

Urban Expansion Influences Shrinkage of Water Bodies in Urban Areas: Evidence from Rajshahi City Corporation (RCC), Bangladesh

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Abstract:- Urban expansion has transformed precious land, particularly water bodies, creating an adverse effect on the entire urban environment. In developing countries, this scenario is quite astonishing, and the rate of urbanisation is quite high. Currently, as a developing country, Bangladesh is experiencing rapid and unplanned urban expansion, resulting in serious environmental degradation. Apart from these, the unplanned and rapid urban expansion has influenced the chaotic growth of urban infrastructure and the filing of wetlands, cutting hills, deforestation, and destruction of precious agricultural land. This study tries to identify the influence of urban expansion on the present condition of water bodies in Rajshahi City Corporation (RCC). To do this, water bodies in Rajshahi city are categorised into four types: good, moderate, poor, and filled up. The analysis reveals that 32.37% of the water bodies are filled up. Furthermore, data regarding the present utilisation of land with the specific objective of reclaiming water bodies has been collected. The current study focused exclusively on changes in water bodies without including any analysis of other types of land cover. There is tremendous opportunity for undertaking research on diverse forms of land cover change and obtaining good outcomes for total land transformation due to urban expansion in the Rajshahi City Corporation (RCC) area.

Keywords:- Urban Expansion, Urbanisation, Water Bodies, Rajshahi City Corporation (RCC), Bangladesh.

I. INTRODUCTION

Water is an indispensable requirement for the sustenance of human existence, particularly freshwater, which is a vital resource for all living forms on the planet [1, 2]. Only a small fraction, approximately 2.5–2.75%, of the Earth's total water supply is freshwater. The water that remains is naturally saline. Surface water bodies serve as the primary reservoirs of fresh water for the whole human population. Hence, it is crucial to protect and utilise surface water responsibly and effectively [2]. Water bodies are essential for recharging groundwater and hence play a critical role in sustaining the region's groundwater table. Surface water bodies serve as effective barriers for flood management [1, 2]. Water bodies contribute to the

preservation of surrounding vegetation and serve a crucial role in lowering the surface temperature of urbanised cities. Water bodies can mitigate cities' urban heat island effect [2]. Adequate water consumption is essential for maintaining a satisfactory quality of life and carrying out various tasks. The magnitude of the worldwide water issue becomes evident when considering that over 1.2 billion individuals lack access to potable water. The current situation, where a significant portion of the population is experiencing water stress, serves as a warning for a challenging future for the planet [1]. The water issue will have a significant impact on urban areas, especially those experiencing fast expansion [1, 3].

The natural environment, particularly water bodies, is profoundly affected by urban expansion, which is driven by rapid population growth and urbanization. As cities expand, the demand for land intensifies, often leading to the conversion of open spaces, including water bodies, into built-up areas. This mechanism has undergone extensive examination, uncovering concerning patterns in the depletion of surface water resources. Similarly, urbanisation refers to the migration of individuals from rural areas to urban areas, resulting in a higher proportion of people living in urban areas compared to rural areas [3]. Throughout human history, urban areas have significantly influenced societal transformations, including social, economic, and political changes. Urbanisation has been occurring globally at an exceptional magnitude and pace, particularly from a social and economic perspective. Although urban areas cover a small portion of the world's land surface, their rapid expansion has significant negative and positive effects on the environment, economic growth, physical development, and societal systems [3-5]. In developing nations, urban growth has predominantly taken place in a horizontal manner rather than a vertical one. Consequently, the invasion of agricultural areas, forests, open spaces, and wetlands has become a prevalent occurrence [3]. In addition, the increase in horizontal expansion has adverse effects on both society and the environment [6, 7]. Urban expansion has affected the water bodies both qualitatively and quantitatively [8].

The reduction and disappearance of water bodies due to urban expansion have been recognized as significant challenges, necessitating proactive land use planning and monitoring to mitigate adverse effects on water resources [2]. This phenomenon often results in an asynchrony between

urban expansion and water management, contributing to negative impacts on urban water bodies [9]. Urban expansion depletes water bodies, causing not only physical changes but also water pollution, habitat destruction, and altered hydrological cycles, highlighting the multifaceted impacts on water resources [1]. Haphazard land use practices during urban growth directly or indirectly contribute to the degradation and depletion of surface water bodies in urban areas, leading to water scarcity issues [10]. Understanding these dynamics is crucial for developing sustainable strategies that balance urban growth with the preservation of essential water ecosystems.

