

Transformation of Urban Growth and Shrinkage of Khulna City in Bangladesh: A Remote Sensing Based Approach.

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Abstract—The main aim of the study is to explore the transformation experience of Khulna city from the year 2000 to 2020 in the presence of factors related to urban growth and shrinkage. The major hypothesis is that both growth and shrinkage phenomena can occur in a city simultaneously. Khulna City Corporation is the observed study area. The study is conducted by using demographic information, land cover data and accessibility data through remote sensing. The findings reveal that from 2000 to 2010, six wards extremely expanded, and two wards extremely shrank. From 2010 to 2020, seven wards extremely expanded, and five wards extremely shrank. However, it is disclosed that ward number 8, 20, and 22 are extremely expanding, and ward number 7 is extremely shrinking in both decades. Population, employment, and accessibility strongly influence the conversion process, while the built-up area has less significance. The results can be used for understanding the connection between urban growth and shrinking factors. Moreover, development hindrance of certain areas can be detected. Apart from this, policymakers can use this as a source of city planning and sustainable land use management to ensure harmonious urban development.

Keywords—urban growth, urban shrinkage, land cover classification, geographic information system, remote sensing, urbanization, transforming the city

I. INTRODUCTION

From the dawn of civilization, people move from place to place to find the best location with high opportunities to make their lives more flexible and more accessible. They are in search of places which can offer them the best services and facilities. Cities are engaged in a global competition to satisfy human nature. Like every other competition, some cities are winning, and some are losing. This winning and losing situation for urban areas is "Urban growth" and "Urban shrinkage."

Urban growth means urban extension in the urbanized land cover [1] and urban population rate [2]. On the contrary, urban shrinkage is the phenomenon of population loss, de-industrialization, and out-migration [3]. Different social, political, demographic, and economic indicators are in charge of growth and shrinkage phenomena. Some cities like New York, Stockholm, Oslo, Delhi, Beijing, Shanghai are overgrowing there some cities are going through shrinkage

like Bulgaria, Detroit, Pittsburg. Though cities tend to grow, not all the cities or areas of a city grow simultaneously [4]. In some cities, growth is happening but comparatively slow because of the presence of shrinking factors.

Besides, in a growing city, it might be possible that most of the city areas will grow, so the city is listed as a growing city. Nevertheless, shrinking is still happening in some portion of that city hidden because of overall growth. Not all cities experience a phenomenon with the exact dimensions. Some cities face growth or shrinkage because of social factors, some for political or economic factors. For instance: Manchester fall of the world's first industrial metropole (economic factor), Detroit downfall by racism (Structural factor), fall of Soviet Union (Political factor) [3]. It is assumed that a city may have both shrinking and growing factors. It is essential to know the underlying factor working behind the transformation of that area to ensure suitable policies and balance development.

A. Problem statement

Khulna is the largest metropolitan town in Bangladesh. The strategic location and connection with big cities and growth center make this metropolitan town the most crucial area of the southern region. It can be said the southern region's capital as it is the center of trade and all essential activities. Khulna was the vital trade center of Bangladesh based on jute mills, Mongla port, shipping trades, Newsprint mill. The city is connected with Calcutta, India, which creates a significant path for its growth and connected with Calcutta through rail lines, which is beneficial for trading. The Sundarbans and Bagerhat make this city the gate for tourist attraction. The sudden decline in a newsprint mill and jute mills in Khulna faced considerable difficulties in its economic condition, and people in the city are unemployed and migrating in search of jobs. Amenities like gas lines, airports, proper recreational center are missing. For salinity and poor soil quality, developers and investors are not much attracted. The presence of a public university, an engineering university, a medical college, and an agricultural university has enriched the educational sector. The Padma bridge and Khulna-Mongla railway station are the opportunity and indicator for this city's upcoming rapid development. Though Khulna is facing slow growth, there is a brilliant opportunity to transform into a rapidly growing city.

