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Emergence of Water Sensitive Design: Alternate Development Strategies for Eastern Periphery of Dhaka Metropolitan Area

Ayasha Siddiqua*

Department of Architectural Engineering, Ahsanullah University of Science and Technology, Dhaka, Bangladesh.

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K E Y W O R D S

Lowland, Urbanization, Flooding & Water logging, Water Sensitive Design.

A B S T R A C T

Dhaka, the capital city of Bangladesh, once had lowland on both the western and the eastern parts. The low-land on the west has already fallen prey to urbanization after the construction of the flood embankment, and the eastern region, it is on a process of disappearing very fast. The city is now expanding to areas that were mandatory open flood plains to keep the city flood-free. Lack of physical planning is very evident here, which causes significant degradation of the situation. At present master planning of the city following subdivision of land provide little attention to water problem when zoning. Dhaka city had an elaborate system of water bodies and low-lands. The vast low-land on both sides let the rivers spread over a broader area, maintaining the depth of flooding in low. The low-land was the flood plains that stored water before discharge into rivers. The city is expanding drastically by grabbing all the least open areas and worsening the flooding scenario rapidly. Keeping these issues in mind this paper tried to understand the water system for the city, reasons for water (flooding, waterlogging) problems, the role of eastern low and wetland to control the city's flooding situation. Focusing on the eastern periphery, this paper will try to find the landuse change for the last two decades with an emphasis on the natural area's conversion. Finally, following the local way of utilizing water bodies in everyday life extracting from literature and fieldwork, this paper will suggest some alternate design strategies for upcoming development through understanding the water system and checking flood problems in control also ensuring environmental quality.

* Correspondent Author contact: ayasha9735@gmail.com , +88 01741887229
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Introduction

Geographically Bangladesh is located at the lowest riparian of the Ganges-Brahmaputra-Meghna basin, one of the largest river systems in the world (Fig. 1). Dhaka, the capital of Bangladesh, was established on the arm of Buriganga dated back to the 6th century. Being located in the world's largest delta system, the abundance of water and land resources has always been the geographical and historical feature of Dhaka city. With rivers all around the city, Dhaka was amidst a rich web of surface water bodies like several hundred ponds, lakes, more than sixty canals, retention ponds, peripheral lowlands and flood plains as early as the 1950s (Dani, 2009; Rahman, 2011). The water bodies comprised about 52% of the city area in 1978 (Khan- et al, 2015) and played an important role in the city's water management system. During the monsoon, the water bodies helped drainage, served as retention basin, and maintained the overall hydrological, ecological and environmental equilibrium. The built environment in this territory adapted the characteristics of natural water system and embraced the landscape through production, trade, communication, defense, distinct social activities. It acquired the title of "Venice of the East' during the seventeenth century (Dani, 2009; Rahman, 2011).

On the west and east side of the city, there are huge low laying areas of Meghna, Sitholakkha and Turag River. The ground elevation of the greater Dhaka varies from 0.5 to 12 meters and most of the urban areas are only 6-8 meters above the mean sea level. 50% to 60% of the areas of the city are between 0.5 to 5-meter levels (DAP, 2010). As surrounded by several major rivers and due to low topography the city is subjected to periodic flooding from an early age. Incessant rainfall during long monsoon, sea-level rise, high temperature and excess rain due to climate change has further aggravated the problem. The climatic condition of this region makes the city more vulnerable to water disasters. In recent years, besides periodic flooding due to spillover from rivers, Dhaka is also facing waterlogging. Every year the city remains inundated for several days during the rainy season. Climate change also has an impact and Dhaka is not immune to it. It is estimated that with 1.5 m sea level rise Bangladesh will lose 16% of its land in the sea and at least 15% population will be affected (Fig. 2) (Khalequzzaman, 2007).

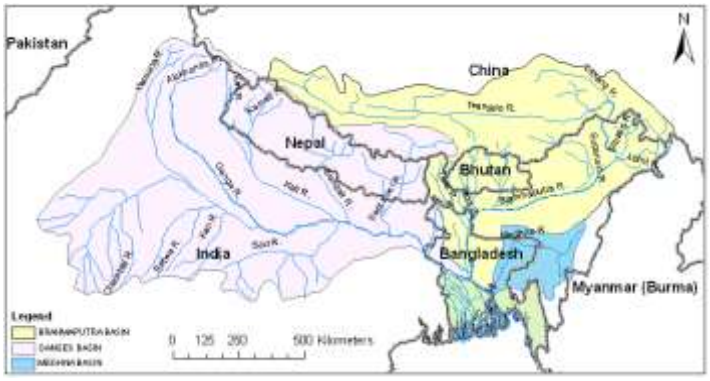


Figure 1: Bangladesh on the basin of world's largest river system: Ganges-Brahmaputra-Meghna basin
Source: www.dartmouth.edu/~floods/images/2003134Loc.JPG

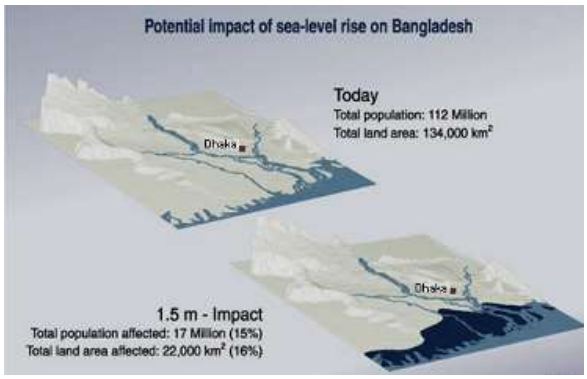


Figure 2: Effect of sea level rise due to climate change on Bangladesh.
Source: http://maps.grida.no/go/graphic/potential-impact-of-sea-level-rise-on-bangladesh

Rapid Urbanization Ignoring the Water System

The rapid increase of technology, material development and the changing socio-economic situation have resulted in urban expansion all over the world (Abhas-et al, 2011). Projections suggest that over the next 30 years, virtually all of the world's population growth will occur in the urban areas of low- and middle-income countries, mainly in the South (UN-Habitat, 2010). The population of Dhaka has rapidly inflated from nearly 1 million people in 1972 to 19.58 million in 2018 (UN 2019) making it one of the most densely inhabited and most quickly urbanized cities in the world. The area of Dhaka Mega city had expanded 17.88 times from its size in the year 1951, over the same period the population had increased 25.09 folds (Islam, 2009).

Due to population pressure and extensive urbanization, the landuse patterns in many countries - particularly in developing cities, has resulted in fragmentation and impermeabilization of the natural landscape and irreversible disturbances of hydrological systems via reclamation, alteration and pollution (Leopold, 1964, Randolph, 2004, Huggett-et al, 2004). These activities have a profound adverse effect on natural resources particularly on our water environment like degradation of natural water system, increase of runoff, flooding, disaster, pollution. Dhaka has seen unprecedented growth in the last couple of decades, experiencing rapid urbanization and the development of urban infrastructure. As a consequence, the land cover and landuse changes of Dhaka city are a common phenomenon extensively by the progressive urbanization. Dhaka Metropolitan Area (DMA) now covers an area of 306 km2 and accommodating the total population of around 9 million in 2015 (Khatun-et al, 2015). Between 1989 and 2014, the urban land use change in Dhaka city revealed that built-up land increased over 10 times (from about 11.6 km2 to 118 km2) (Syeda-et al, 2017) and caused huge destruction of the natural environment (Fig. 3).

