Water Policy 22 (2020) 1142–1162

Tracing the past: an insight on flood risk management strategies in the development instruments of Bangladesh and Dhaka city

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Abstract

Confronting devastating floods regularly is a critical challenge for Bangladesh. Dhaka, the capital and a mega-city at the forefront of rapid, unplanned urbanization, has been experiencing consistent challenges and threats of flood since 1954. Since then, to ensure flood protection and control, the city authorities have adapted diverse flood risk management strategies (FRMS). Regardless of the overall progress in flood risk management policies in the national development agenda, the inertness of their implementation means the city remains vulnerable. Along with that, several divergences from the development plans, for instance, the new town development in flood flow zone, the declaration to convert a residential zone into a retention area, illegal acquisition of wetlands for property development have also been observed. Therefore, the objective is to review the diversification of FRMS at the national level and to identify the convergence or divergence on the development plans at the sub-national level, in this case, Dhaka Metropolitan Area. This study provides a commentary to support policy-makers and researchers in integrating FRMS with the development plans at the local level.

Keywords: Bangladesh; Development plans; Dhaka; Flood risk management; Policy; Urban planning

Highlights

- Analysis of multi-level development policy regarding flood risk management strategies in the context of Dhaka and Bangladesh.
- Identification of diversification of flood risk management strategies in Bangladesh Context.
- Investigation of convergence and divergence of flood risk management strategies in terms of vertical integration and internal coherence.
- Recommendation of coordinating state agencies of different layers in implementing flood risk management plans from national level to local level.
- Recommendation of improving internal coherence and vertical integration in between national level and local level plans especially in case of flood management.

doi: 10.2166/wp.2020.006

Introduction

In recent times, floods have been the leading cause of damage from natural disasters in several parts of the globe and are accountable for a greater number of adverse occurrences than other natural hazards (Klijn *et al.*, 2015). Here, several researchers (Dash *et al.*, 2007; Shen *et al.*, 2008; Douglas, 2009) agreed that Bangladesh, along with several Asian countries, are more vulnerable to environmental risks due to their geographical location, and a significant amount of human and material casualties may be expected. To date, Bangladesh is the ninth highest disaster-risk country with a risk index value of 17.38, high vulnerability level (58.03), and a huge lack of coping capacities (84.96) (Mucke, 2018). As one of the most flood-prone countries in Asia, 15% of its land floods annually on average (Islam *et al.*, 2016). The capital Dhaka was also flooded perennially and specifically, to an unprecedented degree by six severe flooding events from 1987 to 2017. Along with riverine flood, pluvial floods are also a big concern for several areas of Dhaka city that may be flooded for many days, primarily due to heavy rainfall and drainage congestion. The level of water in certain areas can be as high as 40–60 cm, which causes large infrastructure issues for the urban region, economic losses in development, and destruction to existing property and products (Ashley *et al.*, 2007), which can be minimized by taking a holistic approach (Huq & Alam, 2003; Jha *et al.*, 2012). Corresponding to it, previous studies (Hegger *et al.*, 2014; Driessen *et al.*, 2016) emphasized the importance of diversification, coordination, and alignment of the flood risk management strategies (FRMS) to make the urban agglomerations more resilient to flood risks. Driessen *et al.* (2016) also indicate the benefits of diversification regarding more adaptability and flexibility, redundancy, and choice options of flood risk management.

Although floods have a geographical extent, they can only be managed and controlled in the context of the administrative, social, and cultural boundaries (Serra-Llobet *et al.*, 2018). However, on many occasions, multiple administrative levels are involved in flood risk governance, as there is a chance that administrative borders and the boundaries of the water systems involved often do not align (Dieperink *et al.*, 2018). In this case, the elaboration and implementation of the FRMS highly depend on the coordination of these multiple administrative levels which can be ensured by the higher governance level in a centralized governance system. However, these forms of multi-level integration have limitations, which are beneficial but impossible to implement, owing to their time-consuming multi-actor systems or blurred boundaries of accountability (Surridge & Harris, 2007; Walker *et al.*, 2014). Thus, in many cases, these attempts of integration have failed to be achieved (Williams & Sullivan, 2009). Nevertheless, risk governance researchers underscored the value of integration to solve fragmented (Gilissen *et al.*, 2016), or disintegrated (Russel *et al.*, 2018) methods to policy-making. Some degree of collaboration and cooperation was, therefore, needed for multi-level players (from national to city level) to work together within established governance structures to produce knowledge and policies that maximize synergies and handle trade-offs through flood risk management and sector-specific objectives (Cumiskey *et al.*, 2019). To this end, Wannewitz *et al.* (2016) highlighted the need to critically examine the convergence and divergence of integrating FRMS at the national and sub-national levels. Therefore, this paper examines the national planning documents to understand the diversification of the FRMS considered and implemented for Bangladesh. Subsequently, the areas of divergence or convergence in these documents are scrutinized, followed by recommendations on ways to integrate the FRMS in urban planning in Dhaka. This study provides a commentary to assist policy-makers and researchers in integrating FRMS with the development plans at the local level under the specter of future extreme flood events and even, climate change.

A model of flood risk management strategies

Over the past half-century, shifts in thought, from flood control to FRMS have been identified, indicating a growing awareness that constructing flood control structures is only one of many potential solutions open to communities (Sayers *et al*., 2013). The integrated approach in flood risk management includes structural and non-structural measures, guidelines on development activities, spatial planning, and others (Ishiwatari, 2010). Identifying flood as a process and not as discrete events in time and space, Serra-Llobet *et al*. (2016) established four stages in the framework of flood risk management cycle: (i) hazard and risk classification (assessment and mapping); (ii) mitigation approaches that include preventive initiatives (e.g., land-use management) and defense measures (e.g., levees and dams); (iii) emergency management (preparation and response); and (iv) recovery at short and long terms. Correspondingly, Hegger *et al*. (2014) also differentiated between five types of FRMS which focused on the probability of flooding (flood defense or protection); on the potential consequences of flooding (flood risk prevention, flood risk mitigation, flood preparation) and recovery after a flood has struck (flood recovery) (Table 1).

Methodology

The objectives of this study are: (i) to identify the diversification of FRMS in the development policy instruments at the national level and (ii) to investigate the state of integration of FRMS in the development plans at the sub-national level, in this case, Dhaka Metropolitan Area. The reason to select Dhaka city at the sub-national level is based on the risk of severity to perennial flooding, as it is predicted to be the most vulnerable city among the six large cities of Bangladesh (Dhaka, Chattogram, Rajshahi, Khulna, Barisal, and Sylhet) with about 15% of its flood-affected area for a 1 m sea level rise (Ahmed & Suphachalasai, 2014). In this study, the following development instruments were reviewed (see Table 2).