Using regular ideas or experience will not be enough for development activities and policymaking for this unique characteristic. A city facing slow growth most often does not consider the shrinking factors are less than the growth factors. However, in some cases, it can be seen that most of the areas

of a town are facing growth, but fewer areas are facing shrinkage, which is neglected because of growth dominance. For a balanced development, all the portions of a city must be considered because some shrinkage areas can also bring huge shocks and stresses gradually in that region's development. For the city resilience, it is crucial to know about both the strength and weakness. Besides, it is essential to identify the transforming experience in cities that have moved to future growth possibilities after bouncing back from critical condition to ensure balance in future development, use the knowledge for policymaking, and utilize this experience for similar contexts.

Many researchers are working on Urban growth and Urban shrinkage. However, there is rare literature explaining the simultaneous performance of these two phenomena. Even a city going through urban growth might have issues responsible for future decline or shocks. On the other hand, for shrinking and growing factors simultaneously, some portions of the city can face deprivation because of less concern about eliminating the shrinking factors. Alternatively, in some cases, it might be possible that the city is experiencing slow growth. Khulna city was recognized as the most important industrial metropolitan town of Bangladesh because of the jute mills and newsprint mills. However, the sudden fall out of these industries brought shocks to the city's growth and development. The formation of the Padma bridge and other amenities is increasing expectations for further development. These incidents are unique as the city has both expectations and disappointments issues. Here, it creates the scope to conduct this research. By answering the research questions, better knowledge about the city's transformation in both shrinkage and growth factors can be achieved. Besides, the experience of how the city is balancing itself from peak point to downfall and from downfall to possibilities can explore. These findings can contribute to the literature by working as a source to conduct research in a similar context, solve problems and achieve more harmonious urban development.

B. Objective of this study

This study aims to point out the transformation experience of Khulna city in the presence of both growth and shrinkage factors by using GIS and remote sensing data. The main objective of the study is:

- To identify the growing and shrinking areas of Khulna city
- To point out the growth and shrinkage factors for the area
- To explore the transformation experience of Khulna city from the year 2000 to 2020

II. LITERATURE REVIEW

Urban growth and urban shrinkage pattern diversification are becoming significant research fields for physical planning and policymaking. Every city has its characteristics, not to possess the same criteria for growth and shrinkage-related issues. Regions face these phenomena on account of political, economic, social, demographic, and other factors.

Similar factors can be different in different cities. For instance: A city attracts the population by giving them good job opportunities and quality of life, leading to the city's growth [5]. On the other hand, when people get enough

money and jobs, they tend to live in suburban areas to live in a better environment [5]. People are attracted to getting jobs and facilities, but they can also lead a quality life with better jobs and facilities. Employment opportunity is a growth factor for the population who need a job, and after having a job, they are capable of moving on somewhere else to live more quality life. In this sense, this factor is creating a way of shrinkage. However, for every region, the growth and shrinkage factors are not the same. In general statements, shrinking cities affiliates with a high unemployment rate, fewer business opportunities, political failure [5] failed to provide expected service [6], and Growing cities are associated with opportunities, transportation choices [5]. An enormous range of factors is found in different kinds of literature to identify growth and shrinkage cities. The main factors of urban growth derived from different literature are given below:

- Increase in urban population and net immigration [7]
- Road accessibility and transportation network [8]
- Industrialization [9]
- Commercialization [9]
- Availability of educational and recreational facilities [9]
- Extreme investments in building new housing and infrastructure [4]
- Child and age-friendly environment [6]
- Housing opportunities and choices [5]
- Walkable neighborhoods [5]
- Commercial and environmental concerns[1]
- Better quality of the environment and open spaces [5]

The main factors of urban shrinkage derived from literature are given below:

- Unemployment and unavailable business opportunities [5]
- Political failure [5]
- Population decline, a downturn in the economy[2]
- High proportion of older people [6]
- Provide less level of service [6]
- Outward migration [6]
- De-Industrialization [10]
- Dispersion of commercial activities [10]
- Climate change [10]
- Degradation of landscape [10]
- Suburbanization [10]
- Absence of investment [11]

