KHULNA UNIVERSITY

ANALYSIS OF IMPACT OF DEVELOPMENT PROJECTS ON WATER SECURITY OF THE MAYUR RIVER IN KHULNA

Study Report | Kousik Ahmed and Prosun Kumar Ghosh

Water Security in Peri-Urban South Asia
Adapting to Climate Change & Urbanization

ILS IDRC CRDI

1. Introduction

Freshwater is an essential component of the hydrosphere and terrestrial system. But many factors may influence this vital resource leading to inadequate quantities and quality of this vital resource. These influences include land use changes, pollution of the environment, over utilization and inappropriate uses of available freshwater resources and impact of climate change.

With vast low lying areas, Bangladesh is considered as one of the most vulnerable countries in the world to climate change. Strengthening the resilience to climate Change is crucial in all its development and poverty alleviation activities. The city of Khulna, being located in the coastal area of Bangladesh, and influenced by tides from the Bay of Bengal, is highly vulnerable to climate change. The increasing salinity intrusion into the city waters and the anticipated sea level rise might have a major impact on the water resources both ground water and surface water and the water and drainage infrastructure of the city and its surrounding areas.

Khulna suffers from acute water scarcity due to unplanned urbanization together with increased salinity in both surface and ground water. The present water supply to Khulna is mainly from groundwater sources drawn from both deep and shallow tube wells. Due to rapid urbanization and population growth ground water layer deplaning day by day. The need to proactive plan and manage urban growth and mitigate its impact on the natural environment, particularly on urban watersheds and peri-urban areas, is one of the major challenges in restoring and maintaining the physical integrity of the waters of the Mayur River.

1.1 Aims of the study

The study aims at the analysis of the following ongoing projects to assess whether the projects have impact on water security of the river Mayur or not:

- Khulna city corporation (KCC)
- Khulna development authority(KDA)
- Khulna water supply and sanitation authority (KWASA)
- Bangladesh Water development board, Khulna
- Local government engineering department, Khulna (LGED)

1. Study area

The study area is situated in and around the river Mayur flowing along the northwestern peri-urban stretch boarding the Khulna City Corporation (KCC). The Mayur follows a path of 11 km from Hamidnagar to Alutola and flows into Bhairab-Rupsha on eastern KCC. The Khulna City Corporation (KCC) is about 45 km2 and situated between 89°00E to 90°45E longitudes and 21°45N to 24°00N latitudes. The northern boundary of KCC merges in to the low lying plains of Teligati.

2. Methods used for the present study:

- Collection of secondary data from the existing development project proposals
- Analyzing the goals and objectives of the development projects
- Analyzing the projects objective that may influence the water security of the river Mayur by using some indicators

3. Analysis process

Seven indicators have been considered for the study to assess the impact on water security of the River Mayur. The project analyses have been done with respect to the following indicators.

I. <u>Pollution load</u>:

Urbanization increases variety and amount of pollutants carried into streams, rivers, and lakes. The pollutants include:

- Sediment
- Oil, grease and toxic chemicals from motor vehicles
- Pesticides and nutrients from lawns and gardens
- Viruses, bacteria and nutrients from pet waste and failing septic systems
- Road salts
- Heavy metals from roof hinges, motor vehicles and other sources
- Thermal pollution from dark impervious surfaces such as streets and rooftops

II. <u>Solid waste load</u>:

Usually low-income communities– residents tend to either dump their garbage at the nearest vacant lot, public space, creek, river, or simply burn it in their backyards. Uncollected waste

may accumulate on the streets and clog drains when it rains, which may cause flooding. Wastes can also be carried away by runoff water to rivers, lakes, and seas, affecting those ecosystems.

III. Population interference:

Population growth is a direct determinant of increases in water demand for domestic uses. Another key demographic factor is change in the geographic distribution of population, which modifies the spatial pattern of demand for domestic uses. Urbanization, in particular, through increased population density and the concentration of demand, can make the latter a serious constraint on local resources. To reduce pressure on limited water resources, it is important to consider ways to manage population growth.

Human populations affect water in direct and indirect ways. The former consist in modifications to the circulation of water and its quality by withdrawals, waste water disposal, river regulation etc. The latter consist in modifications of vegetation and soil cover: deforestation and compaction reduce the absorptive capacity of the soil and accelerate water runoff; this causes floods and deficits of recharge of aquifers; the loss of soil protection accelerates erosion and leaching, increasing water pollution; finally, air pollution affects the chemical properties of water through precipitations (viz. acid rains)

IV. Traditional water use pattern

Water quality interests are closely related to water use. Reservoir water uses include irrigation, water supply, flood control, hydropower, navigation, fish and wild life conservation, and recreation. Water quality may be more than a descriptor of water chemistry; it may also be considered a reservoir purpose when water is provided to assimilate waste effluents. Conflicts often arise for reservoirs with multiple water uses. Water quality as a descriptor rarely competes with other water uses; rather it is usually a constraint.

