks in Dhaka city, the major two issues appear-1. Food risk and 2. UHI, or heat stress. If we talk about heat-stress, there are no specific policies or that, but there are policies for urban greening or plantation. In the city corporation mandate, there are plantation goals, but generally they are not given priorities in implementation. But For flood issue there is much concern, the climate change effects are a recent addition to it but also, when there was major flood event in 1988, a flood action plan was developed for the whole country. And under that FAP there as 8A and 8B section which was developed for Dhaka. Policies from that document were adopted in the structure plan of Dhaka. Basically, there were considerations of developing embankment, (both western and eastern), excavation of canals, areas for retention (creating and maintaining retention ponds), flood flow zone and sub-flood flow zones. These are the summary of FAP 8A, 8B which are incorporated in 1995's structure plan of Dhaka. But in reality, the structure plan was violated many times. When the work of detail area plans (DAP) started, it was already late as many flood flow zones or wetland were encroached or filled-up. So, in DAP the authority changed the hypothetical locations mentioned in the structure plan and designated some retention areas along the proposed eastern embankment, and merged the sub-flood flow and flood –flow zone together. That is how the DAP was developed. Now, for Dhaka the main problem despite the policies and plan is that, the implementation is very poor. That is my main observation on Dhaka's governance. If we see the studies on wet land loss even after the gazette notification of DAP we have lost many wet lands which are marked in DAP for conservation. Another interesting issue is, RAJUK prepared DAP where they designated wetland areas or flood-flow zones and recently they are proposing housing

development on the same area which was designated for flood –flow zone. Jhilmil project is one example of that. So, I would say policies and laws like water body conservation act, climate change policies etc. are there which are related to flooding issues. The water-body conservation act 2000 is applicable for any kind of water bodies (e.g. which retains, flows) in anywhere cannot be filled up. Particularly, climate change policy is more general, it says we should adopt to climate change. So, for implementation it requires more supporting policies specific to flooding problem. Now, policies or laws are there, we have also strategic plans but the development authorities are failing in implementation. I think they could've taken stronger role (even penalties are not given normally).

Q: So, the authorities need more development opportunities from the plan. In this case, what should be done (e.g. Public involvement, trade-offs, knowledge sharing)?

There is public consensus, but there is no platform to express. When the first draft of DAP was proposed, we (academicians) played activist's role to update it and there were many demonstrations against it. In the initial plan (RAJUK) violated many wetlands and natural spaces from the structure plan. Mainly. Since then, the concern about wetlands was raised. It spread in public-domains, like TV media, newspapers. The political context was different (The caretaker government was ruling). We went to the gov. advisors, secretaries, even finally in the end-workshop (where the plan was presented in public) we opposed the plan under special permission from the advisor. We were allowed to give a feedback presentation and after that we were able to change their opinion about it with the forum's support. After that event, the initial DAP was canceled and suggested for revision. Then, the main concern was about the wetland preservation and agriculture land. But in the present DAP there are many mistakes. Still we are facing issues such as khal (canals) and river enchainment. Local public are involved is such activities but in smaller number, mainly strong private actors are involved in these illegal activities. And as we know, the flood-flow zones are mostly privately owned land. Due to large developments, the local people are getting displaced. It not only an environmental problem, but also a social problem. There is a social dimension to it. From my PhD. research I've seen it the people who are living in those areas have owned those lands for centuries, these very traditional farming lands but in the name of development they are becoming displaced. In public projects, usually land readjustment or similar policies are taken where there is some form of negotiation. But in the surrounding areas of Dhaka, people are getting displaced from their original homestead. Anyway, there are different dimensions of our development problem. Now we're doing project which similar to your question which is assessment of climate policies and their implementation process, to see whether there are any missing links?

Q: Now in this regard, how well do you think our flood-risk management and spatial planning are integrated in the policy documents?

In this regard, the risk-sensitive land-use planning is having professional attentions. Here the risk-sensitive land-use planning concept is not very old. Recently, the risks associated with climate change are being incorporated in the plans. Traditionally, Planners didn't consider the data regarding hazards or vulnerability aspects. Before it was more based on demographic status but now there is a shift towards resilience. Now it is a part of governmental goals or visions. So, climate change is playing an important role in the policy domain. In the strategies plan level, we don't have many examples. The Mymensing city now has a strategies plan where such issues are considered, including earthquake initially, started by a foreign funded project, later, UDD developed it as federal strategies plan. For Dhaka, there are separate projects, we always advocate for those studies to incorporate in the strategies. Now earthquake is also

being considered besides flooding and he stress. The recent structure plan (2016-2035) considered the earth-quake risk (at least the authority argues) but if they've considered the earthquake risk, there should not be too discrepancy with earth quake risk map. They're also combined agricultural and other conservation land. So far, I've noticed there is lack of study, especially lack of primary data. First of all, the exiting DAP could be extended as many of the areas have not been developed rather new DAP has been initialed, if so there should be more field level studies and recent primary dates to support the plan. Which I think, is still lacking.

I've attended the workshops for this recent structure plan. There are many reservations from the public and stakeholders, not only on the disaster-risk issue but also in many other sectors. Mostly participation was a major issue. They failed to involve important stake holders (even public governing bodies) in the planning process of this structure plan.

I think. I've explained the situation which will answer your question. In the policy documents, mostly in national level such as plan developed in 1965, 1975, sustainable development strategies, environment related policies, recent climate strategies all these documents in some extent mentioned adaptation approach for flooding, in strategic plan it is adopted, may not up to the required level due to lack of study but in implementation level there are paramount deviation Jolshiri (Project of military/army housing), Jhilmil all are violation of DAP.

Q: Is there any government or private level incentive for implementing sustainable or green development? Or is there any specific goal for green-blue infra-structure development in Dhaka.

So far, I know, there is no goal for specific green or blue infrastructures in the government sector. But there are concerns about retention pond. The problem is in more metropolitan level. If the 1995's DMDP was realized properly, the landscape would be different now. In that sense, proper land-use is more important. Much can be controlled by land-use. there are some small-scale, project-level initiatives, Hatirjheel project is a good example of that. It has achieved many objectives. There are new transportation options, it restored the old lake area, people are enjoying the area in many events, but how well it can maintain the water quality is still an issue. Dhanmondi lake was a good example, now Gulshan Lake, Uttara-Baridhara lake areas are being developed. But the problems on internal canals (Khals) and surrounding rivers (which are more important for drainage) are under threats. The 'box-culvert type engineering solutions are not suitable for our context. For say, we can stop house hold waste dumping, because now there are good waste management (collection) in many neighborhoods, but what about the natural waste, (e.g. dusts, plant leaves), construction waste etc.? Our municipalities do not have that much-sophisticated management. And my question is why should we still go for 'box culverts'. The khals (canals) are already there, we do not have to create them by demolishing properties and they are not private, these khals are all gov. land, even 200 meter on both sides are also gov. owned. So, developing these water channels are less difficult than the retention pond or flood flow zones which are privately owned lands. To develop those area gov. would face challenges and can opt some mechanism such as transfer of development rights, or any other incentives to balance their economic loss, not by force or land acquiring.

There is one thing I've to mention, when we develop plans we do not think about how to manage it, such as introducing regulatory tools (e.g. taxation, incentives). We don't reach the deeper level of planning. Is it true that we are losing wetlands only for accommodating people? How many people are buying those lands? If we grossly say, we have 20 million (although it is not yet!) people in Dhaka at least more than

60% of these people cannot buy these lands (as 30-40% people live in slums or squatters). Do we really know how much land were require for accommodating people? No, we don't. But it is the major argument of our development authorities. In the land-use plan, acres of lands are proposed for housing, and industrial development. But, is there any land indexing that shows- it has been calculated? Dhaka is the heart of our country; it is true that we have booming business in Dhaka. Here, we don't have the luxury to have big villas. There should be strict land restrictions or control on how much land we can own here? That is another question. We are buying lands in city center and also in the suburbs (!) We should have more strict land policy. We have a land ceiling act which is very flexible. If you build houses on your land, you have to give property taxes and many other bills. But land price gets higher very quick, so there are people who are making business out of lands. They don't build anything just buy lands and wait for profit, which is a very unproductive. Yes, there will be buildings eventfully but, thing about the time frame. So, these are some root causes which contribute to the loss of natural open spaces. Do we need everybody to migrate in Dhaka and start buying houses or living is slums? It a part of national level thinking.

