# WATER CONSERVATION AND MANAGEMENT IN BANGLADESH CONTEXT

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## ABSTRACT

There is a crisis in the water resource scenario all over the world including Bangladesh and it is more acute in urban areas. It is because the available water is not being conserved and managed properly, which has resulted in the deterioration of water bodies and sources. Bangladesh is a deltaic country located in the tropical monsoon zone signifying that the country is full of water bodies, water channels and rivers, besides, receiving high amount of rainfalls. It automatically suggests that surface and rain water management and Conservation should be the prime approach and source of country's water needs. There was a time when water management and conservation system was a part of settlement and shelter planning and design. Contemporary settlement planning system has resulted in the disruption of community participation in water management and therefore there is a collapse in traditional water harvesting and conservation systems. Review of water conservation and management potentialities in Dhaka suggest that, traditional and contemporary ways of water conservation and management systems if interwoven with the system of settlement planning than theoretically Dhaka will not have any water shortfalls. The paper discusses the technicalities to be incorporated into the urban-design system.

Keywords: Urban-Design; Water-Management; Conservation; Environment; Sustainable Development.

## 1. INTRODUCTION

Human being could not save and conserve water and its sources, probably because of its availability in abundance. But this irresponsible attitude has resulted in the deterioration of water bodies/sources in terms of both quantity and quality. Now, situation has arrived when even a single drop of water matters. Average human being require only 5-10 litre of water for drinking and cooking, rest is all non-consumable demand. Half the developing world population do no have access to basic sanitation and safe drinking water. More than 2200 Million Litres per Day (MLD) of water is required in Dhaka, little more than half of which (1500 MLD) is supplied by Dhaka Water and Sewerage Authority (WASA) of which major portion (1300 MLD) is extracted from underground (Mowla,2008). Current annual withdrawal of ground water in Dhaka is in excess of annual recharging of the aquifers. Though there is a huge deficit, withdrawal rate in the city should in fact, be reduced to prevent further lowering of he water table level which is already at an alarming low. To avoid wholesale extraction of underground, new sources of extra water, need to be identified for exploration. Bangladesh is a deltaic country located in the tropical monsoon zone signifying that the country is full of water bodies, water channels and rivers and also receives abundant rainfall (Mowla, 2005). It automatically dictates that Rain Water Harvesting and Water Conservation should be the prime source of our water needs.

In Dhaka about 160 thousand litres of water might be available from a roof top of 100 sq.m in an average year, that is, about 8 person's water requirement of 120 days, which is quite significant. As the water crisis continues to become severe, there is a dire need of reform in water management system and revival of traditional systems. In our cities people depend on public sector water supply system, which has resulted in disruption of community participation in water management and the collapse of traditional water harvesting and conservation systems, ie collapse of traditional water based urbanism.

The Dhaka conurbation, as a meeting point of major riverine routes, served as an outlet to a vast hinterland; therefore, geo-morphology has always played a significant role in the formation and growth of this settlement. Dhaka has grown from a small settlement within the confines of River the Bouriganga and the Dholai Khal (canal) to a sprawling metropolis of about Fourteen million people. Dhaka is encircled by Bouriganga River on its south and south-west, Turag River on its west-northwest and Balu River on its east connected to Turag by Tongi (khal) River to the North. The spatial development followed the prong of flood free terrace originating from the old nucleus along Bouriganga River towards north as a part of Madhupur terrace (Dhaka Terrace) of pre-ostacian age. The Dhaka Terrace sloped towards eastern and western flood plains, marshes and Rivers. Water bodies and Rivers have historically played an important role in the spatial development, life and liveability of Dhaka.

Urbanization, without considering the geo-morphology of Dhaka during recent times has left a deep scar in the city's environment. Dhaka is now at crossroads. Water logging, pollution,

changes in hydro-geological system, land subsidence and building collapse are some of the severe consequences of these environmental changes. In this paper, geo-morphological and hydrological features were explored to ascertain an appropriate role for them for their rejuvenation and integration into the city fabric. The seriousness of this issue and to initiate efforts to overcome those problems must be realized.

## 2. WATER SCENARIO IN DHAKA

Though rain fall and water is in abundance in this deltaic region called Bangladesh the concept of water harvesting is not new in this region. Rainwater harvesting is the process of augmenting the natural filtration of rainwater in to the underground formation by some artificial methods (DAB-PWD, 2002). In the natural process ground water resource gets naturally recharged through percolation. But due to indiscriminate development and rapid urbanization, exposed surface for soil has been reduced drastically with resultant reduction in percolation of rainwater, thereby depleting ground water resource. Rainwater Harvesting is needed to arrest ground water decline and augment ground water table; to beneficiate water quality in aquifers; to conserve surface water runoff during monsoon; to reduce city flooding and water logging; to reduce soil erosion; and to inculcate a culture of water conservation.

The traditional systems in Bangladesh were time-tested wisdom of not only appropriate technology of Rainwater Harvesting, but also water management systems, where conservation of water was the prime concern (Fig.1). Traditional water harvesting systems were tanks/pond, step wells, lakes, wetland etc. These were the water storage bodies to cater for domestic and irrigation demands. Diversion of run off into existing water bodies for storage is a traditional methods but recharge to ground water is a new concept in rainwater harvesting (Mowla,2005). People were themselves responsible for the maintenance of water sources and optimal use of water that could fulfil their needs.

Considering the Dhaka city corporation (DCC) area of urban Dhaka at approximately 500 sq.km with an average annual rainfall of 2200mm, the total rainfall received in Dhaka is about 1100000 million litres or 3013.7 MLD (Mowla,2008). Present demand of water in Dhaka is about 2200 MLD. If 70% of the urban area is assumed to be developed and 50% of it to be roofed and 70% of rainfall received in Dhaka is collected, the quantity of rain that can be realistically harvested works out to 738.36 MLD. This is a significant quantity compared to the DWASA supply in Dhaka. Above assessment shows that about 25% of the rainwater falling over Dhaka can be harvested. With proper planning more of it can be retained for natural recharge through percolation.