Table 1. Types of flood risk management strategies (adapted by the author from Hegger *et al*. (2014)).

Strategies	Characteristics	Measures	Main actors
Flood defense	Flooding can be controlled by infrastructural works, mostly referred to as 'flood defense' or 'structural measures'	Embankments, storm-water drainage	Water management professionals at the national and regional levels
Flood risk prevention	Flood impact can be prevented by proactive urban planning or land-use policies	Green-area protection, coastal afforestation, land-use planning	Actors involved in planning processes
Flood risk mitigation	Flood impact can be lessened by the smart design of the flood-prone region	Urban management, building regulations	Citizens, developers, public and private actors
Flood preparation	Flood impact can be lessened by preparing for a flood event	Warning system, disaster management, evacuation plan	Meteorological office, flood forecasting centers, state agencies
Flood recovery	This strategy facilitates a safe and quick recovery after a flood event	Rehabilitation process, relief and insurance support	Disaster relief funds, insurance companies, and affected citizens

Table 2. The development instruments reviewed for this study.

Flood control and management policies		National development plans		Urban development plans for Dhaka city	
National Water Plan	NWP	Five Year Plans	FYP	Dacca Master Plan 1959	DMP 1959
Bangladesh Water and Flood Management Strategy	BWFMS	Bangladesh Delta Plan 2100	BDP	Dhaka Metropolitan Area Integrated Urban Development Project	DMAIUDP, 1981
National Water Policy	NWPo	National Adaptation Plans of Action	NAPA	Dhaka Metropolitan Development Plan 1995–2015	DMDP, 1995–2015
National Water Management Plan	NWMP	Bangladesh Climate Change Strategy and Action Plan	BCCSAP	Dhaka Structure Plan 2016–2035	DSP, 2016–2035
				Flood Action Plan 8 A and B	FAP 8

In this paper, the evolution of flood control and management policies in Bangladesh has been attempted to examine from a historical viewpoint, which gives an overall scenario of flood control and management through several five-years' national planning processes. Eventually, these initiatives of the Bangladesh Government provide a relevant policy and legal instruments that have direct or indirect impacts on flood control and management policy implementation. The review process has been carried out in the following three stages:

1. Review of sector-level policies and plans (flood control and water management policies) to understand the evolution of these policies in different socio-political context.
2. Review of national plans to understand the integration of flood risk management strategies.
3. Examination of how national-level policies manifest in the city of Dhaka.

Subsequently, the areas of divergence or convergence in these two sets of documents were scrutinized, followed by recommendations on ways to integrate flood management issues at the sub-national level. This procedure is conceptualized in Figure 1.

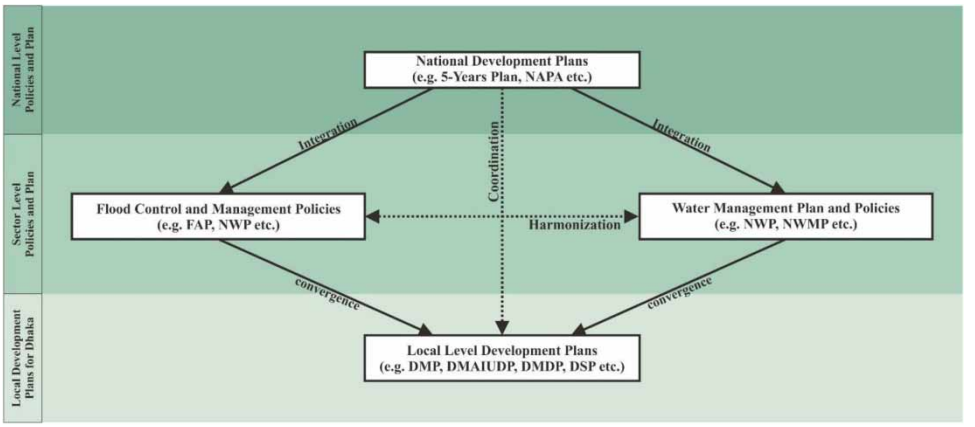

Fig. 1. Conceptual framework (authors' elaboration).

As the central planning organization, the Bangladesh Planning Commission is responsible for designing and preparing the short- to long-term national development planning (Fatemi *et al*., 2020b). Through the Five-Year Plans (FYPs), it determines the overall planning direction for growth and development of the urbanized areas in the country (Damianova *et al*., 2008). The role of the regional government is to create, upgrade, extend, and administer the city and its peripheral areas in conjunction with development planning and control. There are four regional development authorities in four divisions (Chattogram, Dhaka, Khulna, and Rajshahi) (Panday, 2017). In the case of Dhaka Metropolitan Area, the Rajdhani Unnayan Kartripakkha (RAJUK) or the Capital Development Authority is one such authority to prepare regional development plans. Moreover, urban local government responsibilities are performed by city and municipal corporations. For Dhaka city, Dhaka City Corporation performs the administrative and maintenance functions (Parvin & Shaw, 2011) that facilitate the actualization of National Development Plans' goals and objectives.

For planning and development of urban affairs in Dhaka Metropolitan Area, 55 organizations at the national, sectoral, and local levels are involved. However, the key functions of urban planning and development are performed by two ministries – Ministry of Housing & Public Works and Ministry of Local Government, Rural Development and Cooperatives (Damianova *et al*., 2008). Urban administration, urban utilities, and infrastructure are the responsibility of the Ministry of Local Government, Rural Development and Cooperatives, while spatial development, planning, management, and housing functions are under the Ministry of Housing and Public Works. Dhaka City Corporation performs its core duties of urban administration, civic services, and infrastructure development and maintenance under the Ministry of Local Government, Rural Development, and Cooperatives (Wood *et al*., 2012). Conversely, under the Ministry of Housing and Public Works, Capital Development Authority (RAJUK) acts as an autonomous body to prepare, implement and monitor development plans for Dhaka city; to create planned townships including associated infrastructure; and to control the city growth and authorize the land use within its designated areas (Ahmed *et al*., 2007). Therefore, there is no organizational and functional relationship between the Capital Development Authority (RAJUK) and Dhaka City Corporation at present (Panday, 2017). It can be summarized that Capital Development Authority's coordination and management of the physical planning functions such as preparing local development plans as well as implementing spatial planning and development control, as an independent organization for Dhaka, makes the process different from the rest of the country.