Q: The DAP court's the surrounding areas also (which is now greater Dhaka). So, in the regional scale what difficulties do we have creating housing, or commercial areas to release urbanization pressure?

In their structure plan for Greater Dhaka, 5 area were shown as satellite towns (where Purbachal was the last one to develop). We only showed the areas but we didn't think about the communication roles. Although, the vision was to develop self –sustaining satellite towns but to some extent they have to have good communications with central Dhaka. So, in a sense, the real estate developers are much more intelligent than the police mares or planners. Topographically Dhaka is high t middle part and both sides are low and closer to river. The real-estate developer saw there are vast piece of land, agricultural lands so, they were able to buy large area from single owner and those areas were law land, so they bought in cheap price and they easily developed those areas because those were close to Dhaka. But as a planner we didn't think of restricting those areas as retention or flood-flood. Whereas, we opt for fringe areas at eastern side, which is low-laying areas with no embankment and restoration areas (which are being filled by private sectors). So, those fringe areas will be vulnerable to both river flooding and inland flooding. This is the situation of Eastern part, in western side the 'Goranchand-Bari area is reserved as retention area and in the kollanpur area there was another retention area (about 200 acre) shown in the map, but not properly reserved in and already filled-up by encroachment. So, these two are major retention areas at the eastern idea. There are almost no natural canals existing in the western side but it is still possible to protect the natural canals existing in the eastern area.

Now, all these plan violations are difficult to explain in the academic researches. I think you should consider the political dynamics of our planning process, then you can some-how explain the real scenario of our context.

Q: what are your remarks on the Hatirjheel project?

Apart from the many physical benefits (water detention connectivity,) my main observation is –who are the real beneficiaries of this project? In a large project like this there are big costs and also benefits, it is true that many of the people were living there illegally, if we see the surrounding areas, from the Its tire people were evicted, some of them are rehabilitated (still many family did not get the position in the apartment) and many of them are displaced with only the standard compensation fee (which is v very low

compare to the recent market land price). The from the 2nd tire are now at the like front and having real opportunities to benefit from the project. But their individual lands/plots are very small (1000-2000 sqfts). No what is happening there is, big real estate developers are coming to this areas ad trying to buy big chunk of lands, in some cases, they have strong influences and eventually the owner ill sell. So, it is happening because people were not fully aware since the beginning of the project, many of them didn't know the plan and couldn't negotiate properly or manage between neighbors. So, during the realization there were many law-sues. It was possible to proceed with the project because of the army involvement. But to the wall people access to the lake is more limited now. It was necessary to introduce some form of control, but they (army) should be more considerate and allow more connections to the neighborhoods. Presently there are huge development scopes but we should create such situation where the local people would be displaced. For example, now there are concerns that the 'Korail Slum' (next to the Banani Lake) will be demolished. There are gov. lands, (from National Housing Authority), But we've always advocated for improving those areas without relocating the people, there are many mechanisms to get profit, (or recovering cost) from such social housing developments fortunate that, it happens in gov. housing developments. Why there are quotas for gov. officials? Why giving land to privileged member of the society without considering the local inhabitants first? If the gov. has to develop housing or land for housing, the first priority should be the low income and middle income group, because the market doesn't do anything for them. And even if we do something for low or middle income group, why do we develop land instead of housing, they cannot afford to build houses on it and eventually give it to the private real estate companies. This is what happening in the Purbachal Housing area, entire area is now under real-estate developers and it will supersede the estimated population and planned services. The FAR (Flood area ratio) was introduced but in small plots it is not offering much open surfaces. We need combined open areas for water infiltration and managing run off. In small plots if (FAR) is not offering the vertical growth which we need for compact development and drainage management. In FAR, it is regulated that you cannot cover more than 60% of your land, but having mall pieces of lands and combined green land ha different effects in runoff management such as on-site water storage, retention pond as public pools etc.

UH- 01: (Translated from Bangla)

Q: What policies and strategic plans are present/adopted for urban climate adaptation of Dhaka city?

In terms of climate change policy particularly for Dhaka city, there is none. But in national level we have NAPA and BCCSAP. These are public documents developed by the Department of Environment. We also have an old document FAP (component 8A & 8B) developed by JAICA, Japan. There you will find much detail urban drainage study and flood management guidelines. And for spatial plan, mostly RAJUK does all the planning in Dhaka city. The latest strategy we have is from 1995, the DMDP and DAP is its detail plan. Now, the planning horizon of DAP was 1995-2015 and they (RAJUK) is working on a new DAP. But the thing is, the strategies for Dhaka are developed before the climate adaptation plans and I don't think the DAP considered detailed climate adaptation studies, they included some options based on the available documents during that time.

Q: So, what are the challenges in the planning for climate change adaptations for Dhaka city?

As you can see, for adaptation planning we only have the national level policies and they came after the federal strategic plan (DAP). NAPA was published in 2005 and BCCSAP was in 2009. So, the policies came late. Another issue is, we took long time to develop polices and plans and even though, after adopting the strategies, the implementation starts late and between that period most of the land-uses changes in unplanned manner. Implementing the plan in this situation will require lot of re-developments. Only in the under developed areas (mostly the Eastern Dhaka), we can implement the plan without lot of turmoil. For the eastern part, it is already getting late. The land-use change has already been started. The agricultural lands are being bought by private real-estates and the water bodies are being filled up violating the plan. When the new DAP will come, by that time the Eastern Dhaka will be an unplanned built-up area too and the implementation cost will be high. Hatirjheel area is a good example of that. It was an unplanned built-up area and to save the lake we implemented plan with a lot of costs.

Q: Can you explain the planning process of the Hatirjheel lake project?

I should say the Hatirjheel lake project was not an outcome of standard planning process. It was more like a negotiation process between different actors. This project was not realized from strategic documents or any planning program. I think I should give the background for that. Before 2007 when this project was started, there were lot of development proposals from government agencies. Experts were also involved in researches to promote the potentialities of this wetland area (Hatirjheel lake). In 1998, the RAJUK came up with a development proposal where they proposed a narrow canal at the middle and the both sides were zoned and plotted out for residential, commercial, industrial etc. development. In between 2001 and 2002, we (BUET) had couple of studies (mainly on the drainage potentialities) of this wetland. Based on those, we nullified their (RAJUK) proposal and sent a recommendation to them. In that recommendation, we showed at least 100' wide canal from Sonargoan Hotel to Tongi diversion road to be ensured and from Tongi diversion road to Rampura road the 265 acres of land must be acquired to protect the lake. But as you may know, this type of research-based recommendations has little impact on our administration and our recommendation was laying on RAJUK's desk. In 2004, there was another proposal from DCC for constructing an east-west connection road from Tongi diversion road to Rampura in the middle of the lake. This was the most alarming proposal among the all development proposals. They had designed that road and proceeded with all the clearance processes with the planning ministry without conducting any environmental studies. Their focus was traffic jam but, as they proposed the road in the middle filling up the lake eventually they were creating more opportunities for illegal encroachments. They had got all the approvals and were tendering. Fortunately (or unfortunately), in 2004 there was extreme rain events and Dhaka was having lot of logging issues. So, an important inter-ministerial meeting was called to discuss the solution for Dhaka's drainage problems. In that meeting, different stakeholders were invited. High-level government officials, representatives for different organizations, environmental activists, experts and academicians, all the development agencies were there. I was also invited in that meeting as an expert and academician (may be architect Iqbal Habib was also there as an environmental activist). In that meeting, we (experts) strongly advocated to protect the lake. The DCC's role was against us and they were supporting their road project. During that meeting, I explained our drainage problem in very simple language and said to the chairperson of that meeting, "if we build the road on this lake its reflection will be front of your houses, water will flood your houses." The meeting was presiding by the existing minister of the Local Government Ministry. We were lucky that, after all the arguments the ministers dropped the DCC's road project in that meeting and send it to revision. Later the DCC came to