## 3. SYSTEM OF WATER COLLECTION AND ITS CONSERVATION

Techniques used for urban rain water harvesting could be storage in artificial above or underground tanks; recharging aquifer directly through existing dug up ponds, wells and bore

wells; recharging aquifer b percolation / soakage into the ground; and pumping (putting under pressure) rainwater into the soil to prevent sea/pollution/salinity ingress. Broadly there are two ways of harvesting rainwater:

i) Surface runoff harvesting: In urban area rainwater flows away as surface runoff. This runoff could be caught and used for recharging aquifers by adopting appropriate methods. Harvesting and conservation may be at two scales ie city wide scale and household level (Fig. 1). The traditional system was of dig-elevate-dwell whereby ensuring water retention during rainfalls / floods and reservoir for lean period (Fig.3). The system protecting the homesteads above flood levels with crop fields around helped create adequate biomass was a time tested approach of the settlement pattern for sustainability in the area (Mowla, 2005 & 2008). Traditional Architecture, Urban Design and planning in this region offers the best and integrated solutions towards human needs, in their relation with the nature, ecosystems and the community but contemporary development ignored living with nature. Water logging is an inherent problem associated with uncontrolled urbanization and lack of holistic planning in Dhaka. Dhaka structure plan, DMDP (1995)(Fig.4) however, attempted to take into cognisance the water dynamics and the traditional attitude prevailing in the region, but it was not followed due to the short sightedness of the Capital development authority (RajUK).

ii) Roof top rainwater harvesting: It is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building (DAB-PWD, 2002). It can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly helps in augmenting the ground water level of the area (Fig.2).

## 4. WATER URBANISM IN DHAKA – A TRADITIONAL RESPONSE

The Dhaka terrace was crisscrossed by numerous water channels that drained the city as well as served as a main source of service, water supply and communication line. The physiographic effect of water and land can be seen on the settlement pattern, which sited on available ground or on mounds created on the flood plains (Mowla,2005). Due to this local geo-climate and water based development, Dhaka was once befittingly called the Venice of the east (Taylor, 1840).

The settlement pattern of the pre-partition (1947) period in comparison to the contemporary one presents a richly woven urban fabric at the human scale. The rivers spilling over the flood plains and into canals / khals or connecting inland depressions or lakes together provided a hierarchy and network of water bodies and navigation routes giving rise to settlements alongside.

There were flights of steps, locally known as ghats at intervals rising up to the lanes or community spaces (Fig.05). The ghats (landing piers) on the bigger water bodies or rivers were major community spaces where the daily activities take place such as bathing, washing or religious or commercial activities. Historic pattern reveal that the relationship of urbanization and water

bodies was positive and complementary. Ghats were community spaces and urban nodes as well besides providing a hydraulic character to the settlements in the area.

In Dhaka traditionally the settlement structure evolved in consonance with water bodies (Fig.03). The water bodies were the main transport corridors, streets being secondary to it. Planning deep inland together with European planning principles changed the development pattern giving emphasis on automobiles and discouraging water mobility. Contemporary urban planning and design in Dhaka has its roots in the colonial period which ignored the traditional pattern resulting in the settlements to turn its back to the water bodies whereby causing hydro-geological as well as health, sanitation and water logging problems.

## 5. THE PATTERN OF WATER URBANISM IN DHAKA

Historically Dhaka's urban life and living was interwoven with the system of rivers, canals, lakes and ponds scattered and crisscrossing the city (Mowla, 2008). Water channels like the Dholai Khal, the Gerani Khal, the Segunbagicha Khal or the Begun Bari Khal played an important role in the indigenous city life. Most of these Khals lie east-west, that used to serve an important purpose of intracity communication, besides other needs. The prong of flood free Dhaka terrace averages about 6 km in width and the growth has generally been northwards from the old nucleus along the Buriganga river. Boats were the primary means of communication, through numerous Khals within Dhaka until the Mughal period when narrow alleys and roads started to appear in the scene to give way to carts (Taylor, 1840). The effect of physiography can be seen on the settlement pattern rather than on building structures themselves. Settlements are sited on available ground or on artificial mounds. Most of the settlement pattern is linear (Muktadir & Hasan, 1985) in nature, at a regional scale and circular at homestead scale, its location along the river or some sort of water bodies served as the main source of service and communication line. Before the contemporary era network of natural canals within the city served as the means of drainage of the rain runoff and water during the events of flood, besides these canals served as a good means of storage and transportation.

At the time of partition of 1947, about 50% of present Dhaka was low lying flood plain and water bodies. Dhaka relied on the gravity drainage system based on 'khals' and 'wetlands'. Water bodies also offered highly valuable environmental and recreational asset for the area. But gradually in course of time this natural water supply and drainage system is being almost destroyed. Many of the roads in Dhaka are developed by filling the water bodies or by making box culverts, thus shrinking the water carrying capacity as well as reducing ground water replenishment (eg Dholai Khal and Panthapath). Destruction of these water channels and depressions has resulted in the disruption and alteration of the natural process of land accretion, land formation, ecosystems and ecological basis of settlement formation.

## 6. DETERIORATING WATER BODIES IN CONTEMPORARY DHAKA

It is said that Dhaka must have at least 20 retention ponds of Hatirjheel size to tackle the storm water (Bangladeshnews,2009a). Dhaka Metropolitan Development Plan (DMDP, 1995)(Fig.04) considered retaining at least eight flood-flow zones undisturbed – Dhaka West; DND Triangle; Eastern Fringe; Narayanganj West; Dhaka NW; and Narayanganj East (Nagario Prokoton, 1995). Transparency International Bangladesh-TIB informed that around 1,000 ponds, which were in the city, have now been totally destroyed (Bangladeshnews,2009b). TIB reports that 800 acres of land in 5 rivers including Bouriganga and Sitalakkhya were illegally grabbed violating the Wetland Protection Act, 2000. The fact is that the contemporary planning process never took water systems as the driving force in any physical planning in this delta. IRS images of 1996 and 2000 clearly shows that water bodies measuring about 2300sq.m were filled in by the Bashundhara and Bashumoti housing estates and 66 acres filled by Aftabnagar Housing. In 1996 there were 211 acres of water bodies in the Mohamadia Housing Estate and Adabor area of which 91 acres disappeared between 1996 and 2006 and 68 acres from 2006 to 2009 (Rahman, 2010). RAJUK, the main planning body for Dhaka is the major violator of its own plans. RAJUK initiated a residential project in the southern part of Bouriganga River covering an area of 381 acres – over the last two years 3000sq.m of natural water bodies has already disappeared. Purbachal housing is another recent example of many such violations of DMDP,95.