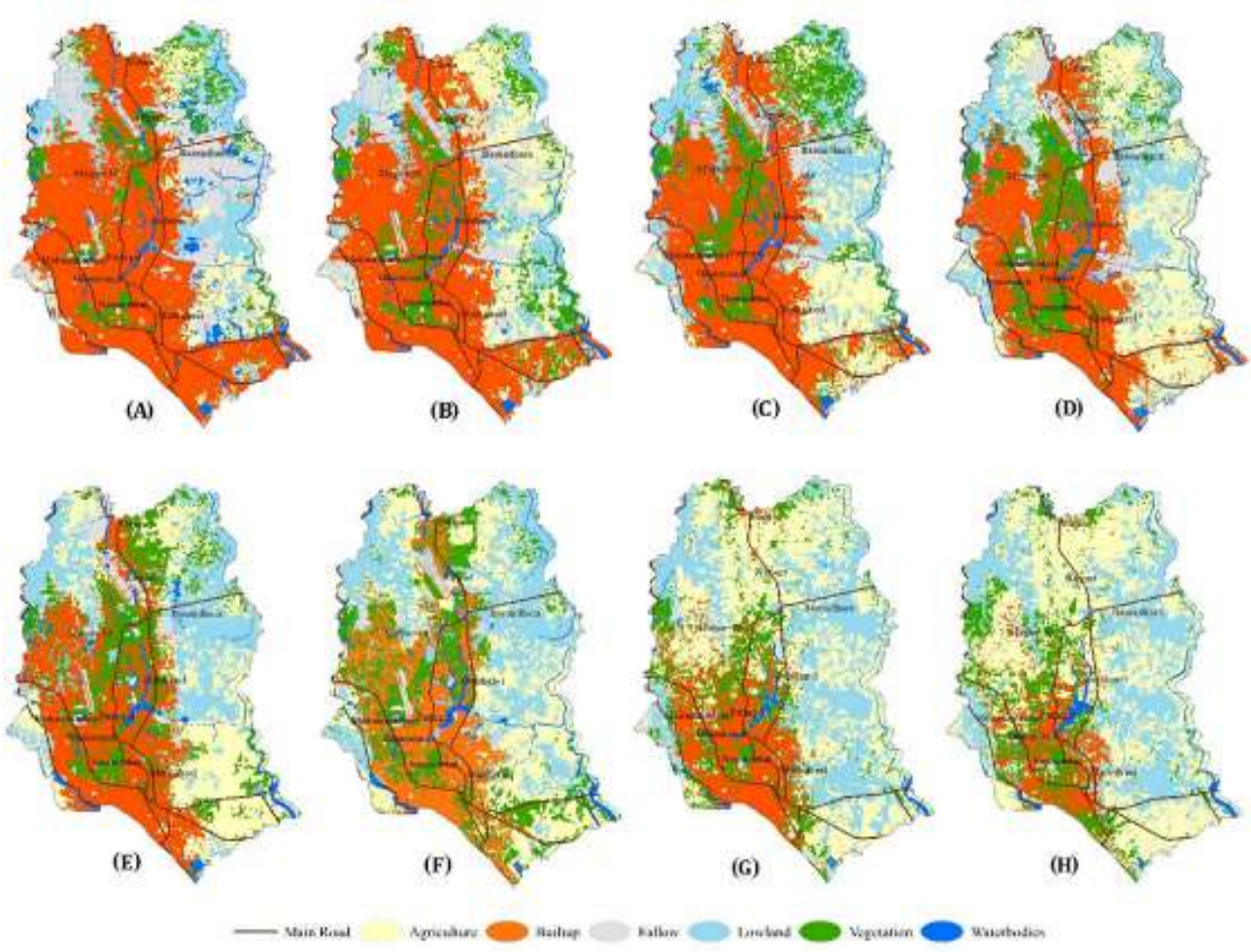


Figure 3: Land cover map of the Dhaka Metropolitan Area (DMA) between 1972 and 2015. (A) 2015; (B) 2010; (C) 2005; (D) 2000; (E) 1995; (F) 1990; (G) 1980; (H) 1972. Source: Hassan-et al, 2018.

In the recent decades, extreme urban expansion has altered the natural surface water bodies and landscape elements of the city which have reduced to about 21% and 17% of DMA in 2009 and 2015 respectively (Khan-et al, 2015, Hassan-et al, 2018) (Fig. 4). Analysis done by Dewan (2012) over DMA shows that the built-up areas increased to about 344% in 2005 compared to that of 1960, whilst the increment of landfill/bare soils is about 256%. About 18.72 km2 of Rivers & Khals, 76.67 km2 of wetland has lost during the last 30 years from 1978 to 2009. That means, about 60% of existing wetlands and about 65% of Rivers & Khals have disappeared in the last three decades in the Dhaka Metropolitan Area (Khan-et al, 2015) (Fig. 5). These activities are rapidly transforming the existing hydrological landscape without considering the possible long-term consequences (e.g. flooding, disaster, pollution) and essential requirements for water sensitive built environment.

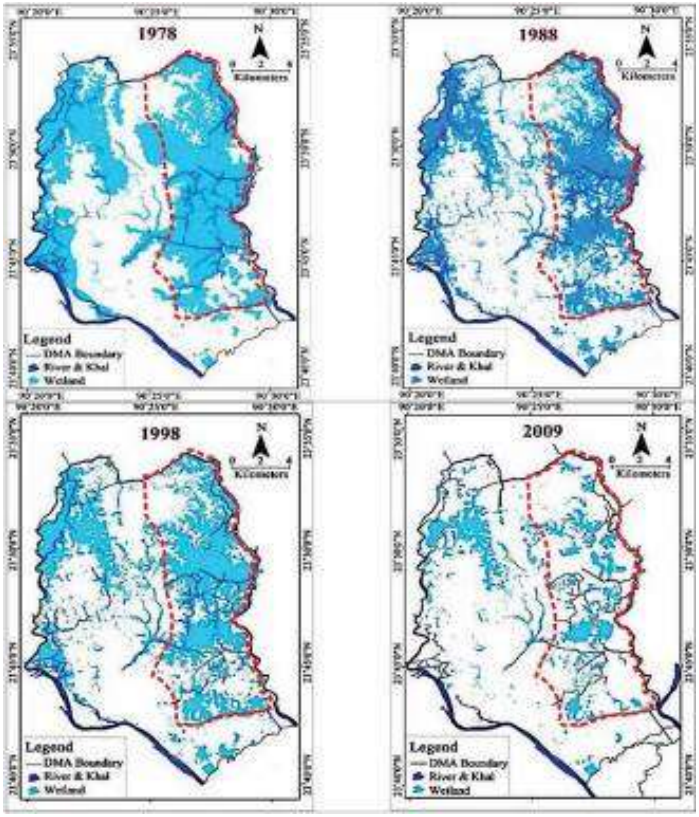


Figure 4: Change in Water bodies from 1978-2009.
Source: Khan-et al, 2015

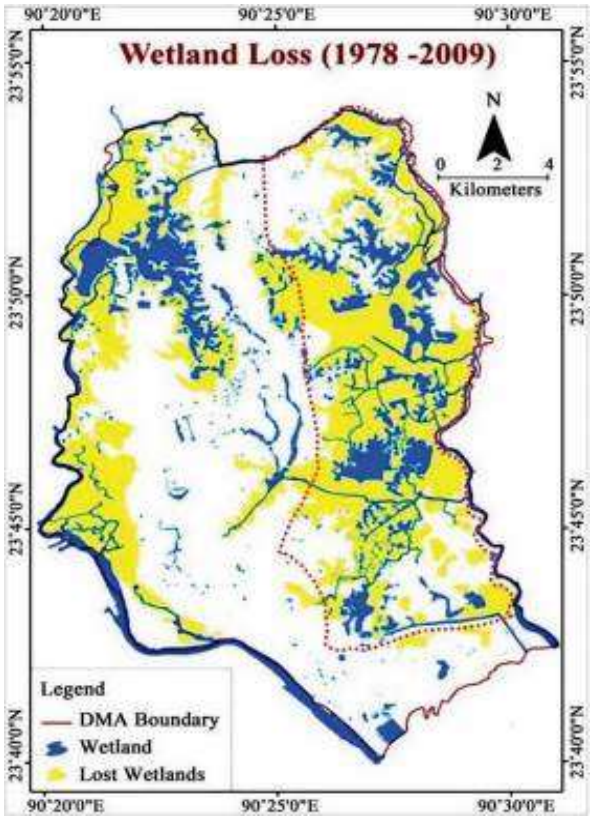


Figure 5: Loss of Wetland from 1978-2009.
Source: Khan-et al, 2015

Dhaka with the Flooding Problem

Flooding in Dhaka city has occurred basically for two reasons. Firstly, because of the backflow from the high water level of surrounding rivers and secondly due to excessive monsoon rainfall. The insensitive urbanization has made Dhaka more vulnerable to natural hazards, particularly to flooding and waterlogging during monsoon. Filling up lowlands and canals for the sake of development disrupts the smooth drainage towards the peripheral lowlands and reduces their storing capacity of water. Therefore, it causes waterlogging for these peripheral areas as well as for the entire city, which has been identified as one of the major problems of the City (World Bank 2007). Construction of new buildings through private land developers, real estate business by filling up water bodies resulting the reduction of water retention areas, thus city losing its storm water storage capacity and increased scope of flooding by waterlogging.

Dhaka experienced several serious flooding since the 1960s, of which the 1988, 1998, 2004 and 2007 floods were the most damaging. These flooding problems are further extended with intolerable waterlogging for several days due to poor drainage conditions. Particularly, the lowest-lying part of Dhaka, located in the Eastern fringe of the city, faces the most severe risk of flooding. Furthermore, experts fear that the flood vulnerability and frequency of Dhaka are likely to exacerbate due to probable climatic change (Faisal-et al, 1999) with increasing monsoon rain and sea level. In addition to the flooding problem, the destruction in the natural hydrological structures are accelerating other environmental degradation like decrease groundwater recharge area, disturbance to bio-diversity, increased impervious surface, disturbance of aesthetically pleasant sites, and above all interrupt the balanced living condition.