V. Drainage pattern:

Drainage pattern of an area depends on the course of the streams and their tributaries. Land-slope, lithology and structure influence the drainage pattern. In general, coarser the drainage texture, higher is the conductivity. Finer drainage texture results in heavier soil type.

Drainage patterns act as guidelines to locate vulnerable areas requiring different kinds and degrees of soil conservation measures.

VI. Landscape of the project area

In urban and suburban areas, much of the land surface is covered by buildings and pavement, which do not allow rain water to soak into the ground. Instead, most developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. The storm water runoff carries pollutants such as oil, dirt, chemicals, and lawn fertilizers directly to streams and rivers, where they seriously harm water quality. To protect surface water quality and groundwater resources, development should be designed and built to minimize increases in runoff.

VII. Ecological service:

Rivers, streams and wetlands provide people with a wide range of benefits often referred to as "Ecosystem Services". These services include maintenance of atmosphere and climates suitable for human life; filtration, purification and delivery of water; maintenance of soil fertility and structure; pollination of crops and other vegetation; control of the vast majority of potential pests, diseases and weeds; provision of genetic resources; production of goods like food and fibre; and provision of cultural, spiritual and intellectual values.

- **Provisioning Services**
  - Goods that ecosystems produce and we use
  - Everything that grows in an agricultural field for food
  - Fish that we catch for food
  - Forest nuts and berries that we gather for food
  - Trees for timber
  - Herbs for medicine

- **Regulating Services**
  - Effects that ecosystems that have on the environment that improve our lives

- Strips of vegetation next to waterways absorb pollutants –we get improved water quality
- Forests sequester carbon–we get climate regulation
- Street trees remove car exhaust from the air–we get lower asthma rates

➢ **Cultural Services**

- Non-material enjoyment and use of the environment
- Recreation–We go rafting, hiking, and fishing, which is a lot more fun if there are fish in the water and trees on the banks
- Spiritual–We enjoy being "out in nature" for specific religious reasons or general aesthetic reasons

➢ **Supporting Services**

- Background processes that we don't use directly but which we need for day to day life
- Agriculture depends on–Nutrient cycling–Soil formation

These points are considered for the potentiality of river mayor for a good contributor to water security in Khulna city.

List of the Existing water Development Projects in and around Khulna City

A. Ongoing and recently completed projects of Khulna Water Supply and Sewerage Authority (KWASA)

1. Supporting the establishment of the Khulna water supply and sewerage authority
2. Strengthening the resilience of the water sector in Khulna to climate change
3. Khulna water supply project
4. Development of water supply system in Khulna city
5. Development and rehabilitation of Khulna water supply and building infrastructure facilities for Khulna Water Supply And Sewerage Authority (KWASA)
6. Installation of production tube well and development of water supply network

B. Ongoing projects of Khulna city corporation (KCC)

1. Construction of linear park on the bank of Moyur in Khulna city
2. Survey to Mitigate Water Logging Problem in Khulna City under "Excavation, re-excavation and preservation of natural canal and rivers and construction of bridge with a view to mitigate water logging problem in Khulna City" project.

C. Ongoing projects Local government engineering department (LGED)

1. City Region Development Project

A. KWASA PROJECTS

1. Project Name: Supporting the establishment of the Khulna water supply and sewerage authority(KWASA)

In February 2008, the Govt. of Bangladesh passed an ordinance published under Gazette No. (Dhaka, 25 February 2008) S.R.O no-43-law/2008- law/division pass-2/K 1/2007 separating the waterworks department of Khulna City Corporation (KCC) and establishing a separate and independent Khulna Water Supply and Sewerage Authority (KWASA). Under the ordinance, the assets and liabilities of the then waterworks department were transferred to the new organization including all the rights and obligations of a WASA under the WASA Act of 1996. Appendix "B"

summarizes the LGD circulars in the SRO defining the extent and terms and conditions of the transfer by KCC to KWASA.

The water utility has been in operation since March 2008 under its new structure as KWASA. It currently serves an estimated 15,236 service connections through piped water supply and operates and maintains some 8,000 shallow and deep tube wells run hand pumps that cater to those not connected to the piped system. With 1.5 million population of Khulna and annual projected growth of 2.5%, there is a big demand for increased and improved water supply services in Khulna.

The main objectives of the project are:

1. To review and evaluate the adequacy and appropriateness of the existing financial management and commercial operating systems and recommend appropriate improvements/enhancements;
2. To review and evaluate KWASA's financial condition and its potential capacity to support immediate as well as long-term improvements and expansion of the water supply system;
3. To assist KWASA develop an interim improvement program covering the 2 -year period prior to the implementation of planned investment programs in 2012 and prepare supporting business plan/financial projections; and
4. To provide initial assistance in the implementation of key priority actions in the interim period.