BRTC (BUET) for suggestions on that transport issue (east-west missing link). We gave them an initial outline drawing of an elevated express road with a lake-surrounding services road at the ground. The service road will increase the neighborhoods mobility but our main intension was to protect the lake from encroachments. In the executive summery we mainly focused on the service road and explained the issue. But the DCC were only interested in the express way and start mobilizing with that part to gather permission and funding. Because, their first proposal (road on lake) was about 400 million tk. where with the elevated road this new project became almost 5400 million tk. project. Again, we were lucky that the finance ministry denied funding due to the large financial requirement of that proposal (there was other political reasons) and sent it back for feasibility study. Later, there was nation-wide political instability and this proposal was stopped. But in 2007, under the Caretaker Government this project was re-opened in another inter-ministerial meeting. The Advisor of Local Government Ministry was impressed by the environmental and transportation rationales of that project. But, the budget required for the elevated road was high and the authority decided to transform the elevated express-way into a ground level express way combing with the initial service road. It was a quick pragmatic decision from the existing body (as you know the administrations was backed by the military power in that caretaker period and they wanted to initiate as soon as possible). In that meeting, it was decided that, due to the complex nature the SWO will do the construction, the RAJUK will do the wetland management (sludge removal and excavation works), the WASA will do the drainage part (waste water diversion) and the LGED will construct the roads. The project DPP was approved very quickly from planning commission in October 2007 and the Hatirjheel project officially started in November 2007. After the caretaker government period, the new government also approved the project for continuing especially due to its environment restoration issue. So, this project had to overcome the administrative barrier in different political environment. You can see there is a political dimension to its development process.

Then there were lot of implementation challenges during the realization process. This project had to deal with the illegal occupants, lower and upper level criminals owning informal settlements (mainly tong-houses) and influential private groups (e.g. BRAC, Eastern housing, Hotel Hilton) to regain the land. We have wet land conservation act 2000 (that states even if you own wetland you cannot change the character of the land) that helped us enforcing the land acquiring. There are lot of legal land owners too. For the road construction, we had to acquired their lands. There is land requisition law (any place can be acquired by the government for public development work except religious places) but only financial compensation would be unjust for the owners (the government rate was very low compared to the actual market price of that area). So, after many negotiations the Work Ministry agreed to manage some lands for the evicted legal tenants and constructed two housing tower for them. For that, the space was managed from the masterplan by the designers. But that provision is not adequate from my perspective. There may be about 40-50 apartments where almost 200 households were demolished. There is also possibility for transparency within the selection process. That is how the land issue was resolved. There were areas where the low-income communities had houses which were taken by the project. Authorities couldn't do anything for then, only compensated the legal house owners. This is an important social effect of this project.

Q: In that aspect, during the social survey I've observed some negative reactions about the wall around Hatirjheel. What is your opinion about it and are there other design issues that conflict with the existing housing character?

In Dhaka, there is much scarcity of public places. When the Hatirjheel project was opened, it was overwhelmed by public gathering in special occasions. Many road side houses started to open food shops and the road side and footpaths became public recreation place.The local living style was effecting the traffic in the express roads because, the such interventions was new to this area and people living in this area are not use to with certain urban manners (road crossings, pedestrian uses etc.). So, the wall was introduced by the army to restrict the access to the express way. I personally don't support this but it is also a fact that, something had to be done about the frequent crossing. May be a different method could be applied. This project was designed as an urban drainage infrastructure and finally the public recreation became a major attraction of it. Whereas, it is not fully designed for recreation rather recreation was a partial goal. As an urban drainage infrastructure, I think it is an exemplary work which will promote awareness about wetlands in Dhaka. There are some drawbacks. This multi diverse objective made it difficult to achieve the full drainage potentiality and ecosystem restoration. But, there will be many ecosystem services. For example, water detention, ground water recharge (may be fishing in future). In the architectural design, I had to intervened for the water detention and drainage issues. The design process was based on this type of discussions between different experts.

Q: What is your understanding from this project that can be helpful for planning and implementing similar projects in Dhaka?

If we can master plan the complete area including the recent additions (e.g. elevated U-loops) which are organically coming up due to the new development scopes, then it would be more efficient. To plan everything at the beginning is the standard planning approach in our infrastructural projects and then can be realized in phases. But, in this case the planning of this project developed by the arguments and discussions. This discursive approach allowed us to interfere other wrong decisions and establish the environmental principles. Even if we could plan the project combing all the objectives, there was a possibility that seeing the enormous amount of work and budget the authority could've backed off from it. I think, for all the challenging projects the government should adopt such discursive approach and also should include the scientific research to plan based on scientific evidence. The scientific knowledge is very important for decision making for the environmental projects. In the Hatirjheel case, we could strongly hold our stand because of the academic researches on that area. These are my learnings from this Hatirjheel project.

Now after the realization, the social and political attitude has changed. The government is very proud of the project and new supports are coming for integrating more developments with this project. So, the project was mainly completed in June 2013 but still ongoing after many extensions and budget increase. The social and economic benefits are there as it improved the living environment and surrounding land price are increasing. It can influence the development agencies to change their common land development attitude. But there is concern for the low-income population. From my experience from Hatirjheel and similar projects, I've realized that there is not much inclusive practice regarding the low-income communities. Most of the cases they don't have legal rights over the land and get evicted or the economic pressure influence them to move out. In such conditions, the authorities should include that affected population and accommodate them within the area. In the Hatirjheel project, the people who

were affected by the land accusation and only got financial compensation also have the right to live in that area. In that case, government can provide houses by rent-purchase basis. Development will be meaningful if it can accommodate the affected communities. We are not asking the authority to avoid the development pressure but to consider these social and environmental issues while planning those projects.

Q: What is the situation of public-private partnership for implementing such environmental projects?

Now, there are not many examples of public-private partnerships for environmental restoration works. Mostly the governmental agencies are working in this sector. But now that the Hatirjheel project is a good example for private investors to see the economic benefit from environmental restoration it will have good impact on the public-private collaboration practice. If the wetlands are developed with multiple development objective, there will be more scope for economic growth and the private agencies will be interested to share the costs and benefits. This could be a strategy for the government agencies to develop Dhaka's watershed and easily achieve city's sustainability goals. Even re-building the green-blue networks demolishing the box-culverts (Dholai khal, Panthapath to Dhanmondi Khal etc.) will be possible if private sectors are involved to share the large investment costs.

UH-02: (translated from Bangla)

Q: What are the cause of urban flooding in Dhaka? And what are the important climate change factors in flooding problem?

In general, for Dhaka city urbanization related issues are more prominent in our flood management. There is climate change effects-mostly UHI and high inanity rain-fall. But we are experiencing these aspects in micro-climatic scales, these are more anthropogenic developments rather direct impact of global climate. In the national level, there are major threats such as sea-level rise and water level problems in our down-streams, these are global climate change threats. But we must realize that, our highly urbanized and poor management are causing significant problems in water management.

Q. What policies and plans are present for the flooding in Dhaka? Are there climate change considerations?

Specially for Dhaka's Flood management FAP (Flood action Plan) 8A, 8B and partially 9A, 9B are the planning documents. The FAP was developed by JAICA (Japan International Corporation Agency. Other than that, we have national level policy and strategic plans. Most of the cases, the donor agencies have developed strategic plans for our government, so many of them are not public documents (gazetted). In our national level policies, there are broad scopes and mostly ideal talks, such as build with nature, respect the nature and so. Recently, climate policy is there. But I Think the climate policies should be more relevant. It is a good document to full fill the international conditions but we should also think about generating specific strategic tools out of it. And this aspect we are very much lacking, implementing the police is the main challenge. We have integration problem between agencies, we have governance problem. In this situation, we need public empowerment.