Rich Wetland in the Eastern Periphery of DMA

The Eastern periphery of Dhaka city bounded by Balu River is lower than the west and acts as lowland for the whole city with rich ecosystem (Fig. 6). These lowlands fundamentally serve as a natural water reservoir for flood mitigation and regulator to recharge of groundwater. This area is also valuable for stabilizing local climatic conditions, and habitat for fishes and other aquatic animals. It is largely used for

seasonal agriculture and offers great scenic beauty to the urban landscape throughout the whole year with seasonal variation. Therefore, by regulating the flooding situation for city these lowlands have multiple values in city life.

Geographically, the eastern part area of DMA is low in topography (2m-5m) (DAP, 2010), which is gradually slopes towards the Balu River and nested with huge natural canals, water bodies. These hydrological infrastructures all together work as detention, retention basin and natural drainage system for the city during monsoon (Fig. 7, 8 & 10). Before 1970, the eastern part of DMA was mostly low laying area and a few village-like homesteads existed there (Jahan-et al, 2013). Most of the part was flooded during monsoon and the rest of the year the area was used for agriculture purposes. But after 1980, the area started to become urbanized and in the 1990s and 2000s it has accelerated (Dewan-et al, 2012).

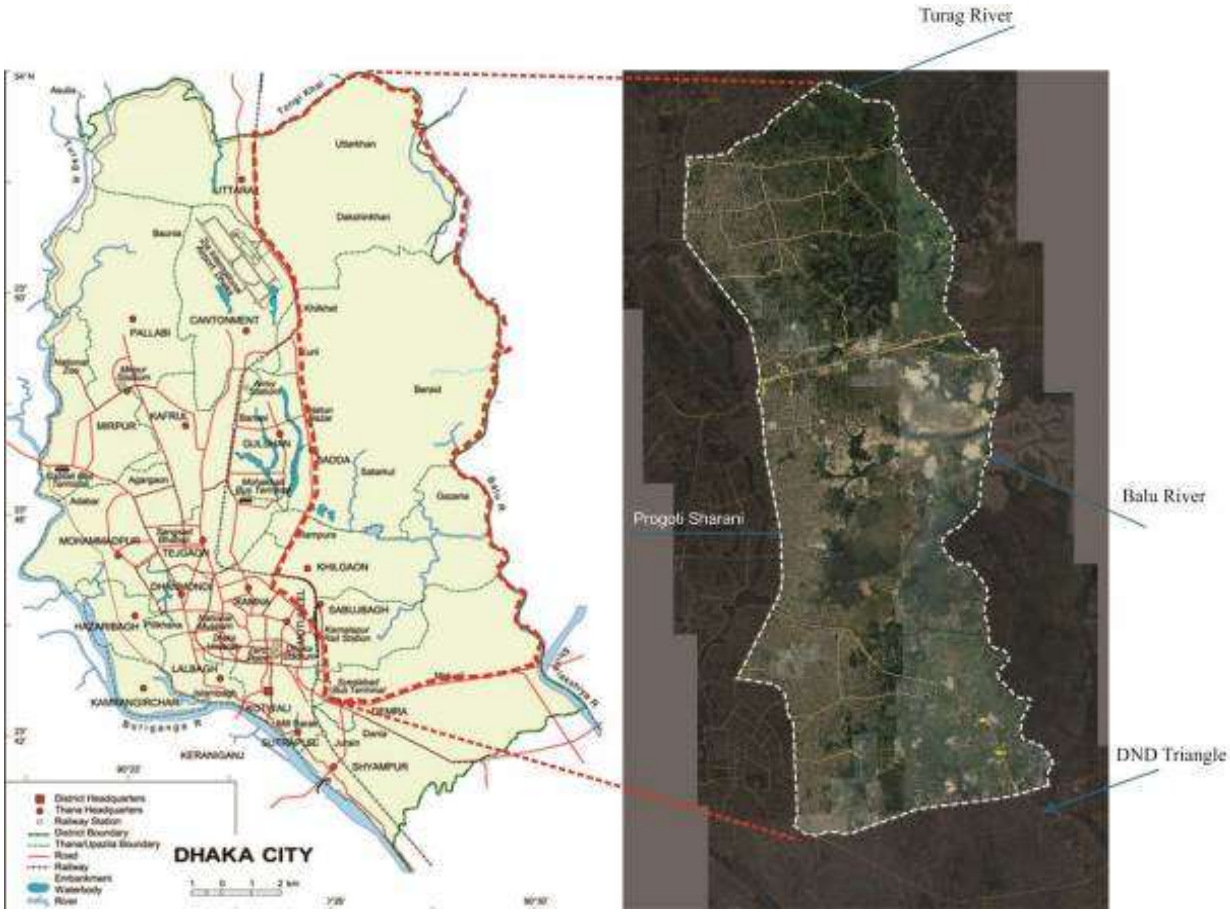
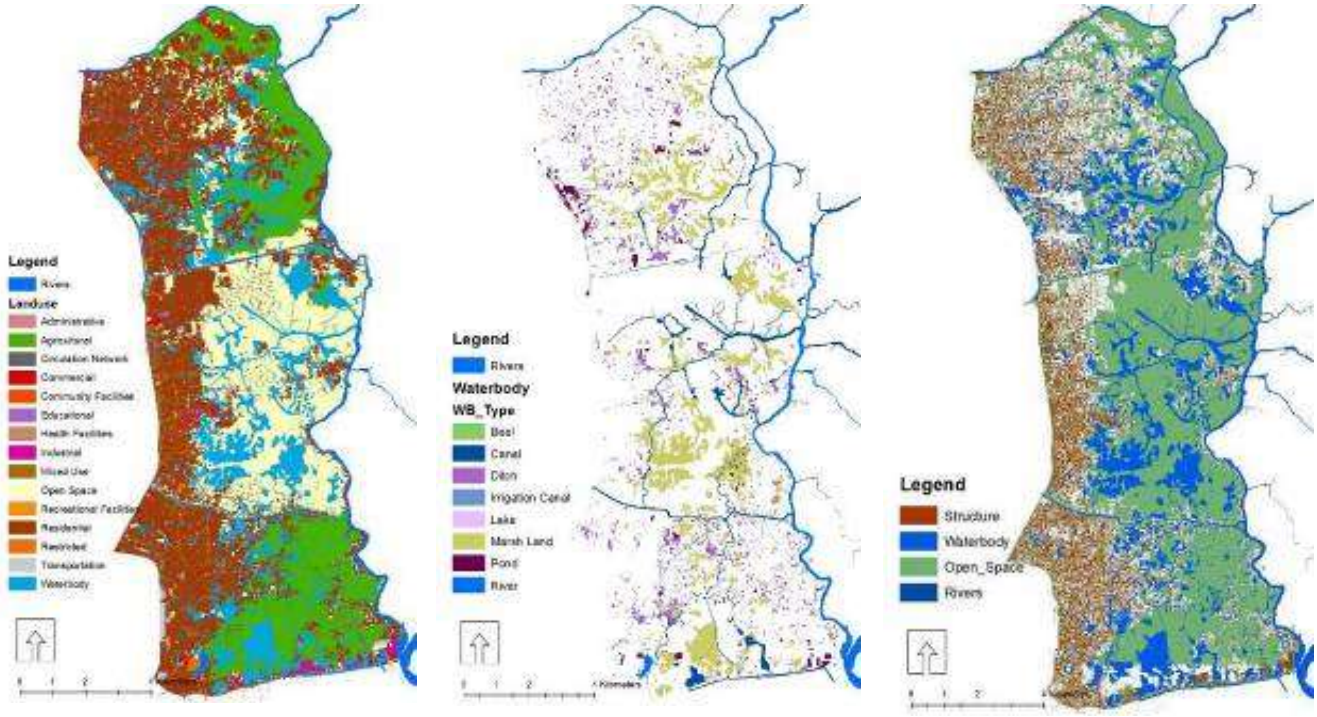


Figure 6: Eastern periphery in the DMA

Figure 7: Rich Eastern periphery of DMA is the great resource for city's hydro-ecological balance



a. Land Use b. Water bodies c. Built and open area

Figure 8: Existing Land use, Surface Water bodies and Open Spaces in Easter part of DMA in 2016. Source: DSP (2016-35)

Destruction in the Eastern Edge

In the early 1990s, the city was extending to the western low-lying areas which was further accelerated after the construction of flood embankment in the western edge in 1992. While in the late 1990s and as well as in the 2000s, urbanization activities redirected to the eastern wetlands (Dewan-et al, 2012) as the southern and western parts have already saturated and controlled for further densification due to embankment and rivers. A vast tract of lowland in the east - located at proximity to the central city has been attracting the greedy private developers since 1980. Being cut off from the drainage network with the city, this area becomes dry up during the dry season and the land grabbers easily occupying the land for their money earning business. Nowadays, there are lots of housing developers occupying this low land and their banners for advertisement of housing are floating over water during the wet season. There are remarkable number of housing projects located on restricted flood flow zone and allocated retention ponds.

