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GOVERNANCE AND WATER LANDSCAPE IN KHULNA CITY: PAST, PRESENT AND FUTURE DIRECTION

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Abstract

This paper examines the water landscape in Khulna City from two perspectives: household water supply and the importance of surface water in the city's ecology. The authors seek to explore whether the current water supply system can achieve goal 6.1 of the Sustainable Development Goals (Universal and Equitable access to safe and affordable water for all), and the drivers of surface water deterioration and the city's ecological changes. Both the primary and secondary materials have been consulted. Analysis of water infrastructure and water body encroachments have been explored using remote sensing and GIS tools. Investigation of the water supply networks in Khulna city shows a clear geographical division, where the planned residential and affluent areas enjoy most of the water network coverage. Affluent areas with piped networks and other sources consumed much more water than other parts of the city. Map-based and observational analysis of the Mayur River and Nirala Canal asserts that the water bodies have been encroached severely. About 65% of the total area of the Nirala canal has been encroached on by the government as well as private organizations and individuals. Businesses on and around the Mayur River are booming. As a result, rivers and canals are unable to maintain water flows resulting in higher intensity of water logging and other ecological disruptions. Several recommendations including supply-based water management, hierarchical water tariffs, increasing water supply coverage, the introduction of non-conflicting activities around water bodies and inter-organizational collaboration have been proposed to make the city resilient against the adverse impacts of climate and man-made disruptions.

Keywords: Water landscape, Ecology, inequality, encroachment, governance, Khulna City

Introduction

Water and its management in cities have a significant role in the urban transformation process and shape the lives of millions. With the cities becoming urban, the production and management of water are shaping and reshaping the city structure. As Swyngedouw (2004; 2009) argues, the water supply and its circulation in the cities become an integral part of the power structure and the political economy. From the developing country's perspective, water resources are scarce and have been facing challenges in providing water to the growing urban population. Consequently, water access has become a critical issue in urban areas. For example, Goldman and Narayan (2019) have shown the extent of surface water encroachment in Bangalore city to accommodate its residents. The city has transformed itself from a mid-sized town to becoming the Silicon Valley of Asia. As a result, residents in Bangalore City are experiencing uneven water distribution to their households, and the water infrastructure cannot keep pace with the rapid urban sprawl (Mogul, Jha and Farooqui, 2024). Residents of poor housing or informal settlements in the cities of Asia are largely out of the formal water supply system (Swapan, 2016). A significant number of the urban population becomes the victim of informal governance-where the powerful individuals or groups dominate the city's poor who find themselves in slums and other informal settlements (Hossain, 2013; Swapan, 2016). Water is becoming the brutal delineator of social power (Gandy, 2004). The supply of water and its presence contribute to the urban fabric by influencing the city structure and coherence with different parts of the city.

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Asian countries such as Bangladesh have seen a significant increase in the urban population in the last couple of decades. Until 1961, only 5.2% of people were living in urban areas (United Nations, 2019). That started to grow significantly from 1974, immediately after the independence in 1971. The percentage of the urban population increased from 8.8% in 1974 to 28% in 2011. It has been estimated that the current urbanisation rate is 37.4% of the approximately 163 million population (United Nations, 2019). Despite having 570 urban centres which are relatively distributed across the country, the five major cities, Rajshahi, Sylhet and port cities Chottogram and Khulna accommodates about 60% of the total urban population (Ahmed & Meenar, 2018). The urbanisation process will be more intense and ADB (2014) expects the urban population in Bangladesh to be doubled by 2030. These five major cities of Bangladesh must be going to take a significant number of future urban populations.

Rapid growth of the population in the cities has led to massive demand for social and physical infrastructure provisions. Cities in Bangladesh are already congested, lack basic services and face mounting pressure to manage natural resources. In Bangladesh, the coverage of piped water connection in urban areas is only 21.4%, compared to 59.6% of households who rely on human-operated handpumps (Bangladesh Bureau of Statistics (BBS) and UNICEF, 2019). Apart from Dhaka city, other major cities have relatively low piped water coverage.

This study aims to explore the water governance system, changing water infrastructures in Khulna city and its impact on the water landscape. While drinking water remains the major issue of water access and inequality in the cities, other uses of water and water sources are also very critical, given the rapid land use transformation and exploitation of canals and rivers. The city has a network of canals that play important roles in its economy and the everyday life of people. The 150-year-old wholesale market in Khulna once received its product through water vessels, and canals play a major role in surface runoff. Moreover, Khulna city is expected to gain from the economic opportunities due to several national and regional mega projects. The construction of Padma Bridge has been directly benefiting Khulna and its peripheries in terms of economic activities, new business opportunities and the movement of people. The rejuvenation of Mongla port started to get momentum in terms of vessel handling and increased import-export activities. The resumption of rail connectivity with Dhaka, Mongla and Kolkata will further boost the economy (Aziz and Podder, 2023; Khulna Development Authority (KDA), 2019).

From the colonial era to the present, the life and economy of Khulna has largely been shaped by its water resources. However, a significant number of current city problems are associated with water: from drinking water shortage to water logging, salinity and exhaustion of the city's canals and river system. With the continuing economic activities and increasing urban population in Khulna city, this paper seeks to explore the urban life of Khulna city from a water resource perspective. Considering the historical importance of water in shaping city structure, this paper attempts to outline Khulna City's water supply system, water governance, water inequality, and the impacts of water on life. The first two sections explore the city's history and chronological developments, followed by three sections that outline the history of water supply, other water sources in the city, water governance and inequality. Finally, the paper concludes before identifying some of the key challenges.

