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Mapping Urban Encroachment in the Rivers around Dhaka City: An Example from the Turag River

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Abstract
Dhaka, the capital city of Bangladesh, is one of the fastest growing and the most densely populated cities in the world. The city has 4 rivers all around which were once lifelines to it for economy and ecology. Being expanded rapidly in an unplanned way with the phenomenal increase of population, land scarcity and land price, the city's peripheral zone reached the banks of the rivers. Consequently, an ill-motivated section of people began to use the riverbanks in a variety of ways leading to river encroachment. Gradual encroachment is narrowing down the rivers putting their existence to threat. This study was conducted to find out the major encroachment points, estimate the area and document the land use of each encroachment point in the Turag River, particularly from the Buriganga Third Bridge (Shaheed Budhijibi Bridge) at Bashila to Tongi Bridge. The study was carried out through field survey with Dhaka City (rivers) map and GPS. The field survey was supported by discussion with focus group of 60 people aged over 70 experiencing changes in the Turag River for over last 50 years. Encroachment map showing the location of encroachment points has been prepared through application of GIS and satellite image. During field survey, the area and land use of each encroachment site was estimated and noted down respectively on sketch map. However, the study found out 51 points where about 1.5 acre of the riverbanks have been grabbed and are being used mainly for trade and commerce as well as housing purposes.
Keywords: Dhaka, Economy, Ecology, River encroachment, GPS, GIS.

1. Introduction

Dhaka, the capital city of Bangladesh, is one of the fastest developed and the most densely populated cities in the world. In Bangladesh, Dhaka is the largest city with a municipal area of 590 sq. miles that homes to more than one-third urban population of the country. The total population of the city is nearly 14 million with a growth rate of around 7% over the last three decades and projected to turn out to be the 6th biggest megacity in the Asia-Pacific region by 2020 with an approximate population of 20 million (UN-Habitat, 2010; Mohit, 2012; World Bank, 2012). In the municipal area of the city, about 45,000 people live per sq. km. leading to one of the highest densities in the world (Cox, 2012). It is a distinct primate city in the national and regional hierarchy and the nucleus of economy, administration and culture of Bangladesh.

Geographically, Dhaka City is located at the center point of the flat deltaic plain of the three major river systems including the Ganges, the Brahmaputra and the Meghna. In particular, the city is surrounded by the distributaries of these rivers. They are the Balu and the Shitalakhya on the east, the Turag on the west and north and the Buriganga on the south. Over centuries, these rivers have been lifelines to the city for both of its economy and ecology. History says that rivers have always shown to have enormous effects on urban economy in a variety of ways. Once, the rivers were the main sources of fish supply to Dhaka City. The city used river water for a variety of purposes as the quality of water satisfied environmental quality standard. The city dwellers would go to the rivers on vacations with family members for recreational purposes. Apart from the above, the rivers supplied fresh air to the city.

Before Mughals reign, Dhaka was a small Hindu trading centre. In Pakistan Period (1947-1971), the city of Dhaka experienced a momentous. In 1947, Dhaka restarted its life as the capital of East Pakistan. Again in 1971, Dhaka became the capital of the independent state 'Bangladesh'. This additional factor as well as the initiatives of the private sectors led to Dhaka's phenomenal growth since 1971 (Chowdhury and Faruqui, 1991) and started having detrimental effects on the rivers as the urbanization in terms of population and areal extension took place in a rapid but unplanned way. One of the effects is the beginning of urban encroachment in the city surrounding rivers.

Despite all odds mentioned thereof, to meet the increasing population pressure, the government took a large project entitled "Dhaka Metropolitan Development Planning (DMDP)" and further expanded the city. According to this project, the total area of Dhaka City is about 1528 sq. km. Although the city was first developed on the bank of the Buriganga River utilizing its multifaceted services, with the passage of time it has spread over an extended area almost on all directions especially on the north, the south, and the west. Consequently, the peripheral zone of Dhaka City spread to the banks of the surrounding rivers. Land scarcity and land price in the city, even in its peripheral zone, increased manifolds. An ill-motivated section of people of this fast growing metropolitan city availed the opportunity of its rapid expansion. They started using the riverbanks and even the dried up portion of the river channel in a variety of ways. In practice, initially, they use the riverbanks on temporary basis as the rivers are no under private ownership to be highly taken care of. Thus, they pave the way

of grabbing the riverbanks. Later when they think that the ownership of the grabbed lands has been vested with them automatically due to illegal occupation for long time, they go for permanent land use eventually leading to river encroachment.