The land use of the eastern peripheral area have started to change from open space and agricultural land to housing for residential purpose by private land developers. In 2006, major land-use categories of this area consisted of agriculture (34.4 percent) and residential use (32.3 percent), followed by vacant land (14.0 percent) and water bodies (14.6 percent) but in 2016, this land use has altered inversely, keeping 37% of area as natural landscape - water bodies and agricultural land (Table 1). From 2006 to 2016 (Fig. 9), in the eastern periphery, the built-up area increased by 12% and the natural area decreased by 12%. Among them, there is a mentionable decrease in agricultural land (17%), which is seasonally converted into wetland. Even more, there are also a large increase in vacant land (8%) due to landfill over agricultural, wetland and water bodies. While the rest of the land of the eastern periphery has already occupied for built-up areas (Fig. 11). Dr. Ishrat calculated that if such a trend continues, there will be no wetland in this area by 2035 (Islam, 2009).

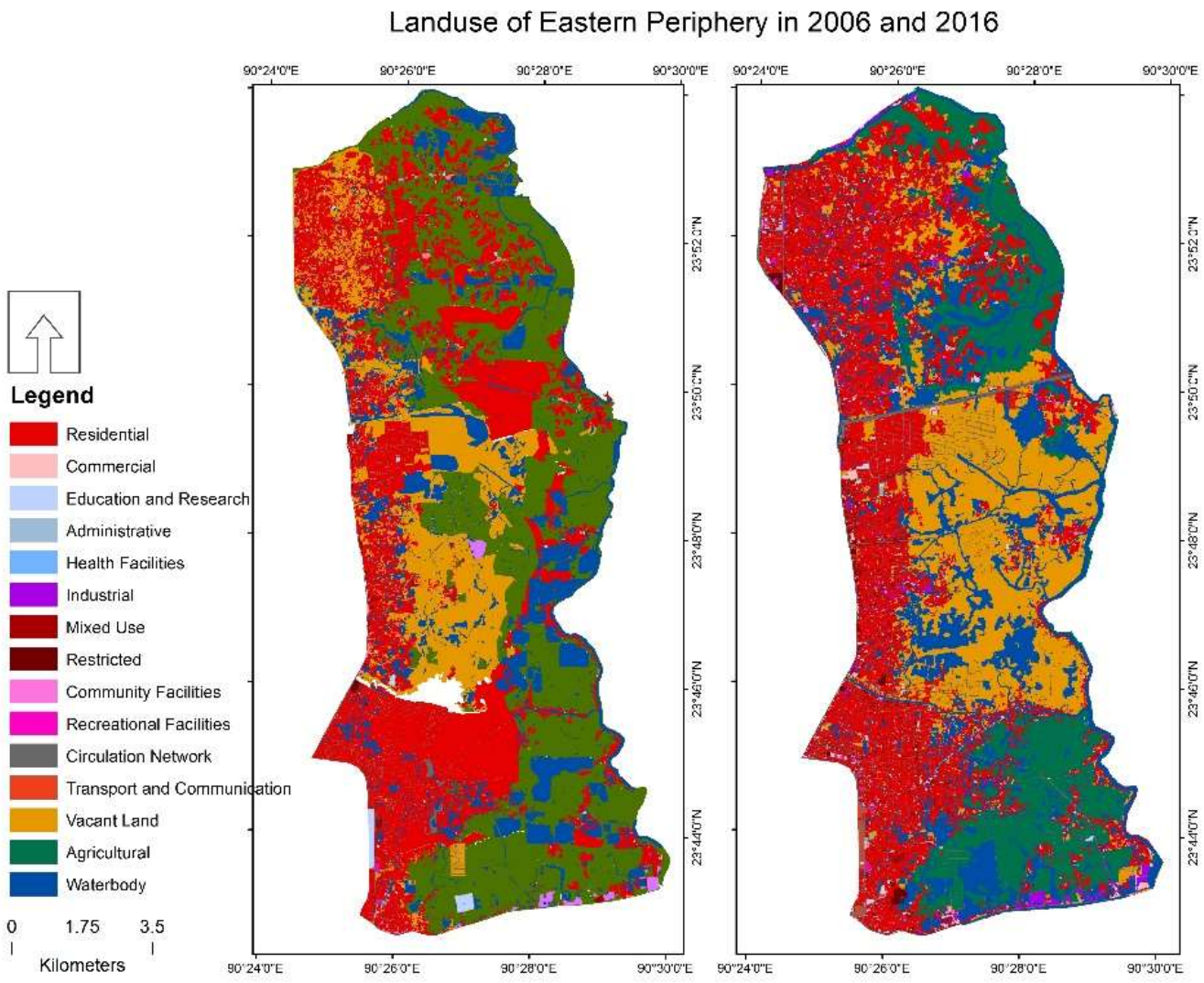


Figure 9: Landuse change of Eastern Periphery fron 2006 to 2016
Source: DAP 2010 and DSP 2016-2035

Table 1: Landuse of Eastern Periphery in 2006 and 2016

Major Landuse Category in 2006			Major Landuse Category in 2016	
Residential	32.30%		Residential	29.52%
Vacant Land	14.10%		Vacant Land	21.48%
Others	4.65%		Others	11.83%
Built-up Areas	51.05%		Built-up Areas	62.83%
Agricultural	34.35%		Agricultural	17.24%
Water bodies	14.60%		Water bodies	19.93%
Natural Area	48.95%		Natural Area	37.17%

Besides filling the land for development, the huge development of unregulated industrial expansion also takes place in this area which is directly throwing untreated waste into this area, thus polluting the surface water quality and contaminating the groundwater. Moreover, almost all the waste from humans, industry, and millions of farm animals, along with tones of pesticides and fertilizers, make their way into Dhaka's surface water and causing a great threat to environmental quality. Degradation of environmental quality makes biologically dead of these lowlands which are destroying the overall ecological balance.

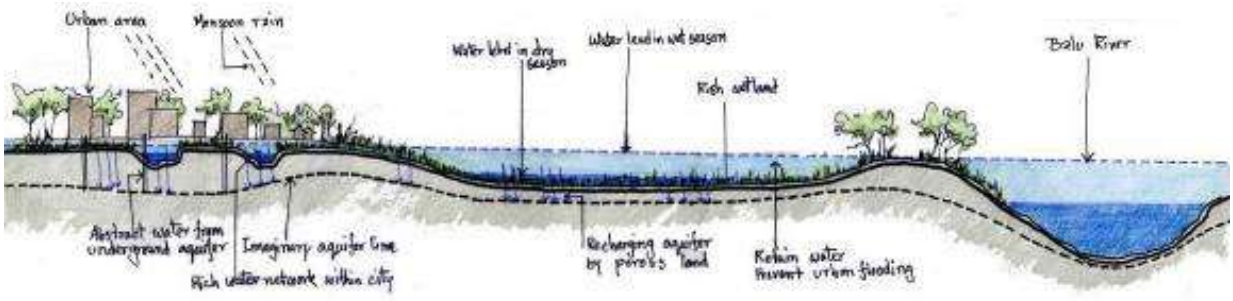


Figure 10: Rich water bodies with natural landscape once provided healthy city

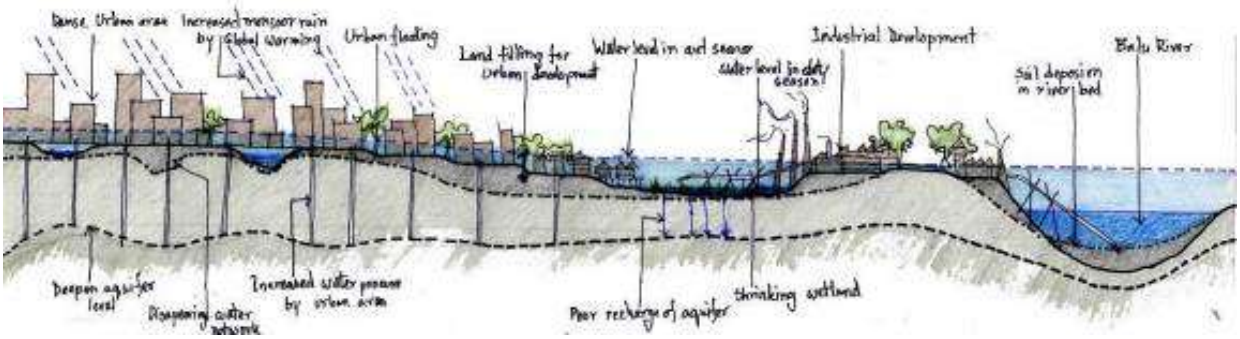


Figure 11: Unplanned urbanization through illegal encroachment of water bodies are threatening the environment balance

