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

Use of a Shared River by Urban and Peri-Urban Residents: Water Use Conflicts and Adaptation Measures

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This study was conducted to assess how urban and peri-urban residents of Khulna have been affected by the Mayur River through its use and abuse, and to explore adaptation measures. To complete the study, primary data was collected through field surveys, stakeholders' consultation, focused group discussion, key informant interview and water quality analysis. Result shows that the Mayur plays a very important role by meeting the agricultural water demand; domestic water demand and water demand for capture and culture of fisheries for livelihoods. However, urban residents use the river as a dumping site for discharging solid waste. River encroachment through various means and practices is also a regular event. Analysis of salinity and tidal water level indicates that salinity intrusion would further increase due to sea level rise induced by climate change. Water and wastewater quality reveals that the river water is extremely polluted to support aquatic life and livelihood services. Physico-chemical parameters, DO, EC, TDS, Na^{+}, Mg^{2+}, PO_4^{3-} and salinity exceed the recommended limits for drinking and irrigation set by the DoE and WHO. These overall situations often initiate water use conflicts. Finally, we discussed the current water management practices and adaptation for long term management of the Mayur.

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This is one of a series of Discussion Papers from the Peri Urban Project of SaciWATERs.

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Use of a Shared River by Urban and Peri-Urban Residents: Water Use Conflicts and Adaptation Measures

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1. INTRODUCTION

Khulna, the third largest metropolitan city (46 km^2) of Bangladesh, is vulnerable to climate change and unplanned urbanization process. The city has been identified as one of the 15 most climate change vulnerable cities of the world (IIED, 2009). In Khulna, the Rupsha and the Bhairab are two major tidal rivers flowing through the eastern part of the city. The Mayur River flowing along the western boundary of the city of Khulna is shared by the urban residents on one side and peri-urban residents on another side for different uses. Although the river Mayur provides important ecosystem services to the urban and peri-urban residents of Khulna, it has been facing severe threats due to unplanned and unregulated urbanization and climate change impact. Future projections indicate that it would be further affected by salinity intrusion and sea level rise due to climate change (ADB, 2010).

The Mayur is now almost a dead river, which is used as a waste dumping site for the city of Khulna (Das, 2011; Kamal et al, 2007; Sabbir et al., 2010). River encroachment and loss in connectivity has severely affected the conveyance and assimilation capacities of the river. Natural tidal flow in the river has also significantly reduced due to flow regulation through two regulators at Rayermahal and Alutala. In Khulna, there is a public consensus that Mayur could be a potential source of freshwater supply for urban and peri-urban residents of Khulna. Thus, any decision making needs analysis of the present state of the river, water quality and quantity, sources of pollutants, and major uses by the local communities. A long term adaptation approach is also essential to save the river from the present abuses.

The Mayur is situated at the back swamp of Rupsha and Bhairab rivers. Mayur receives freshwater from Beel Pabla and urban runoff from the Khulna City Corporation (KCC). The river originated from the vast water body called Beel Dakatia, northbound to the KCC. It is locally known as the Khuder Khal at the point of its origin. From Rayermahal it is known as Mayur. It runs through Chalk Mathurabad and Chhoto Boyra and meets the Bhairab river at Alutola. A branch of Mayur is called Kazibacha or Hatia. The Hatia joint is now dead and therefore disconnected. The river is about 11.69 km long and varies by width widely at different locations. This study was conducted to assess how uses and abuses by urban and peri-urban residents of Khulna city have affected this transitional river and explore adaptation measures for long term management of the shared river in peri-urban Khulna.

