Journal of Engineering Science 14(1), 2023, 11-27
DOI: https://doi.org/10.3329/jes.v14i1.67632

JES
an international Journal

INFLUENCE OF BYPASS ROAD ON LAND USE AND LAND COVER CHANGE OF KHULNA CITY, BANGLADESH

K. Nahar, I. Alam and M. M. Morshed*

Department of Urban and Regional Planning, Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh

Received: 28 November 2022 Accepted: 20 March 2023

ABSTRACT

Transportation has a significant impact on the spatial structure of a place and its accessibility. It can shape urban spatial growth, reorganize the country's land use patterns, and stimulate the advancement of specific patterns. In this study, satellite images of Khulna city and its 5 km buffer area centering the bypass road for the years 1990, 2000, 2010, and 2020 were classified to determine the land use changes as the land cover was categorized in water bodies, agriculture, vegetation, and built-up. Using a single dynamic degree, comprehensive dynamic degree, and expansion or reduction intensity index, the change rate and expansion rate of land use were determined within a 1-5 km buffer. It was found that most changes occurred within the 1-2 km buffer zone of the bypass road. As the distance from the road increases, the influence on land use decreases. To determine the land use transition due to the bypass road, a corridor assessment was done for a 2 km and 4 km buffer area, assuming the changes were uniform. The Difference-in-Difference (DID) estimation determined that the bypass has a significantly positive impact on land use changes. A placebo test was conducted to determine whether the changes were due to the bypass road or some other unobservable factor.

Keywords: *Change detection, Difference-in-Difference, Land use and land cover, Urban expansion.*

1. INTRODUCTION

Urbanization is one of the world's most visible human-induced environmental shifts. In recent decades, developing countries have been characterized by a decline in rural land usage and a rise in urban land usage through urbanization. Increasing populations in developing countries have caused rapid changes in Land Use and Land Cover (LULC) (Corner et al., 2014). LULC change is a complex process which can be defined as the observed physical and organic cover on the earth's surface (Dewan & Yamaguchi, 2009). To forecast potential changes in urban growth, it is very important to estimate the intensity, trend, and form of LULC changes (Lambin, 1997). LULC change due to human activities is currently occurring in the third world more swiftly than in the developed countries (World Bank, 2007).

Like many other developing countries, Bangladesh is undergoing a rapid transition into an urban society, with an extraordinary mix of urban-rural functions and features (Nahiduzzaman, 2006). Rapid urbanization leads the country to the deterioration of its environment, flood risk potential and speculative growth of informal housing. The unequal distribution of land, high unemployment, inadequate education, concentration of poverty in different income group etc. are remarkable in the informal housing and land use (Rahman, 2013). In Khulna city, the open space or vacant land was 7.6% in 1961, down to 1.26% in 2012. The trend can be explained by the increase in residential land use which increased from 28.7% in 1961-2012 to 49.11% (Roy et al., 2018). As government can provide only a small portion of the serviced land in the major cities, the wetlands and the productive agricultural lands are being converted into residential and industrial plots for development in the face of rising demand for affordable land. (Roy et al., 2018). This unplanned violation permanently destroys critical landscape elements and shrinks future opportunities for planned land uses.

For the acceleration of urbanization, like many other influencing factors, transportation has a significant impact on the spatial structure of a place and its accessibility (Knight et al., 1977). Road has corridor impacts, which indicates that newly built transportation routes cause quantitative and dispersed land changes in the corridors in question (Zheng et al., 2021). In the study on interstate highway development, Moon Jr concluded that a significant amount of the change was brought on by the induced economic development of several acres of nearby land along highways (Moon, 1987). The study on the impact of the Kunming-Bangkok highway showed that the greater the distance was from the highway, the smaller were the overall changes in land use within the 30 km buffer zone (Zheng et al., 2021). Infrastructure investment along State Route 32 in southern Ohio focused on pattern of land use changes and extent of development along this corridor. The result showed that even by

*Corresponding Author: mmorshed@urp.kuet.ac.bd

ISSN 2075-4914 (print); ISSN 2706-6835 (online)

2025, the corridor is not expected to be considered an economically feasible roadway as the expected development resulting from the route did not appear to have been fulfilled (Day, 2006).

Like many other cities, Khulna, the third largest metropolitan city in Bangladesh, has faced the outcome of rapid spontaneous development. The increased population growth has created pressure on the available urban land, which has resulted in the reduction of public open spaces (Archer, 1973). In addition, there are many new real estate projects in the urban fringe where agricultural lands are transformed into residential plots and sold off for future use (Sowgat et al., 2017). For Khulna city, due to its linear shape and absence of an alternative major highway, the bypass road was built around 2008 as an economic corridor to connect the city with its peripheral upazilas (administrative sub-units of districts) and Mongla Port. Although the population rate of Khulna city is gradually declining over the years, after the establishment of the bypass road, the city experienced surge in development (Ahmed, 2011). The objective of this study is thus; to evaluate the influence of the bypass road on the LULC changes of the study area. Specifically, the objectives are: (a) to evaluate the LULC changes of the study area for the years 1990, 2000, 2010, and 2020; (b) to explore the pattern of land use changes in this period; and (c) to analyze the impact of the bypass road in the development of land uses of the study area.