Authority's Attitude for Flood Protection and Safe the Ecological Wetland

To deal with the flooding problem, Flood Action Plan (FAP8) for Dhaka Metropolitan Area (DMA) has been formulated which proposed storm water drainage and flood protection measurements for the entire city. As part of these protections, The Dhaka Integrated Flood Protection (FAP 8B) for the western part of the city has already been implemented with cordoned approach which has been criticized as the planning didn't consider the environmental aspects (Helemul, 2016). This way of flood protection has expedited the development activities through unauthorized land-filling which blocked the natural drainage network, shrinkage of water retention area and thus worsening the flooding scenarios (Islam, 2009, Hye, 1998). The flood protection measures for the eastern part - The Greater Dhaka Protection Project (FAP 8A) is yet to be completed with the same strategies. This raises a huge controversy as there is an absence of sensitive hydrological design to manage effective land-water relationships similar to the west part of the city. With a proposal for 12% retention pond and some drainage networks, FAP 8A for eastern part have engineered tech-fix-solutions for flood protection measures like embankment, pumping stations, improved underground drainage network (Halcrow, 2006) (Fig. 12, 13). This centralized below ground piped (box-culvert) network creates huge pressure on the hydrological infrastructure which the city authority incapable to deal with and this invisible water infrastructure disconnected the landuse from the logic of the water system. There is a strong absence of integrated, synergistic and sustainable approach for water design and management in prevailing land-water planning systems, which pushed the entire hydrological system in an intolerable situation, unable to establish a relationship with the built environment and failure to fulfill broader human, ecological and aesthetic objectives.

Additionally, instead of searching land which is sensitive to ecological resources that underpin the city (McHarg, 1995), Rajuk (City Planning Authority) is in the concept of matching between the demand of land and their possible supply and location (DSP, 2016-35) for future land use planning. In one way or another, it is widely accepted that many water-related problems are the outcome of such disordered or ill-conceived land use development practices (Ningrui, 2010). Dhaka's current method of planning corresponds to its urban challenges raises the fundamental question as to its failure to conserve the water bodies and environmentally sensitive areas (Peeters-et al, 2014) and the absence of effective approaches to establish mandatory land-water relationship.

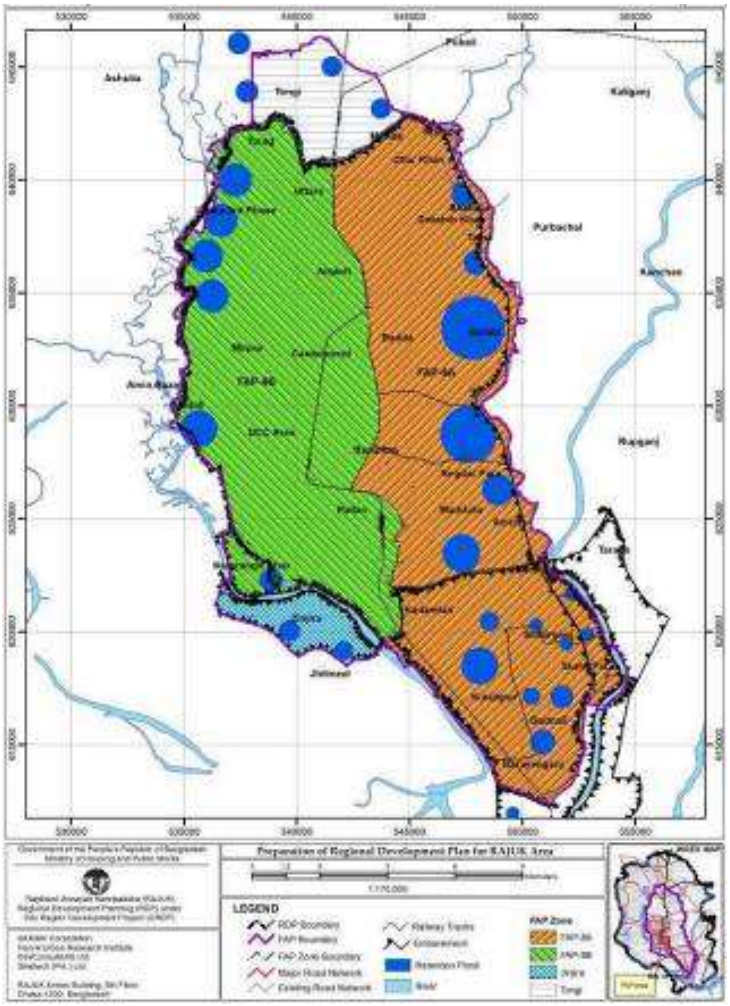


Figure 12: Flood Control measures for DMA after 1998 flood.
Source: JICA, 1990

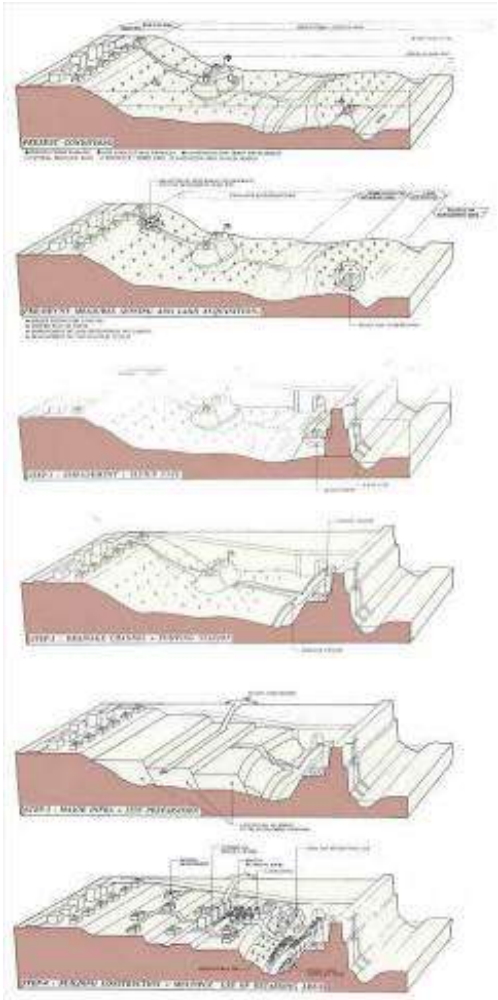


Figure 13: Cordoned flood protection technique proposed by FAP 8A.
Source: JICA, 1992

Local Settlement of Living with Water

Eastern periphery, the essential natural spontaneous territory of Dhaka Metropolitan Area (DMA) to prevent city's flooding problems and environmental degradation, is rapidly converting from traditional homestead to urbanized land through diminishing water bodies, lowlands and agricultural fields to cater the increasing demand of urbanization. This part of DMA was not in target for urban expansion even before 2000. The land use of this area in 2000 has strongly established that the village-like homestead was dominating. The local people with their traditional process in this area are integrating the natural landscape for production, transportation, flood mitigation, open space network have the potential to address present urbanization challenges and create sustainability towards water sensitive urban development. The traditional settlement was spontaneously generated following the geomorphological characteristics of the land. During that time, around 50% of the land was occupied with rural settlements surrounded by natural landscapes. There were abundant agricultural fields with natural water bodies which ensured overall hydrological- ecological safeguard for the entire area as well as for the city. This is also evident that the expansion of the traditional settlement did not follow the landfill like unplanned urbanization, rather find the suitable land without much disturbance to the natural landscape. But, after 2010, these spontaneous development and natural landscape are gradually transforming by the landfilling for development. Still some parts of the eastern periphery contain their local character to build settlement and incorporating the natural resources within it. From the fieldwork and map observation (Fig. 14), it has revealed that the traditional settlement with their spontaneous development creates a sustainable land-water relationship. The locals use the existing natural resources efficiently with their local intelligence. The locals not only occupy the land for settlement, rather provide required space for water which is essential in such a geographical location. These spaces further fluctuated with the water levels by seasonal variation and local people

incorporate environmental diversity within their settlement. They generated various agricultural practices following the water level, moisture content of soil and generate diversified landscape patterns. These practices ensure sustainable water-sensitive development and maintain total hydro-ecological environment of the locality.

Figure 14: The traditional settlement and its land-water relationship

Suggesting the Present Urban Development with Alternate Design Ideas

In the present population pressure, urban growth and associated environmental degradation raise the emergence of proper utilization of natural resources. David (1988) advocated that the sustainable development model requires sound land-water integration that can make the best use of nature's resources to meet human demands, without destroying their sustaining base. It requires a better understanding of territorial setting to incorporate the natural land-water resources into local development practices. From the above discussion, it is clear that the prevailing development process is ignoring the essential presence of natural land-water resources into the built-up areas which consequently generate huge environmental degradation. Whereas, the traditional settlement within the natural landscape ensures optimum utilization of water bodies for various purpose by traditional practices and ensure overall hydro-ecological benefits. Therefore, it requires to generate alternative design ideas from the local process of land-water relationship for the percent development practices in providing solutions to water problems, landscape protection and environmental enhancement. With experiences from the previous part, this part tried to present some alternate design ideas for the eastern periphery. These investigations on urban design might help for further detail, in-depth design solutions for living with lowland in such similar places.

