

Management of Urban Disaster with special Emphasis on Fresh Water Scarcity and Surface Water Pollution in Dhaka City

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Abstract

Dhaka, the capital of Bangladesh, is a Mega City accommodating a huge number of people in a limited piece of land creating excessive demand for dwelling houses and industries, which result in the construction of high-rise buildings and growing slum areas simultaneously. These give rise to environmental hazards along with the paucity of fresh water for household and industrial use. Like many other cities in Asian developing countries, Dhaka is exposed to serious threats of versatile urban disasters viz. seismic, flood, cyclone, fire and the like. Now, environmental hazard in particular has become a community concern in Dhaka Metropolitan City. The environment within and around urban areas is worsening day by day due to unplanned and improper use of water and land. Ensuring safe and reliable water supply has been one of the major urban challenges. The main sources of surface water of Dhaka city are the river Buriganga and other peripheral rivers namely, Shitalyakhya, Turag and Balu, which are extremely polluted by discharge of more than 1.3 million cubic meters of untreated effluents and 0.5 million cubic meters of sewage daily. Most of these waters are unusable for human and other living organisms. These polluted waters can no longer be considered suitable for chemical treatment. On the other hand, the

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riverbanks and beds are encroached by illegal occupants. The scarcity of surface water, therefore, results in increasing pressure on ground water abstraction. Groundwater level of Dhaka city is receding alarmingly by 2 to 3 meter every year because of groundwater mining, which may result in land subsidence. In such a situation if water of surrounding rivers is not improved both in quality and quantity, the capital city will not remain environmentally fit for human habitation. The situation may improve through co-ordination and integration of different institutions engaged in urban development activities under the umbrella of an apex body for emergency mitigation of disaster. The present paper attempts to discuss some major aspects of human-induced urban disasters with special emphasis on fresh water scarcity and surface water pollution, highlighting measures for mitigating them through appropriate Environmental Management Plans (EMPs), including awareness building, active community participation, institutional development and strict enforcement of regulatory and legislative measures. Recommendations are prescribed for judicious use of land and water with proper planning and management of water resources using advanced technologies. Key words: Dhaka city, environmental hazards, human-induced disaster, groundwater mining, land subsidence.

1. Introduction

Mankind is suffering from various kinds of disasters caused by flood, tropical cyclone, storm surge, tornado, river erosion, drought, earthquake, arsenic and environmental pollution. The environment within and around urban areas like Dhaka city are deteriorating day by day due to over-abstraction of ground water and pollution of surface water of the nearby rivers and unplanned use of land. Dhaka is already overcrowded by the dwelling houses, government offices and installations and infrastructures. The socio-economic conditions of people of the entire country depend greatly on Dhaka for various reasons. Dhaka is one of the mega cities of the world, which has already been rated as the environmentally most polluted one. City dwellers have been facing acute scarcity of safe drinking water for shortage of supply against demand. In the backdrop of rising demand for water in domestic, industrial and high-rise buildings and commercial centres, a new paradigm shift is required in the light of globalization. So, it will be a great challenge for the citizens to save the city from the threat of environmental degradation. This paper focuses on and responds to major urban disasters regarding water related issues. Rapid growth of population in a given area is the main reason for the multiple problems in our city. Groundwater level of Dhaka city is now alarmingly going down by 2 to 3 meters every year (IWM, 2006) resulting from mining and disaster threats of land subsidence, which has become

alarming for the urban planners. Time may come when the city will fail to bear the burden of the increasing population with severe impact of environmental imbalance that will lead to a special type of disaster herein termed as human-induced disaster. How this type of disasters can be managed with efficient and emergency response system is the main focus of the paper.

2. Theme of The Study

Access to fresh water resources is a global concern since the beginning of human civilization. As urban centres started growing and technology advanced, the issue got more importance in course of time. In this paper, water refers to surface fresh water from such places as rivers, lakes and wetlands as well as underground water sources. For the last few decades secured, safe, reliable and stable supply of water has been one of the leading economic and social challenges faced by the Asian developing countries as their population, economy, urban areas and mega cities have been growing fast. Water quality problems are becoming increasingly serious day by day. All surface water bodies within and around the urban industrial centres are now highly polluted. Surface and ground water is also becoming increasingly contaminated within and around growth centres of population and industrial areas. The major factors are human activities and interventions, which include encroachment on the river bank, flood plains and low lying areas, sewage and solid waste disposal, insufficient water supply and sanitation, industrial waste disposal, upstream diversions and abstractions (Ahmed, 2004). Waste assimilation capacity of the rivers is decreasing day by day and micro-organism is being destroyed due to increasing water quality deterioration. Now Dhaka has also a large slum population that will create problems for getting safe drinking water, inadequate sanitation and water shortages. The urban poor have become the worst sufferer of unplanned and irrational urbanization. The main objective of the study is to suggest a mechanism for mitigating fresh water scarcity and polluted surface water through good governance by coordinated and integrated efforts of different agencies and institutions, and by Participatory City Management (PCM) to significantly improve the city's social, economic, physical and biological environment.