River encroachment is an illegal intrusion in a navigable river with or without obstruction (Senthil and Anand, 2016). Gradual riverbank encroachment is narrowing the rivers down putting their very existence to threat. Today, encroachment has become one of the major problems faced by the rivers around Dhaka City. Now, it has become urgent to rethink of addressing the encroachment problem not only to save the rivers but also to ensure innumerable socio-economic and ecological services of the rivers to Dhaka City. A recent study to investigate the river encroachment (Chowdhury, Bhuyain and Kabir, 2015, p. 1556) concluded that rapid river encroachment has been observed in many places of Dhaka city's peripheral rivers and that Dhaka City has already started suffering from many socio-environmental problems including flooding, water-logging and other related problems due to river encroachment. Again, to solve the encroachment problem, first it is necessary to unveil the true picture of this problem. At this backdrop, the present study took an important part of the Turag River, particularly both banks from the Buriganga Third Bridge (Shaheed Budhijibi Bridge) at Bashila to Tongi Bridge as an area of investigation. In this part of the Turag River, industries, housing projects and different commercial business farms have been developing along both banks. All these types of land uses which are on the rise rapidly, work significantly as positive factors for river encroachment. In addition, so far as the literature reviewed, there is no specific study on finding the exact locations of encroachment and the area of each encroachment site. There are very few studies related to encroachment in Dhaka and its peripheral rivers. For example, Hossain *et al*. (2014) have focused on overall changes in the wetlands of Dhaka City while Chowdhury, Bhuyain and Kabir (2015) studied the overall encroachment picture in Dhaka City surrounding rivers with the help of GIS and remote sensing. The present study, therefore, spotlighted on finding out the exact encroachment points, estimating the encroached area and documenting the land use practices at each encroachment point in the study area through GPS field survey and focus group discussion. The findings of the study will be highly useful to the Government of Bangladesh, particularly the authorized government agencies to easily locate the encroachment points, take concrete actions to restore the river evicting the existing encroachments and protect the river from further encroachment in future.

2. Methods and Materials

2.1. Selection and description of the study area

The study covers about 29 kilometers of the Turag River, particularly from Buriganga Third Bridge (Shaheed Budhijibi Bridge) to Tongi Bridge, as an area of investigation. This area lies between 23˚74′ - 23˚88′ north latitude and 90˚34′ - 90˚40′ east longitude. About 20 km length of the river is adjacent to Dhaka City (Table 1).

The Turag River is the upper tributary of the Buriganga. The Turag originates from the Bangshi River at Kaliakoir of Tangail District. The Bangshi is an important tributary of the Dhaleshwari River. On the other hand, the Dhaleshwari is also a tributary of the Buriganga (Chowdhury, 2001). It flows through Gazipur and then along the north-western side of Dhaka Metropolitan Area. It joins the Buriganga at Mohammadpur on east and at Shalmasi of Keraniganj on west. Keraniganj and Savar Upazila are on the western side and Tongi Pourosova is situated on the northern side of the river. Again, Uttara and Turag Thana are on the southern side and Mirpur and Mohammadpur are on the eastern side of the Turag River.

The river has an average width of about 0.12 km during the dry season covering about 276 ha of water body which increases about 500 ha during the flood season (BWDB, 2004). The Fig. 1 (Map of the study area) shows the location of the Turag along with other rivers surrounding Dhaka City. Hydraulically, the Turag is not an isolated river. It is connected with the Balu, the Shitalakhya, the Buriganga, the Dhaleswari, and the Tongi Khal. The Turag is connected with Meghna River through the Tongi Khal and the Shitalakhya River. It is also connected with the Padma/Ganges River through the Buriganga.

Table 1: Characteristics of the Turag River

Length around the city (km)	Mean annual maximum water level (WL) & adjacent flood plain area below		Mean annual mean water level (WL) & adjacent flood plain area below		Mean annual minimum water level (WL) & adjacent flood plain area below	
	WL (m)	Area (sq. km)	WL (m)	Area (sq. km)	WL (m)	Area (sq. km)
20	5.62	35	2.80	8	0.77	0

(Source: Khan, 2003)