Project Implementation period: March-April, 2009

2. Project Name: Strengthening the resilience of the water sector in Khulna to climate change

During the fact-finding mission to Bangladesh in September 2008, an ADB Mission discussed with the Government the possibilities of impacts of climate change on two planned water sector investment projects in Khulna, namely the City Region Development Project and the Khulna Water Supply Project. ADB suggested assessing the impacts of climate change and identifying adaptation options before the investment projects are implemented. So this study project titled ˝Strengthening the Resilience of the Water Sector in Khulna to Climate Change˝ was conceived after subsequent agreement between the Govt of Bangladesh and ADB in October 2008.

The main objectives of the project are:

The overall objective of the project is to assess the impacts of possible climate change on drainage, water availability and salinity situation in Khulna and to advice on how to make the system more resilient for climate change. The study has prepared a list of adaptation options including both structural and non-structural, for the above mentioned investment projects. The output of the TA project will be reflected in the design of these future projects and other Government interventions.

The overall objective will be fulfilled by accomplishing the following specific objectives:

1) Identification of impacts of climate change on flooding, drainage, salinity and water availability aspects;
2) providing adaptation options based on social, economic, public health and urban planning aspects;
3) Conducting workshops and trainings to develop capacity of relevant stakeholders/agencies to combat the impacts of climate change scenarios.

Project Implementation period: April, 2009 to June, 2010

3. Project Name: Khulna Water Supply Project

Khulna, the third largest city in Bangladesh, is located in the southwest area of the country and has a population of 1.5 million (2008). To cope with current insufficient water supply and increasing demand, the Khulna Water Supply and Sewerage Authority (KWASA) plans to improve the existing water supply system with assistance from the Japan International Cooperation Agency (JICA) and Asian Development Bank (ADB). The Khulna Water Supply Project (the Project) will be co-financed by JICA and ADB and is being formulated as a project loan to be implemented over a 5-year period (2011 to 2016). The Project envisages a major improvement to the public water supply system and aims to improve the quality of life for all residents and businesses in Khulna.

The project is located in two districts, Khulna and Bagerhat Districts. The Feasibility Study proposed to deliver water to Khulna City Corporation (KCC) from the Modhumati River. The raw water will be extracted at the intake point located on the bank of Modhumati River at

Mollarhat in Bagherhat District. The raw water will then be delivered approximately 33 km to an impounding reservoir near the water treatment plant at Samonto Sena in Rupsha Upazila where the purified water will then be distributed through a system of smaller storage reservoirs and overhead tanks to five service zones in KCC.

The Project will develop a sustainable water supply system in Khulna city. Khulna city relies entirely on groundwater and the project will introduce surface water as the main water source to avoid excessive groundwater abstraction. The project will also strengthen corporate management systems of the Khulna Water Supply and Sewerage Authority (KWASA).

Objectives:

- The broad objective of the project is due to inadequate underground water supply in the Khulna City, improve the existing water supply system through surface water supply to ensure safe, potable and adequate water supply for Khulna City area due to climate change.

The specific objectives of this project are-

- To provide adequate water service for all the citizens including low income people.
- To ensure uninterrupted water supply in the city area.
- To ensure the hygiene of water supply and sanitation in the Khulna city.

To fulfill the objectives, the major components of this project are:

i. Raw water transmission pipeline of 33 km length with 1350mm dia.
ii. Clear water transmission pipeline of 25km length with 300mm to 1000mm dia.
iii. Water Intake with capacity of 110000m^3/day(110MLD).
iv. Impounding Reservoir with capacity of 775,200m^3/day.
v. Surface water treatment plant (SWTP) with capacity of 110000m^3/day(110MLD).
vi. 5 Distribution Reservoir with capacity of 10000m3-20000 m^3
vii. 11 Over Head Tank with capacity of 300m^3-500 m^3
viii. Distribution Pipe Network 700km of 50mm-400mm dia.
ix. Service Pipe Connection 75,000 nos.

The impact of the project will be improved urban services in Khulna. The outcome of the project is that majority of households in Khulna have reliable access to potable water. The outputs of the

Project are presented below. The Project will be co financed on parallel basis by Asian Development Bank (ADB) and Japan International Cooperation Agency (JICA). JICA will finance most activities under Output 1, while ADB's funding will be mostly utilized to finance activities under Output 2 and 3.