Studies show that around 40% of the wetlands of Dhaka city has disappeared in 20 years due to indiscriminate filling up of lowland and flood flow zones (both by public and private agencies) that also has reduces its drainage capacity (Fig.07). It says that the temporary wetland area in DMDP,1995 was 1,528 sq.km. which was 40,765 hectare in 1989 and came down to 35,740 hectare in 1999 and 24,208 hectare in 2005 (Bangladeshnews, 2010). Same study informs that to protect eastern Dhaka from floods, at least 40% (66 sq.km) of the drainage catchment area must be delineated and protected as wetlands and water bodies under Wetland Protection Act, 2000, considering this as an 'ecologically critical area'. Of the recommended 40% drainage area, a minimum of 12% (about 20 sq.km) can be made available as reserved ponds or lakes and another 38% (about 46 sq.km) protected as natural wet lands for retention of storm water. A Dhaka University study reveals that the government owns about 33 lakh acres of khas (Government) land of which about a quarter is water bodies. DAP (2007) covers the area of DMDP,1995 but did not follow the planning guidelines provided in it. Against the 40% requirement, DAP,2007 recommends 21% of Dhaka's land as water bodies where no development would be permitted. DAP recommends 50m land from riverbanks to be earmarked for walkway or driveway; enlisting parks, playgrounds and open spaces; and marking existing canals in the CS and RS maps (DAP,2007). No basis of this recommendation is given.

Surface water (River, Canals, Wetlands, Ponds etc) compliment and supplement underground water. There is a continuous tendency in contemporary times to destroy the surface water

channels but underground water is also not spared. The ground water replenishment rate is much slower than the extraction rate. In 2001, underground water table in Dhaka was at a depth of between 200-300 feet. In 2010, this has deepened to 1,000 -1200 feet. This is not a matter of concern only with respect to water supply but because a large vacuum between surface and under-groundwater has developed which might trigger land slide or subsidence particularly in the event of earth quakes.

## 7. COMPONENTS OF ROOFTOP RAINWATER HARVESTING SYSTEM

The illustrative design of the basic components of roof top rainwater harvesting system is given in the typical schematic diagram (Fig 2) / the system mainly constitutes of following sub components: Catchments; Transportation; First flush, Filter and storage / recharge..

1. Catchments: The surface that receives rainfall directly is the catchments of rainwater harvesting system. A roof with single plane or a reduced number of planes will assist in maximizing the efficient collection of rain water, helping to direct water to storage. Catchments may be terrace, courtyard, or paved or unpaved open ground. The terrace may be flat RCC/stone roof or sloping roof.

2. Transportation: Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of required capacity. Water from sloping roofs could be caught through gutters and down take pipe. At terraces, mouth of the each drain should have wire mesh to restrict floating material.

3. First flush: First flush diverter separates the water received in first shower. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof. It will also help in cleaning of silt and other material deposited on roof during dry seasons Provisions of first rain separator should be made at outlet of each drainpipe.

4. Filter: There is always some scepticism regarding Roof Top Rainwater Harvesting since doubts are raised that rainwater may contaminate groundwater. There is remote possibility of this fear coming true if proper filter mechanism is not adopted. Secondly all care must be taken to see that underground sewer drains are not punctured and no leakage is taking place in close vicinity. Filters are used from treatment of water to effectively remove turbidity, colour and micro organisms. After first flushing of rainfall, water should pass through filters. There are different types of filters in practice, but basic function is to purify water ie. Sand Gravel Filter; Charcoal Filter; PVC Pipe Filter; Sponge Filter; and so on (Fig.8).

Sand Gravel Filter: These are commonly used filters, constructed by brick masonry and filleted by pebbles, gravel, and sand as shown in the figure. Each layer should be separated by wire mesh.

Charcoal Filter: Charcoal filter can be made in-situ or in a drum. Pebbles, gravel, sand and charcoal as shown in the figure should fill the drum or chamber. Each layer should be separated by wire mesh. Thin layer of charcoal is used to absorb odour if any.

PVC Pipe Filter: This filter can be made by PVC pipe of 1 to 1.20 m length; Diameter of pipe depends on the area of roof. Six inches dia. pipe is enough for a 1500 Sq. Ft. roof and 8 inches dia. pipe should be used for roofs more then 1500 Sq. Ft. Pipe is divided into three compartments by wire mesh. Each component should be filled with gravel and sand alternatively as shown in the figure. A layer of charcoal could also be inserted between two layers. Both ends of filter should have reduced than required size to connect inlet and outlet. This filter could be placed horizontally or vertically in the system.

Sponge Filter: It is a simple filter made from PVC drum having a layer of sponge in the middle of drum. It is the easiest and cheapest form filter, suitable for residential units.

## 8. USE OF ROOFTOP WATER HARVESTING

1. Storage for Use: The storage tank has to be designed according to the water requirements, rainfall and catchment availability. Each drainpipe should have mesh filter at mouth and first flush device followed by filtration system before connecting to the storage tank. It is advisable that each tank should have excess water over flow system.

Excess water could be diverted to recharge system. Water from storage tank can be used for secondary purposes such as washing and gardening etc. The main advantage of collecting and using the rainwater during rainy season is not only to save water from conventional sources, but also to save energy incurred on transportation and distribution of water at the doorstep. This also conserves groundwater, if it is being extracted to meet the demand when rains are on.

2. Recharging Ground water aquifers: Ground water aquifers can be recharged by various kinds of structures to ensure percolation of rainwater in the ground instead of draining away from the surface (Fig. 9). The idea is similar to the soak pits for toilet waste commonly used in Bangladesh. Commonly used recharging methods are:

a) Recharging of bore wells
b) Recharging of dug wells.
c) Recharge pits
d) Recharge Trenches
e) Soak ways or Recharge Shafts
f) Percolation Tanks

### 8.1 Recharging of Bore Wells

Rainwater collected from rooftop of the building is diverted through drainpipes to settlement or filtration tank. After settlement filtered water is diverted to bore wells to recharge deep aquifers.

Abandoned bore wells can also be used for recharge. Alternatively, after filter, water may be diverted to the retention / detention ponds of the settlements, part of which may be used as recharger tank.

While recharging, entry of floating matter and silt should be restricted because it may clog the recharge structure. "first one or two shower should be flushed out through rain separator to avoid contamination. This is very important, and all care should be taken to ensure that this has been done." Recharge pits are small pits of any shape rectangular, square or circular, contracted with brick or stone masonry wall with weep hole at regular intervals. Top of pit can be covered with perforated covers. Bottom of pit should be filled with filter media.

The capacity of the pit can be designed on the basis of catchment area, rainfall intensity and recharge rate of soil. Usually the dimensions of the pit may be of 1 to 2 m width and 2 to 3 m deep depending on the depth of pervious strata. These pits are suitable for recharging of shallow aquifers, and small houses.

Soak away or recharge shafts are provided where upper layer of soil is alluvial or less pervious. These are bored hole of 30 cm dia. up to 10 to 15 m deep, depending on depth of pervious layer. Bore should be lined with slotted/perforated PVC/MS pipe to prevent collapse of the vertical sides. At the top of soak away required size sump is constructed to retain runoff before the filters through soak away. Sump should be filled with filter media.