1. Starting from Urban (Water) Design-Setting Hydrological Infrastructure

With the geographical location and topographical condition, Dhaka is totally dependent on water. Rich systems of rivers, continuous canal networks, lakes, ponds, low lying areas were considered great resources to make the city more livable. It is believed that reveling these rich water structures are the only way to get rid of the city's existing flooding problem. Water resource management should arguably be at the core of all scales of planning and development (Fig. 15). Understanding the water nature, drainage pattern, and ecological balance is needed to ensure a livable water-based urbanism. Water infrastructure can serve a lot of important urban functions such as providing transportation, demand for open space for public use, storm and wastewater drainage, storm water retention, food production and water supply, ensuring biodiversity and ecological balance, finally maintaining overall environmental equilibrium.

Topographically central Dhaka is much higher than the surrounding lowlands. Drainage pattern simply flows towards these lowlands in east and west and then finally to nearby rivers (Fig. 16). These lowlands additionally play a vital role to retain the excess water in monsoon when rainfall is heavy and surrounding river levels are higher than the city. Reviling, restructuring, smoothing the city's water network towards these lowlands and ensuring the existence of lowlands are essential to tackle the present flooding problem. Number of water retention ponds in that area might help to balance the water volume for excess rain and river water which can further have multiple uses for irrigation, aquaculture, water storage for the dry season and so on. Productive landscape in fringe areas with huge open space and internal water networks with green areas will obviously check disappearing environment sustainability also. Ensuring a complete water structure increases the absorptive capacity in the concreted city and recharge the quickly deepen aquifer. Finally, water structuring will direct the city towards sustainable urban settings with social, economical, environmental and ecological balance. Innovative design and development techniques that bring water's positive properties to bear, often replicating the historical pattern of hydrology, may include one or any combination of technologies that effectively capture, cleanse, recycle and infiltrate water. This should be the fundamental design and engineering goal for every type and scale of development, regardless of whether the environment is urban, suburban and rural (Farr, 2008).

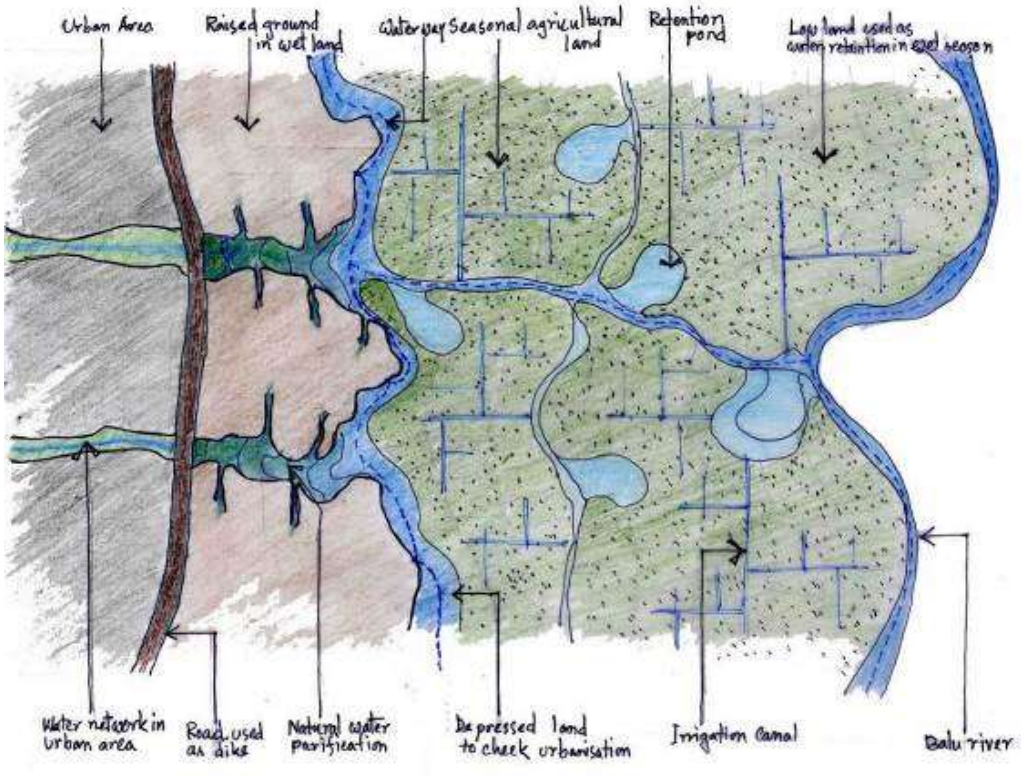


Figure 15: Understanding the water nature of city for future development planning

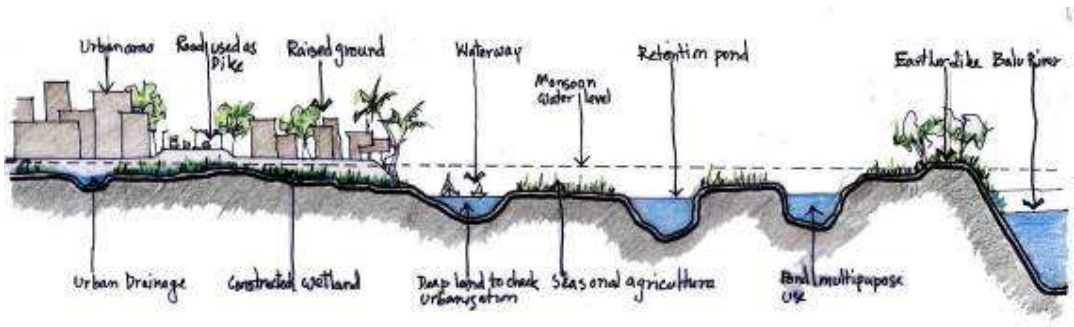


Figure 16: Rich wetland in the periphery require to connect with the entire city for drainage

2. Follow the Traditional Way of Preparing Ground

The city is now in such a position where it has to create a ground to accommodate a huge population every year. The population pressure and uncontrolled growth of Dhaka has given rise to an increasing demand for more than 50,000 new housing units annually here in Dhaka city alone. (Ahmed, 2006) Instead of random filling of low and wetland, it can follow the traditional way of preparing the ground for development. Traditional settlement patterns in the flood plain and low land follow the principle of cut and fill. Throughout low-lying parts of South and South-East Asia, a land amphibious by nature, historical building tradition - from the scale of individual house to hamlets and areas of urban centers rely upon a process of cut-and-fill whereby higher, 'safe' elevations (mounds) are created by digging adjacent land which, in turn, creates ponds or tanks (Shannon, 2008) (Fig. 17). The excavated pond which used as the water reservoir for household work, fishing in small residential areas and as big, large gathering area with public facilities (market, mosques, etc.) on a public scale. The cluster of dwellings is surrounded by wetlands that are used for farming and fishing as a livelihood. These agricultural low lands are subject to seasonal flooding which carries alluvial soil from upstream and make the land fertile for farming. The excavated ditches within the cluster are also stored water during the wet season to use for irrigation to surrounding farmland in the dry season.

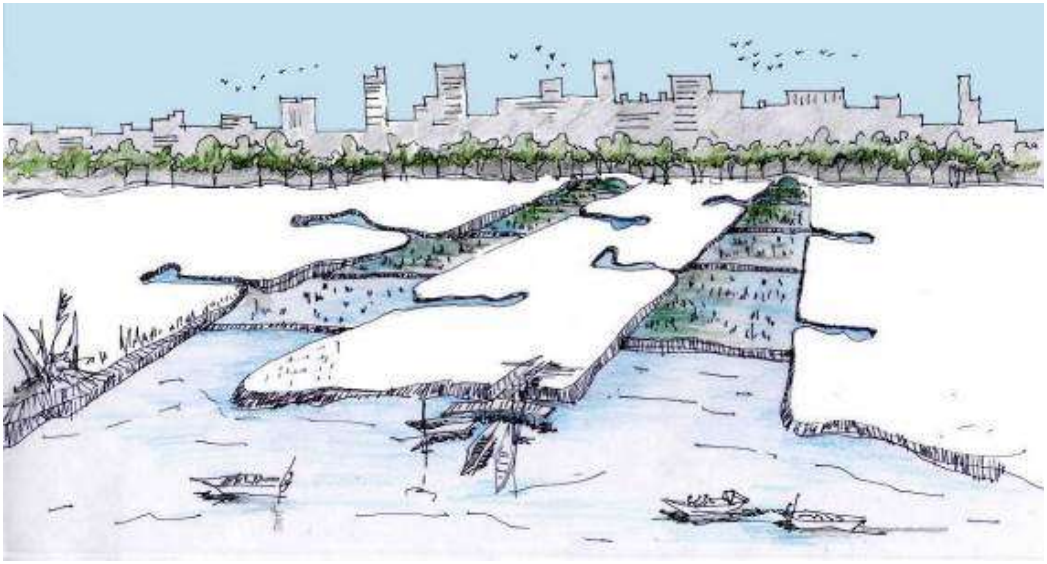


Figure 17: Preparing development ground in lowland following traditional way.