Output 1: Augmented and sustainably managed water sources in Khulna city. Activities under Output 1 include construction of intake facilities, a surface water treatment plant, an impounding reservoir and a raw water transmission main, which will be financed by JICA; and rehabilitation of deep tube wells and monitoring of groundwater, which will be financed by ADB. Quality of raw water will be carefully monitored and appropriately mixed with water stored in the impounding reservoir to meet quality standards, particularly salinity level. Groundwater will be carefully monitored and the abstraction will be limited to a sustainable level.

Output 2: Extended and efficiently managed distribution network in Khulna city. Activities under Output 2 will be financed by ADB and include expansion of distribution network, construction of a clear water transmission main, and establishment of zonal offices. The current system covers only part of the city, which will be expanded to the entire Khulna city. The distribution networks will be organized in five blocks managed by zonal offices, and blocks will be further divided into District Metering Areas (DMA). Amounts of inflow, outflow, and consumption will be diligently monitored for each DMA to identify and minimize leaks.

Output 3: Professional and sustainable corporate management of KWASA. Activities under Output 3 will be financed by ADB and include capacity building programs and consulting services for developing and strengthening KWASA's corporate management system. The Project will strengthen KWASA's corporate management system, since KWASA has been recently established with limited financial and human resources.

The Project will support the implementation of various activities under the first 5-year business plan, which includes a capital investment plan, financial plan, and human resource development plan. In addition to the expansion of service areas, volumetric tariff and other charges will be

introduced to enhance revenues. Human resources will be gradually expanded and adequate training will be provided for professional management of the water supply system.

Table 1: Summary of Proposed Facilities

	Components	Capacity	Quantity	Dimension (m)	Area (acres)	Location/ ownership
1	Water Intake Facility	110,000m^3/day	1 no.	75 x 125 + Access Road 120m	2.521	Madhumati River at Mollarhat (private land)
2	Raw Water Transmission Pipe	-	350mm, L=33km	-		
3	Impounding Reservoir	775,200m^3	1 nos	400 x 400	67.73	Samanto Sena (private land)
4	SWTP	110,000m^3/day	1 nos	250 x 400	24.71	Samanto Sena (private land)
5	Clear Water Transmission Pipe	-	300mm-1100mm, L=25km	-		
6	Distribution Reservoir & Overhead Tank (5 nos)	Reservoir (5,000m^3 - 18,000m^3 OHT (300m^3 - 500m^3)	Deana West Para Reservoir	100 x 70	1.7	Private land
			Ward No.16 Office Reservoir	100 x 70	1.7	KCC (government land)
			Sonadanga Moha Sarak Reservoir	100 x 90	2.2	Private land
			Beside of No.7 Ward Office Reservoir	100 x 70	1.7	Private land
			Khalishpur Charerhat River Ghat Reservoir	100 x 90	2.2	Government land
7	Overhead Tank (6 nos)	300m^3	Rab Sarani OHT	45 x 30	0.33	Private land
		300m^3	Mujgunni OHT	45 x 30	0.33	KCC (government land
		300m^3	Ferry Ghat Power House OHT	45 x 30	0.33	KCC (government land)
		500 m^3	Andir Pukur OHT	50 x 35	0.43	Private land
		500 m^3	South Side of Office OHT	50 x 35	0.43	Private land
		500 m^3	DPHE Rupsha OHT	50 x 35	0.43	DPHE (government land)
8	Distribution Network	-	50mm-400mm, L=700km	-		
9	KWASA offices	Total 15,000 sq ft. (approximate)	HQ (1) Zonal offices (3)		Total 15,000 sq ft. (approximate)	HQ (government land) Zonal offices (1 private, 2 government lands)

DPHE = Department of Public Health Engineering, HQ = headquarters, KCC = Khulna City Corporation, KWASA = Khulna Water Supply and Sewerage Authority, OHT = overhead tank, SWTP = surface water treatment plant.
Source: Feasibility Study for Khulna Water Supply Improvement Project, 2010 JICA Study Team.

Project Implementation period: ongoing project

4. Project Name: Development of water supply system in Khulna city

The main objectives of the project are

I. 13 nos production tube well and 6.75 MLD surface water treatment plant produce 26.75 MLD water
II. 33 km new water pipe line and Rehabilitation of 1.25 MLD Surface water treatment plant.
III. Rehabilitation of 21 km of water pipe line and connect 3000 nos water flow meter

Project Implementation period: July'2010-June'2013

5. **Project Name: Development and rehabilitation of Khulna water supply and building infrastructure facilities for Khulna Water Supply And Sewerage Authority (KWASA)**

The main objectives of the project are:

I. Replacement of 8 nos production tube well and Installation of new 8 nos production tube well to produce 16MLD water
II. Construction and Rehabilitation of 100 km of water pipe line and connect 6000 nos water flow meter

Project Implementation period: July'2012-June'2015

6. **Project Name: Installation of production tube well and development of water supply network**

The main objectives of the project are:

I. Installation of 8 nos production tube well
II. Extension and development of 55 km existing water supply pipe line
III. Installing 5000 flow meter by increasing 5000 nos house connection.