Floods in Bangladesh and the evolution of flood risk management policies

Bangladesh is a small part of the most dynamic hydrological as well as the largest active delta system of the world (BWDB, 2019). The relationship between the steadily growing population, the strength of agricultural development, the intense variability of precipitation during monsoon, and the scale and dynamics of river systems render the management of floodplains in this country a profoundly challenging task (Hofer & Messerli, 2006). This terrain experiences a considerable loss of life and enormous damage to properties, especially in the years of 1954, 1955, 1969, 1970, 1974, 1987, 1988, 1998, 2004, 2007, 2015, 2016, and 2017. The total flood-affected area, the number of affected people, and the total loss of the country in the most severe 13 flooding events are presented in Table 3 (Cerveny *et al*., 2017; BWDB, 2019).

Efforts by successive governments for prevention, controlling, and mitigation of floods in Bangladesh started after the devastating floods of the 1950s. Since then, an incremental change has been observed

Table 3. Year-wise flood-affected area and flood-affected people in Bangladesh.

	Flood-affected area		Affected people due to flood		
Year	Sq. km	(%)	Sufferers	Death toll	Total loss ($)
1954	36,800	25	Data not available	112	Data not available
1955	50,500	34	Data not available	129	Data not available
1969	41,400	28	Data not available	126	Data not available
1970	42,400	29	10,000,000	300,000	25,000,000
1974	52,600	36	38,000,000	28,700	579,200,000
1987	57,300	39	29,700,000	2,680	1,057,500,000
1988	89,970	61	73,000,000	2,440	2,137,000,000
1998	100,250	68	15,000,050	1,000	430,000,000
2004	55,000	38	6,300,000	800	2,200,000,000
2007	62,300	42	4,540,000	500	114,000,000
2015	47,200	32	200,000	19	40,000,000
2016	48,675	33	2,604,455	14	150,000,000
2017	61,979	42	6,775,352	121	628,000,000

by the successive governments, in which the focus of flood mitigation policies was developed and implemented to 'control' and currently, 'manage' the flood risk (Sultana *et al*., 2008). The overall trend of flood prevention and control approaches of Bangladesh can be viewed in terms of three distinct phases of its development (Table 4).

Table 4. Flood risk management policies of Bangladesh in different phases (adapted from Haque (1993), Cook (2010), and Parvin *et al*. (2018)).

Policy regimes	Flood management strategies	Plan/Policy/Acts
The first phase (1955–1986) structural period	This phase focused on **flood defense strategies**, is characterized by an increased willingness to implement technical adjustments. The approach was predicated on controlling hydrological resources using physical structures; initially with large-scale projects and later small-scale, low-cost, and quick-return projects	Krug's Report 1957; Water Master Plan 1964; National Water Plan 1986
The second phase (1987–2000) behavioral period	This phase focused on **flood risk prevention and mitigation strategies**, is characterized by a paradigm shift from 'flood control' to 'flood risk prevention and mitigation' and combined with structural solutions, the combinations of structural and non-structural measures along with water-related social development began to dominate that had previously been limited to risk reduction	Flood Action Plan 1990; National Water Plan 1991; Water and Flood Management Strategy 1995; National Water Policy 1999
The third phase (2001–present) development period	This phase centered on **flood risk reduction and recovery** approaches, which established the need to improve local-level disaster response and preparedness, including immediate rescue resources, emergency funding systems, and improved information management and crisis planning	National Water Management Plan 2001; National Plan for Disaster Management (2010–15, 2016–20)

Following the subsequent floods of 1954 and 1955, the Krug mission was conceived with an emphasis on increasing agricultural development, and large-scale irrigation and flood control programs. The then East Pakistan Water and Power Development Authority (presently Bangladesh Water Development Board) drafted the first master plan of water resources in 1964 which was also centered on several large-scale public works including embankments, gravity irrigation through canal network, and pumping stations (IECO, 1964; Haque, 1993). This master plan consisted of 91 major projects, financed by donor agencies (Haque, 1993) and planned to be distributed over the 20 years from 1965 to 1985 with a projected cost of US$ 2.1 billion at the 1964 price (Chowdhury *et al*., 1997). Correspondingly, it was evidenced that over 8,000 km of embankments and other infrastructures were constructed between the 1960s and 1993 at a cost of more than US$ 5 billion (Haggart, 1994). However, these large-scale structural management frameworks were strongly criticized, notably concerning their costs and benefits by critics, over the whole period (Haque, 1993). Owing to this, the World Bank proposed shifting from large-scale schemes to low-cost and small-scale flood management and irrigation programs (WB, 1972; Sultana *et al*., 2008). Consequently, to harmonize the various requirements of economic development and water resources utilization, and avoid costly disputes among consumers, the government realized a crucial need to improve the planning and developed National Water Plan 1986 with the help of the World Bank and United Nations Development Program (Hossain, 2003; Sultana *et al*., 2008; Ahmed *et al*., 2015). This also ensured inter-ministerial coordination to formulate policies related to water and to act on national issues related to water management and flood control (Haque *et al*., 2019) (see Table 5).

A major shift occurred at the end of the 1980s when flood management strategies developed in a common platform for both national and international dialogues (Haque *et al*., 2019). The severity of flood during 1987 and 1988 reinforced the need to establish a long-term strategic solution and flood action plan (FAP), from 1989 to 1995, which was initiated by the World Bank (Hussain *et al*., 2004). This plan comprised 26 modules focused on flood control and river training, floodproofing, early warning, and flood forecasting (Chadwick & Datta, 1999). Later, National Water Plan 1991 and Bangladesh Water and Flood Management Strategy 1996 was introduced to coordinate, construct, and maintain the water-related projects (Haque *et al*., 2019). During this time, donors and government proposed a participatory approach to development focused on increased roles for NGOs and the transition of responsibilities to local citizens (Sultana *et al*., 2008). Nevertheless, the absence of public support in the decision-making process became the main pitfall for the adoption of the mechanisms indicated in these policies, especially in the FAP. Therefore, a critical paradigm shift was observed in the policy structure to formulate National Water Policy 1999, combining structural and non-structural measures to protect lives, properties, and facilities from flooding in an equal manner (MoWR, 1999).