Conceptual Framework: Governance and Politics Around Urban Infrastructures

Water issues have been studied from an urban governance perspective which focuses on institutional arrangements of the water supply system. The idea of governance was brought to developing countries in the 1990s by donor agencies while addressing poverty and basic services (Swapan, 2016). The growing population in the slums prompted scientific research that follows the growing intervention in slums (Pandey, 2020). The adoption of Millennium Development Goals (MDGs) also expedites the interventions to improve the living conditions of slums (Gilbert, 2007). However, with the growing interventions in slums, the formal service sector pulled itself out from the responsibility of serving the growing slum population. The formal service sector also could not keep pace with the growing population, as they were experiencing resource constraints.

Though the national and international programmes have helped the poor community raise their voice and enjoy improved services, gaps remain consistently high between slums, and middle and high-income areas in the city. As for water, Mamdani (1996) has explored two distinct Groups in Asia and Africa-*Citizens* who could lay claim to potable water and S*ubjects* who are left to make do as best they could. Access to water supply largely depends on the power, control and voice of the household or a particular community (Sultana, 2011). The issues of water access have been studied from the political ecology perspective and it has been found that the shortage of water supply can not only be considered a technical malfunction, but rather a result of collective social action (Southerland, 2002; Marvin and Medd, 2006). Swyngedouw (2004) argues that municipal funds are often used to expand large-scale water distribution system that provides more water to middle and upper-income groups. Smith and Ruiters (2006;

192) argued that weak and underdeveloped administrative mechanisms led to conflict over access to municipal resources in the Global South. Several other studies have argued that mega projects in developing countries aim at leveraging the potential of cities as growth engines but pose high risks for urban spatial fragmentation (Kennedy et al. 2011, Al-Jayyousi, 2003). As with the growing number of areas in Asian cities that are publicly made such as informal settlements and slums, the gaps between 'have' and 'have not' become more widespread as the other areas of the city enjoy more public funding.

Materials and Method

The study has adopted a mixed-method approach, integrating qualitative and quantitative data and analysis techniques. The mixed-method approach complements qualitative and quantitative data collection while minimising the relevant weaknesses (Brewer & Hunter, 2005; Johnson & Onwuegbuzie, 2004). The study holds both the transformative and pragmatist views from the epistemological stance in framing the research methodology. The transformative paradigm emphasizes power and social justice, discrimination and oppression (Cresswell & Creswell, 2018). Since the social and political agendas are responsible for making and remaking space, this research aligns with the pragmatist worldview. The pragmatist approach accommodates the effects of the action on space/environment by adopting qualitative and quantitative assumptions (Morgan, 2007).

Qualitative data collection includes observation of the selected study sites (Segments of Mayur River and Canals) and interviewing key personnel from Khulna Development Authority (KDA), Khulna City Corporation (KCC) and Khulna Water Supply and Sewerage Authority (KWASA). Secondary sources include the water supply network maps, local slums and poor settlements, water supply and related policies and acts, research reports and empirical studies. The water supply network and other maps were collected from KWASA and other offices. Later the maps were digitized and geo-referenced in the ArcGIS environment. Data on the river and canal encroachment has been extracted from ArcGIS 10.5 image processing software. The ISO unsupervised image classification tool was used for image classification and the percentage of features is measured. Google Earth was used for the extraction of images of the rivers of the study area. For identifying the canal encroachment in two different periods, a 1996 mouza map and recent GeoEye-1 Satellite imagery have been obtained. Patterns of encroachment have been identified through satellite imagery and field observations. An observation survey along the canal and Mayur River has been conducted to understand the nature of and use of encroachments. Ten segments of the Mayur River have been studied and the segments fall between Gollamari to Mayuri rail bridge.

Results

Khulna city: urbanization, life, and livelihoods

In the British colonial era, Khulna city was a market hub for Jute and seafood. It eventually started as a police station in 1836. In 1842, the Khulna sub-division was established comprising Khulna, and adjacent two districts: Bagerhat and Narail (JJS, 2003). Khulna was declared a municipality corporation on September 08, 1884, under the Bengal Municipality Act 1884 (KCC, 2021). Later the city was promoted to Khulna City Corporation[1] in 1984 under the Khulna City Corporation Ordinance 1984. In the colonial period, the municipality's area was 12.02 sq. km, which was extended to 37.04 sq. km in the Pakistan period (1945-1971). It was further extended to have a total of 45.65 sq. km of the area after the formation of the city corporation.

[1] Municipality is city corporations are two of the six categories of urban areas in Bangladesh with City corporation are larger urban agglomeration, with population over 100000 (BBS, 1997)