3. Historical Background

Bangladesh is historically a riverine country with diverse ecological zones. A riverine environment shapes the life-style of its people living along river banks. From time immemorial nations, societies, cities as well as civilization have grown near rivers. The city of Dhaka was established by the Mughals on the bank of the river Buriganga in the early 17th century considering its immense potentiality of

growth and development. Since then this Buriganga river has been serving the people of Dhaka city with its entire resources with a flourishing river port. Undoubtedly Dhaka, the capital of Bangladesh, has an exciting history and a rich culture. Historically known as the city of mosques and Muslims, it attracted travellers from far and near. According to history, it was founded in 1608 AD as the seat of the imperial Mughal Viceroy of Bengal. It became a trade centre for the British, the French and the Dutch before coming under British rule in 1757. It was again named the capital of East Bengal in 1905 and became the capital of East Pakistan after the partition of the Indian subcontinent in 1947. As the capital of Bangladesh since 1971, Dhaka has now grown into a dynamic city offering opportunity for millions of migrants with an area of about 256 square kilometre (GOB, 2003), excluding peripheral towns and slum dwelling places. Dhaka's population is currently around 12 million and is projected to grow to 20 million in 2020, making it the world's third largest city (World Bank, 2007). Possessing a blend of old and new architecture, Dhaka is developing fast as a modern metropolitan city. Dhaka is surrounded by Buriganga, Turag and Sitalakhya rivers and inter-connected canals, which used to form a life-line for city residents in the past. During the last twenty years, a convergence of unregulated industrial units, rapid rural to urban migration, encroachment of the rivers and channels, disposal of untreated pollutants to the rivers, unplanned road network, and non-compliance of environmental regulations have all degraded surface water quality. Developers of lands and buildings have made many of the canals non-existent damaging the drainage system, and created water logging. The surface water of the rivers surrounding the Dhaka city is meagre and becomes polluted during the dry season. Most of the surface water is environmentally unfit for any use by human beings or any living organism. The city authorities have failed uptill now to prepare and implement any effective urban planning to keep the rivers free from water pollution and prevent the encroachment of the perennial water bodies and channels.

4. Need for The Study

A pollution-free environment is vital for a decent standard of living. The availability of fresh water and healthy environment is a fundamental right of the city dwellers. Unfortunately, with rapid urbanization and industrialization, urban governance and the provision of adequate safe water and housing have remained below the standard. Poverty has further aggravated the situation with increasing number of slums and squatters in metropolitan cities. Given the magnitude of the problems, the present study emphasizes the need for devising strategies for

accessing safe water towards socio economic enhancement. Emphasis has also been given on planned development of urban areas by strengthening environmental governance through involvement of all the stakeholders for achieving environmental sustainability.

5. Problems and Challenges

Massive and unprecedented urbanization in Dhaka has produced new types of water and wastewater related problems and challenges. The immediate challenges in terms of the management of demand for and supply of fresh water for the city for environment friendly conditions are as follows:

- Augmentation of fresh water supplies from outside Dhaka city from both surface and ground water sources to arrest the continuing fall of groundwater level and increase water supply is the prime need of the hour. Water treatment plants and well fields outside Dhaka will be required to solve this problem.
- All waste water needs to be treated before disposal in the nearby river. All residential houses, commercial places and industrial units within Dhaka need to be connected with sewerage disposal system.
- Proper land utilization planning, keeping provision for open area for recreation and water bodies, need to be provided.
- Proper land use planning and implementation of plan need to be controlled by participation of city dwellers and public organizations through a strong corporate body.
- The city area must be extended wherever possible.

The present and future challenges faced by the Dhaka city are multifaceted that need to be managed efficiently for reducing risks and vulnerability. These challenges are posing threat for optimisation and sustainable management of water resources and poverty reduction strategies. The dynamics of water for growth are extremely complex and highly dependent on driving forces like physical, technological, cultural, political, social and economic priorities.