The Mayur is located at the western boundary of KCC (Figure 1). Demographic characteristic of the city indicate a rapid growth (3.8 per cent) in urban population is due to rural-urban migration (Aqua-Sheltech Consortium, 2002). Literacy rate is relatively higher compared to other major cities in Bangladesh. Gross population density is very high, about 18,000 per km^2 (Khulna city profile, 2002). A large proportion of the local people are engaged in informal sector activities (Murtaza, 2001). The average elevation of Khulna is about 3.32 m from the mean sea level (MSL) (Adhikari et al., 2006). The land use pattern of Khulna has been substantially influenced by the flow of the Rupsha and Bhairab rivers. The study area is situated in a deltaic plain. The land topography is flat and poorly drained. The whole metropolitan area is approximately 2.5 m above the mean sea level. Tectonically, the area lies within the Faridpur Trough of the foredeep of the Bengal Basin (Alam, 1990). The surface lithology of the area is deltaic deposit composed of tidal deltaic deposits, deltaic silt deposits, and mangrove swamp deposits (Alam, 1990).

2. METHODOLOGY

To complete the study both primary and secondary data were collected. Primary data was collected through field visit, stakeholders' consultation meetings, focused group discussion, key informant interview, stakeholders' workshop and water quality analysis. Secondary data was collected from published and unpublished literature, database and research reports. This study involved three field visits from July 2010 to December 2011. During the first field visit, reconnaissance survey, stakeholder consultation meetings with Khulna City Corporation (KCC), Khulna Water Supply and Sewerage Authority, Khulna Development

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Authority, Department of Environment (DoE), Khulna University (KU), Khulna University of Engineering and Technology (KUET) and local NGOs were conducted. Water and wastewater sampling, transect walk along the Mayur and key informant interviews were undertaken during the second field visit. During third field visit, three FGDs (at Alutala, Chhoto Boyra and Rayermahal) and a stakeholder workshop was conducted. In the stakeholder workshop, the present status of Mayur, causes of degradation, and its long term management aspects were discussed in the context of climate change and urbanization.

Figure 1: Location of the Mayur river.

For water quality analysis, a total of 12 water samples and 10 wastewater samples were collected from the mid-stream, at varying depths of about 40 to 50 cm and 15-20 cm, respectively. Acid wash 1 litre plastic bottle was used for sampling collection. After collection, proper labeling was done on the sample bottles (sample number, location, date and time). Aeration was avoided as far as possible during sampling. Then water samples were carefully transported to the laboratory using ice-box within 12 hours. Total analysis was carried out within one month of collection at the water quality laboratory of the Environmental Science department of Khulna University. Some basic parameters, TDS, EC, pH and Salinity were analyzed in-situ. The detail sampling and analytical methods for the water samples have been described elsewhere (APHA, 1998; Ramesh, R. and Anbu, M. 1996; WHO, 1989). Water quality parameters i.e. temperature, pH, EC, DO, TDS, Na+, Ca2+, Mg2+, K+, Cl-, CO32-, HCO3-, NO3-, SO42- and PO42- were selected based on the agriculture and health significances.

3. RESULTS AND DISCUSSION

3.1 Geomorphological and hydrological characteristics of the river Mayur

Mayur is the back swamp of Bhairab river. The major land use pattern around Mayur is dominated by agriculture followed by peri-urban settlements and urban land uses. The present watershed area of Mayur is about 53 km^2 which receives urban runoff and wastewater discharge from 17-22 wastewater canals from the KCC. The total length and width of the river is about 11.69 km and 12-80 m, respectively. The river sinuosity is about 1.37 which indicates the characteristic of a straight river, frequently cited as a 'dead river' by other researchers (Kamal et al, 2007). A rough estimate indicates that the water reserve capacity of Mayur is about 7,25,732,265 gallon in natural conditions. However, in the present situation it could reserve hardly 5,56,542,824 gallon. The maximum water depth was found to be 6 m at Putimari-Taltola location.