Different literature has illustrated the growth and shrinkage factors for different regions. This research tries to delineate the factors applicable for Khulna city as the central concept of this research is to explore the transformation process in both growth and shrinkage factors which is important to understand. Most of the papers describe different issues of shrinkage and growth specifically. However, there is no sufficient paper that describes these two-phenomenon existing in a city simultaneously, generating slow growth. For Khulna city, some papers tend to explain urban land cover growth [12], urban transformation for economic restructure and redevelopment [13], or significant dynamics of urban spatial growth [8]. However, this research assumes that some

areas of Khulna city are expanding, and some areas are shrinking. However, the shrinking factors are comparatively low, so this is no more of a concern. Again, Khulna has faced fluctuation from high growth possibilities to downfall, and then now it is on the path of downfall to possibilities. It is important to identify how Khulna is experiencing transformation in these fluctuating conditions, which is the expected outcome of this research.

III. STUDY AREA

Khulna is one of Bangladesh's important divisions and the most important cities in its South-East region. It is the third-largest city in Bangladesh. The selected study area for this research is Khulna City Corporation Area. Fig. 1 shows the study area map delineating 31 wards of the KCC area. There are several reasons for selecting this area which are:

- Khulna became the largest industrial area with jute mills and newsprint mills before the freedom of Bangladesh. However, suddenly these industries faced a downfall which resulted in huge social and economic declines. Besides, the growth of the city is slow comparing with its locational value. The absence of Gas line, airport, the existence of salinity, lack of high-quality medical facilities, less recreational opportunities make the city less attracted to people and investors. Here comes the need to explore the shrinking factors for this city.
- The city is well connected with the capital of Bangladesh and Calcutta, India. So, it has an excellent opportunity for trading. It is also the gate of a tourist attraction. Besides, the establishment of universities and medical colleges has opened up an excellent quality of education in the city. The under constructed Khulna-Mongla railway station and Padma bridge is

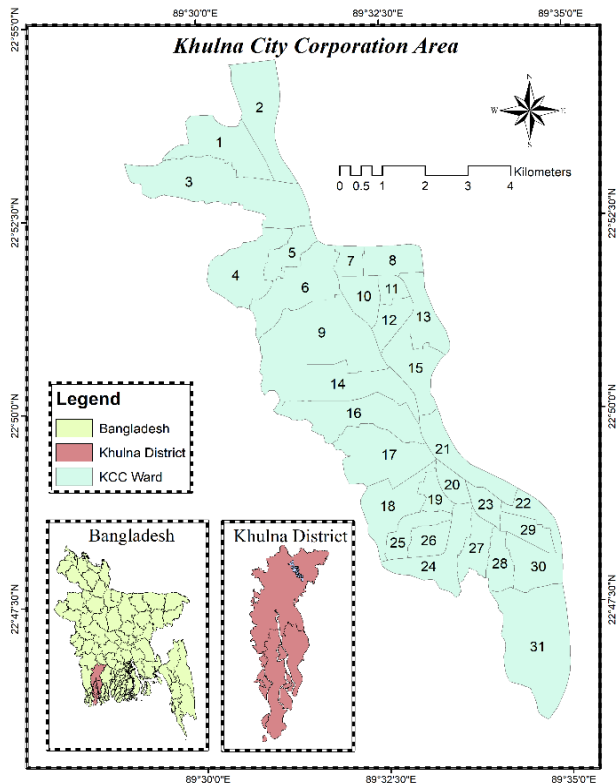


Fig. 1. Study Area Map

creating future possibilities and attraction in this city. Keeping in mind these possibilities of growth is suitable for this research.

- There are several cities in Bangladesh and other homogenous countries with Khulna City so that this study will also be applicable for those cities.
- As the city faces both decline and possibilities, it is suitable to achieve this research's aim.