I'll explain some of our development scenarios. It will help you understand on the climate change and development problem dilemma. From the here beginning we are lacking planning the flood management.

The experts didn't realize the planning issues of the flood. It was about flood control. After liberation. When urban planning. For Dhaka was developed the original natural drainage system was heavily ignored. There were some major flood events in Dhaka between 80's and 90's. After the 1988's flood, pumping was introduced in Dhaka. 3 Pumping stations were implemented within the city. So, the gravity-base drainage was altered they (development agencies) transformed the western part of Dhaka as a "polder". A "Dam" was implemented at the western side and on the other side (now the margin between west and east part) north-south elongated 'Pragati sharani' (a highway road) was constructed. That road was elevated above the flood level and the natural water connections from eastern side were disconnected.

So, planning integration is also absent in our water sectors. The water and flood-risk management regime was more inclined towards flood-control. We still have conflicts over such issues. There are conflicts between organizations. The conflict mitigation is absent in our system. Adaptation is more like a co-operation approach. But there are so many different agencies in related field that do not have integration between them. They are under different ministries and it makes it more difficult. But in terms of infra-structure, we have inadequate drainage and also non-functioning infrastructures. It is mainly because of management problem instead of financial or technical during field visits we often see such miss managements, for example, we saw WASA in pumping out water in a temporary logging situation where the pumped water channeling back to the area, because the drains were blocked. If the DCC and WASA doesn't co-ordinate our drainage system will not function. We mostly depend on surface drainage and water blocking the drains is a common issue for our water logging. As the surface drains are under DCC (City corporation)'s jurisdiction the WASA doesn't clean the drains while pumping out the water and eventually water runs back to the system. There is no formal co-ordination between them. But yes, we are politically "democratic" and we say everything goes through the democratic process. So, no one is here accountable. Every institute in Dhaka they are operating individually.

There is a political-economy behind our developments. Why Dhaka is going for many fly-over roads (free-ways) rather investing on mass-transport? Is it supported by any planning studies? Or any statistics shows people can afford individual transport? There are things which are more political than pure public benefit. There are external and internal benefits of infra-structural investments. We often use the term "economic incentive" for people. Is it a transparent process? For who's benefit we are doing it? there are no "equity" in the process. That is why I said we need public empowerment and also institutional reformation within our system.

Q: In that sense, Hatirjheel is Project which initiated lot of social conflicts. As you were one of the experts of the consul-tency team, what is your experience? What environmental services are there also?

Yes. I did the detention design of the Hatrijheel project. It is a detention lake, not retention. That means the water will be kept here for short-term. In the planning process, I've faced some challenges designing it. The main concern was to restore the lake and enhance it environmental services, but in the name of "Integrated system" the main objective of storm-run off retention was ignored. The system is not integrated, it is rather separate. One of the reasons is that, It was named "integrated" where the initial plan was to incorporate the adjacent Gulshan-Bannai Like into the detention design. (and also, develop urban amenities out of the whole area), But row they (RAJUK and LGED) are doing the Gulshan Banai Lake project separately. If we could've design the water system combining all the wetlands it would be more efficient. During the study, we saw the existing Hatirjheel lake area was not enough for the catchment area. So, it was a better approach to combine the other two water bodies. But now a ware is added to

detain the water inside Hatirjheel lake. They should've initiated the projects together. Secondly, we had to compensate almost 100' width land on both sides for road (70') and landscaping (20-25'). It reduced significant amount of defection capacity. Now there are new opportunities and more built structures are coming up. All these dynamic objectives hampered the main objective of this project. Initially there was only peripheral pedestrian connection proposed (for stopping encroachment and improving the neighborhoods accessibility. Elevated road was proposed to prioritize the detention, the ground area was planned as green corridor with less public interference. Now different things were done. And after finishing the project, they are doing the (spatial) planning of the area (surrounding area of Badda, Begunbari). Whereas, if it was included in the Hatirjheel lake master Plan we would have more options to improve / design the drainage of the surrounding areas. But more or less, some up gradation was done for the drainage lines and surface drains during the project. Now it is a public recreation place, so certain level of water in the lake has to be maintained. There is new pumping station at the connection point with the 'Balu River' channel which maintain the water during intense raining specially, in monsoon. It also functions on gravity during regular period.

Q: Can you explain (and share) more information about the hydrology design (or models) of this project?

The project is still on-going. We used modeling for the defection design, but I'm unable to share the details of the model because, it now LGED'S material. I've used the dynamic programming approach and there is a master's thesis (from IWFM) which I've supervised followed the similar methods. This research also included the whole are combining Gulshan-Bannai and Hatirjheel lake. I would recommend you to study that research for further understanding.

Q: Now, how well do you think such detail hydrological knowledge? Specially, for urban flood management are considered in the spatial strategic plan in Dhaka.

For Dhaka, I don't think the hydrological analysis played important role in the strategic plan (DAP). There are (in DAP) flood management considerations but are very general. Now we have climate policies, urban adaption is a major concern (specially for flooding) So recently strategic planning is considering hydrological studies for decision making. For example, UDD (Urban development directorate) recently developed strategic plan for Mymensing city (an adjacent city Dhaka). Climate adaptation played an important role in that. They (UDD) used hydrological Model and obscuration date for planning. The has been legalized already but Mymensing municipality doesn't have the institutional body to implement and monitor it. So, they are planning for adding new department. I was also involved in the planning process and I think it is an exemplary work specially, considering the flood adaptation.

UH-03: (conducted in English)

The usual in terms of causes is insufficient drainage capacities, excessive sedimentations and solid waste blocking the inlets and also the drains, then unplanned/ uncontrolled urbanization. So as an example, area has a drainage system or waste water system designed for 1000 people/households and now due to unplanned growth has 10,000 people/households. So, the waste water volume was way beyond than what was originally designed. Also, the combined sewer and drainage network is part of the problem. Because, the sludge that enters the system are hindering drainage flows and causing congestion. Most of the areas of the city does not have separate or proper sewer system, so it is a matter of infrastructural

problem for flooding. You can also consider one of the under-laying drivers of in-migration of population growth of Dhaka city. This is one of the major drivers of the un-controlled growth/development. Given all that, how important is the role of climate change? Personally, I think it's not that important. Because, the socio-economic aspects still dominate. We are consistently dumping waste in our canals, drains, manholes and thus our water system is dis-functional. But obviously, in top of that if you put climate change, the situation gets worse. But, this is not an exceptional case that the system is functional at its full capacity and climate change comes and tips it over. We are not at that sort of situation at that moment. Moving on to the next question of about flood risk management strategies/action plans for Dhaka, we do have lots of plans; recently, Dhaka WASA has completed the drainage, sewer and water supply master plans for greater DHAKA (DMDP area). And Dhaka Water Development Board (with help of IWM) is doing a study on the flood protection of Eastern Dhaka (Eastern Dhaka is the area from the Airport road and DIT road to the Balu River) which is at the moment very vulnerable to river flood. Large areas of that part get flooded every year by river water (not pluvial). Once we put an embankment to the right side (eastern part) than this area will be susceptible to inland/pluvial flooding. So, this is the dilemma for the plan for Eastern part of Dhaka. Generally, in the plans there are proposal for separate drainage and sewer lines, new pumping stations (at Rampura Hatirjheel outlet, in the North-west Guwanchandbari) beside the existing pump stations at Kollanpur, Dholaikhal, Maniknagar near Komolapur Railway station (newer than the previous ones). These pump stations pump out water from the city side to outer side of the flood embankment. So, the newer pump stations will improve the capacity of the system to pump out water during the monsoon. But the problem is, if the water is not coming into the drains due to blockages the pumps are not going to help that much. So, in terms of risk management strategies one established strategy is to protect the flood plains. I know that in your research you are focusing on the inland flooding but, there is an import relationship between what is happening in the rivers and inside the city. It is like this, along these embankments especially at the pump stations there are sluice gate structures. Generally, they are open for gravity-based water drainage. For example, in this month of December the water level is low in the rivers and in the city water going to the ponds and canals and later drain into the rivers. In May-July the water level of the river will rise to a certain level when water will enter the city through canals (khals) inundating low pockets of the city. That is why they close the gates during monsoon. And then the city relies on the pumps. We rely on the system of catching and draining storm water into the lake/retention ponds and then to pumps. This system continues about 2-3 months and then again, we move back to gravity based system. So, this urban flooding phenomenon is relevant for 2-3 months (now in some extent 4 months). Now, to see climate change impacts, we've done model studies in the peripheral rivers and their water level have a trend to go up (due to more flow from the upstream catchments from rainwater and in downstream with the sea level rise in long term future there will be less ability to drain). That means we should close the gate earlier and for longer period. So, over time climate change will force us to depend on the pumps for longer periods. This is purely from the climate change point of view, but there are other anthropogenic impacts too. For example, you can see in many areas the river width has been squeezed. It is being encroached and the flood plain (or foreshore) is gone. What happened few years ago, some pillars were put to demarcate the navigation route of the river for the dry season. So, people started to filling up the river up to that boundary for more lands without knowing the actual reason behind it. So, very unfortunately what was initially a good idea, had a bad impact. At the western side of Dhaka in Turag river, Buriganga river and at the eastern side in Balu river, there are areas which are very much constrained. You can understand from a hydrological point of view, if you have only one of these bottle-necks in upstream the water level will go up. And that is already having