3.2 Shared Uses of the Mayur River

The peri-urban residents of Khulna use the Mayur river for meeting the agricultural water demand, domestic water demand and water demand for pisciculture, an important livelihood. It also plays an important role in groundwater recharge. However, urban residents use this river as a dumping site for discharging waste waters, domestic sewerage, solid waste dumping and other related uses. A number of hospitals, clinics, and automobile workshops are located within the catchment area of Mayur which also add to the pollutant load of the river. A large slaughter house is located on the banks of the Mayur at Gollamary bus station from where wastewater is directly discharged into the river without any treatment. Besides, a planned slaughter house is already under construction on the bank of Mayur. Thus anthropogenic activities have retarded the natural flow and degraded the water quality of Mayur. The river now completely looks like a wastewater channel at several points (Rayermahal, Gallamary, Shashanghat, etc). At Gollamary point the river depth is hardly 1 feet or less. A 10-vent regulator on the city protection dam was constructed at Alutala by the Bangladesh Water Development Board (BWDB) (1982-1983) for flood control. However, this regulator is not maintained properly; and sometimes only regulated by muscle-power for illegal fishing activities through forceful encroachment (Karim, 2011; Kamal et al., 2007). About 30 years back, Mayur was a forceful river. Trawlers and gigantic country boats were used on this river for transportation of goods, services and people. Till date Mayur River is the main drainage channel for the eastern part of Polder 28/2, via the 10-vent regulator at Alutala.

3.3 Evaluation of Water and Wastewater Quality

Water quality of Mayur is too polluted to support aquatic life and any other forms of livelihoods for the peri-

urban residents of Khulna. The river water quality (TDS 9528 ± 5221 mg/L) shows a dramatic degradation (Das, 2011 and Islam et al., 2011). Water quality analysis results indicate that DO, EC, TDS, Na^{+}, Mg^{2+}, PO_4^{2-} and salinity levels in the water and wastewater exceed the recommended limits for drinking and irrigation water quality guidelines set by the Department of Environment (DoE) and World Health Organization (WHO). Whereas, pH, Ca^{2+}, Cl^{-}, HCO_3^{-}, NO_3^{-}, and SO_4^{2-} do not exceed the recommended guidelines and values set by the DoE and WHO. Table 1 shows the average water quality of the Mayur and wastewater quality of the KCC flows at the Mayur outfall. During the dry season, water level drops drastically and pollution level rises, which completely depletes fisheries and other aquatic resources, resulting in significant impact on the livelihoods of the urban and peri-urban poor.

Parameters	Water quality of the Mayur river (Avg.)		Wastewater quality of KCC at Mayur outfall (Avg.)	Standards for Irrigation	
	High Tide	Low-Tide		DoE	FAO
Temp. (°C)	30.45	33.59	21.35	-	-
DO (mg/L)	2.97	3.04	0.75	= 5.0	-
pH	6.68	6.87	6.65	6.0-8.5	6.0-8.5
Salinity (ppt)	9.17	10.58	-	-	-
EC (dS/m)	13.98	16.11	1.94	2.25	0-3
Na^{+} (mg/L)	5046.67	6453.67	19.13	1000	0-920
K^{+} (mg/L)	148.25	180.29	4.97	12	0-78
Ca^{2+} (mg/L)	40.50	41.92	24.47	75	0-400
Mg^{2+} (mg/L)	67.40	81.30	20.65	30-35	0-60
HCO_3^{-} (mg/L)	383.32	317.31	329.29	-	0-610
Cl^{-} (mg/L)	276.22	385.52	366.47	600	0-1050
NO_3^{-} (mg/L)	7.13	7.54	3.21	10	0-620
SO_4^{2-} (mg/L)	217.75	396.49	38.57	400	0-960
PO_4^{3-} (mg/L)	8.12	4.73	19.13	6	0-62
TDS (mg/L)	6195.33	7868.75	1044	1000	0-2000

Source: Primary survey, 2011

3.4 Water Use Conflict

Water conflict among different users is more complex in urban and peri-urban Khulna than in other parts of the country. The nature and dynamics of these complexities mainly depend on social, economic and political factors. An analysis of the complexities indicates that there are mainly four types of conflict in the area: i) conflict between agriculture and fisheries; ii) conflict between urban and peri-urban users; iii) conflict among the urban users and; iv) conflict among the peri-urban users. Agriculture is a predominant occupation in the peri-urban areas of Khulna. However, farmers at the upstream and downstream sites claim that they have been suffering due to discharge of urban waste and unfair gate operation at the Alutala regulator. About 30 years back, the Mayur was an important river for agriculture, subsistence fisheries, navigation and domestic uses. But now it has lost its importance after construction of the Alutala regulator and later for mismanagement of the regulator. The natural flow is now almost disrupted and the water is stagnant used by the powerful elite involved in fisheries culture and agriculture. Local farmers at Chhoto Boyra claim that the Alutala regulator is operated only for those involved in culture of fisheries, not agriculture. They often suffer from unexpected flooding in their paddy fields due to mismanagement of Alutala regulator. These overall situations have significant impact on their life and livelihood.