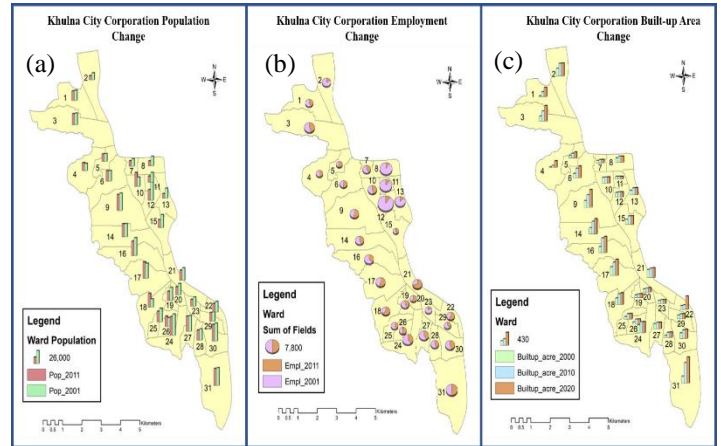


Fig. 2. (a) map shows the population change between 10 years of Khulna City (b) map shows the employment change of wards (c) map shows the built-up area change and it's clear that the built-up area has increased as the time being

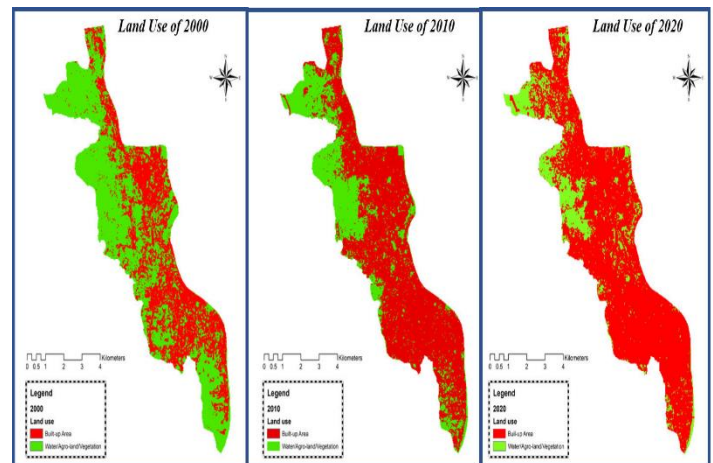


Fig. 3. Land Use Map of Khulna City Corporation Area of 2000, 2010 and 2020

IV. METHODS AND MATERIALS

A. Data Collection

Secondary data is used for performing the study. The population and employment data are derived from the Khulna Zilla Population and Housing Census of Bangladesh, 2001 and 2011 [14] [15]. The Landsat-7 imagery of 2000, 2010, and 2020 is used here collected from USGS earth explorer. Finally, the data on accessibility is collected from Khulna's detailed area plan.

B. Remote sensing image classification

Landsat imagery of the years 2000, 2010, and 2020 are collected from USGS earthexplorar. These images are classified using the supervised classification technique, where the maximum likelihood algorithm is applied in ERDAS IMAGINE 2015 software. The land cover data for each year are composed of two major land-cover classes

named: the built-up area including commercial, residential, road network, urban features, construction sites, and non-built up area including vegetation, agricultural land, water bodies. Fig. 3 shows the land use maps. Finally, each year's output file was exported in ArcGIS 10.5.1 for data preparation and spatial analysis.

C. Data preparation and calculation

Based on the literature review, four factors (built-up area, population, accessibility & employment) are used for analyzing the transformation from 2001 to 2010. Two factors (Built-up area & accessibility) are applied to show the 2011 to 2020 transformation for data shortage.