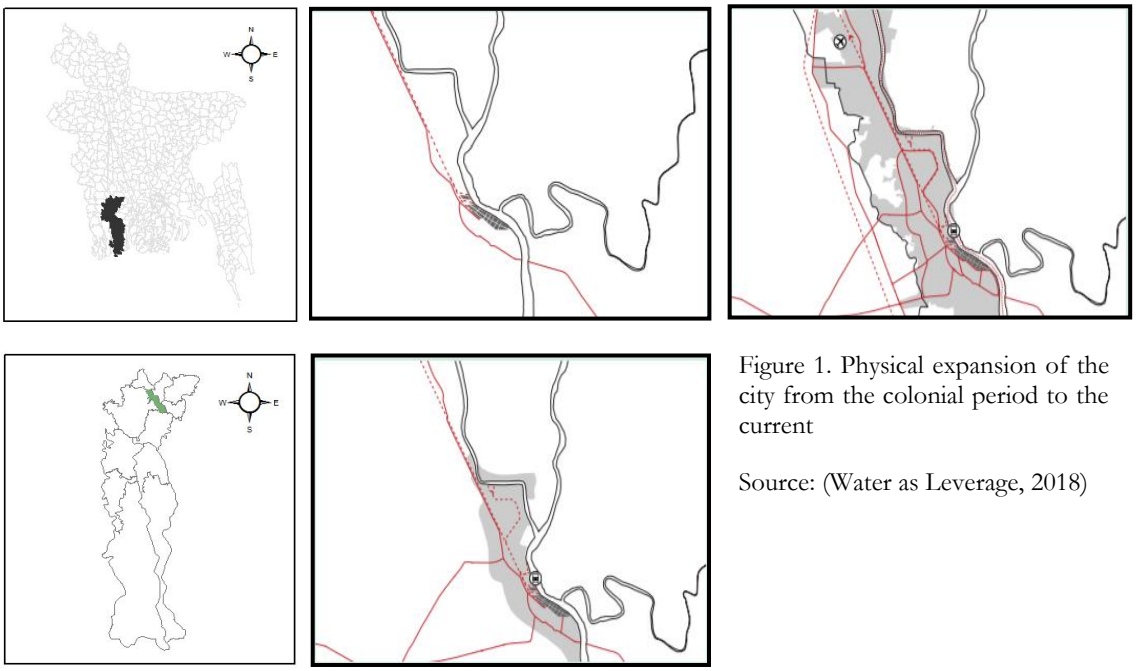

Figure 1. Physical expansion of the city from the colonial period to the current

Source: (Water as Leverage, 2018)

Khulna experienced a fast growth of population and industrial expansion during the 50s and 60s (Figure 2). During that period, Khulna became an important centre for industrial development. With the establishment of a second seaport of the country at Chalna, just about 33 kilometres south of Khulna, the city's growth gained further momentum. Many new industries were set up at Khulna, and commercial activities increased manifolds, thus, the city became a focal point of industries, especially jute industries and jute trade in Bangladesh. Population increases gained momentum between 1971 to 1981, mainly due to jute-based industries and migration from rural to urban areas for employment in those industries (Hasan et al, 2000). However, the growth of jute industries stalled, and in the 1970s and 80s, there were hardly any significant investments made in Khulna city (Murtaza et al, 2000). Jute industries continue to decline between the 1980s to 1990s.

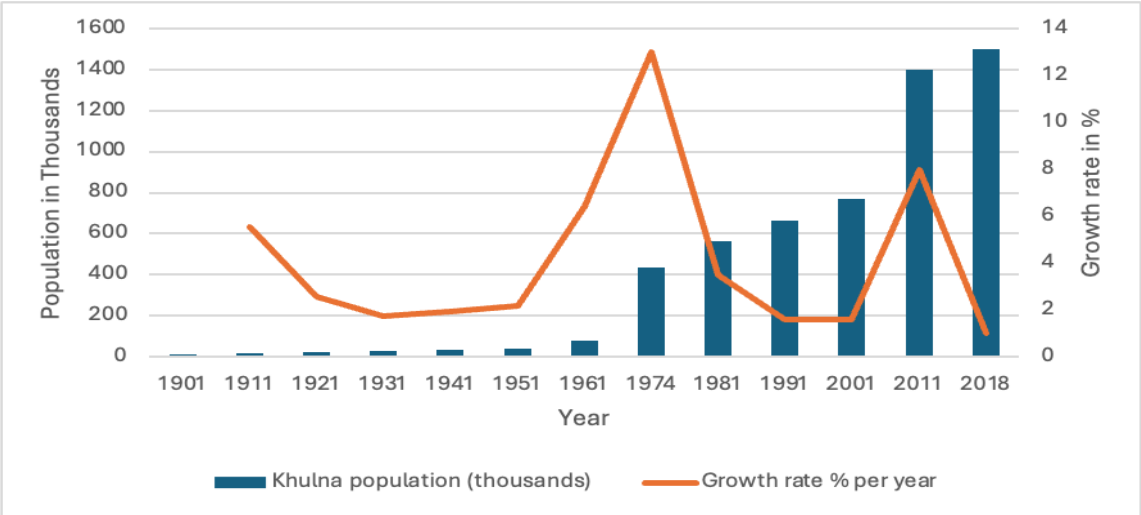

Figure 2. Khulna city population and growth rate in different periods

Sources: (Bangladesh Bureau of Statistics (BBS), 1974, 1994, 2001, 2016; Khulna Development Authority (KDA), 2019)

After the liberation war of Bangladesh in 1971, Khulna City experienced a significant increase in population due to migration from rural areas and the returning population who fled to India due to the war. The industrial sector did not grow with the population growth. In fact, after 1968, industrialisation mostly stopped, and the vast labour force in the city was forced to seek alternative employment elsewhere (Parvin & Anirban, 2010). The city experienced a decline until the 1990s when the economy started to revive again mainly due to shrimp farming and related activities (processing, freezing, transportation, banking, and insurance etc.) and the activities related to the establishment and development of a new University in Khulna (Khulna Development Authority (KDA), 2001; Rekittke, 2009). Some notable companies with the highest employment are Khulna Shipyard, Bangladesh Cable Shilpa Limited, Bangladesh Oxygen, and Platinum Jute Mills (UN.ESCAP, 2019). In addition, the informal sector is another major employer to many new migrants of Khulna city. There is no estimation of informal employment, but KDA (2019) estimates that the informal sector is the crucial employment generation sector in Khulna City.