B. KCC PROJECTS

1. **Project Name: Construction of linear park on the bank of river Moyur in Khulna city**

Objectives of the project:

(i) To create recreational facilities for city dwellers as children of Khulna city.
(ii) To protect the river bank from illegal encroachment
(iii) To improve the environmental situation in city area

Outputs-

Construction of park including construction of

i. Approach road, internal pathways (walk ways), cycling ways, parking
ii. Entry plaza, cycle shade
iii. Office shed & security shed, ticket counter, public toilet,
iv. Jetty/ghat
v. Plantation, beautification:flower beds, replica, sculpture, tilla, fountain
vi. Umbrella shed, bench, resturent/ floating restaurant, boundary wall, babade wire fencing, decorative wall
vii. Observation tower
viii. Swimming pond
ix. Children zone

2. **Project Name: Excavation, re-excavation and preservation of natural canal and rivers and construction of bridge with a view to mitigate water logging problem in Khulna City.**

Many areas of the Khulna city population face tremendous problem during the rainy season in the absence of proper drainage network. Eventually water logging causing serious damage not only to road but also to other infrastructure developed by KCC and other line agencies. Consequently, KCC has to incur huge financial outlay to restore/ rehabilitate the infrastructure. Therefore, developing a well planned drainage network in this city has become very urgent. Keeping this in view, the development was proposed to the Local Government Division (LGD).

In the light of that, KCC firstly initiate with a detailed survey project entitled as "*Survey to Mitigate Water Logging Problem in Khulna City*". Under this project Khulna city along with the extended areas was surveyed to gather information on ward wise population, road network, drainage network, footpath, location of dustbins, open space, natural canals, rivers, island divider, slums and relevant features. After collecting all these information different type of maps such as drainage map, contour map, and road network maps was prepared for assessing the actual needs and estimating relevant costs for developing integrated drainage system for the city.

All the information collected and maps prepared would be used to prepare a drainage master plan for the city to mitigate its water logging problem and allow smooth drainage of waste and storm water.

Objectives of the project:

1. Detailed topographic survey of all types of roads (pucca, semi puca,katcha), and drains (pucca, semi puca, katcha), canals, river, island divider, footpath, open space, vegetation ward-wise population, location of dustbins, waste generation etc.
2. Detailed land use map
3. Contour map
4. Cost estimation and design of construction of drainage, excavation of canals and rivers etc.
5. Training of officials

Basic principles of the project development:

The principles under which drainage services operates are expected to be:

- To protect municipal infrastructure investment by maintaining the existing drainage collection and treatment facilities
- To provide an acceptable level of service to city dwellers
- To maximize environmental protection
- To support orderly development in KCC area
- To operate drainage service s in an efficient and effective manner

C. LGED PROJECT

1. Project Name: City Region Development Project (formerly Megacities Development Project)

Project Aim:

The project aims to increase growth potential and environmental sustainability of two city regions based on coherent regional urban planning. A city region is defined as an organic

agglomeration of a large city, surrounding secondary towns, and adjacent peri-urban areas. The project will target the city regions of Dhaka and Khulna.

It will support the development of key urban infrastructure, focusing on urban environment and local economic development. The project also supports government efforts to improve regional and urban planning, and to strengthen municipal management and capacity for effective and sustainable urban development.

Impact and Outcome

The impact of the project will be enhanced growth potential and environmental sustainability of the two city regions. The outcome will be improved urban environment and infrastructure services based on effective regional and urban planning.

Project Outputs

Output 1:

- **Enhanced Capacity of Urban Infrastructure**

The project will enhance the capacity of crucial urban infrastructure. This output will be achieved through implementation of subprojects selected according to pre-established criteria. The subprojects will be developed and prioritized within the framework of the updated regional urban plans (output 2) to ensure coherent regional development. Municipalities are required to meet certain performance criteria for funding of subprojects, which will create strong incentive to improve municipal management and governance (output 3).

- **Water supply and sanitation.**

Subprojects relating to water supply and sanitation will expand access to such services. Water-supply subprojects will initially focus on rehabilitating existing facilities to reduce leaks, before expanding the system. They will adopt energy-efficient pumps which will be piloted under TA for energy efficiency improvement. Sanitation subprojects will emphasize better design and maintenance of septic tanks, as introduction of a sewer network is premature. Design and management of the subprojects will take into account women's requirements since they tend to fetch water and manage sanitation facilities for the whole family.