Apart from this, the population growth rate in developing countries is quite high compared to developed countries, which are accompanied by extraordinary rates of urbanisation. Owing to the tremendous urbanisation, pressure has been placed on the adjacent land and biotic and abiotic resources. Like other developing countries, Bangladesh is a country with the status of one of the most populated countries in the world. At present, the country has been experiencing rapid and unplanned urban expansion, which is followed by serious environmental degradation. According to the Bangladesh Bureau of Statistics (BBS), the country has seven major cities and slightly more than five hundred urban centres, which together comprise about 28% of the total population, and those urban areas contribute approximately 65% of the national GDP [11]. Apart from these, the unplanned and rapid urban expansion has influenced the chaotic growth of urban infrastructure, and in this process, the filing of wetlands, cutting hills, deforestation, and destruction of precious agricultural land have become very common phenomena. As a result, the country has faced uncountable losses of natural resources and substantial damage to the environment [12].

Rajshahi is the fourth-largest metropolitan city in Bangladesh [13]. The Rajshahi City Corporation (RCC) stands on the bank of the Padma River. Rajshahi City Corporation (RCC) has recently witnessed expansion in multiple directions. The growth is mostly towards the north, following the airport road, to the west across the Padma River embankment and the city bypass corridor, and to the east along the Dhaka-Rajshahi Highway. Urban areas are expanding radially from the city centre and progressively encroaching upon adjacent agricultural land, vegetation, low-lying areas, unused land, and water bodies [14]. The proliferation of urban expansion has resulted in a steady reduction in the number of water bodies over time. Most of the wetland area has been converted into a built-up area, leading to a negative effect on the environmental quality [15]. This study aims to evaluate the influence of urban expansion on the quality and quantity of water bodies in the Rajshahi City Corporation (RCC).

II. METHODOLOGY OF THE STUDY

A. Study area

The study area, Rajshahi City Corporation (RCC), is the fourth largest city in Bangladesh and is located (see Figure 1) along the Padma River to the northwest part of Bangladesh, between 24° – 21' to 24° - 26' north latitude and longitude 88° – 32' to 88° - 40' east longitude. The total study area is about 48.06 sq. km. [14, 16]. Rajshahi city is experiencing slow but steady urban expansion. Though the city exhibits a low rate of urbanisation compared to other big cities, it at the same time demonstrates symptoms of the ills of urbanisation like other fast-growing cities in Bangladesh [14].

Rajshahi City was one of the first municipalities in Bangladesh, which was established in 1876. In 1987, Rajshahi Municipality was renamed Rajshahi Municipal Corporation, and later in 1991, Rajshahi Municipal Corporation was upgraded to Rajshahi City Corporation [13]. In 1991, at the beginning of Rajshahi City Corporation, the total population was about 288391, covering an area of 30 sq. km. In 2001, the population of RCC was 333384, and after that, in 2011 (the last recent population census in Bangladesh), RCC accommodated about 449756 people. The current density (in 2011) of RCC is 9358 per sq. km, which is much higher compared to the density in 1991 (6001 per sq. km) [11].



Fig. 1. The study area (map of Rajshahi City Corporation)
(Source:

https://en.banglapedia.org/index.php?title=Rajshahi_City_Corporation).

B. Data collection and analysis

The study has been based on both primary and secondary data. Primary data were collected through field observation. A field situation was observed to gather first-hand experience on the present status and location of water bodies. The problems and issues were identified through this process. The urban structure features and water body features were extracted from the Rajshahi Metropolitan Development Plan 2004, which was prepared by the Rajshahi Development Authority (RDA). ArcGIS 10.6.1 was applied for spatial analysis functions for measurement, classification, and visualisation using the extracted spatial data. The amount of water body reduction from 2004 to 2022 was calculated and displayed spatially. Furthermore, the conversion of these water bodies into different land use types was identified.

Secondary data were collected from various sources, likely population census data, city-wise statistical yearbooks, and city development authorities.

III. RESULTS AND DISCUSSION

The results and discussion section will analyse the evolving condition of water bodies within Rajshahi City. Figure 2 displays the road, structural, and waterbody features in 2004, along with the city boundary. The data has been gathered from the Rajshahi Metropolitan Development Plan 2004, which was prepared by the Rajshahi Development Authority (RDA). Figure 3 exhibits the precise geographical positions of water bodies within Rajshahi City.