6. Socio-Economic Impacts of Water Pollution

Dhaka suffers from water pollution, scarcity of pure drinking water, sewage management, water logging etc.. which pose a serious threat to public health, ecosystems and socio-economic life of the people. Pollution of the rivers and the change in the environment has seriously influenced the livelihood and living pattern of the city dwellers of Dhaka. Dhaka has not been able to keep pace with

the needs of the rapidly transforming social and economic demands of the growing population. Most migrants come from rural areas and their contribution to economic growth is significant, as they provide essential services to garments factory, housing, manufacturing, services etc. Dhaka has emerged as a mega city in the new millennium (World Bank, 2007). Dhaka, being a very large and dynamic city, has drawn substantial industrial investments, particularly in the ready made garments industry, which has created demand for workers and services. This migration, however, also adds tremendous strain on an already crowded city with limited inhabitable land and a low level of public services. The major socio-economic features of the city now are excessively high land prices, a large slum population, poor quality housing, traffic congestion, water shortage, poor sanitation and drainage, irregular electric supply, increasing air pollution, and poor governance. There is no urban planning to protect peripheral rivers and channels, which would accommodate the drainage water, and to assimilate waste discharges. Various studies and reports reveal that the extent of river pollution is now at an alarming level. Industry alone is responsible for discharge of more than 1.3 million cubic meters of effluents into the rivers everyday, compared to the daily discharge of 0.5 million cubic meter household waste water (Daily Star, 2008). As a result, natural resources and social life are severely endangered. Due to bad smell and unhygienic physical environment, people in large number are migrating from river side to other places. Inhabitants have become socially isolated from their relatives and friends. People are less interested to build relationship with the people living along river sides.

Three major types of diseases: skin diseases, diarrhoea and dysentery are spreading sporadically with industrial water pollution. Moreover, 20 types of illness due to industrial pollution have been increasing in the last ten years. Evidence of ground and surface water contamination has been found in areas near the polluted river Buriganga, particularly in Hazaribag area. High values of *E. coli* form have been observed in these areas (RPMC, 2008). Even people living in the vicinity of Buriganga are likely to be attacked by cancer for their contact with chemical wastes dumped into the water. The number of fish species has severely declined due to water pollution in the rivers. A recent study conducted by the Water Resources Department of Bangladesh University of Engineering and Technology (BUET) reveals that the oxygen level of the Buriganga and Turag is less than 1 mg/L. All species of local fish need 4-6 mg/L oxygen to survive. Many of the fishermen and boatmen dependent on the rivers for livelihood have shifted to other professions as the rivers have been polluted and dried up. Most of the the industrial effluents are dumped directly into the rivers Buriganga, Balu and

Sitalakhya. Pollution from tanneries in Hazaribagh is responsible for the increase in the health-related expenditure to 125 US dollar per capita of people living in the vicinity of the tanneries (GOB, 2005). These pollutants are causing serious damage to freshwater and healthy ecosystems as well. The unabated dumping of industrial wastes and sewage has polluted the waters to such a magnitude that it is no longer economically viable for chemical treatment. These kinds of pollution have a strong human health impact, particularly among the poor communities who are exposed to water-borne diseases.

7. Effects of Urbanization on Water Resources

Safe, affordable and stable water supply, proper sanitation facilities are vital requirements for human development and ecosystem survival. Without adequate quantity and quality of water, it will not be possible to ensure food, energy, health and environmental security (ADB, 2007). But as a result of rapid urbanisation and population boom, Dhaka city is facing serious environmental problems. Industrial expansion, rural to city migration, encroachment of the rivers/canals/water bodies, and lack of strict enforcement of environmental regulations with climatic change have significantly been contributing towards increased intensity of disasters. Consequently access to freshwater now has become a serious concern for city population and mankind as a whole. Unplanned urbanization and unregulated industrial expansion produce adverse impact on drainage situation, water quality, recharge of ground water, wetland ecology, and water retention.