Dug well can be used as recharge structure. Rainwater from the rooftop is diverted to dug wells after passing it through filtration bed. Cleaning and desalting of dug well should be done regularly to enhance the recharge rate. The filtration method suggested for bore well recharging could be used.

Recharge trench is provided where upper impervious layer of soil is shallow. It is a trench excavated on the ground and refilled with porous media like pebbles, boulder or brickbats. it is usually made for harvesting the surface runoff. Bore wells can also be provided inside the trench as recharge shafts to enhance percolation. The length of the trench is decided as per the amount of runoff expected. This method is suitable for small houses, playgrounds, parks and roadside drains. The recharge trench can be of size 0.50 to 1.0m wide and 1.0 to 1.5m deep.

Percolation tanks are artificially created surface water bodies, submerging a land area with adequate permeability to facilitate sufficient percolation to recharge the ground water. These can be built in big campuses where land is available and topography is suitable preferable in relatively low laying areas. This is the most common type seen in Bangladesh. Surface run-off and roof top water can be diverted to this tank. Water accumulating in the tank percolates in the solid to augment the ground water. The stored water can be used directly for gardening and raw use. Percolation tanks should be built in open spaces and roadside green belts of urban area. Recharge trench and Percolation tanks can be integrated into the settlement planning.

## 8.2 Precautions in the rainwater harvesting

Harvested rainwater is used for direct usage or for recharging aquifers. Following precautionary measures should be taken while harvesting rainwater:

- Roof or terraces uses for harvesting should be clean, free from dust, algal plants etc.
- Roof should not be painted since most paints contain toxic substances and may peel off.
- Do not store chemicals, rusting iron, manure or detergent on the roof.
- Nesting of birds on the roof should be prevented.
- Terraces should not be used for toilets either by human beings or by pets.
- Provide gratings at mouth of each drainpipe on terraces to trap leaves debris and floating materials.
- Provision of first rain separator should be made to flush off first rains.
- Do not use polluted water to recharge ground water.
- Ground water should only be recharged by rainwater.
- Before recharging, suitable arrangements of filtering should be provided.
- Filter media should be cleaned before every monsoon season.
- During rainy season, the whole system (roof catchment, pipes, screens, first flush, filters, tanks) should be checked before and after each rain and preferably cleaned after every dry period exceeding a month.
- At the end of the dry season and just before the first shower of rain is anticipated, the storage tank should be scrubbed and flushed off all sediments and debris.

## 9. WATER IN THE URBAN DESIGN FRAMEWORK

Bangladesh is a deltaic country and has abundant rainfall, but due to the absence of clear policy-guidelines, useable water quantity is declining fast. Wetland Protection Act, 2000 in Bangladesh restricts change in the wetland areas but doesn't regulate the use of water. Neither the building construction rules, or building code or any planning regulation nor wetland act calls for integrating natural water bodies or channels into the urban planning and design frame work.

Given the fact that Dhaka is subject to frequent flooding, an appropriate plan for living with flood is needed. A formal holistic policy and plan at national level sets priorities identifying major areas and quantities of uses i.e. Forest, wetlands & water bodies, natural areas, agricultural, rural, urban and industrial areas. Urban structure plan (SP such as DMDP,95) is the second level plan within broad national urbanization policy guidelines of national vision. The level three planning and designing is the detail area plan (DAP) within the planning guidelines set in SP. In the fourth level is small area and plot level designing. Such a sequential plan is not evident in the Detailed Area Plan (DAP, 2007), which rather than setting aside adequate space for water retention ponds and for permeable surfaces (including parks and other unpaved surfaces), focuses instead on roads and buildings, embankment and pump oriented flood control approach which further

intensified the suffering of Dhaka residents due to flooding. Considering the geo-morphology of Dhaka, contrary to the embankment- and pump-oriented flood control and drainage management approach of DAP, 2007, flood management and a detention reservoir-based gravity drainage system is expected to be more reliable and appropriate for storm water drainage system in a floodplain landscape like Dhaka with rivers encircling the city (Mowla,2010). Some sporadic attempts to integrate water bodies with the settlement pattern are observed in Dhaka without any link with upper and lower level planning and design framework (Fig.06&07).

To assess the sustainability status of integrating water bodies in the urban design under contemporary context without compromising on the social, environmental and economic interests, a hypothetical project was introduced in the Level-4 urban design studio of the Department of Architecture, BUET with the title 'Integrating the Urban Water Bodies in Dhaka's Fabric: An Imperative Issue of Sustainable City'. A day long workshop with the same title was also organized (BUET,2009) which was participated by the level-4 BArch students of BUET and 5th year architecture students from KUL (Belgium). One of the many proposals submitted by the students (Fig.12) suggest that traditional approach of planning and design of living with nature is still valid without sacrificing contemporary needs and that natural areas be strictly controlled by regulations. Considering the geo-morphology of Dhaka, it seems essential that if and when needed the earth cutting to fill / raise lands must be judiciously planned and invariably done on the channel ward side that would get rapidly filled up by the natural process of siltation / accretion. The western embankment of Dhaka is a response to the floods of 1988. The attitude of zero tolerance for floods amounts to demanding equal protection from floods along different stretches of rivers irrespective of the geographical difference found there, which in practice is not possible. It increases the ferocity of flood flow in the lower reaches. Embankments saves some areas at the expanse of some other areas but have a long term effect of higher river beds than their surrounding, insufficient percolation and diminishing soil fertility. According to noted water resources expert Prof Shahjahan (Mowla,2000) 'such flood control and irrigation projects tend to focus exclusively on engineering aspects, neglecting the people, water, soil, fish, vegetation – many vital concern.'

## 10. CONCLUSIONS

Historically Dhaka's development responded well with the hydro-geological realities of the place. Traditional Architecture, Urban Design and planning in this region offered the best and integrated solutions towards human needs, in their relation with the nature, ecosystems and the community but contemporary development ignored living with nature. After abusing urban water bodies through the years of hard use and neglect, when it has retaliated with unthinkable magnitude, there is a realization on the stake holders that they are valuable natural assets / resource for the community.

Urban development with water bodies as focus was not given a trial during the rapid urbanization over the last 50 years. Review of Dhaka's geomorphology reveals that for the sake of ecological, hydrological integrity and development sustainability, natural systems must be protected and can be protected. Studies show that much greater environmental as well as socio-economic success or advantages can be achieved through design with ecological principles in mind than without it. Fragmented approach of planning must be avoided.

Review of water harvesting and conservation potentialities in Dhaka at both building and urban scale suggest that, if it is interwoven with the system of building and urban design in Dhaka than theoretically Dhaka will not have any water shortfall both for consumable and non-consumable water demand. Building and planning regulations should therefore incorporate / integrate water harvesting and conservation issue in the physical development framework of Dhaka. There is need to enact water policy and regulatory laws for water conservation and management (particularly ground water), in the urban design.