Additionally, in 2001, the Government adopted a 25-year National Water Management Plan to promote the implementation of the National Water Policy (Gain *et al*., 2017), offering a broader framework lacking from previous policies and plans, in which line agencies would create state or local water management strategies and execute them in a structured manner (Ahmed *et al*., 2015). Disaster management programs related to water also endorsed the development of the National Disaster Management Plan (2010–2015) and later the National Disaster Management Plan (2016–2020) as a follow-up to the earlier strategy for updating flood hazard maps and the revised overall flood management plan (DMB, 2010, 2017) (see Table 5). Thus, in recent times, flood risk preparedness and recovery approaches have gained broader policy consideration, but the process has not been linear, as various policy mechanisms have been implemented at different points, addressing problems directly at hand.

Table 5. Incremental changes in the contents of flood risk management policies in Bangladesh (adapted from Sultana *et al*. (2008) and Haque *et al*. (2019)).

Plan/Policy/Acts	Key policy intervention	Technical context	Socio-political context
Structural period (1955–1986)			
Krug's Report 1957	Riverbank protection from the flood by large-scale constructions	Lack of knowledge of flood risks	Multilateral donors' interests in large projects
Water Master Plan 1964	Drafting a master plan focusing on flood control and drainage projects (both large and small)		
National Water Plan 1986	Drafting a National Water Plan	Complete ongoing projects, growing capacity for engineering	Inter-ministerial coordination for responding to the regional challenges
Behavioral period (1987–2000)			
Flood Action Plan 1990	Long-lasting solutions to floods by structural measures; focus on floodproofing, river training and warning	The debate on embankments covered technological viability, maintenance efficiency, economic returns; negative effects on the environment and livelihood of destitute populations, with uncertain agricultural benefits	Donor consortia, allied with the government, consultants, and professionals failed to justify the implementation of major embankments and ultimately moved to the improvement of the existing schemes' performance, institutional efficiency and public participation
National Water Plan 1991			
Water and Flood Management Strategy 1995	The involvement of all stakeholders in the implementation phases of projects		
National Water Policy 1999	Integration of structural and non-structural measures to protect lives, properties, and facilities from flooding	Participation of all actors from all sectors in decision-making for all project cycle steps	Donors and government accepted the increased roles of NGOs and local people and include them in water management schemes
Development period (2001–present)			
National Water Management Plan 2001	Provision of guidance on the implementation of water and flood management functions at the regional and national level	Integration of environmental issues in the multilevel government policy	Participation of local experts in defining important environmental problems and possible solutions
National Plan for Disaster Management (2010–15, 2016–20)	Sustainable human development by enhanced resilience processes	Introduction of a comprehensive disaster management process including flood risk management	The definition and application of the responsibility of all parties involved in disaster management

Flood risk management strategies in national development plans

The First Five-Year Plan (FYP) (1973–1978) included a massive flood control program, when in 1971, Bangladesh became a sovereign state. However, flood management systems during the time included flood protection projects to shield low-lying regions from flooding, coastal projects to shield the land from saline inundation, and even to build polders for irrigation and drainage (BPC, 1973: 149). During the period of the Second FYP (1980–1985) and Third FYP (1985–1990), the focus was also on flood protection embankment and coastal embankments along with the implementation of those flood control projects. As of 1984, 19 flood control projects were completed and an additional 14 were under implementation (Rahman, 1985). Then, the Third FYP was the first to address the Disaster (Flood, Cyclone, etc.) Warning Program for Coastal Area. It mentioned that '*the objective of such a program is to minimize the effect of such natural calamities on human life and property*' (BPC, 1985: 51). In fact, for the first time, during the Fourth FYP (1990–1995), it was understood that the building of embankments along with major rivers and flood management in adjacent flood plain compartments would have both socio-economic and environmental consequences. The plan indicated that the flood control measures would be implemented under an action plan, integrated with that FAP. The Fourth FYP (1990–95) is seen as the first step towards the long-term flood control plan adopted by the government. During this time, the priority was on the small-scale Flood Control, Drainage and Irrigation (FCDI) scheme, with minor development in irrigation, to expand both irrigation coverage and flood control and drainage improvement in the desired direction.

On the other hand, the Fifth FYP (1997–2002) included the objectives: to promote water management for irrigation and other uses; protect cities, commercial centers, farmlands from flooding by inland and border rivers; ensure active involvement by citizens in the planning, execution, and maintenance of projects in the water sector and carry out research on potential water resources development projects. This plan also covered flood risk management in cities and referred to the laws and regulations for development in coastal regions (BPC, 1997). The Sixth FYP (2011–2015) also included the above-mentioned flood risk protection and control strategies, but along with those,

> '*disaster management practice, disaster mitigation, emergency preparedness, emergency response, disaster management mechanism, early recovery and immediate rehabilitation, space technology and disaster management, space technology in disaster prediction, warning, flood monitoring, mapping and use of internet facilities for disaster monitoring, prediction and information dissemination*' (BPC, 2011: 153)

are mentioned for the first time. During this planning period, the Coastal Embankment Improvement Project of $400 million assisted Bangladesh to alleviate several large impacts of cyclones and flooding, and ultimately, strengthen the emergency response in the coastal areas of Barguna, Patuakhali, Pirojpur, Khulna, Bagerhat, and Satkhira (Forni, 2015). However, the articulation of the sustainable development plan of the Seventh FYP (2016–2020) includes a wide variety of actions under three main themes: '*(i) Climate Change Management and Resilience (comprising adaptation and mitigation); (ii) Environmental Management; and (iii) Disaster Management*' (BPC, 2015: 402). Several goals and strategies identified under the Sixth FYP, although not addressed or executed, have now been listed under the Seventh FYP, so that they have an instrumental role to play in achieving the main priorities. Relief and rehabilitation for disaster-affected people are mentioned for the first time in the Seventh FYP

(BPC, 2015: 585). During this period, the flood forecasting and early warning program have been improved via Bangladesh Weather and Climate Services Regional Project of $113 million, an integrated community-level early warning system for flash flooding in the districts of Netrakona, Sunamganj, Rajshahi, and Naogaon (WB, 2016).

Recently, Bangladesh Delta Plan 2100 has been formulated to minimize the long-term challenges presented by climate change and natural hazards where the vision is to

> '*ensure long term water and food security, economic growth and environmental sustainability while effectively reducing vulnerability to natural disasters and building resilience to climate change and other delta challenges through robust, adaptive and integrated strategies, and equitable water governance*' (BPC, 2018: 14).