- **Solidwaste management.**

Subprojects for solid-waste management will improve collection and disposal of solid waste. Theywill be accompanied by awareness campaigns for the 3Rs (reduce-reuse-recycle). Primary collection will be mostly outsourced to community-based organizations (CBOs) or nongovernment organizations.Women will be encouraged to participate in awareness campaign and CBOs. Opportunities for private sector participation and registration with the Clean Development Mechanism will be explored, particularly if disposal involves composting. To exploit economies of scale and nurture inter-municipality cooperation, the project will promote the sharing of treatmentand disposal facilities among municipalities.

- **Energy efficiency program.**

Subprojects in the energy efficiency program will reduce energy consumption to mitigate CO2emission, and cut energy costs to improve municipal finances. The program will focus on introducing energy-efficient water pumps and solar-powered streetlights. It will start with detailed energy audits and a pilot program, followed by capacity and awareness building among municipalities for an expansion of the pilot program. Opportunities to register the subprojects with the Clean Development Mechanism will be explored.

- **Urban transport**

.Subprojects relating to urban transport will focus on infrastructure that can directly stimulate local economic activities. In addition to improving key roads, bus and truck terminals, and other facilities, a pilot program will be carried out to introduce modern traffic management, such as control of roadside parking, improvement of sidewalks, and use of signals to boost traffic flow and provide a safer environment for pedestrians.

- **Drainage.**

Subprojects relating to drainage will rehabilitate or extend drainage and associated facilities to reduce floods and water logging. This will be accompanied by an initiative to improve collection and disposal of solidwaste, and/or an awareness campaign on the hazards of dumping solid waste into drains.

- **Urban revitalization**

The project will support a small-scale pilot program to revitalize an inner-city area of historic importance and to stimulate local economic activities. This will include upgrading and relocating public infrastructure, and restoring public buildings of historic importance. The pilot program

will assess detailed implementation and financial requirements for an eventual expansion via private sector participation.

Output 2:

- **Improved Urban Planning**

The project will support the review and update of urban development plans and formulate a framework for coherent regional development. The current DMDP (1995–2015) will be updated for the period of 2016–2035 in order to reflect the continued socioeconomic development of the Dhaka city region. Development plans for pourashavas will be prepared and/or updated to ensure consistency with the DMDP. The review will put particular emphasis on protecting the urban environment, taking into account the impacts of urbanization and industrial activities on water bodies. The subprojects to be supported under the project will be prioritized and designed along the framework of the DMDP to ensure coherent regional development. To help realize the DMDP, the project will support feasibility studies for future projects, including one for a satellite town. Extensive public consultations will ensure public participation in developing the DMDP and feasibility studies. RAJUK will be responsible for updating the DMDP in collaboration with urban planners from the Dhaka city region's municipalities. The joint exercise will nurture a culture of collaboration between planning agencies and municipalities.

Output 3:

- **Strengthened Municipal Management and Capacity**

The project will support municipal capacity building in the areas of property tax collection, public participation, and urban planning. Public participation will be ensured through citizens' committees with broad representation, including women and the poor. The program will build on lessons learned from the UGIIP—that effective improvement of municipal management is best achieved when capacity development programs are combined with rigorous performance monitoring and performance-based fund allocation. The capacity development programs will be aligned with activities to meet the performance criteria.

Pourashavas that were covered by the UGIIP have developed sufficient capacity in core areas, and the capacity development program will focus on sustaining these achievements. It will boost capacity in other areas such as tax assessment, human resource management, public–private partnerships, and energy efficiency. Pourashavas that were not covered by the UGIIP will start with core training programs established under the UGIIP, such as tax collection, citizen participation, and urban planning. City corporations and urban centers will start with a pilot program in selected areas.

Project Implementation period: ongoing project

5. ANALYZING INDICATORS

A. Overview of the selected indicators

1. Pollution load:

The Mayur is one of the major drainage channels through which a large volume of water both from urban Khulna and adjacent Beel Pabla and Beel Dakatia area is discharged into the river Rupsha.

2. Solid waste load:

Solid waste management in Khulna, and in many other Bangladeshi cities, is hampered by the absence of adequate national or local legislation relating to municipal SWM and the treatment and disposal of hazardous waste. In particular, there are no mandatory regulations or performance standards for city corporations (e.g. KCC) to establish and manage an effective SWM system; nor are there any sanctions to prevent littering and indiscriminate dumping.