3. Other than Engineered Dike

The severity of floods has intensified partly due to unplanned urban development but also due to wrong physical planning. After the 1988 flood, a city flood protection embankment project was taken up hastily and its implementation started. But its impact has so far been more negative than positive since it has caused water logging inside the embankment area. So, it is needed to think different ways of protection instead of sealing off the city from rivers. Engineered embankment could be essential where the city required to protect its important infrastructure but along the eastern edge different approaches can be

introduced. Instead of making concreted embankment, earthen soft edge without road might be made this area less attractive for development as the dense urban development tends to take place near high ways (Fig. 18). Moreover, smoothen and enhanced natural water flow to the river must be ensured as the water volume of discharge is rising day by day due to high rain intensity by climate change. In some points, it is required to allow the river flow inside up to the acceptable limit to make the land wet and low for making it non-buildable as will check the urbanization. This can serve many more benefits that recharge of surface water bodies, use of canals as alternative means of transportation, moderation of temperature due to the presence of water bodies, fishing, the aesthetic value of healthy water bodies inside the city and so on. Further deepening the lowland will not only make un-buildable but also increase water storing capacity in flooded season as well as make a balance for disappearing water bodies. This open approach will lead to safer and sustainable urbanization because people will be aware of the flood level and thereby be forced to follow the time tested "dig-elevate-dwell" rule of settlement in flood plains of a delta (Islam, 2009).

Figure 18: System of flood pockets, irrigation canals, lowlands, earthen dike as flood protection

4. Why Not Urban Agriculture

Each city should identify its opportunities and resources. It is believed that these water bodies and lowlands are Dhaka's opportunities as well as resources to make it more livable. With an average elevation of 2-3 meters, the floodplains on the eastern fringe areas are inundated between 2-4 meters for several months each year. Ensuring this wetland free from development could be a good source of seasonal agriculture and aquaculture (Fig. 19). Moreover, being flooded by the river this land will be more fertile with the river sedimentation and become productive landscape for the city. This might be a good source of urban employment and economy also. The city people can easily engage themselves with this production as the new city dwellers arriving in the last few decades are from rural background. They have brought with them the useful agricultural skills that can be easily applied to food production in the city should they be presented with the opportunity (Mayeed-et al, 1998). The lowlands from the urban edge to the Balu River can be terraced in different levels so that it can take different vegetation with the change of water level throughout the year. The entire area could be structured with a system of irrigation networks in combination with natural drainage networks and the whole system connected with the allocated water reservoirs then finally to the river. The water network in the lowland will always in water by taking water from urban areas after natural purification in the development edge and from the water reservoirs (designed as flood pockets) for watering the productive landscape. Introducing agriculture practice into urban fabric must help to think in different ways to fight with the loss of arable land by sea-level rise. Moreover, as Tom Turner (Turner, 1998) suggested vast agricultural land in and around the city could contribute water conservation, aquifer recharge, habitat creation and conservation, scenic conservation and enhancement, recreation, conservation farming and so on.

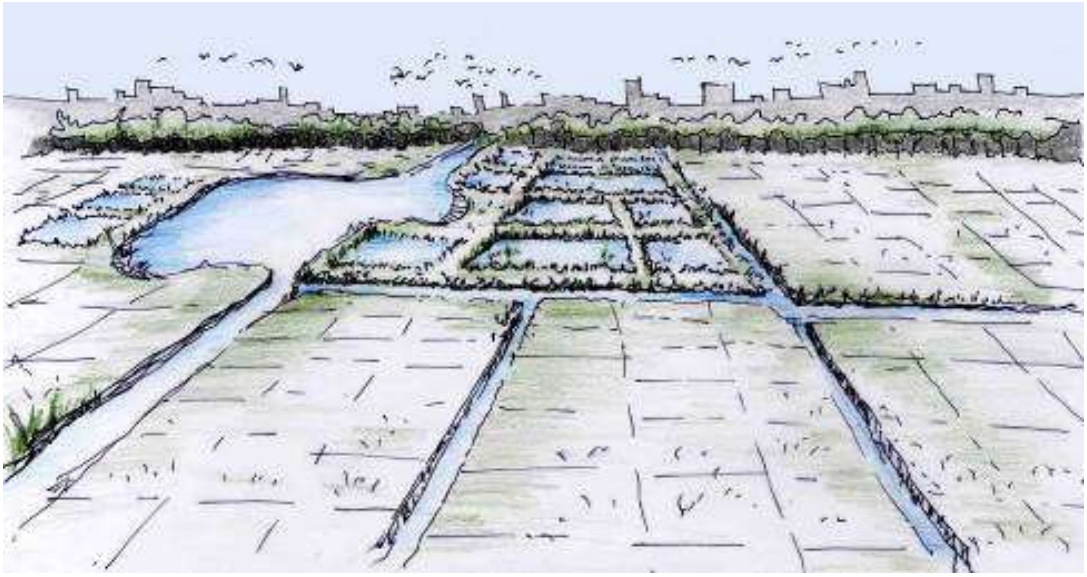
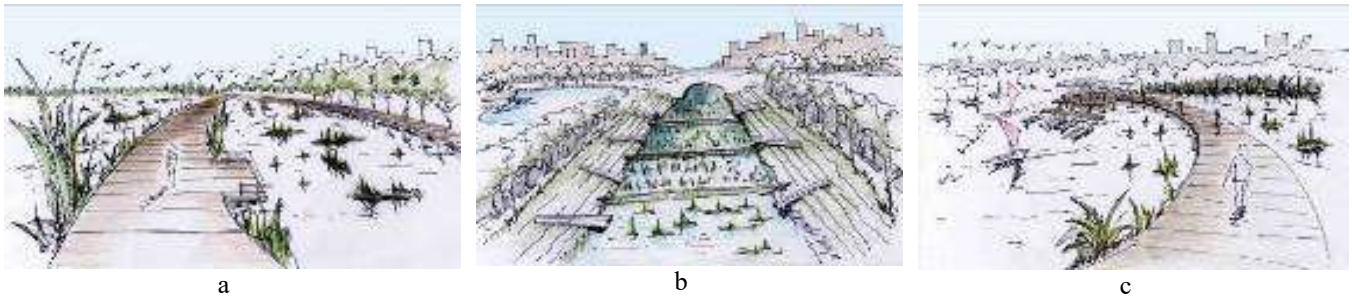


Figure 19: Agriculture and aquiculture practice within urban setting

5. Self-Maintenance, Drinking Water, Sewerage, Recreational Spaces, Economy:

The natural process of purification can easily be implemented in gifted lowland where urbanization creates its edge. The drainage network carrying wastewater from the city can pass through some series of constructed wetlands for purification before releasing it into the groundwater system (Fig. 20a, 20b). Self-cleaning ecological wetlands also can be introduced for treating urban surface runoff rainwater. In such wetland- reeds, rushes and other indigenous wetland plants act as purifiers when water passing through them. Afterward, the treated water can easily use for irrigation, aquaculture and mix-up with groundwater.

Access to potable water is also insufficient presently in the city. Nearly 60% of the residents in Dhaka city are connected with a piped water supply system, another 30 % have access to tube wells whereas rest have to depend on surface water. Reduce the dependency on water abstraction from the ground is very essential to save the city from coming land subsidence. Rainwater harvesting during heavy monsoons could be a good alternative in such a situation. When preparing safe ground for development with the principle of cut and fill, the excavated tank in the higher land can be used for drinking water collection. This system would be combined with water-based recreational facilities. Wetland water purification area with greeneries near lowland, rainwater harvesting area in the higher ground with public access could be turned into public places (Fig. 20c). Fixing their position before coming urbanization in the periphery they can secure the position for public accessibility as well as act as obstacles to urban sprawl into rich wetland. Public spaces near wetland with the seasonal variation of water levels and scenic natural beauty into productive landscape will help to aware people of preserving the natural resources and their importance for social, economic, ecological up-gradation.



a b c

Figure 20: Ecological wetland can have multiple functions with seasonal variation like educational, constructed natural wetland, recreational purpose.