Dhaka-Narayanganj-Demra (DND) project covering an area of 56.79 sqkm was ranked as one of the most successful projects of Bangladesh Water Development Board (BWDB), but it has now become a burning example where extreme environmental degradation has occurred due to unplanned urbanization and population increase, growth of illegal fish farms, and encroachment of canals/borrowpits by the filling stations without proper drainage facilities. The continual growth of fish farms in the project area is responsible for water logging. These fish farms block free flow of water into the canals to maintain their ponds leading to water logging. Another problematic factor is the encroachment of the canals that are being filled up by the filling stations (CNG/petrol pump) in the project area. Highways borrow pits/canals, which were 100 feet wide, have been narrowed down at points to only 12 feet. Most of the canals in the DND area have been filled up due to industrial waste and garbage dumping causing severe water logging during the monsoon because the project area is beyond the jurisdiction of the municipal authority to dispose up the garbages. About 1.5 million people (2005) of the DND project area live with the risk as the authorities concerned

failed to take long term measures to improve the situation. Two national highways such as Dhaka-Chittagong road and Dhaka-Narayanganj link road have bifurcated the DND project into three parts without adequate drainage facilities which cause obstruction of natural flow of water. Unplanned road network also causes flood hazards, drainage congestion and disruption in urban utility services. So, to improve the existing drainage situation, re-excavation of drainage canal, rehabilitation of pump station and construction of road crossing bridge and culverts are needed to restore the normal livelihood for the dwellers in the project area adjacent to the Dhaka city with socio-economic and environmental upgradation (BWDB, 2008). Hence the urban planning should be based on comprehensive and integrated approach towards mitigation of such adverse impacts.