The plan also included specific goals like

> '*to ensure safety from floods and climate change-related disasters; enhance water security and efficiency of water usages; ensure sustainable and integrated river systems and estuaries management; conserve and preserve wetlands and ecosystems and promote their prudent use; develop effective institutions and equitable governance for in-country and trans-boundary water resources management, and achieve optimal and integrated use of land and water resources*' (BPC, 2018: 14).

Among all the development plans in Bangladesh, the national-level strategies of Bangladesh Delta Plan included all the diversification of flood risk management strategies and addressed them along with funding and implementation procedures (Table 6).

In National Adaptation Plans of Action (NAPA, 2005 and 2009) also, the flood is recognized as a climate hazard and perennial disaster. Bangladesh was one of the first countries to devise and submit its National Adaptation Plans of Action in 2005, later revised in 2009. Adaptation measures regarding flood as prioritized in NAPA for Bangladesh are (MoEF, 2005: xvi):

(a) 'as intervention measures:
   (i) construction of flood shelter, and information and assistance center to cope with recurrent floods;
   (ii) reduction of climate change hazards through coastal afforestation with community focus;
   (iii) enhancing the resilience of urban infrastructure and industries to impacts of climate change including floods and cyclone,
(b) as facilitating measures:
   (i) capacity building for integrating climate change in planning, designing of infrastructure, conflict management and land water zoning for water management institutions;
   (ii) exploring options for insurance and other emergency preparedness measures to cope with extreme climatic disasters;
   (iii) mainstreaming adaptation to climate change into policies and programs in different sectors (focusing on disaster management, water, agriculture, health, and industry).'

On the other hand, Bangladesh Climate Change Strategy and Action Plan (BCCSAP) is the long-term national strategy framework to develop the country's capacity and resilience to tackle climate change and meet its Vision 2021 objectives (MoEF, 2009). In the chapter, 'Flood as a climate hazard'

Table 6. Flood risk management strategies mentioned in planning directives.

Flood Risk Management Strategies		1st FYP 1973-1978	2nd FYP 1980-1985	3rd FYP 1985-1990	4th FYP 1990-95	5th FYP 1997-2002	NAPA 2009	BCCSAP 2009	6th FYP 2011-2015	7th FYP 2016-2020	BDP 2100 2018
Flood Defense	RCE										
	SD										
Flood Risk Prevention	GPCA										
	LUP										
Flood Risk Management	UM										
	BR										
Flood Preparation	WS										
	DM										
	EP										
Flood Recovery	RP										
	RIS										

Flood Defense | Flood Risk Prevention | Flood Risk Management | Flood Preparation | Flood Recovery

'Box filled with color' means 'Mentioned in the Plan', while 'Box filled with no color' means 'Not Mentioned in the Plan'.
FYP= Five Year Plan, **NAPA**= National Adaptation Program of Action, **BCCSAP**= Bangladesh Climate Change Strategy and Action Plan, **BDP**= Bangladesh Delta Plan 2100.
RCE= River and/or Coastal Embankments, **SD**= Storm-water Drainage, **GPCA**= Green-area Protection & Coastal Afforestation, **LUP**= Land Use Planning, **UM**= Urban Management, **BR**= Building Regulations, **WS**= Warning System, **DM**= Disaster Management, **EP**= Evacuation Plan, **RP**= Rehabilitation Process, **RIS**= Relief & Insurance Support.

(MoEF, 2009: 6), it emphasized the investment for different schemes to combat the flood risk since 1970, such as

> '*flood protection and drainage schemes to protect urban areas from rainwater and river flooding during the monsoon season; coastal embankment projects to prevent tidal flooding and incursion of saline water; construction of shelters to provide refuges for communities from storm surges caused by tropical cyclones and river floods; comprehensive disaster management projects, involving community-based programs; development of early warning systems for floods and cyclones; and coastal 'greenbelt' projects*'.

Among the 37 programs introduced in Bangladesh Climate Change Strategy and Action Plan, 17 programs are addressed in the action plan for flood and flood-prone areas. Among the climate change policies in Bangladesh (National Adaptation Plans of Action and Bangladesh Climate Change Strategy and Action Plan), the FRMS are also listed in Table 6.

Flood risk management strategies in Dhaka city development plans

Dhaka is bounded by six peripheral rivers (Tongi Khal to the north, Balu and Sitalakhya to the east, Turag and Buriganga to the west, and Dhaleshwari to the south) (WB, 2015; Fatemi *et al*., 2020a), which overflow frequently during the monsoon, making the city vulnerable. According to Shaw (2013), when a flood occurs, several areas of Dhaka become inundated for a few days. In so-called regular flood conditions, some roads become inaccessible for at least 8 hours, although during heavy flooding, this can escalate to 12 hours or

more. The illegal encroachment of low-lying flood plains, rivers, canals, and other water bodies traditionally used to drain or retain water during rainfall along with rapid and unplanned urbanization has intensified this issue (Dasgupta *et al*. 2015). Since floods have become perennial events, and thus, part of life for the people there, to achieve physical resilience, flood management has been considered in different development plans of the city. A timeline of the policies, planning, and development initiatives adopted by Dhaka and Bangladesh at different periods reveals gradual changes and paradigm shifts in flood control and management approaches is shown in Figure 2.

British town planner, Sir Patrick Geddes, prepared the first planning document for Dhaka in 1917, however, the then Government did not adopt the plan. Long after that, Dacca (former name for Dhaka) Improvement Trust was founded in 1956 under the Dacca Improvement Act, 1953, to manage the city planning and development. Dhaka's first comprehensive master plan, Dacca Master Plan 1959 (DMP) was developed in 1959 by Dacca Improvement Trust as the first functional physical plan of the country. Later, other metropolitan development authorities came into place and formulated their physical plans such as DMAIUDP (1981), DMDP (1995–2015), and DSP (20162035) (Figure 2). In the Dacca Master Plan (1959), to ensure flood risk control and protection, only a few strategies were included, such as protection and improvement of the existing embankment at Dhaka West, dredging the natural water channels and canals, and connection of the natural water bodies through the city. During this planning period, the first major flood control project in the Dhaka area was identified and was started to be constructed in the Dhaka-Narayanganj-Demra area from 1962. As one of the pioneer projects to manage floods in the greater Dhaka area, this project introduced the flood wall and embankment along the trunk road (WB, 2015). Dhaka Metropolitan Area Integrated Urban Development Project (1981) was driven by stormwater drainage and flood problems in Dhaka Metropolitan Area and was designed to provide a long-term growth strategy for urban expansion (Kabir & Parolin, 2012). The proposal of a primary drainage network was provided for the first time. The focus was also on acquiring developed land and city expansion after realizing the difficulty to make low areas flood-free. Experiencing the destructive floods of 1988, the Government of Bangladesh formulated a FAP to minimize flood damage for the whole country. FAP-8, as a part of the FAP, carried out a feasibility analysis for integrated flood management strategies to keep Dhaka flood-free (Das, 2010). This plan is based on year-round water management integrating river management in