In the first section, built area data is extracted from land cover analysis for each ward. Then, the required data is entered using Excel. Next, data is normalized to make different scales or units similar by this equation (1) & (2):

For positive relation,

$$NV = \frac{cv - \min v}{\max v - \min v} \quad (1)$$

For negative relation,

$$NV = \frac{\max v - cv}{\max v - \min v} \quad (2)$$

Here, NV= normalized value; cv= cell value; maxv= maximum value; minv= minimum value;

Finally, the average of the factors is calculated. In the next section, the analysis is performed by using ArcGIS 10.5.1. The first step of this section is to join tabular data derived from excel and spatial data.

In step two, five classes (extremely shrinking, moderately shrinking, less change, extremely expanding, moderately expanding) are selected for classifying change types by using natural break.

D. Preparing maps and representation

Thematic and change maps are created for result representation by overlaying different layers in ArcGIS. Thematic maps are related to a particular topic of interest. These maps emphasized population employment and land use features distributed across space in every ward of Khulna City Corporation.

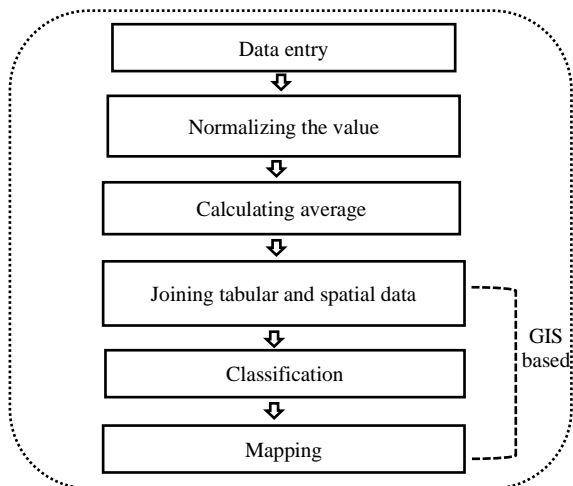


Fig. 4. Steps of methodology

V. RESULTS AND DISCUSSION

This segment is divided into three principal parts to represent the outcomes: A) Transformation pattern B) Function of each element, and C) Co-existence of growth and shrinkage

A. Patterns of the city transformation

Fig (5), (6) shows the urban growth and shrinkage scenario of Khulna city from 2000 to 2020. By analyzing the result of 2000 to 2010, among the 31 wards, it is found that six wards were extremely expanding, twelve wards were moderately expanding, seven wards showed no significant change, four wards were moderately shrinking, and two wards were extremely shrinking

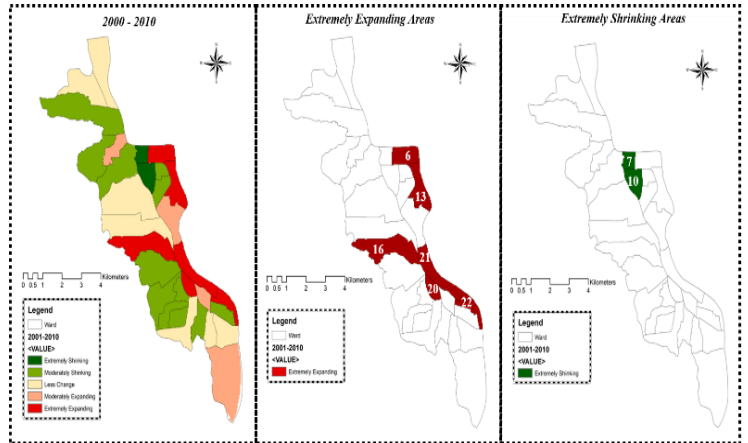


Fig. 5. Urban growth and shrinkage area map of Khulna City Corporation of 2000 to 2010, green and red color wards showing the extreme expansion and shrinkage