The main reason of selecting this area is that along both banks in this specified part of the Turag River, there have been started developing industrial units, housing projects along with different trade and commercial farms over the last 10 years. A bird's eye view of the river implies that over a limited part of the river particularly in Tongi and Mirpur area, encroachments occurred about 30 years ago but most parts of the river have recently experienced bank-encroachments because of rapid areal expansion of Dhaka City and these parts

of the Turag River are more likely to fall a victim to grabbers in the near future because of the land uses recently developed along both banks. If the encroachments in this part of the river can be assessed as well as proper strategies and policies can be taken without delay, the river can easily be saved from substantial intrusion and permanent illegal occupation by the land grabbers. In particular, all these types of land uses which are on the rise rapidly facilitate the land grabbers to take riverbanks under their possession. Scattered settlements are located along both banks of the river, mostly along the south-eastern bank (city side bank). Settlements along city side banks of the river are particularly confined to Mirpur and Tongi area. The settlement dwellers are mainly boatmen, fishermen, cargo ship workers and businessmen (riverside shop owners, and construction materials traders) by profession.

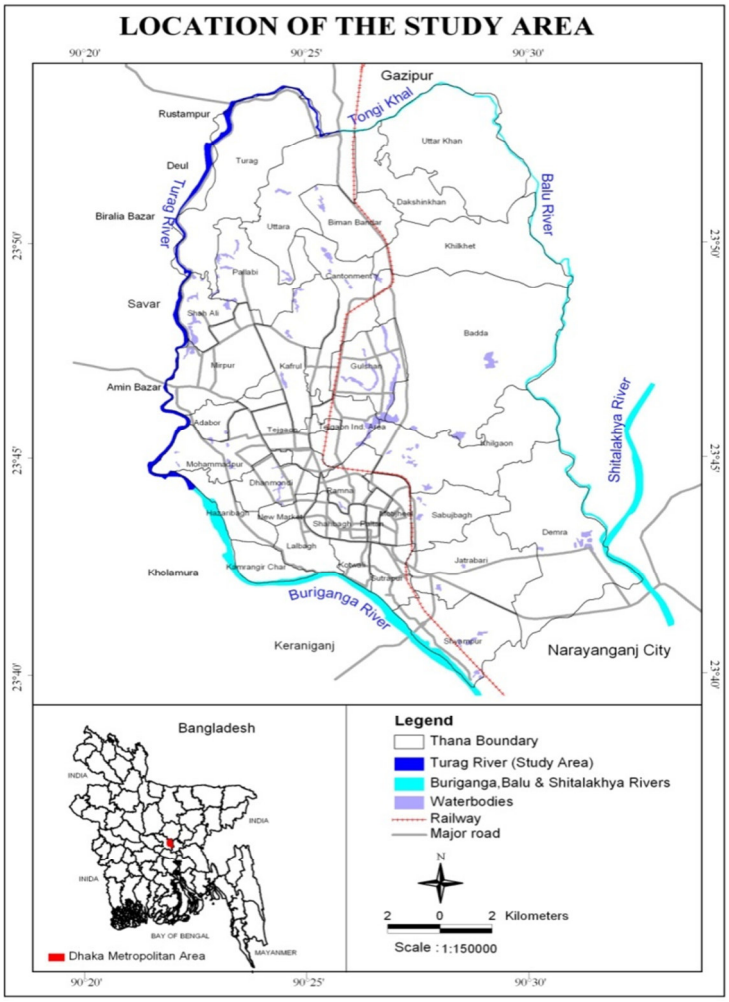

Figure 1: Map of the study area

The Turag River provides multifaceted services to Dhaka City. Firstly, it is navigable by boat all year round. As waterway provides easier, cheap and traffic congestion free means of transport, it is still found to use engine-run boats for transportation of passengers and goods through this river. The industrial areas of Tongi, Ashulia, Mouchak, Konabari, Madhapara and Mirzapur have been developed utilizing transport, water and other opportunities of the Turag River. Secondly, the Turag offers a spacious drainage facilitates to Dhaka City through its khals (canals). Thirdly, there have been developed numerous trading farms of building materials (sand, bricks, stone, coal and cement) and brickfields along the banks of the river. These farms use this river as their sole trade route. Fourthly, farmers in dry season irrigate their cropland from the Turag River because from Bagchotra of Savar Thana to Machimpur of Tongi Pourosova, the major portion of the western bank area of the river is dominated by agricultural land use specially rice cultivation. Fifthly, The Bishwa Ijtema, the second biggest Islamic congregation after the Hajj, is organized by the Turag River in Tongi and attracts millions of Muslims annually from over sixty countries. Sixthly, almost all types of industries need a huge amount of water. Earlier, the industries beside the Turag would use its water in whole production process though it is impossible today as the quality of water has seriously deteriorated due to disposal of huge pollutants in the river. Seventhly, the river Turag works as natural freshener of polluted air of Dhaka City and provides fresh air to the city. Eighthly, the river provides entertainment facilities to the city dwellers like supporting river resorts, boat race,

moving in the river by recreational boats and last but not the least, adds to the poetic beauty of Dhaka City.