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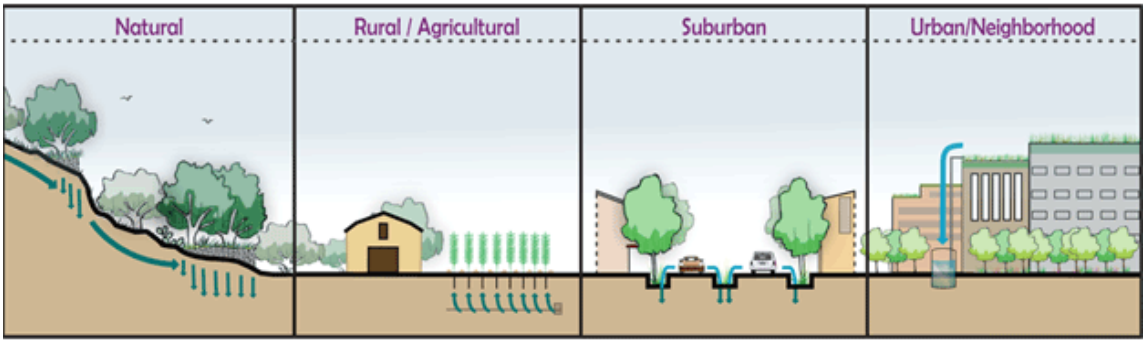