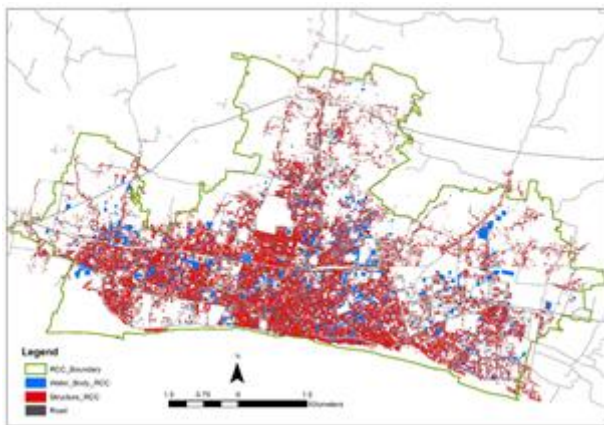


Fig. 2. Different features of Rajshahi City Corporation (RCC) in 2004.

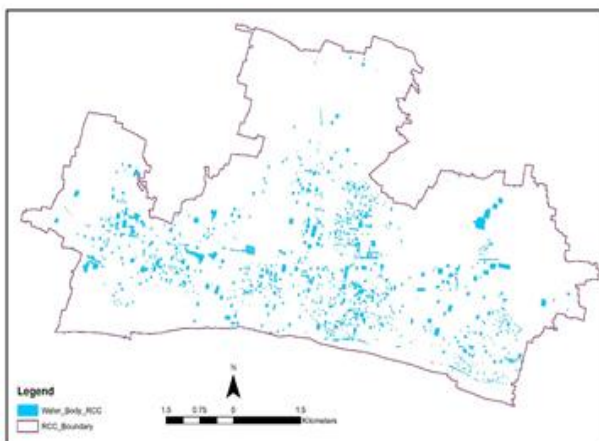


Fig. 3. Location of water bodies of Rajshahi City Corporation (RCC) in 2004.

The Rajshahi city area encompasses a total water body area of 2.22 sq. km, as seen in Table 1. Additionally, a total of 1038 water bodies have been identified. A field survey was done in the first quarter of 2022 to gather data on the current condition of the water bodies within the city vicinity. Table 2 outlines the classification of water bodies into four distinct groups.

Table 1. The Existing condition of water bodies (in 2022)

Water Body Condition	Count	Area (sq. km)	%
Good	346	1.36	33.33
Moderate	171	0.29	16.47
Poor	185	0.17	17.82
Filled-up	336	0.39	32.37
Total	1038	2.22	100.00

Source: field survey (2022).

Based on the field survey data, it has been determined that out of the total of 1038 water bodies in Rajshahi City, only 346 are in good condition. The aggregate extent of good-quality water bodies encompasses 1.36 sq. km, which accounts for approximately 33% of the whole area occupied by water bodies. There are a total of 336 water bodies in the filled-up category, while there are 171 water bodies in moderate condition and 185 water bodies in poor condition. According to the field survey data, over 32% of water bodies are in the filled-up category, with approximately 18% being in poor condition and around 16% in moderate condition.

Table 2 Details of water body category

Water Body Category	Present condition
Good	Water bodies are in good condition and used by the residents of the city
Moderate	Water bodies are not in good condition, and people started filling up the process
Poor	Water bodies are very dirty with lots of garbage and waste, almost filled up
Filled-up	Water bodies are already filled up

The expansion pattern of Rajshahi City is primarily evident in the northern and western directions, prompting individuals to seek residential options in these locations. In addition, the majority of recently developed residential areas are located in the northern and western regions of the city. Figure 3 depicts a prominent scenario in which a significant number of water bodies are concentrated in the central and western regions of the city. Additionally, it is evident that these two areas have filled up water bodies. Based on the observations in Figure 4, it is evident that the majority of the water bodies situated in the northern and western parts of the city are completely filled. In addition to the filled-up water bodies, there are also several water bodies of moderate and poor quality situated in the centre and western regions of the city. In Figure 5, the representation excludes the majority of water bodies as it only includes water bodies classified as being in good condition. It is important to focus on water bodies in good condition because filling has already begun for water bodies in moderate and bad conditions in Rajshahi City Corporation.