3.5 Impact of Tidal Water Levels

The Mayur river is hydrologically linked with the Rupsha-Bhairab river systems in Khulna. Thus, fluctuation in the tidal water levels of the Rupsha-Bhairab river systems would have significant impact on the salinity profile in the Mayur. Analysis of tidal water level of Rupsha-Pasur indicates that the annual maximum high tidal water levels of the Rupsa-Pasur River at Khulna for a period of 74 years (1937-2010) are increasing at a rate of 18 mm per year, and the annual minimum low tidal water levels are decreasing at a rate of 8 mm per year. At Hiron Point, (11km inland from the coastline) these increasing (7 mm per annum) and decreasing (4 mm per annum) trends are also significant at 80 per cent and 90 per cent level of confidence.

To analyze local people's experience on tidal water variation, key informant interviews were conducted, considering occupational diversity of the local people and found similar perceptions of increasing tidal level in Khulna. Bangladesh Inland Water Transport and Authority (BIWTA) Port and Traffic Officer, the Alutola sluice gate operator, a ferry driver of the age of 75 years, a shopkeeper of 60 years and a wood trader also revealed an increasing trend in tidal water level in the Rupsha-Bhoirab river system in Khulna. They also reported that salinity in the groundwater and river water has been increasing day by day. As a result, drinking water is becoming insufficient to meet the people's demand. The BIWTA official mentioned that the present landing yard at Rupsha was built about 25 years back at 1-2 feet above the then high tidal water level. The landing yard used to be flood-free at that time. However, it now gets flooded most of the years. Construction of coastal polders, Farakka barrage, Rupsha bridge, encroachment into the rivers and sea level rise were cited to be the main reasons for siltation in the area by the local people, and hence reduction in conveyance and increase in water level and flooding. Thus, increasing tidal water level accompanied by a sea level rise of climate change may exacerbate the flooding, water logging and salinity problem in Khulna (Ahmed, 2008). More agricultural lands along the river may come under tidal water influence, the soil salinity of those lands may further increase, the cropping pattern may change and some of the lands may be diverted under shrimp or saline water aquaculture. Finally, small farmers and agricultural labourers may be adversely affected by the change in land use and livelihood.

3.6 Water Management Practices

The primary and dominant drinking water source in Khulna city is groundwater. However, groundwater contains relatively high levels of salinity (TDS) making it unpleasant and unsuitable for drinking, domestic and irrigation purposes. At present Khulna Water Supply and Sewerage Authority (KWASA) has a capacity to supply piped water to only 30 per cent of the urban population. The rest of the urban and peri-urban population depend on shallow hand tube wells, deep tube wells and surface water bodies such as ponds, khals and rivers. Agriculture activities in Khulna are mostly rain-fed. In the peri-urban areas farmers also depend on surface water from nearby rivers, canals and ponds. Our stakeholder consultation result shows that there is a strong NGO platform in Khulna. It is however, very difficult to find a common ground for protecting water resources in the areas. In most cases water management institutions and local people have conflicting interests. For example: Fultala Water Supply Project lead by the KCC was not successful due to local protest; the slaughter house project near Mayur river is now under judicial proceedings; some of the conflict among users of the Mayur river in the upstream and downstream areas. In the study area, Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED), Khulna Development Authority (KDA), Khulna City Corporation (KCC), Khulna Water Supply and Sewerage Authority (KWASA), Department of Public Health Engineering (DPHE), DoE are the leading water resource management institutions. However, participatory coordination is rarely seen among these institutions. In Khulna, KCC Mayor is very popular for leading the 'water resource' projects. KWASA and KCC are implementing 'climate resilient water' projects to save Khulna's environment and the people. BWDB has almost failed to manage their existing water infrastructures in the study area, and is largely criticized by the public forum in Khulna. KDA is the responsible authority for developing and implementing Master Plan. But till date KDA Master Plan is not finalized although it was drafted in 2002. KWASA is the responsible authority for water supply and sanitation in the city area. However, institutional capacity of KWASA is still very limited for providing their services to the whole KCC area. Till date waste management capacity of the KCC is very poor. DoE could not maintain the environmental quality standards due to lack of its institutional capacities for implementation.