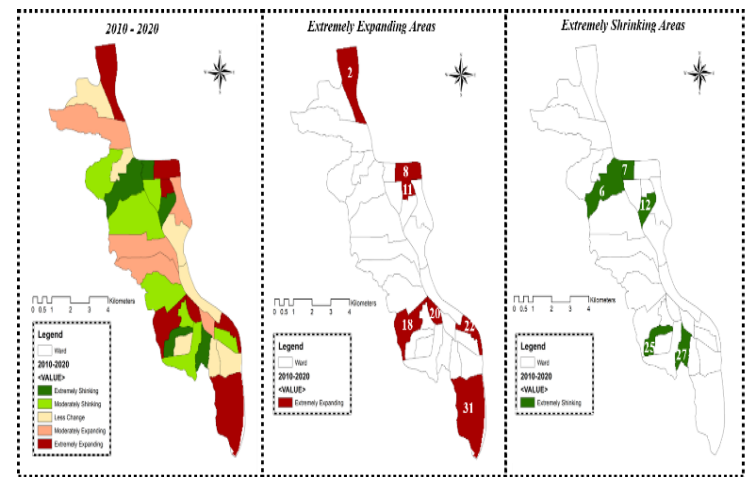


Fig. 6. Urban growth and shrinkage area map of Khulna City Corporation of 2010 to 2020, red and green wards showing the extreme expansion and shrinkage

From 2010 to 2020, it is seen that seven wards are extremely expanding, five wards are moderately expanding, seven wards are experiencing less change, seven wards are moderately shrinking, and five wards are extremely shrinking.

Comparing table (I) and (III) shows that wards 8, 20, and 22 are extremely expanding in both decades. Table (II) and (IV) show the extremely shrinking areas are situated in ward 7 in both decades.

B. Role of different factors in urban transformation

An indicative issue is that almost every ward's population has been decreased, which means the Khulna city corporation area's overall population is minimizing gradually. In fig (2), it is visible that the population in the year 2011 is less in maximum areas than in 2001, which is unexpected. In 20 years, ward 7 is the most contracting zone where the population reduces by nearly four thousand.

Some areas are losing their employment number, where others are gaining. It is noticed in Fig. 2 that extremely or moderately shrinking areas have lost employment over the past decade whereas expanding areas have achieved the number of employed people.

By analyzing the accessibility map, it is observed that the areas are growing more with increasing road facilities. Ward 20 is well connected with Khulna-Jashore Road, Khan Jahan Ali Road, and near to CBD. Whereas ward 22 is close to upper Jashore road and Khan Jahan Ali Road.

From the Land use map in fig (3) and the Percentage of built-up area change map in fig (7), it is visible that built-up areas are increasing rapidly. Built-up area is increasing nearly in every ward by maintaining its urban characteristics. There is no notable change in built-up areas to form a growing or contracting area.

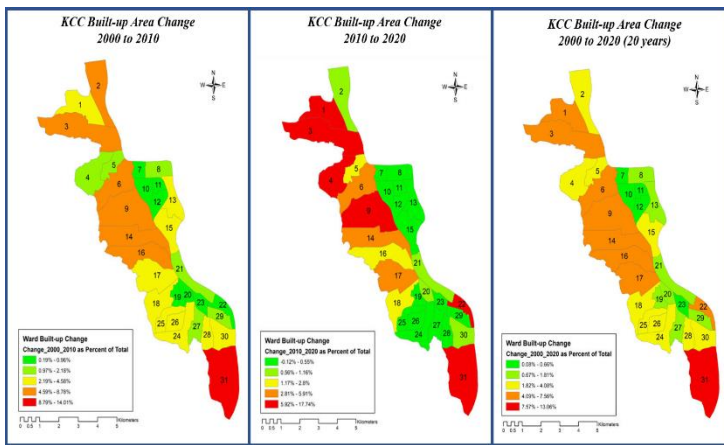


Fig. 7. Percentage of Built-Up area change from 2000 to 2020

Finally, it can be said that, in the Khulna city corporation area, population, employment, and accessibility is highly influencing the transformation norm of the city. In contrast, the city is reserving its urban nature without influencing growth and shrinkage with the increasing built-up areas.