an effect before climate change. Water levels are going up more than before and therefore the sluice gates are had to be closed earlier and we are susceptible to pluvial flooding for longer period. In terms of risk-management strategies, we should go backwards to protect our river corridors and flood plains. Even if you look here (in the DAP map; Purbachal area) it was a flood flow zone which was given to housing development, this area is naturally a higher area but have lots of natural drainage canals. But the new plan still incorporates those blue networks. Conceptually/ theoretically it shouldn't have any impact but in reality, how much of these open canals will be left open is a question. We are facing that sort of challenges from the land-use or land control point of view. Other strategies that are in place e.g. Flood forecasting warning system (operated by the Water development board, FFWC website), signaling of danger levels. But most of the signaling or warning system are more useful in the rural areas to reduce the impact on agriculture. For the next topic (strengths and weaknesses of policy, strategies and plans) generally, I think the policies and plans are strong (designs are generally ok) but the weaknesses are in terms of implementations and enforcement. Before financing was a big problem but now-a-days, I think we have enough finances to implement some of these flood-management projects (GOB funding, not from donors). The weakness is in terms of delays of formulating the projects and implementing the plans. Day by day more people are coming in the city and less case is available to put in green-blue infrastructures and costs will also go up.

Q: Why there is so much dependency on pumps and infrastructure?

I definitely agree that the situation is not ideal. These approaches were taken as a reaction to the big flood events in 80s (1988). At that time, the strategy was to separate the urban areas from the river through embankments and use pumps to evacuate water. That mentality is still there. The mentality to live with the flood or adapting to it hasn't reach Dhaka. In some other parts of the country it is there but in Dhaka due to its urban nature (high density commercial land-uses) the concepts of allowing water to pass through is not present. If you do a little case study in the northern part, we have Uttara phase 3 project. This place was very ideal for water detention zone (with lots of wetlands, low areas, natural water bodies). This area which in now under development by RAJUK, was naturally treating waste water and helping percolation to a certain degree. Most importantly in the wet seasons it acted as a buffer. But now we have totally changed it, we 've filled it up and left little bit of canals and lakes. So, again we are putting this area to more vulnerable situations.

Q: Why not these issues are considered in the new flood management plans?

I think, the land value or potential land-use is the driver. From purely economic point of view, the land was underutilized. For that case, all the surrounding land value was so high, there was pressure to develop this land. From flood management point of view, these lands will reach to certain height (after development) where historically internal flood water level will not reach. In the development area people are building adaptation by elevating road level and plinth level etc. They are also increasing the pump capacities in response to the loss of retention ponds. In some areas, they have doubled it and yet again they are thinking of increasing the capacity more because they are expecting that there will be lesser areas for retention from the present trend of development. But these are still traditional thinking in terms of flood managing. So, again it's not an optimal situation when you are putting all your eggs in one basket. But due to the immense pressure Dhaka also doesn't have the luxury to dedicate land for the wetlands. So in my opinion, the problem is more fundamental and Dhaka should learn how to deal with the development pressure. There are some options which we've thought about and learned from modeling,

there are still some remaining parks and playgrounds which can be used as dry ponds. In big events, you can allow those areas to flood in controlled manner. And when the peak of the flood events start to subside, you can drain those spaces. So, it's a distributing solution and should be low cost. But, that option is still not viable as long as the waste water is connected to the storm water. We are constantly facing large rain events and the drains over flow with heavily polluted water. So, allowing such water to the playgrounds and fields are going to create health hazards. May be in 10-20 years of time some part of the city can have these options because some part of the city is already separating their sewer system from storm water system (Gulshan, Banani). In those areas, we have parks and open spaces and we can lower the level and make some functions (e.g. amphitheater). That will give the drainage system some breathing space. But, like I'm saying this for future situations, at this moment due to the water quality issue it's not an option.

Q: What was the consequences of covering natural canals with culverts? How to utilize the old canal system?

There were 47 (approx.) canals (khals) in Dhaka, if you look at the broader map of Dhaka all the rivers around it are draining towards Dhaka. Gravity is pulling the water to Dhaka. Historically, not far back (like in 70s) the water used to pass through the canals. Only in the extreme cases like 1988, 1998 the river level was very high the city got inundated. So, the reaction was embankment. The box culverts were built to develop new road over the canal system, there were no sufficient east-west road connections. Reviving those canals will be a huge undertaking due to the piles of solid waste and sludges underneath the culverts. It will be a challenge to manually or mechanically remove the suited-up material. If those structures were designed properly and the system were maintained and cleaned properly, theoretically it could've worked. In the Kualalumpur, Malaysia they have done it. The Kaulalumpur city is situated at the conference of rivers and they also had natural canals. But they also had taken engineering approach and maintained it. So here our water logging issue is mostly because of the solid waste issue. I hopefully will see some improvements because the City corporation has taken the waste management issue very seriously and taking initiatives. I'm positive about the regular flooding issue and hopefully it will have reduced if the system is maintained. But for extreme events it depends. We have done some simulations for the extreme events based on the design capacities of the primary drainage system. The result was not very bad and can absorb 30-year design event in our recent studies. But again, "it was assuming that water comes into the drains properly".

Q: In the recent report of IWM why it is mentioned that in coming 2030 and 2050 scenarios less areas within Dhaka will be inundated?

The developed area in that study really applies for outside the built-up area of Dhaka. We did a very course level estimate for the development area. So, showed that due to population and other development activities land levels are tend to go up. And because of that, some areas will become flood free. But within the existing built-up area we had some important assumptions. One was the whole separation of storm water and waste water. Not only does that reduce the volume but also there is less chance to have sedimentation (sludge, fiscus materials) in the drains. We did assume a certain amount of sedimentation in the drainage and the new pumps will come online. So, based on that, in the model the system showed good capacity to absorb a medium size event. As you know in Dhaka, the street drains are managed by City corporations (DSCC, DNCC). And WASA manages the large drains and canals which are connected to the Khals. In that study, we focused on the large canals and their new plans. That study showed the value

of these new plans. It gives a reference point that, if those plans are implemented than we don't need much adaptations. The city has some level of resilience, but in reality, we are deviating from the plans. Implementation has been delayed and at that time most of the areas in the DAP designated as detention could be filled up. Otherwise if we can implement our existing plan maintain the system, we may not need an embankment at the eastern side.

Q: Now Dhaka is rushing into the new developments in the eastern side but the service infrastructures (road, drainage) are not ready yet. What possibilities do you think eastern part has on protecting Dhaka from flooding?