3.7 Adaptation response

Urban community is the main abuser of the Mayur river. Peri-urban users pointed out that KCC should take necessary initiatives to save the river. Farmer community affirmed that proper maintenance of the Alutala and Rayermahal regulators may improve water quality and quantity of the Mayur. Some of them explained that if solid waste is not dumped in the river, and the Alutala regulator is fully opened, the Mayur would be automatically revived to its natural condition due to tidal water current. Since long, local activists, NGOs, civil society group and media professionals of Khulna have urged the need to save the river, but none of those initiatives were successful. In this case a set up of a formal River Commission may be useful for better adaptation practice of the water bodies. The conflict in the roles, responsibilities, jurisdiction and its impact and effect on implementation of policies and programmes is very clear when KCC mentioned that although Mayur is within the boundary of the KCC, the land is owned by the District Commissioner, which of couse does disrupt the implementation process. In a discussion forum, KCC Mayor said that it is becoming increasingly difficult to provide water security in Khulna due to climate change impact. Frequency and intensity of natural disasters have been ringing warning bells to adopt better adaptation practices especially in the water sector. For this reason, climate resilient development has been of highest priority for all sectoral development in Khulna. KCC is the pioneer in undertaking adaptation responses in the water sector of the country. KCC has already developed a climate resilient drainage master plan for reducing water logging in the city. KWASA has started surface water-based water supply project for better adaptation for drinking water supply in the KCC.

At present linear-park project has been implemented to protect the Mayur river from encroachment. However, local people claim that they have not been involved in the discussion of the proposed project. Result of stakeholders' workshop indicates that excavation of the Mayur is essential for improving the water security in Khulna. This may also contribute to the groundwater recharge in Khulna. Finally, our research results revealed that, community based solid waste management, re-excavation of the natural rivers and canals, establishment of small-scale wastewater treatment in the selected drainage outfalls of KCC, community-based sluice-gate operation and a multi-stakeholders' managerial platform would improve and help in the sustainable use and management of water in Khulna.

4. CONCLUSION

Mayur is a shared river used by urban and peri-urban residents of Khulna. Although Mayur provides important ecosystem services to the peri-urban communities, it is now almost a dead river due to abuse by the urban communities of Khulna. The present water quality of Mayur indicates high levels of pollution to support aquatic life and agricultural activities. Wastewater quality also exceeds the recommended values set by the DoE and WHO. Water use and user conflict of Mayur is very complex and have socio-political connotations. Outcome of the stakeholder workshop indicates that Mayur river could be used as a freshwater source in Khulna. Study results also revealed that community-based solid waste management, re-excavation of the natural rivers and canals, establishment of small-scale wastewater treatment at selected points of outfall of KCC, community-based sluice-gate operation and a multi-stakeholders' managerial platform would improve water management and adaptation practice in a sustainable manner.

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Working primarily on water security issues in Peri-Urban South Asia, across India, Bangladesh and Nepal, the project's main concerns are the rapidly changing peri-urban landscapes due to urbanisation and implications for water security in specific locations in the larger context of climate change. As an action research project, working across four locations in South Asia, it will serve as a basis for capacity-building at the grass roots level to address concerns of the poor, marginalised and other vulnerable communities to water security and seek to understand the dynamics of adaptation in the specific locations, for action and policy agenda at the regional level. It will build their capacities to cope with climate change induced water in-security.

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