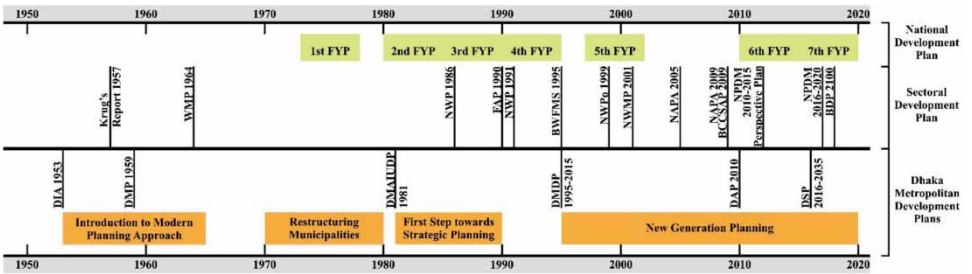

Fig. 2. National policy, strategy, plans related to flood risk management with Dhaka City Development Plans. DIA, Dacca Improvement Act; DMP, Dacca Master Plan; DMAIUDP, Dhaka Metropolitan Area Integrated Urban Development Project; DMDP, Dhaka Metropolitan Development Plan; DAP, Detailed Area Plan; DSP, Dhaka Structure Plan; WMP, Water Master Plan; NWP, National Water Plan; FAP, Flood Action Plan; BWFMS, Bangladesh Water and Flood Management Strategy; NWPo, National Water Policy; NWMP, National Water Management Plan; NAPA, National Adaptation Program of Action; BCCSAP, Bangladesh Climate Change Strategy and Action Plan; NPDM, National Plan for Disaster Management 2010–2015; BDP, Bangladesh Delta Plan 2100; FYP, Five-Year Plan.

water development projects with a high degree of protection for urban areas through a combination of structural and nonstructural interventions (JICA, 1992). Among the 26 studies of this plan, specifically two action plans (FAP-8A and -8B) emphasized flood issues in Dhaka. FAP-8A covered plans for the broader area such as Dhaka-Narayanganj-Demra area and also Tongi, Savar, and Keraniganj were included in the detailed area plan (JICA, 1992). This plan recommended structural measures to develop the drainage system through improving pumping capacity and dredging of khals along with nonstructural measures through flood forecasting and warning systems, land regulation, and zoning. The core city area was covered by FAP-8B with flood mitigation and stormwater drainage plans (WB, 2015).

The Dhaka Metropolitan Development Plan (1995–2010) was developed to identify the features of spatial development strategy through three tiers – Structure plan, Urban area plan, and Detailed area plan – which also formulated the utilization of the city's existing urban resources through consolidation and accelerated development. The primary goal was to devise a hierarchical, multi-sectoral development plan to coordinate the flood and drainage management for the city (Barua *et al.*, 2016). This plan introduced the first-ever policies on drainage and hydrology to ensure the protection of flood flow zones and retention ponds, and to develop flood control and drainage through land-use planning (Rahaman, 2008). The Urban area plan acted as a mid-term strategy for 1995–2005 to protect and preserve the retention ponds on the western embankment (RAJUK, 1997). Later, the Detailed area plan 2010 addressed the safety and critical environmental issues including drainage, retention pond, flood flow zones through a land-use zoning plan along with an infrastructure development plan identifying areas of potential land use as a part of development control. Additionally, it was also prepared as a detailed implementation guide to integrating the development policies, guidelines, and framework set by Dhaka Metropolitan Development Plan and a detailed development proposal, including three-dimensional proposals for each area; for example, for the provision or improvement of the road network, community facilities, utilities and services, outdoor spaces and squares, and overall, a detailed indication of urban design for the city.

The latest development plan, Dhaka Structure Plan (2016–2035) considers maximum flood risk management strategies among the earlier planning directives, having 55 objectives and 132 policies under nine planning policy frameworks (RAJUK, 2015). Among those, seven policies under three objectives are directly related to the reduction of flooding and the protection of communities, lives, and properties from flooding. The policies include protection of flood flow zones, protection of canals and rivers, protection of floodwater retention areas, the building of new flood protection embankment, monitoring and evaluation of flood protection embankments around the city, improvement of capacity and institutional strength of the agencies responsible for flood control and drainage, and building urban resilience to floods (RAJUK, 2015). The plan mentioned a few strategies for the first time, such as the introduction of open spaces to convey and store floodwater during wet seasons, redesign of infrastructure into a collection of diverse functional elements that are flexible in operation, and even, it recommended remodeling that buildings in the future be elevated, floatable, or wet-proofed in delineating areas of flood plains and water retention areas. The FRMS included in the Dhaka city development plans are listed in Table 7.

Discussion

The progressive integration of flood risk management strategies in the development instruments (see Table 6) is the follow-through of the learned lessons from past disasters and, thus, it is possible to develop a relatively effective flood mitigation policy and disaster control framework for Bangladesh

Table 7. Flood risk management strategies mentioned in Dhaka city development plans.

Flood Risk Management Strategies		DMP 1959	DMAIUDP 1981	FAP 8A &8B	DMDP 1995-2010	DSP 2016-2035
Flood Defense	RCE					
	SD					
Flood Risk Prevention	GPCA					
	LUP					
Flood Risk Management	UM					
	BR					
Flood Preparation	WS					
	DM					
	EP					
Flood Recovery	RP					
	RIS					

Flood Defense Flood Risk Prevention Flood Risk Management Flood Preparation Flood Recovery

'Box filled with color' means 'Mentioned in the Plan', while 'Box filled with no color' means 'Not Mentioned in the Plan'.
DMP= Dacca Master Plan, **DMAIUDP**= Dhaka Metropolitan Area Integrated Urban Development Project, **FAP**= Flood Action Plan, **DMDP**= Dhaka Metropolitan Development Plan, **DAP**= Detailed Area Plan, **DSP**= Dhaka Structure Plan
RCE= River and/or Coastal Embankments, **SD**= Storm-water Drainage, **GPCA**= Green-area Protection & Coastal Afforestation, **LUP**= Land Use Planning, **UM**= Urban Management, **BR**= Building Regulations, **WS**= Warning System, **DM**= Disaster Management, EP= Evacuation Plan, **RP**= Rehabilitation Process, **RIS**= Relief & Insurance Support.