**Fig 1. Various Levels of Rain Water Harvesting, at regional to household level.**

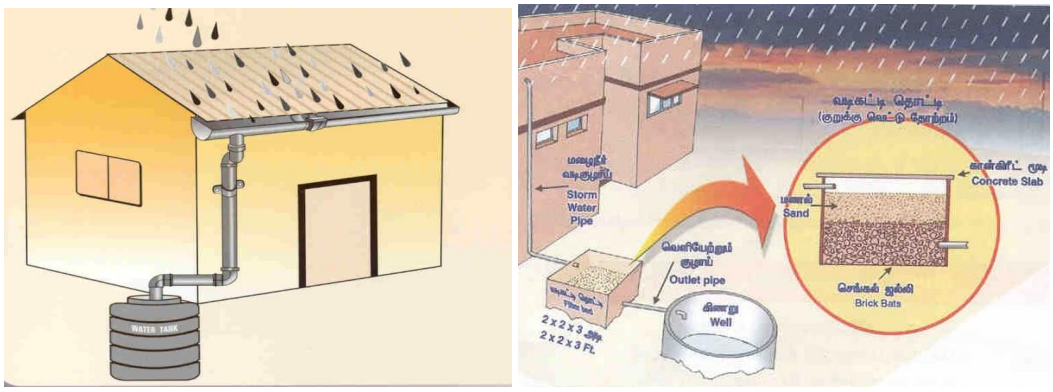



**Fig 2. Roof top rainwater harvesting Systems**


**Fig 3. Settlement Pattern Evolving out of traditional needs in response to water bodies.**

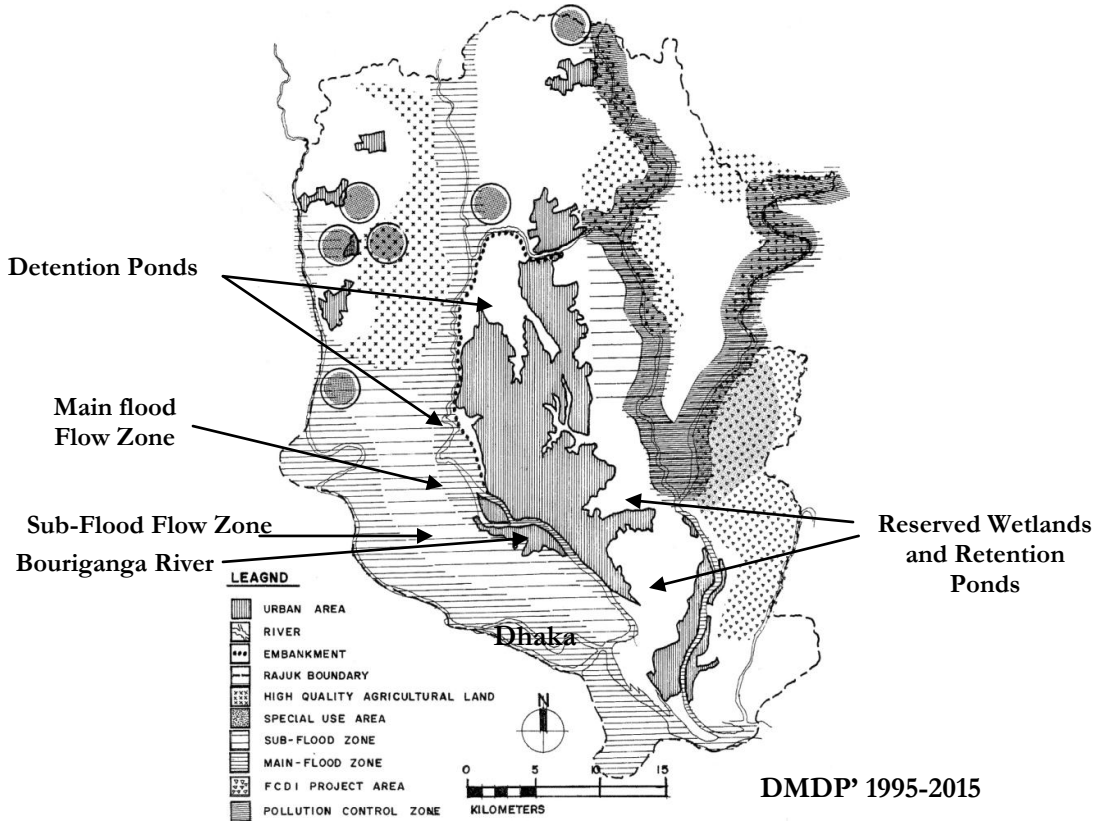



**Fig 4. DMDP' 95 - Proposed Plan Policy Areas i.e. Built and Natural Areas for Dhaka.**

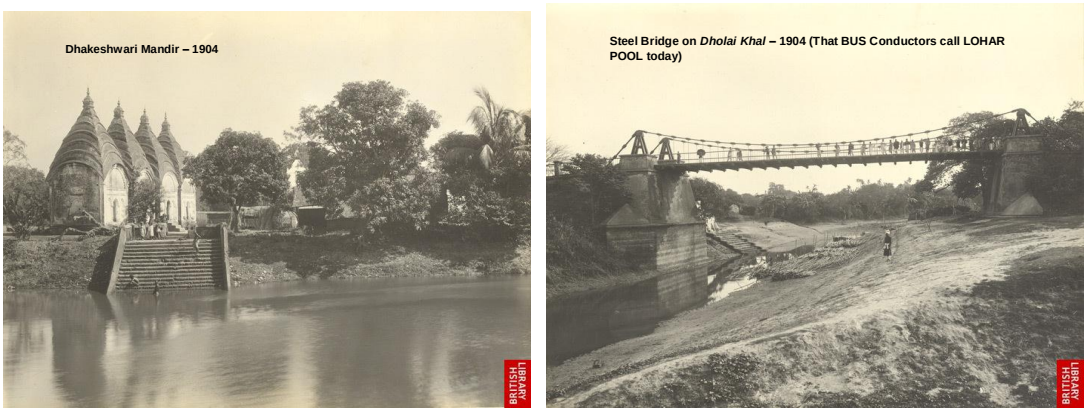



**Fig 5. Glimpses of historic development responding to water.**

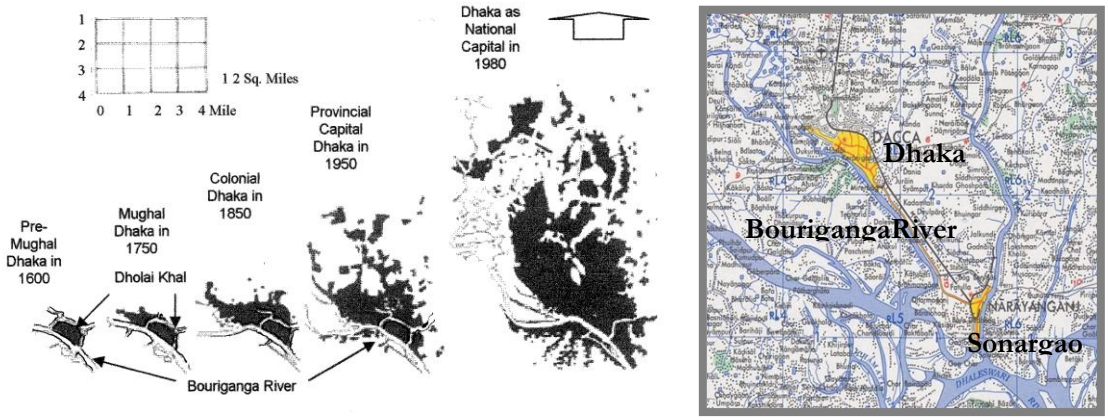



**Fig 6. Physiographic Setting of Dhaka and its growth**

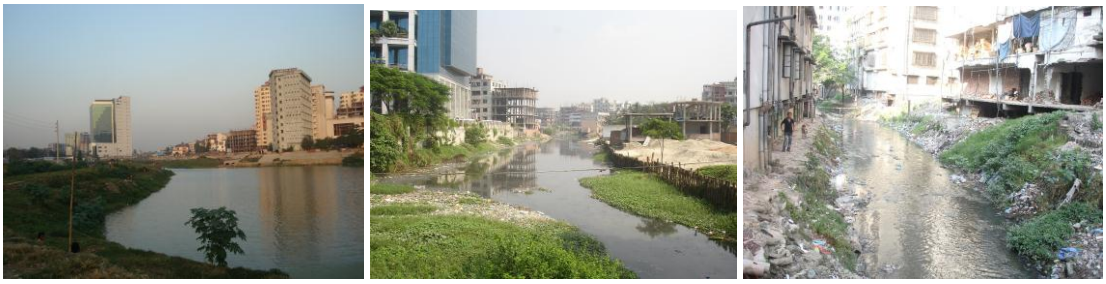
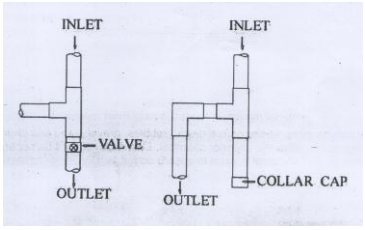
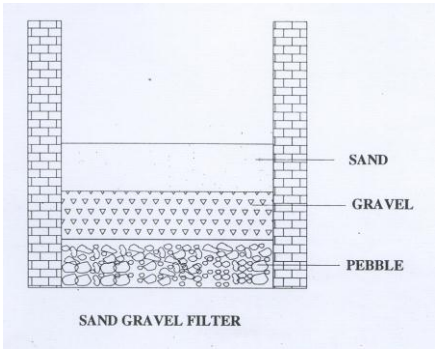


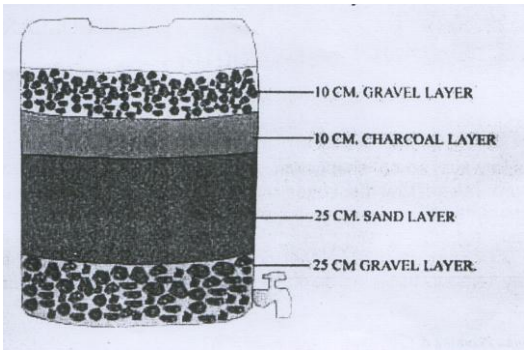
**Fig 7. Contemporary Planning with water bodies was never in the development agenda: See the Bagunbari Canal and Kalyanpur canal being encroached indiscriminately.**



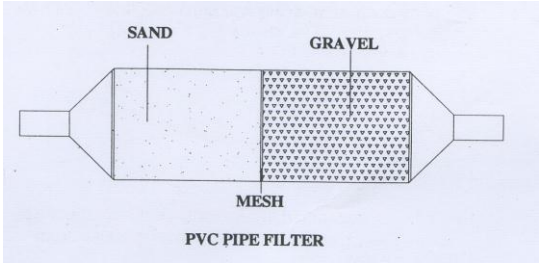

First flush diverter



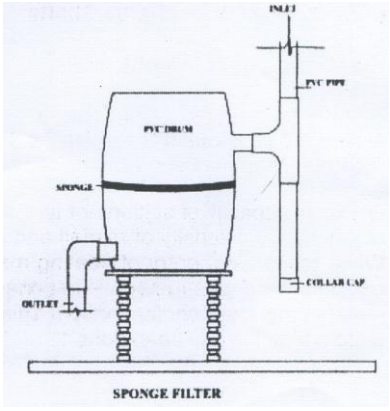

Sand Gravel Filter;




Charcoal Filter;