The city has been experiencing an increasing influx of climate refugees since 2007 (Leckie, 2009). In a single event, caused by cyclone Aila in the southwestern part, about 125,000 people migrated to the cities (Islam & Hasan, 2016). In Khulna city, about 43% of the total population is migrant. Among other factors, migration contributes significantly to the rapid urbanisation in the cities of Bangladesh (Planning Commission, 2015, p460). Being the regional primate city, Khulna receives migrants mainly from the southwestern coastal belt. Frequent natural disasters push people from adjacent rural areas to Khulna city (Hasan, 2010, KDA, 2019). Migrant people, who are often from low-income families, find themselves in slums and informal settlements across the city. However, the city has experienced a population decline in the 2011 census. People who migrated to Khulna further moved to Dhaka and other cities for employment opportunities as the city lacked industrialisation.

Slums and informal settlements have primarily influenced the urban physical growth pattern. Recent poor settlements by UNDP (2017) have identified about 897226 people, which is 59% of the total Khulna city population, living in slums and poor settlements (figure 3b). Some of the biggest slums in Khulna city (Rupsha slum, Railway colony, Bastuhara slum) were established 50-70 years earlier, and residents have lived for generations. Access to these slums is restricted because current residents live there by generations, and new entrants are only allowed within the relatives. As a result, spontaneous poor settlements are growing across the city. There are no neighbourhoods or any areas which can be classified as high-income or low-income only. Pockets of poor settlements can be observed in the high-income planned residential areas.

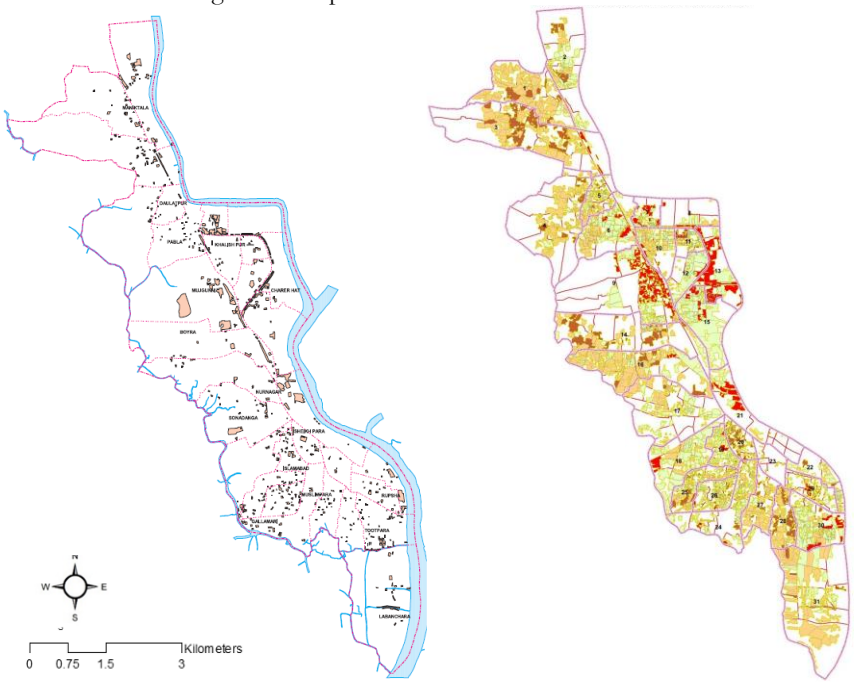

Figure 3. Location of slums and poor settlements: (a) in 2005 (b) in 2017 Source: Measure Evaluation (2005) and UNDP (2017)

Khulna city's water landscape and governance

Khulna city is located on low-lying land with an elevation of 2.5m above the mean sea level, varying between 0.45 m to 5.4 meters (ADB, 2011). The city is located beside the two main rivers Rupsha and Bhairab. Besides, as the city is located in the tidal flooding zone, other rivers such as Madhumati, 60km north of the city, and other natural water reservoirs are integral to the water management system. As many as 21 canals run through the city, which plays a key role in flood and drainage water management (KDA, 2018). Moreover, the city has numerous water tanks which were previously used as a source of surface water. The networks of tanks, canals and rivers have crucial roles in Khulna city, from channeling out the water flows during the high tide from the Rupsha-Bhairab River to acting as a water retention reservoir in the period of excessive rainfall and outflows of drainage networks. This vast network of water landscape is also contributing to the city's water supply as the system is entirely dependent on groundwater. This section explores the city's water landscape from these two perspectives for household consumption, and water in shaping the city's economy and its ecology.

Household water supply system

Khulna Water Works department was established in 1906 to provide safe water to its citizens. The Water Works Department emphasised surface water and began to excavate and manage the city's ponds and canals. At that time, there were six prominent reserve tanks with the following names: 1) Main Reserve, 2) Post Office, 3) Civil Court, 4) Tutpara, 5) Dak-Bangla, and 6) Bazar. To provide safe water, a water treatment plant (only to boil water) was constructed in 1921 to treat 900,000 litres per day, marking the start of a modern water supply system in Khulna municipality. In 1929, the Water Works gained momentum in supplying water by constructing two overhead tanks with a capacity of 0.9 MLD and 0.22 MLD each at Hadis Park and Sher-e-Bangla Road (KWASA, 2021). Later in the same year, the department introduced public tap in the streets.