2.2. Types of data

The data used in the whole study including in the encroachment map are mainly the primary ones. Field survey with Global Position System (GPS) technology was the main method of primary data collection. Along with field data, existing literatures were also consulted to collect some background information about the study area and Dhaka City.

2.3. Preparing base map using GIS and satellite image

To show the location of the study area, a map of Bangladesh with district boundaries was prepared where Dhaka metropolitan area has been shown with red color. Then a base map of Dhaka City with surrounding rivers on the scale of 1: 50000 has been prepared through digitization of satellite image and use of Arc GIS software.

2.4. Encroachment assessment by field survey and FGD

The study area has been visited and keenly observed by the author on foot or by boat to survey encroachment. The field survey used a Dhaka metropolitan area topographical map on 1:50000 scale to successfully identify the study area in the field and drew a sketch map of the study area (the selected portion of the Turag River). Through field observation and focus group discussion, the sites of encroachment were identified along the Turag River, particularly within the study area and the encroachment points were plotted on the sketch map. The focus group consisted of 60 riverside residents and river-dependent low income people (such as boatmen, fishermen, riverside shop owners and ship workers) aged over 70 who have been experiencing changes in the Turag River for more than 50 years and who are the direct witnesses of river encroachment.

2.5. Preparing encroachment map using GPS and GIS

From the base map, the Turag River segment, more specifically the study area was cropped to prepare the encroachment map transferring the encroachment data on it. Using GPS, geo-reference (X and Y coordinate values) of each point was noted down on the sketch map next to the respective encroachment point. Geographic Information System (GIS) was used to prepare encroachment map of the study area. Initially, using Arc GIS 10.1, widely known GIS software, the map of Dhaka City with rivers was prepared digitizing from satellite image 'Landsat 8' with multispectral resolution of 30 meters. At the same time, the sketch map of the study area was also digitized. Again, the Turag River map digitized from satellite image was overlapped with the map digitized from the sketch map to prepare a map of the study area (the particular segment of the Turag River). Then, the geo-reference of each encroachment point was inputted on the map to turn it into an encroachment map showing the exact locations of the encroachment sites in the study area. This encroachment map works as a sample area analysis of river encroachment around Dhaka City. Different shape files have been created using the Arc GIS.

2.6. Estimation of encroached area and documentation of its land use

During the field survey, the area of riverbank grabbed in each identified site was estimated through discussion with the riverside age old people. Finally, the existing land use of each encroached site was investigated and noted down accordingly on the sketch map.

3. Results and Discussion

The study reveals that the Turag River fell a victim to land grabbers in the early twentieth century and it was confined in particular portions of the river specifically from Gabtali to Suto Diabari and from Turag Thana to Tongi municipal area. According to BCAS (2010), encroachment has massively attacked the Turag after 1980s. Now, this ill-practice has touched every part of the river and the possibility of riverbanks to fall under encroachment freshly is very high in the Turag River as many housing projects like Chandrima Model Town, Dhaka Uddan, Silicon City, The Babylon City, Pratyasha Housing Estate are developing filling lowlands along the Turag River.

The present study found encroachments along both banks of the river from Buriganga Third Bridge (Shaheed Budhijibi Bridge) to Tongi Bridge. Encroachment has occurred at 51 points of the river where river bank, even river channel has been occupied by the land grabbers. The Fig. 2 shows the location of all encroachment points with unique IDs on map while the second column of the Table 2 describes the location of each point.

From the distribution of the encroachment points on the map, it is clear that the distributional pattern of encroachments is not the same along the both banks of the Turag within the study area. In fact, the frequency of encroachments is much higher along the south-eastern bank (city side bank) of the river than that along the north-western bank. Statistically, out of 51 encroachment points, 37 have been found along the city side bank whereas only 13 have been found along the north-western bank and the rest one has been found at the midpoint

of the river channel near Shaheed Budhijibi Bridge. In percentage, about 72.55% of the total encroachment sites have been observed along the city side bank of the river. On the other hand, only about 25.49% have occurred along the north-western bank and only 1.96% at midpoint of the river channel.