(Ahmed *et al*., 2015). As a result, on a national scale, incorporating adaptation to climate change into legislation also proved a remarkable success in flood management (Abbas *et al*., 2016; Ashraf *et al*., 2017), especially in the coastal areas mentioned by Forni (2015) and Fakhruddin & Ballio (2013). Here, IPCC (Intergovernmental Panel on Climate Change) also has particularly acknowledged, how improvements in disaster preparedness, emergency response, and households' adaptive capacity have a significant impact on decreasing flood fatalities (Field *et al*., 2012). Correspondingly, Cooke (2018) pointed out the positive impact of the integration of climate finance into the public financial management systems of Bangladesh, which is also an exemplary decision to improve the overall climate resilience, especially for disasters like flood and cyclone. Therefore, being one of the most flood-prone countries, Bangladesh has not only developed numerous policies but also adopted multiple and diverse FRMS. In its first phase (Table 6), several structural measures were adopted, and later in the second and present phases (Table 4), it shifted toward nonstructural measures of flood prevention and management as well (Paul & Routray, 2010). In recent years, structural methods have proven to be economically extravagant due to their construction cost and continuous maintenance, which require extensive financial investment and are also not environmentally friendly (Mutton & Haque, 2004). Similarly, Brammer (2014) emphasized the impact of over-dependence on structural measures, such as embankments and polders to control flood, as their poor maintenance has contributed to issues with internal drainage, inundation, and siltation. Furthermore, the severity of floods is very likely to increase with each passing year along with continuous siltation in the rivers, and the landscape deforestation which is increasing upstream (Mirza *et al*., 2003). Thus, increasing attention has been turned towards less expensive nonstructural measures, which become suitable for the flood-affected people of developing countries like Bangladesh. In the Seventh FYP and Bangladesh Delta Plan 2100, it is noted that all types of FRMS have been addressed, although focus is being put on the inclusion of local citizens by enabling inclusive bottom-up participation in the decision-making process, especially at the community level (BPC, 2015: 405, 2018: 16).

As mentioned in Tables 5 and 6, the change of the government's focus from 'flood control' to 'flood management' occurred at the later stages of FAP 1990, and was addressed by the government after the destructive floods of 1987 and 1988 (Rahman & Salehin, 2013). After another disastrous flood in 1998, more changes in development policy for various infrastructures were observed, which included strategies such as, '*all structures having strategic importance were built above the 100-year flood level*' (Chadwick & Datta, 2003), '*laws were enacted to stop encroachment in the flood flow zones*' (BPC, 2015), and '*school buildings were built with the provision of temporary shelter in flood-prone locations*' (Rahman *et al*., 2015), etc. From this period, improving the flood forecasting and early warning systems, along with a strategy to engage the community in flood risk management, has already generated promising results through reducing vulnerabilities and enhancing local capacity to cope with flood risk, as Fakhruddin & Ballio (2013) showed in Sirajgonj, Faridpur, Gaibandha, and Lalmonihat districts of Bangladesh. Current effective evacuation procedures and shelter management have prevented many casualties in the coastal areas of Barguna, Patuakhali, Pirojpur, Khulna, Bagerhat, and Satkhira, especially due to the attention on safeguarding communities and reducing potential damage of flooding (Forni, 2015; Abbas *et al*., 2016).

On the other hand, for Dhaka city, from Dacca Master Plan (1959) to Dhaka Metropolitan Area Integrated Urban Development Project (1981) (Table 7), only structural measures such as construction, protection, and improvement of the embankment, construction of stormwater drainage, introduction of floodwalls and pump house were planned to control and provide protection against flood. Later, the FAP-8 for Dhaka city also focused on flood defense strategies, rather than flood prevention and management. After the severe floods of 1987 and 1988, the government undertook the Greater Dhaka Integrated Flood Protection Project under FAP-8A and -8B to protect the more rural flood-prone eastern part and the more urbanized western part of the city, respectively (JICA, 1992). While Phase I of the project, intended to protect the more urbanized western part of the city, was developed in the early 1990s, Phase II was never completed due to resource constraints (Chowdhury, 2003). Unfortunately, during the unprecedented flood of 1998, protected Dhaka West went underwater again, indicating that current flood management practices must be improved (Huq & Alam, 2003). Later, Dhaka Metropolitan Development Plan 1995–2010 and Dhaka Structure Plan 2016–2035 (Table 5) included a few structural and non-structural measures, such as protection of flood flow zones, wetlands, and water retention areas, monitoring and evaluation of flood protection embankments, improving capacity and institutional strength of the agencies responsible for flood control and drainage, and building urban resilience to floods, etc. However, unfortunately, flood preparation strategies and flood recovery strategies such as evacuation procedures, shelter management, etc., have not been reflected in those plans.

Although Dhaka Metropolitan Development Plan 1995–2010 emphasized protection of the flood plains, it did not introduce any specific procedure to earmark those flood plains properly. Identifying this gap, in both the Structure plan and Urban area plan, some property developers swallowed the lowlands of floodplains. Another huge flaw of these plans is the permission for development of rural settlement in these flood flow zones, without defining the scope and limit of the development of the rural settlement. Therefore, for these types of flaws, the chances of losing the very valuable lands in those flood flow zones, as well as the agricultural lands, were increased, when the process of development started carelessly (Roy *et al*., 2011). Under those circumstances, the Detailed area plan 2010 was expected to act as a critical legal instrument to control such development. However, unfortunately, the Detailed area plan failed to be published on the due date, rather it took another 13 years to prepare and publish it. Meanwhile, many flood flow zones were filled up and developed as suburbs (Barua *et al*., 2016). Moreover, the custodian and regulatory authority of the Detailed area plan, RAJUK (Capital Development Authority) also repeated the same gross violation

contradicting its own guideline indicated in the Dhaka Metropolitan Development Plan (RAJUK, 1997: 37) by developing the 'new townships' in the defined flood flow zone (Morshed, 2013). According to the Bangladesh Institute of Planners (BIP, 2008) proposed land uses within flood flow zones are also violating the obligation to the Ramsar Convention, to which, Bangladesh is a signatory.