After the establishment of the Department of Public Health Engineering (DPHE) in 1960, groundwater started to be used as the primary source of drinking water. DPHE was established as the guardian of water extraction irrespective of urban or rural areas. It has been argued that population pressure in cities after the separation between India and Pakistan and widespread waterborne diseases drive the shifts towards groundwater extraction. By 1963, DPHE claimed to achieve one tubewell for every 400 population and later reduced the target to 1 tubewell in every 200 (Zohir and Salauddin, 2015). The availability of water pumps and machinery also contributed to the shift and more powerful deep tube well were introduced in the city areas (Zohir and Salauddin, 2015). By 1980-81, Khulna had twelve deep tubewells which were producing five million litres of water per day. During 1988-89 similar initiatives helped increase the total water supply to 25 MLD by 1994. Khulna City Corporation assumed the water supply management responsibility in 1984. By 1998, there were about 49 pumps in the KCC area (Urban and Rural Planning Discipline, 1999).

KWASA, since its establishment in 2008, installed 32 and 19 small generators supported production well (3" x 8"). In 2012 KWASA had a total of 26 large production wells (6" x 14") and 48 small generators-supported production wells (3" x 8"), 9262 deep and shallow tubewell with 1.5" diameter and 270-kilometre pipelines (Table 1). Apart from the KWASA-operated handpumps, there are about 13733 individual handpumps owned and used by households to meet their fresh drinking water demand (KWASA, 2020).

Table 1. Changes in Water infrastructure between 2010 and 2023

Items	2010	2012	2020
Production well	109	74	85
Water production/day	85	1.02 MLD	119 MLD
Demand	170	240 MLD	250 MLD
Total pipeline	227	269.16	708
Shallow Hand tubewell	5526	5526	10000
Deep hand tubewell	3736	3736	
Street Hydrant	503	503	
Total connection	12057 (23.96)	14523 (22.94)	50019 (2018)

Source: ADB 2010, KWASA, 2010, KWASA, 2012, KWASA, 2020

Water demand was soaring with the increase in urban population and reached 240 MLD in 2012 from 170 MLD in 2010. However, KWASA could supply only 1.02 MLD, about 23% which is lower than 2010 (24%). To extend the water pipelines, KWASA has implemented the Khulna Water Supply Network Extension Project (2011-2018) with funding from ADB, JICA and the Government of Bangladesh. The project component includes the construction of 680 km of pipeline, two surface water treatment plants with a capacity of 110 MLD, and 10 overhead tanks. Water is extracted from the Madhmati River for the water treatment plant.

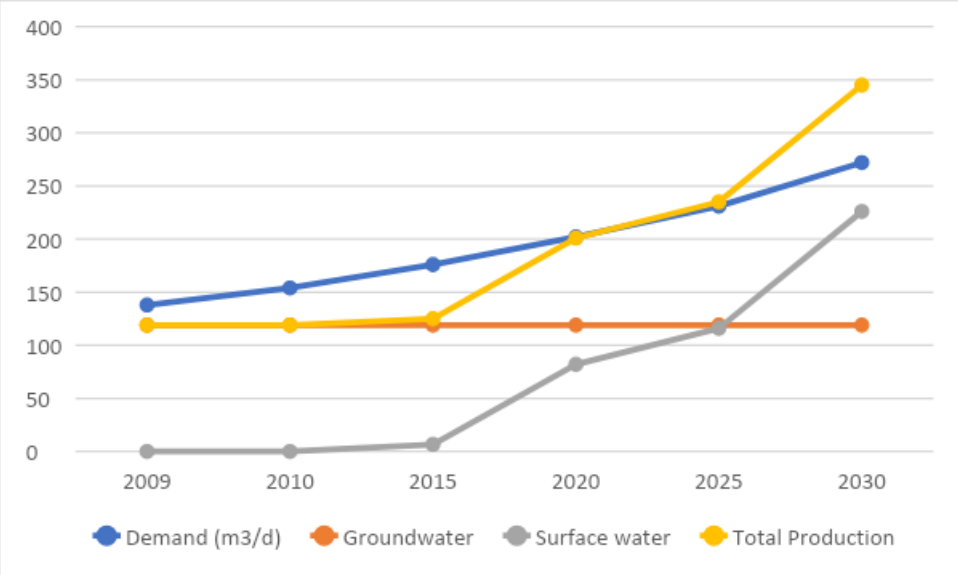

Figure 4. KWASA water production plan by 2030

Project Impacts and Water Inequality

The current water requirement is higher than the projection. The current water demand is 250 MLD. As Figure 4 above suggests, groundwater sources will continue to provide a significant volume of water to the city residents. The groundwater contribution is 60% in 2020, while this will be halved by 2025. From 2030 onwards, the contribution of surface water will be higher (65%). However, the project poses some degree of technical and financial uncertainties that can hinder the achievements.