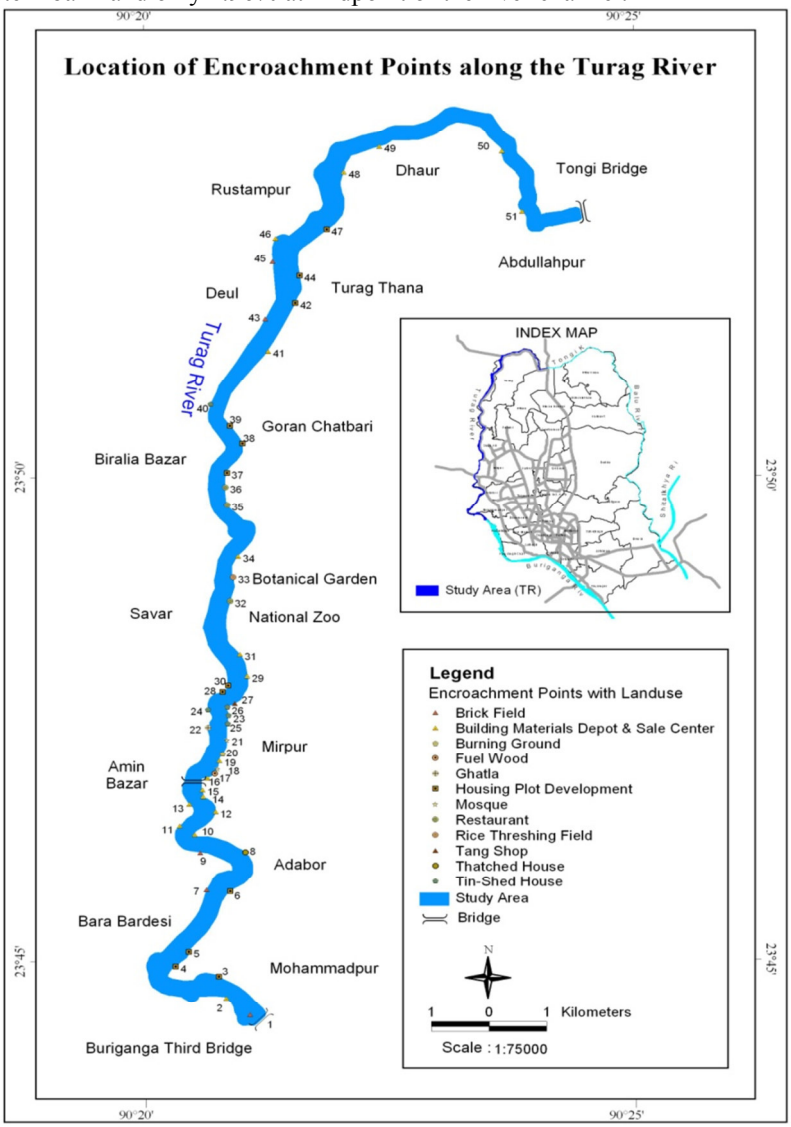

Figure 2: Encroachment map

Again, distributional pattern of encroachment points varies from north-western bank to south-eastern bank. In case of north-western bank of the river, most of the encroachment points are concentrated from Chapra to Bagchotra area. No encroachment point has been found from Shibpur to Sarulia and one or two points are scattered throughout the rest of the portion of the bank. On the other hand, along the south-eastern bank (city side bank) of the river, most of the points are concentrated from Gabtali to Sinnir Tek Landing Station and from National Zoo area to the opposite river bank of Birulia (Fig. 2).

The study finds out that about 63, 299 square feet or about 1.5 acre area of the riverbanks has been grabbed by the local influential. In terms of riverbank area under encroachment, out of 63,299 sq. ft. encroached land in the study area, about 38,447 sq. ft. belongs to the south-eastern bank, about 22,352 sq. ft. to the north-western bank and only 2500 sq. ft. to the main river channel. In percentage, about 60.74% area belongs to the south-eastern bank, about 35.32% of total encroached land goes to the north-western bank and only 3.95% of total encroached land to the river channel.

The main cause of huge difference between the two banks of the river in terms of encroachment points and area is that most part of the south-eastern bank (city side bank) is adjacent to the Dhaka City Corporations (DCCs) area where both land crisis and land price are very high. If a grabber can somehow manage to develop a piece of land filling riverbank, he in fact owns a valuable land resource. Therefore, the grabbers apply full-hearted effort to encroach particularly the city side bank of the river.