If the development goes as DAP's land-use plan, the built-up area get elevated up to 5-6m PWD level and the natural canals (khals) are left open than, there is much less change of vulnerability and that area can cope with the river. Still it can be entuned with the concept of living with the water. But in western Dhaka we can't really avoid the dependency on pumps. So, for now it will be a great mistake if we don't control the development. DND area in Dhaka is an example of that. It was a low land, bucket shaped. Initially was an irrigation land and now has very dense unplanned houses with narrow streets. And now is the most flood prone area of area of Dhaka. So, there is risk for eastern Dhaka to became another disaster like DND area. It is important to develop the eastern side of Dhaka in a planned manner to release some pressure from the western side.

The average life span of Dhaka's building structures are 50 years (approx.), so in coming 15-20 years we have the chance to re-develop/ re-engineer western Dhaka's landscape. The embankment on eastern side is also seen as a future road-rail link. We still can have road and rail connections with bridges allowing canals to flow, for eastern Dhaka that option is still available. The eastern side will always have the under laying pressure of urbanization. It is very clear from the economic perspective. Now this area has some business (e.g. fisheries, agriculture, water navigation but the household income at that part is too low comparing to the western part. So, if we hold that pressure, more pressure will build up at the western Dhaka. So, for eastern part the trade-off is between land area for urban development and its natural drainage and retention capacity. So, now the government is trying to find the trade-off to develop that eastern part in proper way. It is sticking that the either sides of Dhaka have quite opposite landscape characters. And it is not at all natural. So, eventually the development will spread out and release pressure from one side.

Q: As you mentioned the contrasting situations of the either sides, could those areas be compatible from hydrological point of view?

In my opinion, not really. The embankment of Pragati Sharani (at the eastern side of western Dhaka) has totally cut of the drainage between the two parts. The disconnect is there between east and west. So, presently the eastern side is not directly providing any service to the western side in terms of flood events. So, we modeled the two part as separate system to represent the flooding processes.

As I mentioned earlier, one of the biggest challenge for us is to keep the water clean. As a megacity, we only have one water treatment plant. And it is not functioning optimally. It is not getting enough waste water because of the problems of the sewer collection system. So, with a separated system we can have lots of options with storm water (e.g. recycling, reusing for irrigation and other uses). The new sewer master plan has envisaged 11 sewage treatment plants (STPs) in and around Dhaka. Recently proposed

STP at Dasherkandi area is a part of such development. The waste water collection from the new sewer networks of Gulshan, Banani, Baridhara areas will be treated at the Daserkandi STP.

Q: What are the regulatory tools that can stop the solid waste dumping into drainage in case of the separate storm water sewage?

I don't think there are many. I think the National building code (BNBC) still goes with the septic tank approach for main urban area. Outside of main city, in the townships (e.g. Savar, Ashuliia) I don't know if there are any specific guidelines. Dhaka is also surrounded by areas with clay soil. So, it is another problem that the onsite solutions are limited by the soil condition. Some direct strategies for water management is to control the water consumptions (less water consumption will lower the volume of drainage). So, one strategy is (which still hasn't been improved) that, the water tariff will be 'block tariff' instead of flat tariff (one for domestic and one for commercial use). In the coming master plan of WASA, they have proposed 3-step tariff.

Q: As an expert of hydrology, you have discussed many important spatial planning issues and their possible solutions. Do you think such spatial measures are important to consider in water/flood management strategies?

Yes. I think it is. And there are already some indications. Such as, certain amount of space must be permeable/pervious for ground water recharge and absorption. There are a large number of small ponds in Dhaka. Some of them are privately owned. These ponds are identified by DAP. These small ponds should be protected by laws. Now all of these ponds are not connected with storm-water (due to the water quality) but, if these ponds are acquired by the government, there is much possibilities to develop a network for distributed flood-management approach. There are some projects like lake projects at Uttara 3rd phase which are well not designed for storm water retention. Such as, the Dhanmondi lake was designed to collect storm water runoff only at a small peripheral level and now is not connected at all. So, the lakes are only collecting water from direct rainfall.

Q: Are there any national databases on flood management information? What flood management policy/plans are available?

No. not so much database on national or city level (DEM, existing land use). For land-use planning there is DAP. Presently, the water development board is doing a feasibility study of eastern Dhaka. They are updating the FAP developed by JAICA, HARCRO for the recent development issues in eastern part. May in the middle of next that document will be available for public. And the WASA sewer master plan is also going to be published as public document very soon. Now, the draft structure plan is probably available.

Q: Are lake projects like Dhanmondi, Hatirjheel, Gulshan-banani locally community driven or outcome of management strategies?

I think these are not solely developed from the flood management plan. The process was partially inclusive. Experts from different communities played an important role in those projects. I think they have advocated for these historical lake areas to be realized designed projects. They played an important role in promoting their ideas but the decision was top-down (from the ministry level). There were difficulties in implementation level also. In the Hatirjheel project, lot of the land had to be recovered from

encroachments and government had to involve the army to speed up the process. But, initially, when they opened that area for public it was very much vibrant and attracting. But suddenly the army management put boundary wall in front of the surrounding houses which I believe, very much against the nature of that place. Probably, there are some social or management issues which was not considered in the initial design. There are also other technical problems. Recently, there are complains about the water quality of the lake. The lake was designed in such way that, only in the monsoon seasons it will collect water from the drainage system (by outlets underneath the lake) and in the dry seasons the waste water will bypass the lake and directly flow to plants. This is because, in the rainy seasons the waste water is somewhat diluted with rain water and fresh lake water, and in dry seasons the waste water is more concentrated and the lake has less amount of water. But now, I think this system is leaking/over flowing because of blockage of sludge and solid waste. Another consideration was to have certain amount of water in the lake throughout the year for recreation. In the Kollanpur water detention pond it was also design to have water at certain level (5m) due to encroachment issues. But, before any large events (if any signal from water forecasting) these lakes will pump out water to make more room for rain water.

Q: Are there any other design initiatives (besides detention ponds)?

There were some pilot projects. Such as, WASA has considered the option of artificial ground water recharge. In our subsoil layers, we have deep clay soil. So, unless we inject water deep into the aquifer level it is difficult to recharge ground water. Such artificial recharge points are being piloted done by WASA (e.g. Shegunbagicha and Lalmatia recharge points). But a silly mistake of those projects was, these are situated close to WASA pumping stations. So, it is difficult to see the results of these experiments. There are some inter-departmental initiatives, such as in the new national building code (BNBC) building above a certain FAR Floor area ratio) must have their individual rain water harvesting system. For green roofing, there are many challenges. In our climate during monsoon, green roof will be very effective for slowing the runoff and can also cool down building temperature. But, the down sides are it will increase costs. In the dry seasons people, will spend lot of drinking water to maintain the plants which will inflict water cost and structural cost of the building will be high. This approach will be more suitable if maintained by recycled gray water or harvested rain water. Over water consumption in household is a big issue for the government. Considering the lower income population, government is maintaining low price for water. But, other than that it is important to have an optimal pricing signal to stop miss-use of water. As a delta with lots of river, we think that we have good access to water but it is not true for the whole country. When we pump close to the river, indirectly we are pumping river water for house-hold uses. More than seven months we don't have rain and this period is getting longer. In some districts (e.g. Rajshai) they are even suffering from droughts.

Q: For flood-events how WASA is considering climate forecasting? Do the management agencies plan measure for upcoming monsoon from seasonal forecasting?

There is not yet good connection between WASA and Meteorological Department to use forecasting. But, some pro-active engineers use update information to maintain water level of the detentions. Seasonal forecasting is not considered by WASA before monsoon and I think, it is not necessary yet because, the pumps have enough capacity to drain and lowering the water. What I think is necessary is good communication network and signaling system should be established.

Thank you very much for this long session. I'm much obliged by your feedbacks in this research.

UH-04: (translated from Bangla)

Q: What are the causes of urban flooding of Dhaka city and how important is the role of climate change?