Firstly, KWASA supplied as much as 40% non-revenue[2] water. As a result, about 90 MLD of water from the 119 MLD of current water production from existing sources could reach the consumers. KWASA aims to reduce the loss by half after operating with the new distribution network (JICA, 2011; Personal Communication, 2023). Nevertheless, the amount of total supply may not exceed the demand. Moreover, during the interviews with the KWASA officials, it was understood that the newly built surface treatment plant could operate at best at 70% capacity, given the logistics and financial capacity of KWASA. Therefore, considering the surface water system's water loss and functionality, the actual water production could be 152 MLD, 176 MLD and 253 MLD in 2020, 2025 and 2030, respectively. This will account for about 25% shortage of water than the demand in 2020 and 2025.

Secondly, the financial costs of the project till 2030 would be 342 million USD considering the capital costs, O&M, system costs and replacement costs. Currently, KWASA charges BDT 8.2 per 1000 litres of water (residential). The project is financially considered as not viable with the proposed operation and maintenance (O&M) recovery tariff as the calculated tariff for the full cost recovery is more than six times higher for domestic use. The impracticality of raising the tariff to this level means KWASA cannot be self-sufficient during the project life period and will be dependent on government assistance.

[2] System loss due to leakage and other issues with the distribution.

Moreover, from the water infrastructure point of view, the project and network distribution produce geographical inequality. The total length of the current water distribution network is 708 km. Khulna WASA uses pipelines of different diameters for household water supply. Communication from KWASA (K.S. Ahmed, personal communication, 12 August 2023) suggests that pipelines of 75 mm in diameter mostly connect one-storey houses, and it goes up to 250mm for multi-storey residential buildings. Analysis with 75mm diameter pipelines shows that the piped water supply distribution is mainly skewed to the city core areas and the wards with the planned residential areas. The five wards that house the four planned residential areas in the city enjoy about 40% of the total 75 mm pipeline. The distribution of other pipelines higher than 75 mm diameter also follows the same trend as the 75mm diameter pipeline makes the connection between households and the higher-order distribution networks. Figure 5 reveals that many industrial and city core areas lack a water network of 75mm diameters (connects to one and two-storied houses). Poor settlements are also dense in these areas which means KWASA-supplied water is absent.

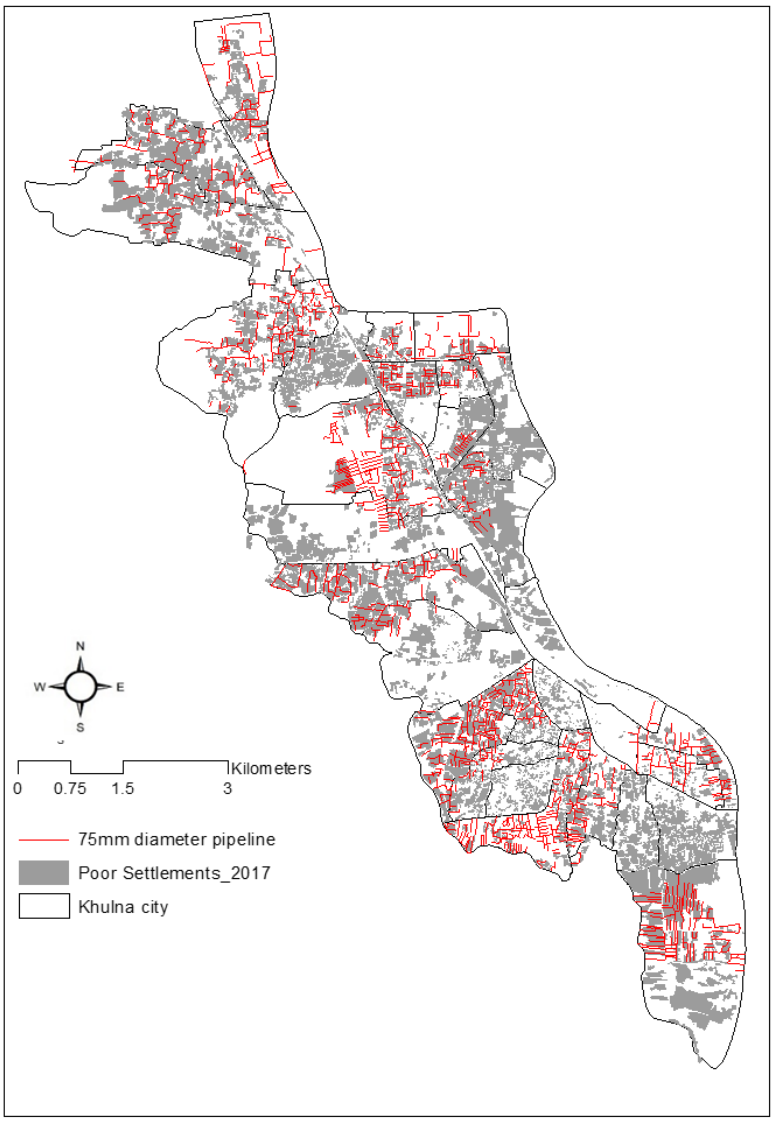

Figure 5. Water pipeline network (75mm diameter)
Source: Author's creation from UNDP, 2017

An increasing number of the urban poor living in informal settlements are far behind the formal water supply network coverage. Though slums in Khulna city have received interventions on housing tenure, water supply, and health under some prominent programmes, safe water remains outside of reach of many urban poor households in Khulna city. KWASA does not feel obliged to supply water to slums and poor settlements as they need some legal documents (building number, other utility bills, building approval letter) and a minimum road width (at least 5 meters), which are not available for slums and poor settlements. Shallow hand tubewells cover these areas, provided through aid projects and NGO interventions. However, slums and poor settlements are facing a myriad of issues regarding drinking water, such as water quality, inadequate water sources and management issues. Water from most of the sources, particularly in the major slums, such as the Rupsha slum, is brackish and not suitable to drink. As a result, long waiting lines can be seen on the premises of handpumps. In contrast, average water consumption in the city core areas, where water networks are high, is as much as 2100 litres per day per household (Khan & Uddin, 2018).