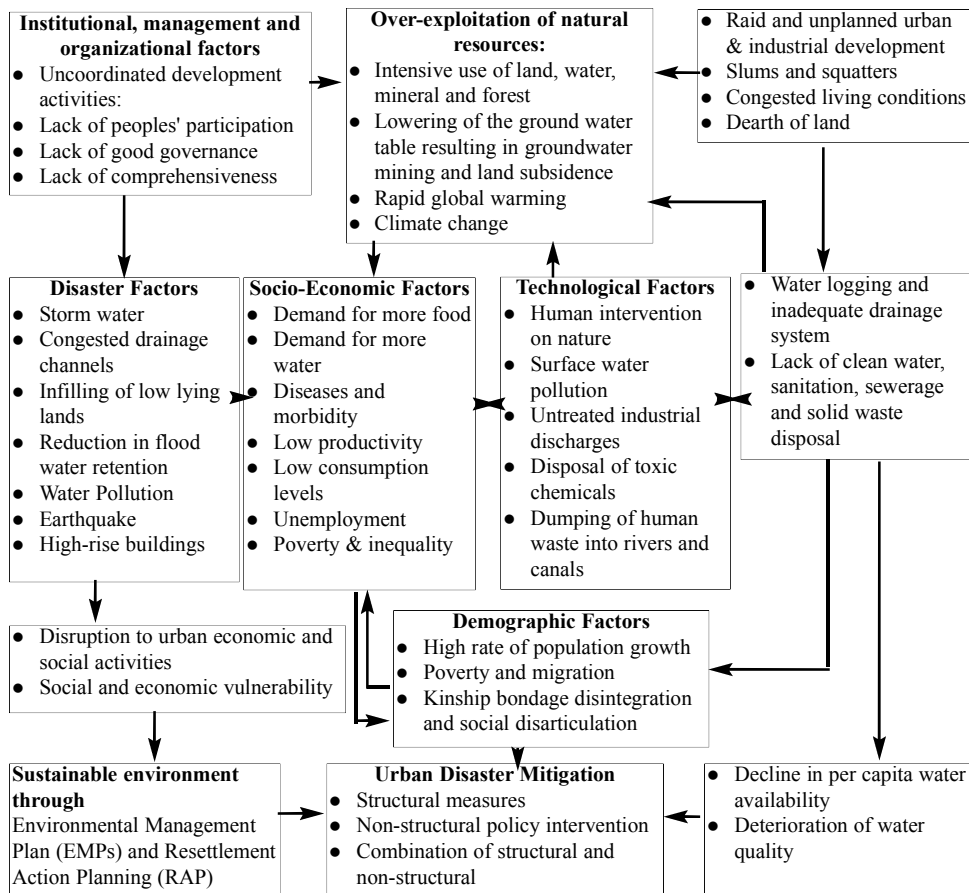
7.1 Water Quality

Surface water of Dhaka is in a very poor condition, especially in the dry season. Consequently, dilution of contaminants is drastically reduced in the dry season (World Bank, 2006). The water quality of the rivers has been seriously affected. Water and air pollution has already become a serious concern. The surface water in Dhaka is polluted severely through dumping of municipal solid wastes, indiscriminate discharge of untreated waste water and industrial effluents, oil and lube spillage from the operation of river ports and ship wreckage. The serious surface water pollution is found in Buriganga river due to tannery wastes and industrial discharges and domestic sewage (Islam, et.al, 2003). It has been reported in recent surveys that around 60% of pollutants are generated from industrial sources and the rest 40% are mainly from domestic sources and to a lesser extent from untreated dispersal of lube and burnt oils from river transport/vessels. It is reported that more than 60,000 cubic meter/day of toxic waste from industries enters the Dhaka canal and river system. Both industrial effluent and domestic waste water are being disposed mostly untreated into the wetlands and natural streams in and around Dhaka city causing pollution of river water and affecting ground water quality. Every year ground water level is receding fast due to over extraction. River encroachment is narrowing the river width and reducing the water flow. Large scale sedimentation in river beds is causing reduction of normal depth of river (RPMC, 2008). Because of human activities like encroachment of rivers, floodplains and low lying areas, disposal of sewage and solid waste, industrial waste disposal and high rate of migration of the poor people in the slum areas of Dhaka city, the peripheral rivers are being polluted seriously. Apart from industrial sources, surface water in Dhaka is also extensively polluted by human faeces as sanitation is inadequate.

8. Environmental Concerns

Dhaka city is under threat due to rapid urbanization, population pressure and extensive resource use, conversion of wetlands and channels into housing settlements and other various human interventions. Interrelationships of different factors of disasters and their possible impacts are shown diagrammatically in figure-1. Human interference on nature has limited the biodiversity and aquatic habitats. Bio-diversity preservation is an urgent need of time to save the civilisation and face the challenges of the 21st century. Quality of water and soil has deteriorated due to unplanned land use, undesirable encroachment for settlements, indiscriminate disposal of hazardous industrial and sewage wastes. A serious problem in the urban areas is the mushroom growth of real estate business,

Figure1: Dynamic and complex interrelationship between urbanization and environmental issues



which accelerates the filling of low lying areas, natural channels and ponds for construction of high-rise residential and commercial buildings.

The growth of high-rise buildings is causing reduction in the floodwater retention areas, thereby causing water logging and drainage problems in the city area. Illegal occupation and constructions in the surrounding rivers drastically reduced the drainage potentialities of the city which enhanced degraded environmental condition. Smooth navigation and fisheries are also adversely affected by such kind of encroachments (BWDB, 2007).

9. Role of Government in Combating Surface Water Pollution

The pollution of both surface and ground water around various industrial centres by untreated effluent discharge into water bodies is a critical water management issue (NWP,1999). The National Water Policy on industrial pollution states that the policy (1999) of government in this regard is:

- Zoning regulations will be established for location of new industries for fresh and safe water availability and effluent discharge possibilities
- Effluent disposal will be monitored by relevant government agencies to prevent water pollution
- Standards of effluent disposal into common watercourses will be set by Water Resources Planning Organization (WARPO) in consultation with Department of Environment (DoE)
- Industrial polluters will be under law to pay for the cleanup of water-body polluted by them

The departmental agencies and their functions in combating surface water pollution are shown in Table1.

Encroachment and pollution of the rivers surrounding Dhaka continue despite the existence of good number of government agencies involved in the management of the rivers and water bodies. It has worsened due to lack of co-ordination among different service agencies like DCC, Roads and Highways Department (RHD), RAJUK, BWDB, DWASA and DoE. There is a serious problem of overlapping of jurisdictions among many government agencies which leads to inaction. The roles of DCC, the planning authority RAJUK and the line ministries in urban management are not clear and co-ordination among them is very limited. All relevant government agencies need to come forward for a comprehensive management of environment in land and water in and around Dhaka city. The existing laws and regulations need to be updated, including restructuring and re-

Table 1 : Responsibilities of Government Institutions regarding water quality of Dhaka