Again, the Structure plan and Urban area plan were supposed to follow the principles of FAP-8A and -8B in terms of the preservation of canals and retention ponds (JICA, 1992; RAJUK, 1997). But minor initiatives were undertaken to maintain and rehabilitate those canals, and the land acquisition according to the proposal for retention pond sites was also unsuccessful (Islam, 2009; Das, 2010). The Detailed area plan repeated the same mistake by following the drainage proposals of Halcrow (IWM, 2006), where fewer retention pond areas are suggested. For instance, compared to JICA's proposal (JICA, 1992) of 12% of total land area as retention ponds, the Detailed area plan proposes only 5.05%. Indicating the importance of a large number of retention ponds, Barua *et al.* (2016) emphasized the problems to address urban flooding after the construction of the eastern embankment, adding that without the embankment, flood scenarios would be even worse as both river and rain floods are a concern for Dhaka. Moreover, as the lowest tier, the Detailed area plan was expected to comply with the policies stated in the Dhaka Metropolitan Development Plan, but it omitted the category 'sub-flood flow zone' proposed in the Dhaka Metropolitan Development Plan. It also combined the categories, 'high-value agricultural land' and 'agricultural land' indicated in the Dhaka Metropolitan Development Plan into one category and relabeling it as 'agriculture with rural homestead'. Proposed changes of these land-use categories for flood flow zones and agricultural land in the Detailed area plan create unbridled avenues for land developers to extend the urban growth, thereby aggravating flood risk.

On the other hand, for Dhaka city, development issues such as urban growth and expansion, urban green spaces and wetlands preservation, and protection of flood flow zones and building urban resilience were framed in Dhaka Structure plan. The plan also identified some strategies that Dhaka can adopt to confront water logging issues within the city including 'conservation of the water bodies' and 'the integration of the water bodies with the city fabric'. To actualize these strategies, RAJUK completed three projects: 'Integrated Development of Hatirjheel Area Including Begun Bari Khal Project', 'Gulshan-Banani-Baridhara Lake Improvement and Beautification Project', and 'Uttara Lake Improvement and Beautification Project'. However, some of the strategies of the Dhaka Structure plan are considered as inherently contradictory, like the previously mentioned Dhaka Metropolitan Development Plan and Detailed area plan. For example, regardless of the proposals for a 'green network' and 'urban and peri-urban forestry and greenery' (RAJUK, 2015), there is no clear implementable strategy and regulations to prevent and protect previously planned open spaces, which are experiencing continuous encroachment by RAJUK itself (Mowla, 2015). Moreover, Mowla (2015) suspected that proposed development in the flood flow zones induces flooding and waterlogging risk, while earth filling could be susceptible to liquefaction hazards.

Conclusion

Flood is now one of the threatening developmental problems of this period (Pelling, 2003). Bangladesh, as well as Dhaka, faces the severe threat of flooding regularly. Although floods and disasters cannot be fully controlled, prevented, or eliminated, the impact can be significantly minimized by integrating measures and coordinating agencies (Rahman *et al.*, 2007). Thus, the study analyzed the extent of flood management strategies in the multi-level governance layers of Bangladesh to have a clear indication of integration and coordination between them.

The overall findings of this study are as follows.

First, as the diversification of FRMS:

- This study reveals that a progressive integration and incremental change in flood risk management has been acknowledged in multi-level policies and plans, although a few gaps and deviations have been identified in the case of implementation, especially in the Dhaka city development plans indicated in the Discussion section.
- The analysis shows that the development plans have shifted their standpoint and philosophy from 'flood defense' to 'flood risk management', to confront flood risks, which is also common in flood-prone countries like the UK (Butler & Pidgeon, 2011), the Netherlands (Jong & Brink, 2017), China (Kobayashi & Porter, 2012) and other South Asian countries (Abbas *et al.*, 2016). Therefore, in the coastal areas of Bangladesh, flood preparedness, and flood recovery strategies mentioned in the national development plans have increased the overall capacity to control and manage flood risk. However, in Dhaka city development plans, the lack of integrating these strategies still exists and thus, these strategy areas need to be improved in the future.

Second, as the convergence of FRMS:

- This study reveals that the internal coherence in between the latest national development plans (Seventh FYP and Bangladesh Delta Plan 2100) are in a similar order. In almost every category (flood defense, flood risk prevention, flood risk management, flood preparation, flood recovery), similarities in flood management strategies have been recognized. Although there is an absence of 'evacuation plan' in the flood preparation category in the Seventh FYP, it has been included in Bangladesh Delta Plan 2100.
- The study shows that vertical policy integration in between the latest national development plans (Seventh FYP and Bangladesh Delta Plan 2100) and Draft Dhaka Structure Plan 2016–2035, are in similar order from flood defense to flood preparation category. Therefore, through this study, it is recommended to include 'evacuation plan' in the flood preparation category and flood recovery strategies in the final Dhaka Structure Plan 2016–2035.

Third, as the divergence of flood risk management strategies:

- The study identifies that the lack of coordination and absence of knowledge sharing between the Bangladesh Planning Commission and RAJUK create the scope to generate divergence (the 'flood preparedness' and 'flood recovery' strategies are not yet integrated) and, thus, obstruct the vertical policy integration.
- This study also identifies the divergence of flood management strategies related to flood flow zones between the implemented plans and recently developed plans, especially in the Dhaka City Development Plans (contradictions between Dhaka Structure plan 1995–2010 and Detailed area plan 2010), which withhold the advancement of flood management to make the city flood resilient. This indicates that the absence of internal coherence still exists in the Dhaka City Development Plans. Therefore, through this study, it is recommended to overcome those inefficiencies and establish internal coherence in the next Detailed area plan (which is still in the process of formulation).

Above all, this study recommends establishing coordination among the institutions responsible to prepare and update the development plans and ensure vertical policy integration and internal coherence. It has also been suggested (Parvin *et al.*, 2018) that the present development instruments at the national level and their integration at the city level are required to be examined, reviewed, and even improved, to ensure effective and sustainable flood risk management. Moreover, the development and

implementation of these policies and planning directives require active public participation (Samuels *et al*., 2006) and advanced research (Ashraf *et al*., 2017). This study also advocates managing the conflicts and ambiguities between the strategies, to learn positives from the implemented projects, and to recognize the limitations through continuous monitoring and evaluation. Last of all, it also recommends a coordinated attempt encompassing good governance, active community involvement, and institutional support, along with an integrated framework incorporating disaster response, preparedness, and adaptation planning to ensure an overall FRMS for Bangladesh and Dhaka city.

Data availability statement

All relevant data are included in the paper or its Supplementary Information.

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Received 6 January 2020; accepted in revised form 9 October 2020. Available online 13 November 2020