Water as a nexus between the city's economy and ecology

A city is considered a living thing and is shaped by the collective activities of humans and organizations. The Chicago School of Sociology and aligned thinkers (Park, 1925, Burgess, 1925) were concerned about the ecological degradation in the human-dominated system and sought to answer the effect of human activities on the natural environment. Human society has been transforming natural and built environments for its needs, and in this process, exploitation and overconsumption happen, leading to an ecologically imbalanced society. Among the natural resources, water has played a significant role in shaping society's economy and environment. Water is the top three consumable resource alongside food and fuel and has been studied widely to understand the city (Decker et al. 2000; Warren-Rhodes and Koenig 2001). This paper seeks to briefly explore the contribution of water to Khulna City's economy and the current ecological disruptions the city is experiencing.

Economy and water

Water plays a key role in Khulna's economic activities. The largest commercial hub in Khulna city, which is also one of the largest in the southwestern region, is located along the river Bhairab and the city's very core. The 178-year-old market is a vibrant place and serves traders from surrounding towns and rural areas. Goods are taken and delivered using the river stations (ghats). There are as many as 11 river ghats that remain busy collecting and delivering goods. However, due to the closure of industries, a decrease in naval routes has impacted the volume of goods transported through the river system.

Surface water encroachment and the city's ecology

Khulna City has several surface water sources including the Mayur River, about 22 canals and a distribution of ponds. There are about 55 established and recognized ponds in Khulna city area (Zohir & Salauddin, 2015). Earlier reports identified 250 ponds in the city that were used as the source of water (Urban and Rural Planning Discipline, 1999). This report also observed that some of the ponds were in the process of being filled up and some remained uncared. About 15 canals have disappeared due to the construction of roads including Sher-e-Bangla Road, one of the major arterial roads that connects the Nirala residential area, Khulna University and Satkhira highway (Nargis, 2001). A significant portion of three other canals: Shahabkhalir Khal, North. khal, and Malokhal have been partially or fully converted into roads. The act of encroachments also has seen the development of the main bus terminal of the city and other planned residential areas (Sonadanga residential area)-which compelled the canals to shrink and become close to extinction.

Mayur River was considered one of the major surface water sources in Khulna City. The river has severally encroached along its banks for fish cultivation and temporary and permanent structures. Its water quality has deteriorated and become unusable for any use (Biswas, 2012; 2015). The physical survey on the Mayur River reveals that 93% of the total 30 segments studied have the presence of solid waste disposal, of houses and businesses along the river are dumping solid waste into the river. land-filling for homestead (77%) and filling the land with solid waste (73 to 77%). Other prominent uses are hanging latrines and shops, vegetable cultivation and fish cultivation. A crude valuation of the structure and fish cultivation suggests an annual business of 5-6 crores and 1100 persons are engaged part-time and full-time.

The study on the Nirala canal shows that almost 65% of its area has been encroached. The canal is about 484 meters in length. The 1996 Mouza map shows that the area was 3.49 acres, but the current area is only 1.22 acres (Figure 6). About 1.09 acres have been encroached for creating and selling plots. Khulna Development Authority and Khulna City Corporation (KCC) also encroached 0.77 acres for providing road access, about 0.15 acres encroached for residential and 0.01 for commercial purposes. 0.18 acre of land is encroached for small shops and houses by poor people and another o.7 acres by religious and educational institutes.