TABLE I. EXTREMELY EXPANDING AREAS (2000-2010)

Ward no.	Name of major areas
8	Khalishpur Jute mil, Berge mounted power plant, BIDC road, Bhairab river
13	Khulna newsprint mill, Chorerhat
16	Choto Boyra, Boyra main road
20	Power house mor, Seikhpara, Farazipara
21	Boro Bazar, Dakbangla, KCC, Khulna railway station, Railway market
22	Munshipara, Hazi Mohsin road, Rupsha river.

TABLE II. EXTREMELY SHRINKING AREAS (2000-2010)

Ward no.	Name of major areas
7	Govt. BL College, Bhairab river
10	Noyabati more, Chitrali supermarket

TABLE III. EXTREMELY EXPANDING AREAS (2010-2020)

Ward no.	Name of major areas
2	Gilatola
8	Khalishpur jute mil, BIDC road
11	Khalishpur, Wonderland, BIDC road
18	Mohammadnagar, Sonadanga Bypass Rd.
20	Powerhouse Mor, Seikhpara, Farazipara
22	Munshipara, Hazi Mohsin road, Rupsha river.
31	Labonchora, Jinnahpara

TABLE IV. EXTREMELY SHRINKING AREAS (2010-2020)

Ward no.	Name of major areas
6	Doulatpur, Goalkhali
7	Govt. BL College, Bhairab river
12	Khalishpur housing state
25	Basupara, Banorgati
27	Moulovi para, Baniakhmar

C. Co-existence of Urban growth and shrinkage

As every portion of a city is not developed or gets all the services and facilities equally, some portion of the city will not expand. Although many factors influence the growth or shrinkage of an area, population, employment and accessibility are crucial for any region. By analyzing the 20 years information of Khulna city, urban expansion and shrinkage are happening simultaneously. Where ward no.7 is shrinking within 20 years, there ward no. 20 and 22 are expanding. Areas are facing growth and shrinkage because of different characteristics in different locations.

VI. CONCLUSION

The study is focused on exploring the transformation experience of Khulna city from the year 2000 to 2020 in the presence of urban growth and shrinkage factors. Even though urban areas will develop, not every part of the urban areas or city's space will develop together. Khulna city faced enormous economic decay as numerous ventures were shut down and individuals moved on. Nevertheless, the presence of good education facilities, Padma bridge construction, and the Khulna-Mongla railway station indicate tremendous possibilities of rapid growth. Due to efficient decline, some portion of the city is losing its attraction while altering development direction some segment of the city is pulling in individuals.

Demographic data (population & employment) collected from Population census 2001 and 2011, major road and landcover data of year 2000, 2010 and 2020 is used to conduct this research. By combining the selected factors through remote sensing analysis, the final result is generated by considering each ward.

From 2000 to 2010, ward no. 8, 13, 16, 20, 21, and 22 extremely expanded, whereas ward no. 7 and 10 extremely shrank. On the other side, from 2010 to 2020, ward no. 2, 8,

11, 18, 20, 22, and 31 extremely expanded, and ward no. 6, 7, 12, 25, and 27 extremely shrank. In both decades, wards 8, 20, and 22 are common as these areas are growing. However, ward no. 7 is contracting in both decades. Besides, population, employment, and accessibility strongly influence the conversion process while the built-up area has less significance. The variation of different factors in every ward growth and shrinkage coincides in the city.

It might be possible that the areas facing shrinkage can cause a decline in the city's development. Therefore, to ensure balanced development, it is crucial to maintain the growth of these declined areas. From the result, it is found that ward no. 7 is contracting in both decades. Thus, it is necessary to take the required step to pull back this portion for the melodious urban growth of Khulna city.

To ensure equilibrium development, every segment of a city is crucial to consider. The downfall of certain parts can cause stress. In order to make the city resilient, it is important to know about the vulnerable portions. The study's findings can help understand the nature of different factors in urban development and decline. However, it can be used as the source for policymaking and sustainable land use management for ensuring balance growth. Moreover, this experience will be supportive for supervising similar settings.

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