As a result SWM in Khulna has developed in a piecemeal and un-integrated manner with NGOs, CBOs, informal recyclers and private enterprises being involved along with KCC. Apart from one ward where KCC operates Door to Door (DtD) collection, its main responsibilities are the transport of waste from Secondary Disposal Sites (SDS) and roadside Dustbin Points (DBP) to the landfill site it operates about 8km to the west of the city. NGOs mand CBOs, along with a KCC contracted private company, collect household waste door to door on a daily basis, using rickshaw vans, in parts of several wards and then transport it to the SDS; these are considered to

be effective operations, although only a minority of city dwellers receives this service. For the most part, householders take the waste to the SDS themselves or dispose of it indiscriminately. Informal recyclers collect and dispose of the great majority of recyclable materials but this waste only constitutes a minority (around 20% by weight) of the total daily generated household waste. The great majority of household waste is bio-waste. Although there are some composting initiatives, their total output is negligible, 20-25 tons per month when compared to the average daily household waste generation of just under 300 tons. Commercial waste is disposed of by individual enterprises. An NGO collects separated hazardous hospital waste around 1/3rd of Khulna's health facilities but there is no system for its disposal. It is currently estimated that only 50-60% of household waste is collected with most of the remainder being disposed of indiscriminately in drains, at roadsides and into vacant areas - a practice which exacerbates flooding. The major reasons for Khulna's inadequate SWM system are:

- The low managerial, technical and financial resources available to KCC to operate an effective SWM system;
- The lack of public awareness and commitment by a large proportion of the population which leads to indiscriminate dumping of waste exacerbated by a resistance to NGO operated DtD services for which payments additional to the conservancy charges levied by KCC need to be made.

In response to this situation urban runoff with solid waste mixed with mayur river time to time.

3. Population interference:

Khulna is one of the seven divisional cities of Bangladesh. It is the 3rd largest industrial city and also a port city of the country. The city has moderate population density with an estimated total population of 1,227,239 lakh. Khulna City Corporation covers an area of 50.63 km^2 of land area. The town population is about 52.57% of the district population (2,334,285). density of population is 59,574 km^2. Khulna consists of 38 wards and 183 mahallas in a 20.60 square kilometers.

4. Traditional water use pattern:

The present water supply to Khulna is mainly from groundwater sources drawn from both deep and shallow tube wells. In the long term as demand increases, conjunctive use of groundwater

and surface water will be required, even though surface water may suffer from salinity intrusion in dry season.

5. Drainage pattern:

The existing drains in KCC are discharging into the nearby khals, rivers, low lying areas and beels. The existing drainage network within KCC area 1165.48 of these about 1124 km is pucca and about 41.48 are kathca. All most all of them are made of RCC, a few being brick works. There is no underground storm water drainage system in Khulna City. Concrete box culverts are being used for road crossing only. The existing drainage facilities in the fringe and sub-urban areas are inadequate and unsatisfactory. The major KCC areas in the town is not subject to direct flooding from the Bhairab-Rupsha River, but the low-lying areas situated on the western and southern part of KCC are flooded by the rain water and tidal effect during monsoon season .

There are 6 regulators and 8 sluice gates which drain out storm water from KCC area. The 10-vent sluice gate located at Alutala performs major drainage function of the Khulna City. Out of these, 4 regulators drain out storm water into the Rupsha River and the other two regulators drain into the Khudir Khal, the upstream of Gollamari River .

a. Long and Narrow Strip of Flat Highland along both Sides of the Bhairab and Rupsha River(Right Bank)

There is a long and narrow strip of flat high land along the Bhairab and Rupsha River and stretching along northwest to southeast direction; this strip consists of KCC core and urbanizing area.

The ground elevation of this narrow strip decreases sharply towards west and south direction and gradually turns into a flood plain and swampy lands/beels comprising flat and low-lying areas, criss-crossed by numerous tidal rivers and channels. The drainage water is discharged into the Bhairab and Rupsha River through BWDB sluices/ regulators lying on the embankment cum road. The drainage and flood protection works of this area are the responsibility of the LGED and BWDB and covered by the STIFPP and BWDB Flood and Bank Protection Projects.

b. Strip on the Eastern Side ofthe Bhairab and Rupsha River (left bank)

These areas are drained through natural drains, borrow-pits and ground profiles sloping towards adjacent low-lying areas/flood plain and ultimately into the outfall river/khals, viz., Bhairab, Rupsha, Atharbanki, Atai, Majudkhali,etc. Theseareas comprise the fringe area of the town.

c. South and South-eastern Area on the Left Bank of Rupsha, Kazibacha River

These are fringe areas and drained through numerous tidal creeks, low-lying Areas/beels and flat land situated in the flood plain of the major rivers, which ultimately drained into the adjacent Rupsha, Kazibacha and Atharbanki rivers.

d. Western Part of the KCC Area along Left Bank of Calamari River and Khudir Khal

The western part of KCC between Daulatpur and Kazibacha River is drained by the upstream of Gallamari river or Khudir khal and downstream of Gallamari river and ultimately through a regulator at Alutala which discharges into the Kazibacha - Rupsha river. A small part of the catchment area adjoining Khulna University area on the right side of the Gallamari River used to drain by two BWDB sluices, but now drains towards west and into the lower Sholmari river due to occurrence of siltation problem in the Gallamari river and Khudir khal.

e. Northwestern Part of KCC and Structure Plan Area, Western Part of the Structure Plan Area

This catchment maybe subdivided into two areas:

i. North and northwestern part of structure plan area between Daulatpur , Phultala.

ii. Middle and southwestern part of the structure area between upper and lower Sholmari river on the west (left bank of Sholmari river) and Gallamari river/Khudir khal on the east (right bank of Gollamari and Khudir).