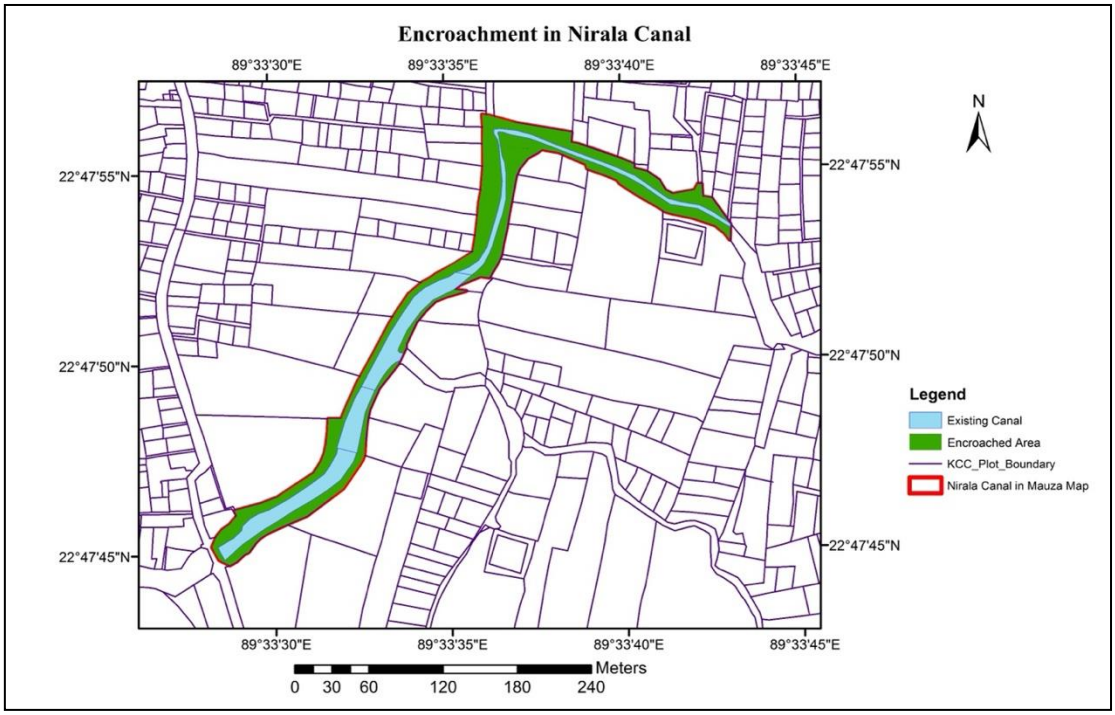

Figure 6. Encroachment of Nirala Canal

Canals have a significant impact on local ecology and biodiversity preservation. During the wet season, these canals merge with the adjacent rivers and become the drainage channel. Encroachments of canals situation are reducing the depth and width also, which disrupts the natural flow of water. Drainage is one of the dominant urban problems of Khulna city. With the process of urbanization, the natural drainage situation of Khulna city is gradually deteriorating. The city can serve only 55% of its residents through its drainage system and the encroachment will make the situation worse. This has resulted in some unhealthy and inconvenient situations in city life that may endanger the future of the city services. For example, the introduction of the tubewell and deep tubewell expedites the disappearing ponds and canals in the city as the land value increases. This, in turn, lowers the groundwater level-pushing residents to use submersible pumps, and the authorities to go further (Madhumati River, 60km from Khulna city) to extract water for the city.

Discussion and Recommendation

This paper explores the water in Khulna City from two perspectives: household-level water supply and water sources for the city's economy and natural drainage systems. As the paper reveals, the current water supply network largely ignores the growing population living outside of the city core areas, the majority of whom find their shelters in slums and poor settlements. This has resurfaced the debates about the right to get essential services. This study also asserts that the water supply network extension project, which was designed to supply 65% of the households, lacks technical and financial sustainability in the long run. The city's water supply system is also not prepared in the ear of climate change, as the system relies only on supply-side management without any concrete plan for the reduction in underground extraction, and reuse of water.

The easy-to-get groundwater and available technologies, coupled with the inflows of external resources and a project-based development approach left the surface water unattended. Thus, other interests such as dumping of human wastes, industrial wastes, and encroachment into public water bodies, came to play a bigger role in shaping the fate of (surface) water bodies. The network of natural channels has disappeared which creates numerous social, economic, and ecological pressures on the city.

Based on the findings, the authors are keen to provide the following recommendations:

1. A supply-side management approach, such as a reduction in freshwater demand by water reuse, the introduction of 'lifeline water' for the urban poor, a multi-tier water tariff and the use of smart appliances are necessary.
2. The current resource flows are very separate in the water infrastructure provision: NGOs and Donor agencies provide water in poor settlements, whereas government-supported and government-backed projects for the remaining part of the city. These two types of resource flows hardly coincide. Authorities like KWASA need to extend its customer base to generate more revenue. From this perspective, discussion, and mechanism of formalising the informal need to start.
3. In the case of the canals and rivers in the city, it is understood that people from different professions, most of whom are based in Khulna, have stakes in the public land on or near the banks of the Mayur River. There is a silent voice that may affect election outcomes at local levels. Many of these occupants, legal or not, are willing to make way for better use of the water body if alternative arrangements can be made for their residences. Thus, asset-wise, viable options may be sought with little or no resistance. However, in terms of the current flow of income, major resistance is expected from the shrimp/fish cultivators.
4. Canals, rivers, and other water sources will be occupied in some form if remain unattended given the high and ever-increasing value of urban land. Reclaiming the land and water bodies is as important as protecting these by the introduction of non-conflicting activities such as walking lanes, playgrounds, and other similar activities.
5. Khulna City lacks institutional coordination in terms of water resource management. This arises mainly from the different ownership structures of the water bodies. An active task force comprising officials from the District Commissioner's office, KCC, KDA, and community people is required.

Conclusion

This paper explores the water system, changing infrastructure and water landscape changes in Khulna City. The water resources and its infrastructure are critically significant for cities and their residents. United Nation's Sustainable Development Goal (SDG) six also concentrates on a better and more accessible water system for everyone. However, growing urbanisation and climate change are fostering changes in the urban system that put pressure on water resources. The paper's contribution is to analyse the water ecology in Khulna City, realistically showing how institutional and political power nexus generates informalities and inequalities in terms of water access. Institutional and individual actions deteriorate the surface water making the city highly susceptible to prolonged water scarcity and capital-intensive projects. The Khulna water supply project fails to address the importance of surface water in the city as well as the needs of the people living in the informal settlements. Thus, communities except some affluent areas are mostly deprived of access to water in Khulna city. The paper also reveals that water is playing a pivotal role in generating urban divides and thus is forming informal procedures in the water supply system leading to more unequal distribution of resources. This paper emphasises the need to reshape policies and practices. Strategies should focus not only on urbanisation and infrastructure spending in the city but also on the spatial distribution of resources and benefits out of the infrastructure provision.

Conflict of Interest

None of the authors present any conflicts of interest.

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