The role of climate change is very important in urban flooding issue. Most of our urban areas are situated very close to river and therefore, very vulnerable to river flooding. The river flow system is affected by the climate change effects. But urbanization also plays part in that, rivers, canals, water retention areas are being filled up for buildings. There is siltation of river and canals. With intense rainfall, there are more chances of inland flooding as the water cannot flow to the river system. All these aspects are stressing the drainage process in the urban areas. The urban growth enhances the climate change effects.

Q: What policies are present for urban climate adaptation of Dhaka city? Are the strategic plans reflecting the climate policies?

In terms of climate change, there are mostly national level policies and plans, such as the national adaptation program for action (NAPA), final report 2005, Bangladesh Climate change strategy and action plan (BCCSAP) 2009. I think in any strategy, its translation towards local level is difficult. In our cases, policies are open-ended and difficult to transfer in a detailed spatial plan. I think it is now necessary to transfer the BCCSAP'S plans to DAP for Dhaka.

Q; Do you think spatial planning and flood –risk management are integrated in the police? What is the institutional context of such integrated approach?

Yes, there are some integration in the policy documents, but to a limited extent. For institution, particularly in governing agencies, there are gaps between inter-agency coordination. They have overlaps in works, funding delay etc. These issues happen because of inter-agency communication gap. At the city-level it is a problem. But, at secondary town level (Pouroshova) it is well refined. At the secondary town level, there is 'coordination committee (the committee title may differ from area to area but works in same principle) which organize a coordination meeting and exchange plans. But, in Dhaka corporations are independent and have lengthy communication.

Q: How to develop communication/dialogue between the two sectors (land-use and flood management) for integrated policies?

I think, through arranging expert-level workshop from the initiation of any project which require integrated planning is an important step. In this case, the Hatirjheel project is a good example of that. They involved multi-disciplinary experts in this project.

Q: In implementation, what are the institutional/governance structures present in different levels and what are their actions?

At national level, the ministries and Bangladesh water development board operate. In local level, city corporations, Municipalities, Department of Environment, DWASA, RAJUK are the major agencies responsible for implementing the climate change policies or flood-risk management plans and necessary infrastructures.

Q: What legally binding instruments/tools (e.g. zoning plan) are there for implementation the climate change policies? And what are the challenges in operationalizing?

The Dhaka Detail Area Plan (DAP), 2010, Dhaka Metropolitan Development Plan (DMDP), Environmental Conservation Guidelines, Building Construction Rules, EIA guidelines etc. are the existing instruments of our governing agencies. But, proper implementation seems problematic. It is wrong that; the agencies do not implement. Actually, partial implementation is the problem. For example, in Bhola district they are struggling to control flood because they've been constructing dam partially. Funding doesn't appear in proper time, or there are overlaps in the work. Sometimes, there are repetitive works due to lack of coordination. I would say time is a very important factor, because lot of the flood management issues requires timely development but delayed work eventually lose the functionality of the whole system. Another problem is, conflicts over jurisdiction. In the Hatirjheel project, (the SWO mentioned that) there were too much confusion about who is going to do the water quality maintenance structure. Neither WASA nor LGED was sure whether it is there responsibility or not. Before, funding was a major issue but now only about 5-10% of our development fund are international funds (according to gov.). So, the challenge is more a coordination gap than funding. But, we do have inadequate resources and lack of capacity in the technical sectors.

Q: As an urban adaptation measure, what specific vision/goal is there for Green infrastructure of Dhaka?

In the new structure plan (2016-35), there are objectives for green (and blue) networks and they mentioned some tools for that. But it is more in conceptual stage and hopefully they will incorporate it in the future detail plan. In the green-network concept plan the railway line and major traffic roads are shown as a green corridor which is can be possible as there is a law for it. The dams, railway, highway have the ownership of certain setback areas on both sides and also have policies for greening those areas. It appears that, RAJUK is considering this green-blue infrastructural approach for their coming strategic plans but, the WASA doesn't have any planning for this green-blue approach. I think they (WASA) shouldn't rather they should plan for incorporating their drainage plan with the RAJUK land-use plan. My opinion is, there should be separate planning and implementation authorities. Why in our Dhaka planning and implementation agency (namely RAJUK) is same? Then there is more chance of corruptions.

Q: What is the public-private partnership or skate holder's participation level for implementing green infrastructural projects?

Currently, good public-private partnership for implementing green infrastructure is in place in Dhaka. One example is the Hatirjheel Project. In that project, there were private consulting agencies and constructions groups including SWO. Now there are some business opportunities such as bus services, which are given to private companies.

Q: What are the scientific methods/knowledges available for urban climate adaptation (e. g. Urban hydrological model, surface covers changes)?

Hydrodynamic models for flood, Adaptation Planning approaches, GIS-RS based models etc. are the scientific methods for studying adaptation from urban flooding. Recent landuse or climate data is not publicly available but, there is the National Water Resources Database developed by CEGIS and maintained by WARPO. RAJUK, DWASA maintains their own individual databases. Modeling for flooding is challenging, if detail data is not available it can give wrong information and miss-interpretation can

happen. In terms of drainage management, the challenges are huge in quantifying the capacity. The drainage capacity has to be calculated using the volume of the entire drainage system. There are ongoing and previous drainage studies for adaptation but they are not well addressed in the strategies.

Q: How the spatial planning, land-uses, zoning can help the urban climate adaption (specially from urban flooding) of Dhaka city? And what human benefits can be associated with is?

Spatial applications of adaptation measures can greatly reduce the flooding impacts. If the spatial plan creates opportunities for environmentally improves areas for adaptation such as Hatirjheel project, there will be less chance of urban flooding. These places will also offer recreational, healthy and breathable environment.

ANNEXES II:

LIST OF CODES FOR EXPERTS INTERVIEWS:

Table: list of interview codes

Categories	Codes	Respondents	Sub codes	Respondents	Comments
Bio-physical	climate	UP-1, UH-2, UH-3, UH-4			
	drainage system	UH-2, UH-3, UP-1	Box-culverts	UP-1, UP-2, UP-3, UH-2, UH-3	
	land-use pattern	UP-1, UP-3	Land development	UP-3	
	plant character	UP-2			
	soil types	UH-3			
	surface cover	UP-1, UP-3, UH-3			
	surface elevation	UP-3, UH-3			
	urban form	UP-1, UP-3, UH-3	urban renewal	UH-3	
Socio-political	social acceptance	UP-1, UP-2, UP-3, UH-1, UH-2			
	social practices	UP-1, UP-2, UP-3, UH-3	Waste dump, encroachment	UP-3, UH-3	
				UP-3, UH-3	
	population fluctuation	UP-3, UH-3			
	planning legislation	UP-1, UP-2, UP-3, UH-1, UH-2, UH-4			
	institutional structure	UP-1, UP-2 UH-1, UH-2, UH-4			
	governance practice	UP-1, UP-2, UP-3, UH-1, UH-2	politics governance level	UH-1, UH-2	

			displacement/ rehabilitation	UP-1, UP-2, UP-3, UH-1, UH-4	
	scientific/institutional knowledge	UH-2, UH-3, UH-4,	local/traditional knowledge	UP-1	
	economic driver	UP-2, UH-2			
	budget allocation	UP-2, UH-1	development fund	UP-1, UH-2, UH-4	
GBI_ spatial planning	communications connectivity	UP-1, UP-2, UP-3, UH-1			
	scale	UP-1, UP-2, UP-3, UH-4			
GBI_ hydrology	water quality	UH-3			
	water quantity	UH-2, UH-3			
GBI_ management	multi stakeholder	UP-2, UP-3, UH-1			
	multi functionality	UP-2, UH-1, UH-4			
Professional constrains	time	UP-2, UH-1			
	space	UP-1, UP-2, UP-3			
	human value	UP-2, UP-3, UH-1, UH-2			

LIST OF CODES FROM QUESTIONNAIRE SURVEY:

Table: List of codes from questionnaire survey (location-1,2)