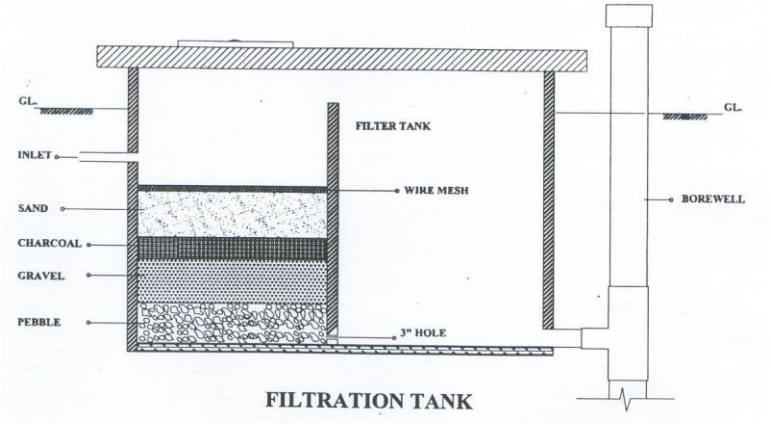


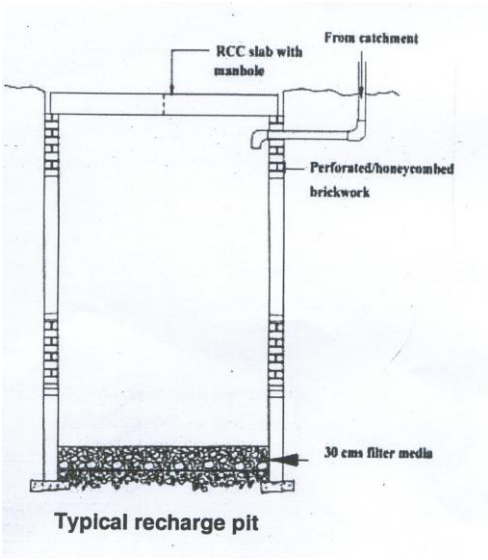

PVC Pipe Filter;