Agency	Services
Department of Environment (DoE)	Enforcement of environmental rules, administration of the Open Space and Wetland Conservation Act, 2000 and Urban Water Body Protection Law, 2001.
Dhaka City Corporation (DCC)	Responsible for handling and disposal of solid waste; management of public green spaces; surface drainage maintenance of some lakes, operation of health facilities.
Rajdhani Unnayan Kartipakha (RAJUK)	Detailed Area Plan (DAP) for a planned township ensuring environmental upgradation.
Dhaka Water and Sewerage Authority (DWASA)	Responsible for ensuring supply of pure, safe, and dependable water to city dwellers and regular disposal of sewage.
Bangladesh Water Development Board (BWDB)	Implementation and Maintenance of water resources projects for flood control, drainage and environmental improvement.
Ministry of Land (MoL)	Control and administration of government owned land, including land reclassification and settlement of land reclaimed and accreted.
Bangladesh Inland Water transport Authority (BIWTA)	Responsible for inland water transport and maintaining navigable waterways; dredging, shipping terminal maintenance
Ministry of Industry	Overall policy direction for industrial development; a role in development of industry in specified zones in compliance with pollution control regulations in factory design.

organization of the different development agencies and their co-ordination for effective and balanced development of the mega-city in the present context of socio-political and structural realities. It is important to establish an apex body with administrative, financial and enforcement power for co-ordination of their activities effectively as well as for cost-effective mitigation measures to build support for better management. Environmental concerns are multi-sectoral issues for which institutional arrangements are critical to the success and failure of all initiatives.

9.1 Promoting Compliance

Industrial discharges into rivers, canals and ground water must be controlled if water quality is to be improved. This will require strict enforcement of environmental clearance condition and effluents standards. There has been no strict enforcement of environmental regulations to date. To reduce the pollution of

surface water bodies, both on-site and centralised treatment plants for industrial effluent are required. Each industrial unit should have an effluent treatment plant according to the Environment Conservation Act-1995. To reduce the pollution of ground water bodies, a reduction of pollutants leached to the aquifer can be achieved by on-site treatment in combination with improved conveyance of effluents to a centralised treatment facility. Strict control on new industrial setups around the city must be applied through more effective use of the Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA). It is encouraging that Government of Bangladesh (GOB) has already taken decision to remove the Hazaribagh tannery in the industrial complex at Savar with a provision of treatment plants of the effluents. Similar action should be taken for Dholai Khal outfall containing sewage wastes.

9.2 Priority Projects Under BWDB

Dhaka Integrated Flood Protection Project was implemented covering the most densely populated western part of about 136 sq. km. with a view to providing the city dwellers a living condition free from floods, drainage and environmental hazards (BWDB, 1992). Environment of city improved as polluted water does not stay within the city area and trees have been planted on the sides of the embankment. Living standard of the city dwellers has improved due to this project. Yet a vast area of about 124 sq.km. of Eastern part remains unprotected. However, the Dhaka Integrated Flood Control Embankment cum Eastern Bypass Road Multipurpose Project is now under the process of approval of GoB (BWDB, 2008) to protect the eastern part of Dhaka city from floods, drainage and environmental hazards. Realistic remedial measures are also being undertaken to augment the flow of Buriganga for ensuring proper management of water resources for environmental conservation (BWDB, 2006). Besides, some steps need to be undertaken for protecting the existing flood control works, preventing illegal use of land and illegal occupants, including construction of illegal structures, which create the problem of water logging by narrowing the drainage canals. Treatment of all industrial waste needs to be ensured to protect environmental degradation. It is also equally important to recover areas occupied by land grabbers in the absence of Rajuk Detailed Area Plan (DAP) for accumulating waste water for pumping and protecting the overall environment.

9.3 Further Actions to be Taken

Government should have a dynamic role to mark the areas of rivers and canals, which were illegally encroached upon, to bring back their original shapes and sizes. Following steps will need to be taken for that purpose.

- Land reclassification for industries, commercial and residential areas
- Strengthening water quality monitoring for participatory EMP/ETP
- Strict enforcement of the Environment Conservation Act-1995 & Rules for maintaining a habitable environment
- Establishment of standards of effluent disposal into common watercourses
- Providing fiscal and other financial incentives for retrofitting or for reduction of effluents from industries
- Devising effective water quality management technology
- Applying polluters pay principle to make the polluters land to rectify them