6. Alternate Transport:

Depending on the road based infrastructure causing random filling of water bodies and lowlands for development because of increasing land values. Reclaiming past water networks within the city and connected with the existing water system as well as surrounding rivers will add another dimension of circulation integration with road and rail systems (Fig. 21). Waterway would reduce pressure on land infrastructure and protect from impervious asphalt layer on ground furthermore check fragmentation of continuous water network by the road system. At the edge of the periphery, further depression of lowland for waterways will provide additional protection from flooding for urban land and check the urban sprawl in wetland. This waterway inside the city could act as drainage of floodwater for preventing waterlogging and finally discharged to the connected lowland. Moreover, incorporating public facilities and green with the continuous water network will fulfill the demand for the city's open spaces for recreational purposes, check ecological continuity and increase the land absorptive capacity maintaining the environmental balance of the city.

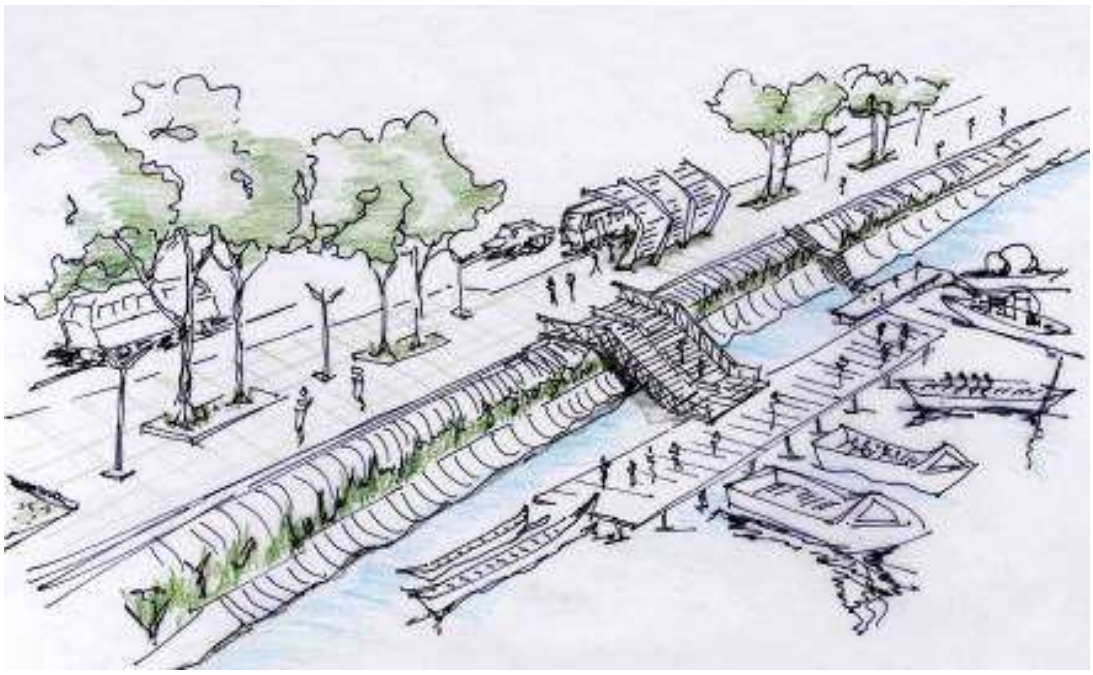


Figure 21: Water way integrating with other road and rail system could contribute to environmental quality

7. Integrated Approach:

Lack of coordination between urban development agencies is one of the main reasons for the great mass in urban development. In the context of land use management, Dhaka city has a complex administrative structure with a number of different local and metropolitan authorities. Here understanding the entire situation it can certainly claim that all disciplines involved in the development of urban territories need to shift their focus towards integrated, landscape-based solutions to the seemingly independent challenges of water and infrastructure provision, environmental and social improvement and creation of site-specific identities (Stokman, 2008). Water management should be the guiding department for urban planning and development in such a geographic setting of the city. Integrated approach is argent to solve present environmental degradation where water strategy could take a major role in co-operation with civil engineers, urban designers & planners, ecologists, landscape experts (Fig. 22). To make the city livable, instead of zoning based planning for the city, the interrelationship between natural resources to urban infrastructure system is the demand of time. Incorporating related disciplines will not only prevent the current water problems but upgrade the environmental quality and check ecological balance as well.

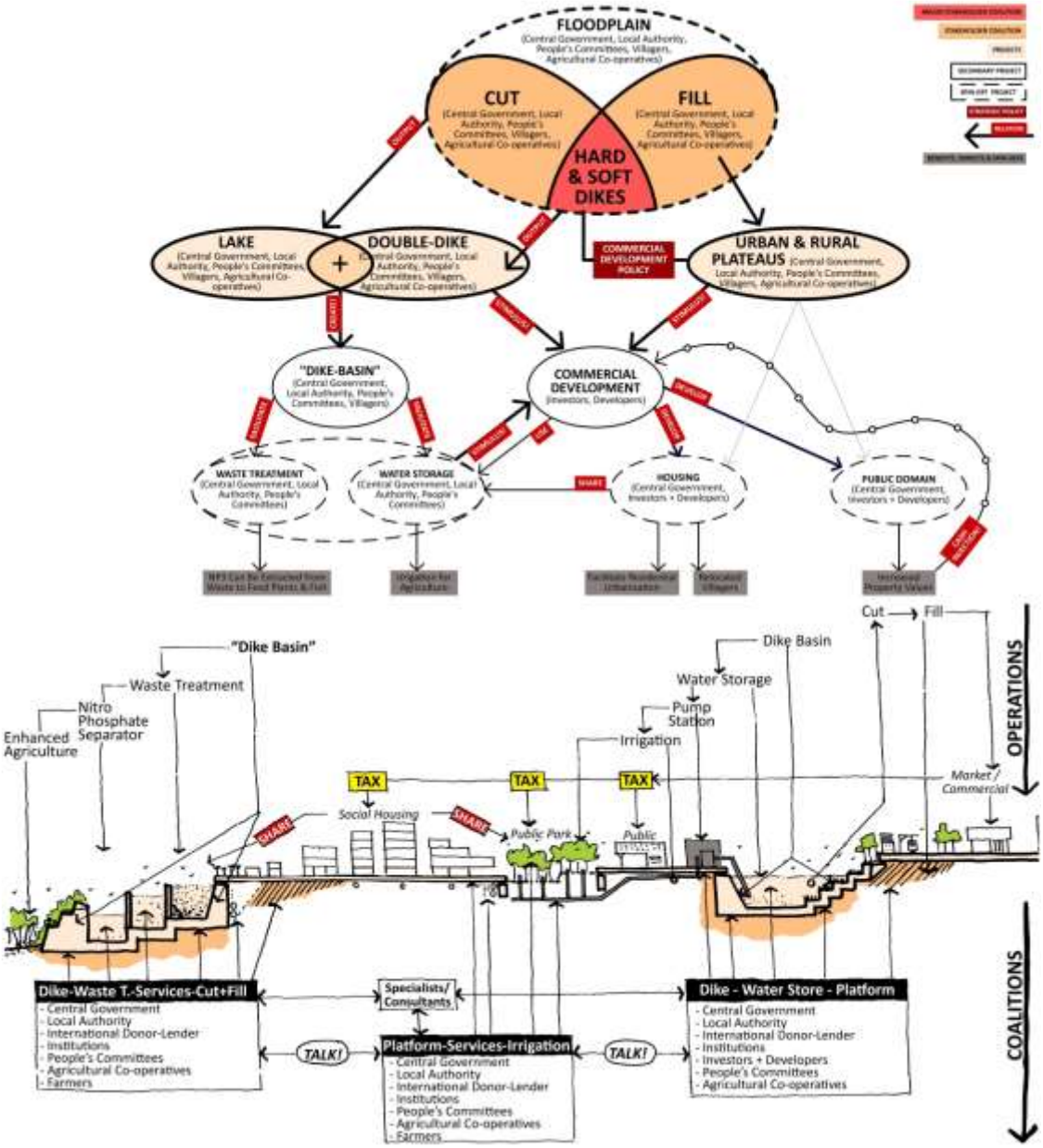


Figure 22: Relationship between different stakeholders in the strategic location for improved cooperation

Conclusion

Proper understanding of the land setting and its relation with natural resources is obligatory to structure the future urbanization. For the water-born cities like Dhaka, analysis the hydrological origin and nature is essential for grounding the settlement to check and minimize water disasters. Large scale interventions on shaping the landscape will have massive consequences on land-use issues and subsequent value and identity of a place. Understanding the peoples' relation with natural resources and their way of integration in everyday life is mandatory to develop sustainable built-up areas. Way of integration of natural watercourses in traditional ways for structuring land formation, production, transportation, flood mitigation, purification, climatic comfort, open space network have the potential to address present urbanization challenges. Investigate these regional intelligences and incorporate those into present development activities can create sustainable development in such low laying land.

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