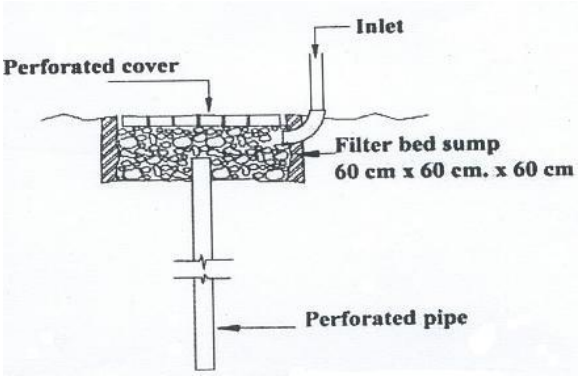

Sponge Filter

**Fig 8. Different types of Filter Systems for Rainwater Harvesting**

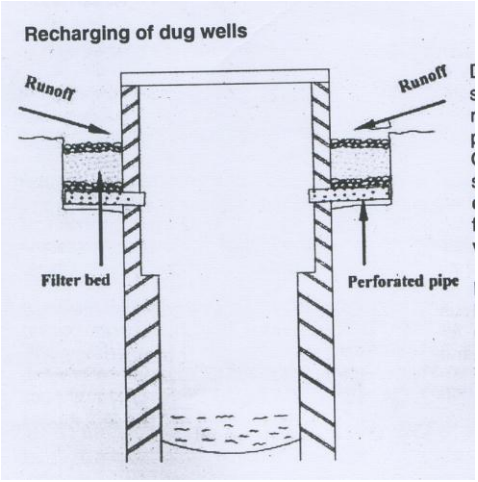


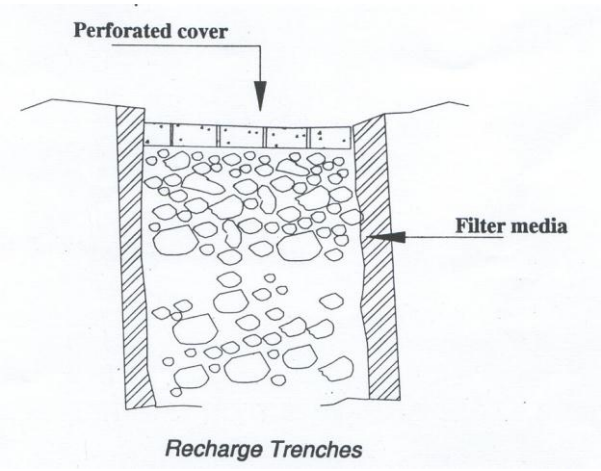




Recharge Pits




Soak ways or Recharge Shafts




**Percolation tanks**

**Fig 9. Filters and ground water Recharge Systems**

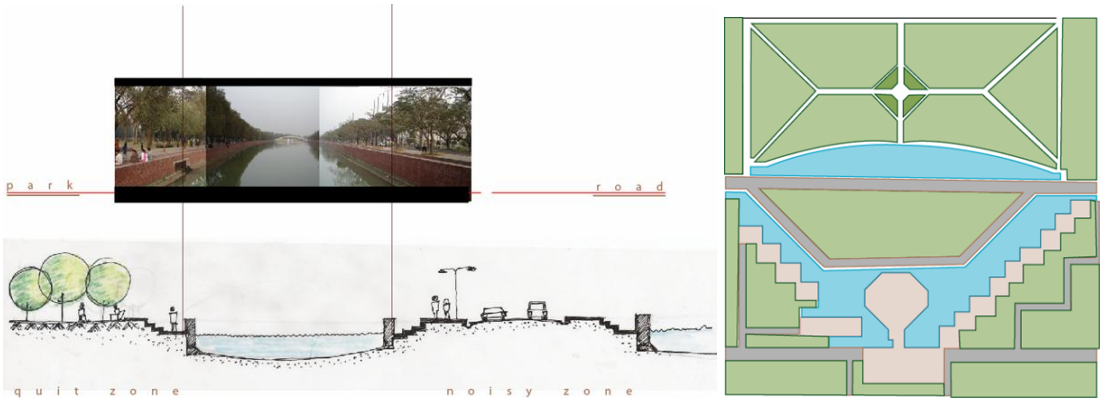



**Fig 10. Shangshad Bhaban Precinct design considering water bodies as its integral part.**

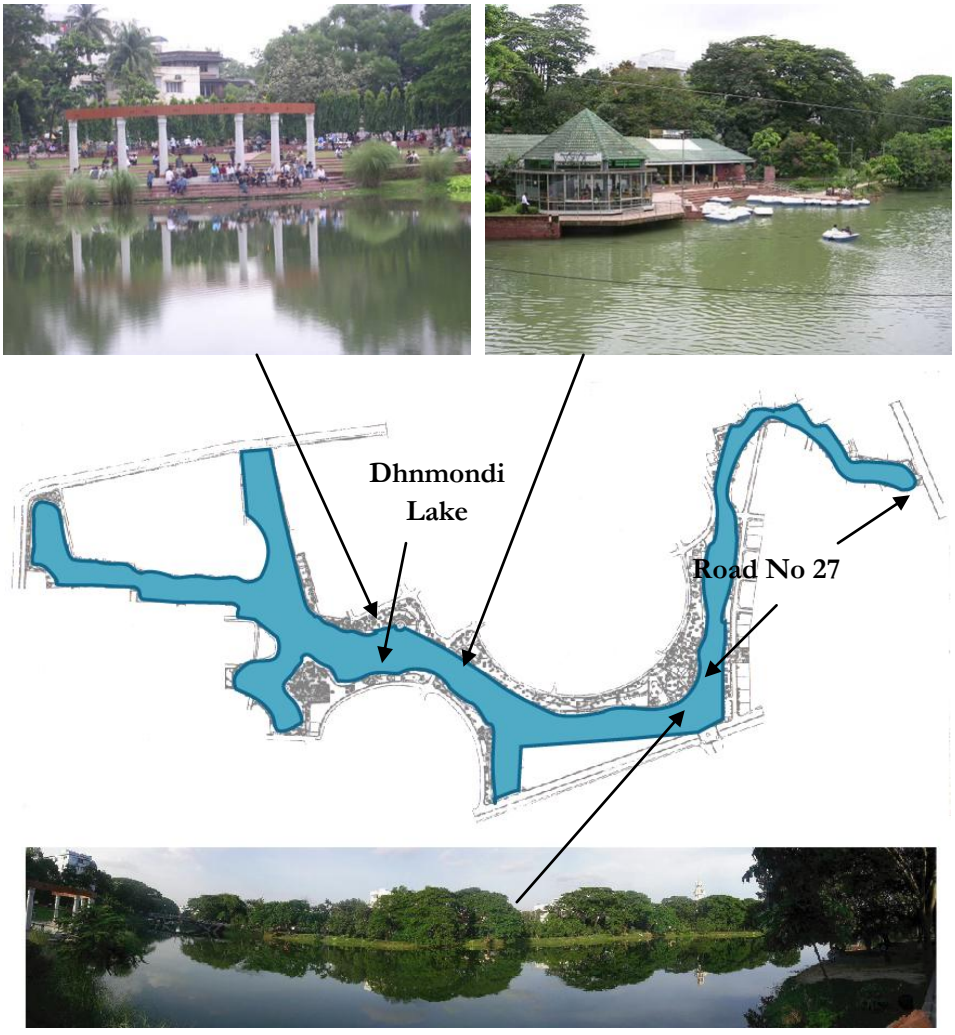



**Fig 11. Dhanmondi R/A Designed with water-bodies but not integrated.**

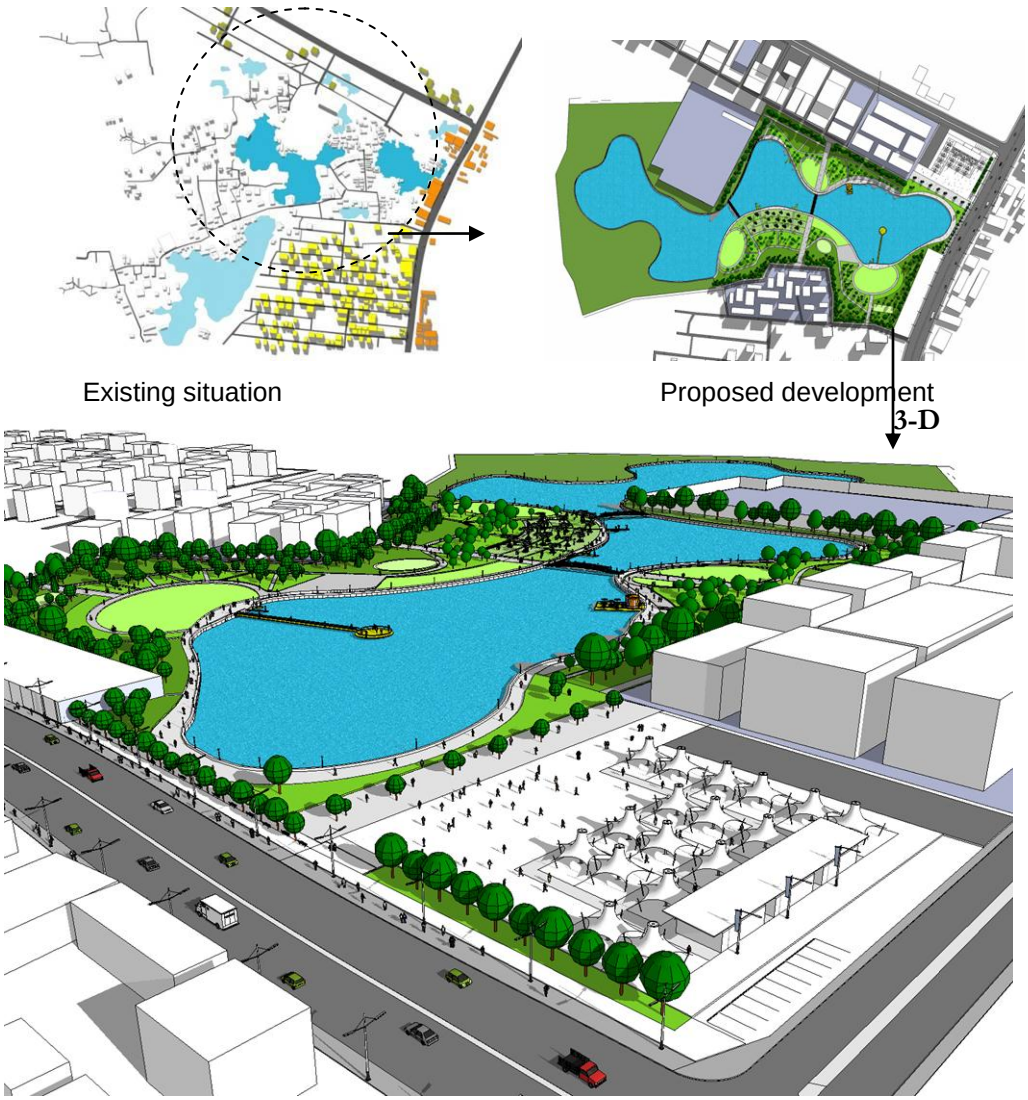



**Fig 12. Badda retention pond development area students' vision of development without sacrificing density or contemporary needs but integrating nature with the development.**