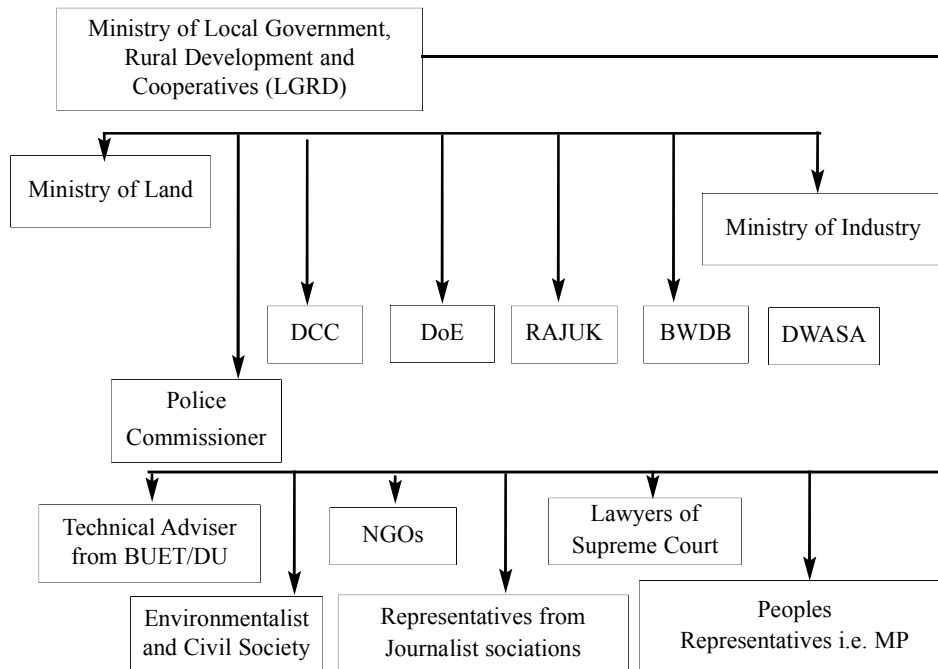
10. Participatory City Management (PCM)

The administrative structure of service delivery by government institutions in Dhaka city is complex. Services are delivered by different agencies with poor governance and lack of co-ordination. The main causes are the limited role and authority of the DCC in urban management. It has a limited role in city planning and management and is highly dependent on the central government. Urban planning still lies on top down planning approach without consultation of the local. The approach should be bottom up wherein the local will be involved and participate in urban planning and management. The Government alone can never solve the problems and disasters properly without people's participation with its limited resources and manpower. For this reason peoples' participation is essentially required. DoE has the responsibility of enforcing environmental regulations as these affect land and housing development. In the circumstances, without public awareness, and consciousness development and structured planning procedures, it is impossible to achieve better institutional framework. It is evident that government have failed to solve and mitigate the different problems faced by city dwellers. What is still lacking is structured planning, and development and management procedure with enhanced peoples' participation in city management. In the case of Dhaka city with a population of about 12 million, government alone cannot face the different types of urban disaster. For successful management and mitigation of water-related disaster, peoples' participation is essential. So, participatory approach of city management is given emphasis to effectively cope with complex issues of current trends of urbanization. Government alone is not enough to manage, mitigate and to conduct rescue operations during the onset of disaster. A strong apex body should be formed to promote cross-sectoral coordination and minimize jurisdictional conflicts. An important element of the strategic framework will be to monitor environmental pollution in compliance with public information, aimed at raising awareness of

the causes and impacts of environmental degradation and at disseminating information about related intervention. Such initiatives are essential to build civil society and private sector support, both for the necessary investment and for strengthening enforcement of environmental regulations. The participatory approach of management has been proved to be pragmatic in different sectors e.g. water sector, community self help programs etc. The Participatory City Management (PCM) will work in other areas of city management including disaster. An organizational framework of the PCM may be conceived as follows (Chart 1).

PCM will bring opportunities for local people's participation to achieve compactness in townships to maximum level of economy, convenience and beauty. Both government and people should come forward for sustainable service delivery. By ensuring good governance PCM will determine the preparation and implementation of city master plan to a great extent. PCM is one in which people can work and perform their tasks easily, conveniently and economically. The purpose of PCM is to make the city functionally efficient for all the residents and users making the city environmentally healthy and sustainable.

Chart 1 : A suggested organizational framework for Integrated Environmental Management (IEM) in Dhaka city



11. Mitigation Measures of Urban Disasters

Urban disaster management in Dhaka is not only limited to technical aspects but it also encompasses social, economic, cultural and environmental needs. The mitigation measures will include integrated strategies for structural and non-structural interventions, institutional participation, infrastructural security, and enhanced community safety and resilience. In a nutshell, integrated disaster risk management, effective monitoring and evaluation, active community participation and networking are the key factors for successful mitigation of urban disaster. It recommends appropriate method of mitigation, preparedness and emergency response, proper education, information, effective forecasting and early warning.