The study reveals that the encroachment sites vary in size or area across the study area. The area including

length and width of each encroachment site has been presented in the second column of the Table 2. The encroached sites have been found very small in size at Adabar, southern side of the Gabtali Bridge area and on both banks of the river from Gabtali Bridge to Suto Diabari particularly in Coatbari, Jahanabad, Palpara, Harirampur and Suto Diabari of Mirpur-1 and Sudhur Tek, and Tikal Tek of Savar Thana because along the banks at this portion of the river, land value, land use density and land crisis are very high. Encroachment points are also found to be small in size on both banks of the river from Dhaur to Tongi Bridge. Maximum-sized-lands have come under encroachment at Bagchotra of Savar Thana, just opposite to Sinnirtek Landing Station and at Kaundia of Savar, just opposite to Suto Diabari. Each of the two encroachment points has covered about 7500 sq. ft. respectively and both sites have been used for housing plot development.

Various civil society organizations including *Bangladesh Paribesh Andolon* (Bangladesh Environment Movement) and *Paribesh Bachao Andolon* (Save the Environment Movement) are continuously raising their voice for the protection of the rivers through organizing seminars, rallies and cultural programs (such as music programs on boats in the rivers), forming human chains and even filing summonses. In response, the government is also taking measures from time to time. For example, the Government of the People's Republic of Bangladesh published a gazette on 4 October 2009 declaring the rivers around Dhaka City as the Ecologically Critical Areas (ECAs) and prohibited all types of activities that harm the normal life and environment of the rivers (MoEF, 2009). In 2009, the High Court of the country directed the district administrations concerned to demarcate the rivers around Dhaka City as per Cadastral Survey (CS) and Revised Survey (RS) and protect river area with pillars, walkways and plantations. The district administrations of Dhaka and Gazipur along with the (Bangladesh Inland Water Transport Authority (BIWTA) have drawn the boundary line of the Turag, the Balu and the Buriganga. There is also a controversy revolving round this issue. The allegation is that the rivers have been delimited during the dry season excluding foreshore land. It has rather facilitated the river grabbers.

However, despite all the private-public initiatives to save the rivers, the river grabbers are still active and taking their greedy looks at the rivers. Encroachment is causing the river to narrow down with time. For an instance, in Sinnertek of Mirpur ('Sand trading'2013), the Turag River was once around 400 feet wide. Now it has narrowed down to 80 to 100 feet. Again, Chowdhury, Bhuyain, and Kabir (2015) stipulated in their latest article that the Turag was once an affluent 100 meters wide river on an average which has now turned into a narrow canal of 30-40 in width in some places. On the top of that, there are some clear indications that encroachment problem may be worsened in the Turag River, particularly in the study area in future as different structures, business farms, industries and housing projects are rapidly developing along both banks of the river.

Table 2: Location, area and land use of the encroachment points in the study area

Point ID	Location of encroachment point	Encroachment area (length X width) (sq. ft.)	Land use type in encroachment site
1	Within river channel at Bashila, Mohammadpur, Dhaka	50′×50′= 2500	Brickfield
2	Western bank of Turag near Burigang 3rd Bridge,Washpur, Keraniganj, Dhaka	55′×10′=550	Brick depot
3	Katasur, Mohammadpur, Dhaka.	30′×10′=300	Housing plot
4	Ramchandrapur, Mohammadpur, Dhaka	35′×15′=525	Housing project
5	Ramchandrapur, Mohammadpur, Dhaka	45′×10′=450	Housing Project
6	Adabar, Dhaka	36′×8′=288	Housing project
7	Barabardesi, Savar, Dhaka	40′×10′=400	Brickfield
8	New Sand Ghat, Mirpur, Dhaka	30′ ×20′=600	Thatched house
9	Chapra, Savar, Dhaka	22′ ×20′=440	Brickfield
10	Gabtali, Mirpur, Dhaka	35′×10′=350	Brick and sand sale centre
11	Bardesi, Amin Bazar, Savar, Dhaka	45′×10′=450	Brick depot
12	Gabtali, Mirpur, Dhaka	37′×12′=444	Brick, sand and stone sale centre
13	Amin Bazar, Savar, Dhaka	39′×8′=312	Brick, stone and sand sale centre,
14	Gabtali, Mirpur, Dhaka	38′×10′=380	Sand and stone depot and sale centre
15	Under old Gabtali Bridge, Gabtali, Mirpur, Dhaka	30′×15′=450	Sand depot and sale centre
16	Under New Gabtali Bridge, Mirpur, Dhaka	80′×50′=4000	Fuel wood depot and sale center
17	Coatbari, Mirpur, Dhaka	50′×30′=1500	Sand sale center
18	Coatbari, Mirpur, Dhaka	25′×8′=200	Mosque (Boro Bazar mosque)
19	Harirampur, Mirpur-1, Dhaka	50′×20′=1000	Brick sale center
20	Harirampur, Mirpur-1, Dhaka	30′×30′=900	Cremation ground