Question	coding	results
Q1	C1L1L2Q1-monsoon; prolonged monsoon; rarely	Monsoon
Q2	C1L1L2Q2-intenseevent; regular event; predevelopment; post development	regular event (predevelopment) extreme event (R#1, Wapda, Noyatola, Banasri, Rampura, Bagunbari slum areas) (post development)
Q3	C1L1L2Q3-residence; shop, road; open field; road level; predevelopment; post development	shops; residences; bellow road level; open field; road (predevelopment)open field (post development)
Q4	C1L1L2Q4-2-3hrs; half day; whole day; weeks; months; predevelopment; post development	Months (max value) predevelopment
Q5	C1L1L2Q5	Figure
Q6	C1L1L2Q6-postdevelopment; housing; activity; wall, roads	roads, wall (post development) food(predevelopment)
Q7	C1L1L2Q7-pros-plantation; clean; activity; house rent; distant connection; health. cons-water quality; accidents; pedestrian; unsafe; wall	text
Q8	C1L1L2Q8	30%yes, 5%no,65%neutral
Q9	C1L1L2Q9	Figure

Other	C1L1L2other-management, surrounding land use, wall, inequity, accident, water quality, recreation, health	text

Table: List of codes from questionnaire survey (location-3,4)

Question	coding	results
Q1	C1L3L4Q1-monsoon; prolonged monsoon; rarely	Monsoon
Q2	C1L3L4Q2-intense event; regular event; lake side; inner side	Extreme event (Jamaibazar, Jhilpar, lake side areas)
Q3	C1L3L4Q3-residence; shop, road; open field; road level; lakeside slums; inner slums	residences; bellow road level;(lake side slum)
Q4	C1L1L2Q4-2-3hrs;1day;1week; weeks;1months; months;(lake side slums) (inner slums)	Months (max value) lake side slums;2-3hr (inner slums)
Q5	C1L3L4Q5	Figure
Q6	C1L3L4Q6-post development; less income; high expenses; less communication	text
Q7	C1L3L4Q7-pros-NGO works. cons- water quality; road blocks; wall; no boasts; no rickshaws; possible eviction	text
Q8	C1L3L4Q8	1yes, 19neutral
Q9	C1L3L4Q9	Figure
Other	C1L3L4other - local management, inequity, slow displacement; informal compliance and high cost, need good leaderships	text

Table: List of codes from questionnaire survey (location-5,6)

Question	coding	results
Q1	C2L5L6Q1-monsoon; prolonged monsoon; rarely	Monsoon
Q2	C2L5L6Q2-intense event; regular event	intense event
Q3	C2L5L6Q3-residence; shop, road; some part of park	Some part of park (post development)
Q4	C2L5L6Q4-1-2hrs; half day; whole day; 1week	Half day
Q5	C2L5L6Q5	Figure:
Q6	C2L5L6Q6-postdevelopment; housing; activity; visitors; access; safety	Text
Q7	C2L5L6Q7-pros-plantation; clean; activity; food; housing; safety; pedestrian access cons – crowds; traffic; schools; detention capacity	Text
Q8	C2L5L6Q8	35%yes, 65%neutral
Q9	C2L5L6Q9	Figure
Other	C2L5L6other-management, surrounding land use, water based activity, shift use	Text

ANNEX III

QUESTIONNAIRE FORMS:

Questionnaire

Urban climate adaptation
Land-use Planning, WUR, Netherlands
MSc Thesis 2016

Interview questions:

Users/residents, slum dwellers, Visitors

General information
Name:
Occupation:
Area of residency/Address:
Contacts: Email: Phone No.:

1. Which time of the year your neighborhood gets flooded mostly?

2. How frequently your neighborhood get flooded during that period?

3. Which type of settlements get affected by the water logging?

Residence
Shop
Road
Other (e.g. park, pond, playground)

4. Generally, how long the water logging extends and in which parts?

5. How do you find the nearby natural spaces (e.g. parks, road side green, lakes, ponds) useful? Or, what functions you prefer in these areas?

Environmental	0	1	2	3	4	5
Recreational/cultural	0	1	2	3	4	5
Business	0	1	2	3	4	5
Health	0	1	2	3	4	5
Connectivity	0	1	2	3	4	5

(use of Likert scale) 0=no comments 1=strongly irrelevant 2=not relevant 3=relevant 4=necessary 5=immediate

6. Are there any significant changes after the development of the following projects in their surrounding areas?

7. What positive and negative effects are these developments/ land-use changes have in your neighborhood?

	Pros	Cons
Environmental		
Recreational/cultural		
Financial		
Health		
Connectivity		

8. Do you find urban adaptation measures (e. g. increasing vegetation and water retention areas) urgent for the flooding of your area?
   Y) N)
9. What kind of adaptive measures do you find more applicable in your neighborhood for urban flooding and why? Will you apply them by yourself?

Green roofs
Urban forestry
Water parks, Wetlands
permeable surface materials
Others

Interview questions:

Planners, City managers,

General information
Name:
Occupation:
Organization:
Position:
Contacts: Email: Phone No.:

1. What policies are present/adopted for urban climate adaptation of Dhaka city?

2. Do you think spatial planning and flood risk management are well integrated in the policy documents? If not, what are the scopes for that?

3. How to develop communication/dialogue between the two sectors for integrated policies?

4. What are the strengths and weaknesses in the current policy and what are the options to improve?

5. What legally binding instruments/tools (e.g. zoning plan) are there for implementation such policies? And how they are operationalized?

6. In implementation, what are the institutional/
governance structures present in different levels and what are their actions?

Regional
Local

7. What are the challenges for implementation of these adopted policies?

Institutional
Political
Economic
Social
Technical

8. As an urban adaptation measure, what specific vision/goal is there for Green infrastructure of Dhaka?

9. What is the public-private partnership, skate holder's participation level for implementing green infrastructural projects? Please explain.

10. What are the roles of different stakeholders/groups in the planning process of the following projects?

	Hatirjheel Lake	Dhanmondi lake	Gulshan Lake
Public/users			
Private investors			
Experts			
Politicians			
NGOs			

Interview questions:

Urban hydrologist

General information

Name:
Occupation:
Organization:
Position:
Contacts: Email: Phone No.:

1. What are the causes of urban /inland/pluvial flooding of Dhaka city and how important is the role of climate change?

2. What flood risk management strategies/action plans are there for Dhaka and how they deal with urban /inland/pluvial flooding?

3. What are the strengths and weaknesses in the current strategies/action plans and what are the options to improve?

4. What are the scientific methods/knowledges available for urban climate adaptation (e. g. Urban hydrological model, surface covers changes)?

5. Are there specific models to quantify the requirements of green infrastructures and surface cover/land-use changes for Dhaka city (or particular zone)?

6. How well these knowledges are addressed in urban climate adaptation policies?

7. What are the drainage capacities of Dhaka metropolitan area? What are the infrastructural/ management challenges for overcoming urban flooding?

8. What are the environmental potentialities (e.g. Rain water runoff retention) of the following places?

Hatirjheel Lake
Dhanmondi lake
Gulshan Lake

(Please discuss other urban places if necessary)

9. Are there digital (GIS) maps available for analyzing climate change affects (e.g. flooding), land-use changes and water resources?

10. Is there any available (national or city level) database on water resources/user's information/systems?

Interview questions:

Architects, Urban designers

General information

Name:
Occupation:
Organization:
Position:
Contacts: Email: Phone No.:

1. How the spatial planning, land-uses, zoning can help the urban climate adaption (specially from urban flooding) of Dhaka city?

2. Are there any aesthetical conflicts in the climate adaptation and urban design?

3. How the spatial growth/development is contributing to the urban flooding in Dhaka city?

4. How environmental projects (e.g. Hatirjheel lake) can be an active urban/public places? And what are the opportunities of 'place-making' of such projects?

5. What human benefits (e.g. social, economic, educational, health) does these projects offer besides environmental protection?

Hatirjheel Lake
Dhanmondi lake
Gulshan Lake

(Please discuss other green infrastructure projects if necessary)

6. What are the roles of different stakeholders/groups in the design process of the following projects?

	Hatirjheel Lake	Dhanmondi lake	Gulshan Lake
Public/users			
Private investors			
Experts			
Politicians			
NGOs			