Recommendations are made for implementation method of land use planning and legislation, housing and settlement, landscape design, urban conservation and the management of water resources up to the optimal level. More attention should be given while implementing projects for flood protection and road network. Any solution to be permanent and sustainable for mitigation of disaster calls for broad political and social consensus for the comprehensive plan. The present system as experienced cannot be the solution and it must be changed. What is needed is to think strategically for a properly planned city to promote PCM to enforce regulatory measures to protect environment and combat surface water pollution. There should be PCM to deal with public health, education, water supply and sanitation problems necessary for healthy growth and socio-economic development. Participatory approach of city management is essential for overall improvement of economic, social and environmental condition. It is urgently needed to establish an apex body which will co-ordinate the activities of DWASA, RAJUK, DCC, BWDB and other agencies to save Dhaka city from any disaster. Citizens should be sensitized and motivated through awareness building by DCC and through community participation. DCC should provide adequate service to urban people and formulate an appropriate slum development policy with the participation of slum dwellers.

The mitigation measures can be phased into three stages for prioritized implementation:

Immediate measures

- Strengthening the performance and promoting co-ordination of the government and non-government institutions.
- Restoring illegally occupied lands in canals and rivers of Dhaka city and to

finalize the Detailed Area Plan by Rajuk.

- Building awareness amongst the citizens and ensuring participatory management.
- Ensuring sustainability of water supply and monitoring of water quality by DWASA.
- Compelling the polluters to install Effluent Treatment Plants (ETP) for all industries.
- Shifting of Hazaribag Tannery and treatment of Dholai outfall containing sewage.
- Establishing sewage treatment plants.
- Water quality monitoring by applying polluters penalty system.

Mid-term Measures

- Opening silted up river and channels by dredging for improving the drainage water flow systems and navigations.
- Shifting of dockyards from Buriganga river banks to further downstream for making proper environmental management.
- Establishment of phase-wise Central Effluent Treatment Plants (CETP) in industrial areas.
- Increasing DWASA's sewage coverage from present 30% to 75% of the city area.
- Bringing industrialists under a broader commitment for overall pollution control.

Long term Measures

- Augmentation of the Buriganga flow by restoring silted up links with Jamuna by BWDB.
- Maintaining navigability of the Buriganga and improvement of water quality of the surrounding rivers.
- Ensuring full sewage coverage by DWASA.
- Bringing all industrial units under full CETP coverage within 2015.
- Using state-of-art technologies and a wide range of alternative materials.
- Decentralising Dhaka and spreading out the economic activities outside Dhaka.
- Motivating industrialists to introduce cleaner production technology to minimize pollution load at industries.
- Implementation of Dhaka Integrated Flood Control Embankment cum Eastern Bypass Road Multipurpose Project to protect the eastern part of the city from floods, to remove water logging and to upgrade overall

environmental condition by BWDB.

- Develop a plan for protecting floods and proper drainage of the city area and implement it through PCM approach.
- Need-based research and development on monitoring and evaluation of water resources in Dhaka city.

12. Conclusion

Among the disasters that occurred, human-induced disasters are no less important than natural disasters. Pollution of both surface and ground water caused by human activities and interventions may create a havoc making the city uninhabitable. Hence, natural disasters and human-induced disasters should be concomitantly addressed. Water use efficiency and pollution control of both surface and ground water in the future should be taken within the framework of emerging technology, social goals, national and international rules and regulations, environmental concerns and socio-economic realities. Needless to say, surface water treatment would be cost effective if the pollution level of surface water can be reduced substantially through effective preventive measures in cognizance with acceptable water quality standards. Existing pollution of surface water should be treated and protected from further pollution by untreated domestic and industrial waste water. Many opine that the urban environment is going to face impending crises if the surrounding rivers and water bodies are not appropriately protected to make a pollution-free healthy environment. Improved performance and coordination among the Government and NGOs are crucial with greater involvement of participation of the commons. GoB alone will not be able to face all of these problems. As an approach to solve the problems, PCM may be considered a possible strategy by involving all the stakeholders of a city to address such a complex issue. In fine, management of water-related disaster in a populous mega city like Dhaka needs an intensive and comprehensive study. People of Dhaka city would discover a “new sun” shining overhead when such anthropocentric vision would ultimately be achieved. Indeed, it would be of utmost help to humanity in the long run.

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