Point ID	Location of encroachment point	Encroachment area (length X width) (sq. ft.)	Land use type in encroachment site
21	Jahanabad, Mirpur-1, Dhaka	25′×10′ =250	Mosque (Jahanabad Mosque)
22	Tikal Tek, Savar, Dhaka	40′×15′=600	Boat passenger station
23	Jahanabad, Mirpur-1, Dhaka	30′×15′=450	Tin-shed house
24	Kaundia, Savar, Dhaka	10′×40′=400	Semi-concrete building
25	Palpara, Mirpur-1, Dhaka	60′×20′=1200	Rice mill
26	Jahurabad, Mirpur-1, Dhaka	57′×10′=570	Semi-concrete building
27	Suto Diabari, Mirpur-1, Dhaka	25′×20′=500	Temporary shop on bamboo posts
28	Kaundia, Savar, Dhaka	150′×50′=7500	Housing plot
29	Sinnir Tek, Mirpur-1, Dhaka	120′×50′=6000	Sand depot and sale centre
30	Bagchotra, Savar, Dhaka	150′×50′=7500	Housing plot development
31	Noaberbag, Mirpur-1, Dhaka	140′×20′=2800	Sand depot and sale centre
32	Noaberbag, Mirpur-1, Dhaka	60′×34′=2040	Park and restaurant (Monpura)
33	Noaberbag, Mirpur-1, Dhaka	100′ ×30′=3000	Rice grinding field
34	Goranchatbari, Mirpur-2, Dhaka	70′×25′ =1750	Sand depot and sale center
35	Goranchatbari, Mirpur-2, Dhaka	50′×25′=1250	Park (Tamanna Family World)
36	Goranchatbari, Mirpur-2, Dhaka	40′×10′=400	Housing project
37	Goranchatbari, Mirpur-2, Dhaka	75′×9′=675	Housing project
38	Goranchatbari, Mirpur-2, Dhaka	50′×10′ =500	Housing project
39	Goranchatbari, Mirpur-2, Dhaka	50′×10′=500	Housing project
40	Birulia, Savar, Dhaka	50′×10′=500	Tin-shed house
41	Ponchoboti, Pollobi, Mirpur, Dhaka	50′×10′=500	Sale depot and sale centre
42	Mahimanagar, Airport Thana, Dhaka	45′×10′=450	Land filling for plot development
43	Deul, Savar, Dhaka	100′×15′=1500	Brickfield
44	Solahati, Air Port Thana, Dhaka	35′×11′=385	Land filling for plot development
45	Rustampur, Savar, Dhaka	60′×20′=1200	Brickfield
46	Rustampur, Savar, Dhaka	50′×20′=1000	Sand depot and sale center
47	Rustampur, Turag Thana, Dhaka	38′×10′=380	Land filling for plot development
48	Nalbhog, Turag Thana, Dhaka	60′×20′=1200	Sand depot and sale center
49	Dhaur, Turag Thana, Dhaka	50′×20′=1000	Sand depot and sale center
50	Khaer Tek, Dhaur, Turag, Dhaka	40′×12′=480	Sand depot and sale centre
51	Ranabhola, Uttara thana, Dhaka	52′ ×15′=780	Sand depot and sale centre
Total		63,299 sq ft	

Source: Field survey by the author using Global Positioning System (GPS)

The study has conducted a land use survey in the encroachment sites on the riverbanks. The survey result as presented in the Fig. 2 by different symbols and in the third column of the Table 2 discloses that the plots of the encroached riverbanks vary from one to another in terms of their existing land uses. Overall, 12 types of land uses have been found on the encroached riverbanks in the study area. They include (i) brickfield, (ii) building materials (sand, brick, stone & wood) depot and sale center, (iii) burning ground (cremation ground), (iv) fuel wood, (v) Ghatla (boat passenger station), (vi) housing plot development (housing project), (vii) mosque, (viii) restaurant, (ix) rice threshing field, (x) tang shop (temporary shop on bamboo posts), (xi) thatched house (hanging house on bamboo posts), (xii) tin-shed house (bamboo-wooden house and semi-concrete house).