Landscape of the area:

The land surface slope of Khulna is westward whereas the regional slope is southward. The average land surface elevation of Khulna is about 3.32 m from the Mean Sea Level (MSL) (Adhikari et al., 2006). The area comprises of mostly flat land with the natural ground slope in two different directions: one from northwest to southwest, parallel to the general flow direction of the Bhairab river 4.2 Information on the study area (upper reach) and Rupsha river (middle to lower reach); and another from northeast to southwest, which allows the sea water intrusion into the aquifer system of Khulna. The Khulna City Corporation (KCC) area lies on the Late Holocene-Recent alluvium of the Ganges deltaic plain in the north and Ganges estuarine plain in the south (Adhikari et al., 2006). Tectonically, the area lies within the Faridpur Trough of the foredeep part of the Bengal Basin (Alam, 1990). The trough is filled with Tertiary and Quaternary sand and clay rich sediments with few coarse sand beds. Lithologically, the area is composed of coarse to very fine sand, silt and silty clay to a depth of 300 m with peat soil and calcareous as well as non-calcareous soil at the top. The surface lithology of the area is of deltaic deposits which are composed of tidal deltaic deposits, deltaic silt deposits, and mangrove swamp deposits (Alam, 1990).

6. Ecological service:

The ecological environment of Khulna city is characterized by a human managed landscape characterized with agricultural uses.

B. <u>Impact analysis on the river Mayur</u>

The Mayur can be used as a freshwater reservoir as a strategy to cope with the impact of climate change. So, it is important to analyze the existing development projects which may have impacts on water security of the Mayur and it is shown in Table 2.

Table 2: Impact of development projects on the river Mayur

No	Name of the project	Indicator						
		Pollution load	Solid waste load	Population interference	Traditional water use pattern	Drainage pattern	Landscape of the project area	Ecological service
1	Supporting the establishment of the Khulna water supply and sewerage authority	Nil	Nil	Population as well as water demand will increase	Will be change, depend on supply water	Nil	Khulna city	Nil
2	Strengthening the resilience of the water sector in Khulna to climate change	Nil	Nil	Population as well as water demand will increase	increase	Will be change	Khulna city	Increase
3	Development and rehabilitation of Khulna water supply and building infrastructure facilities for Khulna water supply and sewerage authority **(**KWASA**)**	Increase	Nil	Population as well as water demand will increase	New ground water production pump will set up	Will be change	Khulna city	Decrease
4	Development of water supply system in Khulna city	Will increase in the project area		Population as well as water demand will increase	New production pump and surface water treatment plant will be established	Will be change	Khulna city	Decrease
5	Khulna water supply project	Increase	Nil	Population as well as water demand will increase	Water reservoir surface water treatment plant, over head tank, underground reservoir will be constructed	Will be change	Khulna city	Positive
6	Installation of production tube well and development of water supply network	Increase	Nil	Population as well as water demand will	New tube wells and water supply connections will	Will be change	Khulna city	Nil

No	Name of the project	Indicator						
		Pollution load	Solid waste load	Population interference	Traditional water use pattern	Drainage pattern	Landscape of the project area	Ecological service
				increase	set up			
7	Construction of linear park on the bank of Moyur in Khulna city	Reduce	Reduce	Population as well as water demand will increase	Positive	Will be changed	Khulna city, Mayur river Landscape will be changed	Positive
8	Survey to mitigate water logging problem in Khulna city.	Reduce	Will be Increase in dry season	Population as well as water demand will increase	Positive	Will be changed	Landscape of Khulna city will be changed	Positive
9	City Region Development Project	Nil	Nil	Population as well as water demand will increase	Positive	Will be change	Khulna city will be changed	Negative

Conclusion

From this study, it is found that a large number of development projects have been undertaken in and around Khulna city without proper consideration of the environment. Moreover, the different institutional sectors have no significant coordination which is very important for sustainable water development projects. The impact analyses have shown that most of the development projects have negative impacts on the water security of the river Mayur directly or indirectly. So, all this potential impacts will have to be considered while designing a landscaping of the river Mayur as a freshwater reservoir to cope with climate change impacts in future.

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