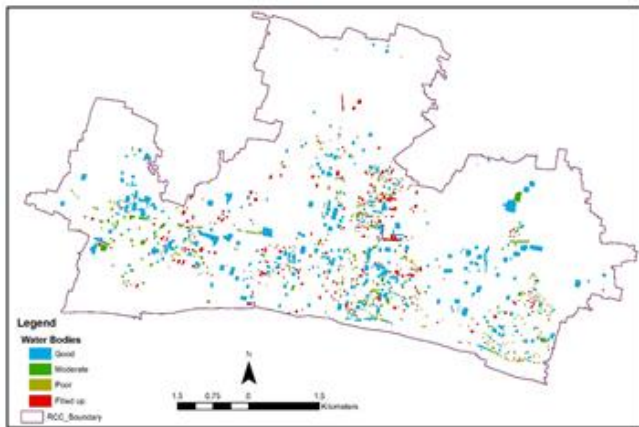


Fig. 4. Location of water bodies (categories based on different conditions) of Rajshahi City Corporation (in 2022)

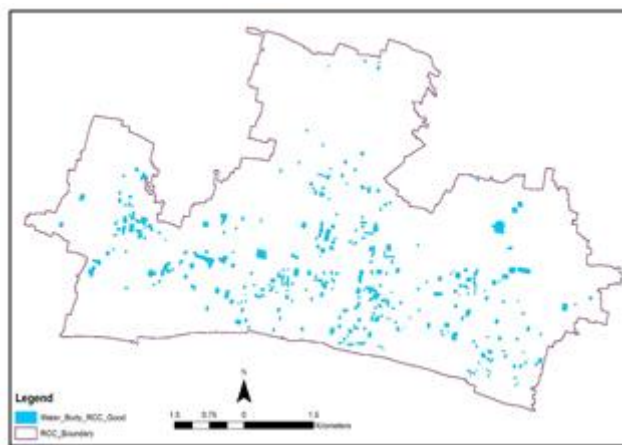


Fig. 5. Location of water bodies of good condition in Rajshahi City Corporation (in 2022)

Table 3 shows that out of the 336 filled-up water bodies, 78 of them have been classified as having residential land use. A total of 252 water bodies have been identified as vacant land, while 6 water bodies have been utilised for commercial purposes. It is noteworthy that the majority of the filled-up areas are currently vacant land. One of the main reasons behind this scenario is that water bodies are filled with sand, which requires several years to settle and reach a state acceptable for the construction of residential or commercial buildings.

Table 3 Existing use of filled-up water bodies (2022)

Existing Use	Count	Area (sq. km)
Vacant	252	0.2709
Residential Use	78	0.1121
Commercial Use	6	0.0075
Total	336	0.3904

IV. CONCLUSION

Urban expansion is a complex process that both presents challenges and offers opportunities. It has a significant impact on various aspects of cities, including their socio-economic structure, the development of infrastructure, and their ability to maintain environmental sustainability.

The rise of urban areas has significant consequences for the natural environment, including water bodies. The reduction in the size of water bodies as a result of urban expansion has become a widespread phenomenon in developing nations. Rajshahi City Corporation (RCC) is a rapidly developing municipality and metropolitan area in Bangladesh. The population growth rate in Rajshahi city is moderate, although it exhibits a consistent and incremental trend. A significant influx of individuals from adjacent regions has occurred in Rajshahi City. Consequently, there is a significant demand for vacant land for residential use. Furthermore, there is a limited availability of undeveloped property inside the urban area. While there may be a few exceptions, the majority of the selling prices are considerably high. Consequently, individuals purposefully fill up the water bodies and market them to those seeking undeveloped land. This is a significant factor contributing to the filling of water bodies in the central, western, and northern regions of the city. This study has identified the present state of water bodies. In order to accomplish this, the water bodies within Rajshahi city are classified into four distinct categories: good, moderate, poor, and filled up. The result shows that 32.37% of water bodies are filled up. The present investigation solely addressed the alteration of water bodies, excluding any examination of other categories of land cover. There is significant potential for conducting research on different forms of land cover change and achieving favourable outcomes for overall land transformation due to urban expansion in the Rajshahi City Corporation (RCC) area.

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