Figure 3: Brick field development encroaching main river channel (encroachment point 1)

According to the land use pattern as is observed in Fig.2, the highest number of land use types, specifically 10 out of 12, has been found in the encroached lands along the south- eastern bank of the river. On the other hand, only 5 types of land use have taken place in the encroached lands along the north-western bank of the river. Therefore, the diversity of land uses found in the encroached lands is more along the south-eastern bank than that along the north-western bank of the river. Yet, the encroached lands along the south-eastern bank is dominated by two land use types, such as housing development and building materials depot and sale center. On the other hand, no single land use has dominantly developed in the encroached lands along the north-western bank of the river.

Land use analysis reflects the dimension of human activities on a given environment (Lopez *et al.,* 2001). In order to further analyze the existing land uses in the encroachment sites, the land use types presented on encroachment map (Fig. 2) have been classified into 5 broad categories including- (1) trade and commerce, (2) housing, (3) industry, (4) religion and culture, and (5) agriculture (Table 3).

Table 3: Land use classification

Land use category	Land use types	No. of encroachment sites	% of encroachment sites	Area (sq. ft.)	% of area
Trade and commerce	Brick depot and sale center, Sand depot and sale centre, Coal depot and sale centre, Stone depot and sale centre, Fuel wood depot and sale center, Temporary shops on bamboo posts, Park, Restaurant, and Boat passenger station	23.00	45.10	29,336.00	46.35
Housing	Housing plot, Housing project, Thatched house, Hanging house on bamboo posts, Tin-shed house (bamboo-wooden house), Semi-concrete building and Land filling for housing plot development	18.00	35.30	22,373.00	35.34
Industry	Brick field and Rice mill	6.00	11.76	7240.00	11.44
Religion and culture	Mosque and Cremation ground	3.00	5.88	1350.00	2.13
Agriculture	Rice threshing field	1.00	1.96	3000.00	4.74
Total		51.00	100	63,299.00	100

Source: The author's calculation

The Table 3 gives a summary of the land use classifications. According to the summary, trade and commerce is the largest of all categories of land use where encroached lands are usually used for trading construction materials, shops, parks and restaurants. There are 23 out of 51 encroachment sites which land use types fall into this category. It covers 45.10% of the total encroachment sites extending over an area of 29,336.00 sq. ft. which represents 46.35% of the total encroached area. The second biggest category is housing referring to different types of houses, such as vast residential area (housing project), semi-concrete building, tin-shed house and thatched house. This land use category has 18 encroachment sites which equal to 35.10% of all encroachment sites. It spreads over an area of 22,373.00 sq. ft. which stands for 35.34% of the whole encroached area. Again, industry category has embodied only two land use types including brick field and rice mill and occupied only 6 encroachment points. It covers 11.76% of the encroachment sites and 11.44% of the encroached area. The land use analysis above implies that in the three above mentioned land use categories, their percentages

in encroachment sites are more or less equal to their percentages in encroached area. On the other hand, the percentage of religion and culture is 5.88 in encroachment points but 2.13 in encroachment area. Similarly, one encroachment site belongs to the land use category of agriculture which includes 1.96% of encroachment points but 4.74% of encroachment area.

4. Conclusion

From the present study it can be concluded that urban encroachment has emerged as a threat to the existence of the Turag River. It is narrowing the river down day by day. The frequency and intensity of encroachment along the south-eastern bank (city side bank) of the Turag is very high as the land value is going up day to day in the city and its peripheral zone. Most of the encroachment points have been found along this bank of the Turag, particularly from Adabar to Noaberbag, Mirpur 1. These encroachments have mostly occurred over the last 10 years. Majority of the encroached lands have been used for trade and commerce as well as housing purposes.

Given the scenario of urban encroachment in the rivers around Dhaka City, the future of the Turag seems to be bleak. If the river grabbing practice can't be checked, it will suffocate the river to dying within the next 20 to 30 years. Now, it is more than imperative to come up with some realistic strategies to evict the existing land grabbers demolishing their illegal structures on riverbanks and save the river from further encroachment. The findings of the present study will be helpful to Dhaka and Gazipur district administration to find out the specific encroachment points with respective area and land use. Therefore, this type of study should be conducted in three other rivers around Dhaka City to properly map and check river encroachment.

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