For third world countries like Bangladesh, remote sensing has proven its effectiveness in updating spatial data and, in particular, providing reliable and timely geospatial information illustrating the complexities of LULC in metropolitan areas like Dhaka, Chittagong. For example, among various studies related to LULC changes, using multi-sensor data, Griffiths mapped the urban growth of the Dhaka megacity area from 1990 to 2006. They used a Support Vector Machine (SVM) classifier and post-classification analysis to expose spatio-temporal patterns of changes in LULC (Griffiths et al., 2010). This study describes the results of the LULC changes in Khulna city, Batiaghata, Dumuria and Phultala derived from satellite images, topographic maps, and multi-temporal remotely sensed data. While focusing on specific sector like ecology, socio-temporal analysis, or urbanization with LULC changes, many studies often failed to mention transportation development-induced land use changes. In this study, the effect of transportation project bypass road on LULC change, which leads to urbanization, will be shown using this methodology and the Difference-in-Difference estimation method.

2. METHODOLOGY AND DATA COLLECTION

2.1 Study Area

As shown in Figure 1, the study area is 5 km buffer zone surrounding the bypass road. The buffer zone consists of Khulna city on the east side, Batiaghata upazila (an administrative unit of Khulna District) on the south west, Phultala upazila on the north west and Dumuria upazila on the west side of the bypass road, which is located in geographical boundary range from 22°45′ to 22°59′ north latitude, 89°25′ to 89°34′ (BBS, 2015). The study areas' importance lies in a variety of strategic factors of Khulna city. Firstly, the city offers vital connections to the country's second seaport, Mongla Port. Moreover, after the completion of the Padma Bridge, Khulna and Mongla Port are expected to face the increase of the economic activities. Finally, Khulna is the ultimate source of export processing activities for shrimp cultivation, which is the second largest foreign exchange earner in Bangladesh after garments (Mustafa et al., 2012). The city's future growth and prosperity also lies on its efficient circulation network. As the city stands at a transit point between the Mongla Port, the regional urban centers, and the rich agricultural hinterland, taking advantage of the transport facilities, especially the inner bypass road, a large number of people commute to the city from surrounding regions. Due to the establishment of the bypass road and improvement of transport facilities, people lean toward living in the city's' peripheral upazilas than in the city. As a result, the population of the surrounding upazilas such as Batiaghata is increasing while that of the city is facing decreasing trend. Though the city is facing decreasing trend in its population growth, it is in its peak development phase (Macrotrends, 2020).

2.2 Data Acquisition and Preparation

To assess LULC change in Khulna city, The Landsat Satellite images were taken in 1990, 2000, 2010 and 2020 from the official website of 'United States Geological Survey' (USGS). To help the satellite image processing and data analysis, secondary data such as the Bangladesh administrative and upazila boundary, the base map, KCC road network etc. were collected. For our research, our concern is KCC and west side of the bypass, which is selected by 5 km buffer zone.

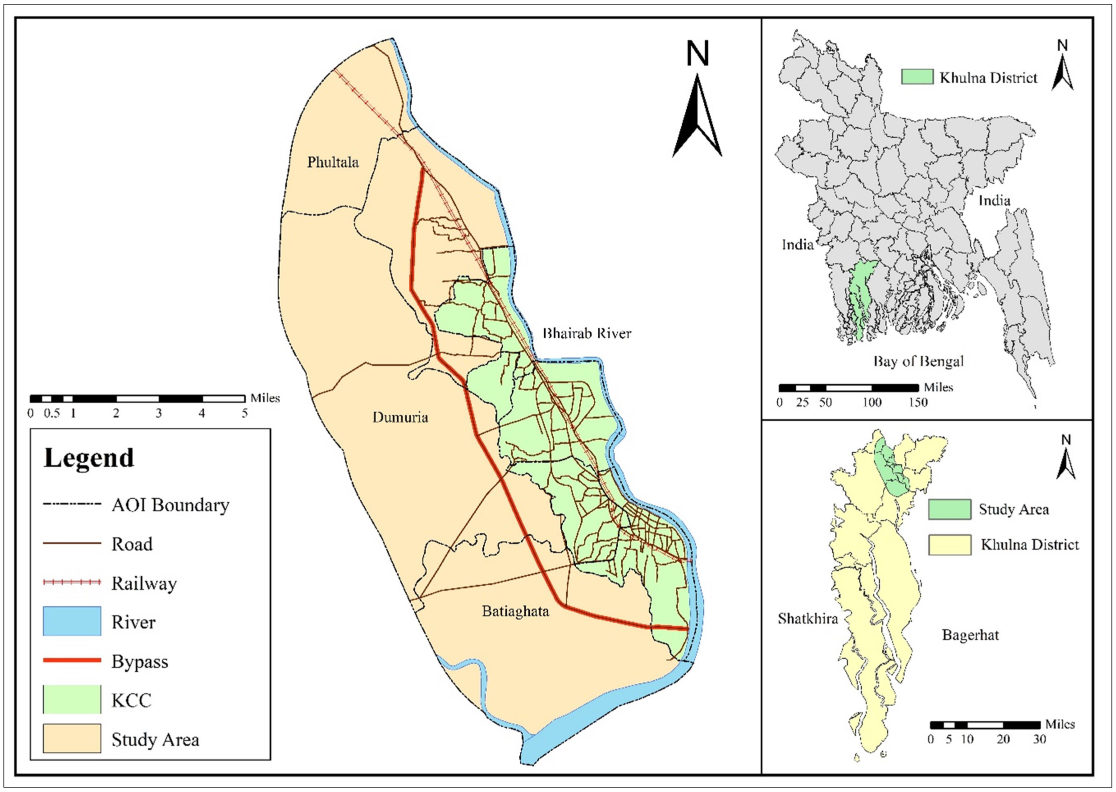

Figure 1: Study area map in context of Bangladesh and Khulna District.

2.3 Data Processing

Maximum Likelihood Classification for supervised classification of satellite images was used to evaluate LULC changes in the study area. The land uses were categorized as waterbodies, agriculture, vegetation and built-up. For the accuracy of each supervised image, kappa coefficient was used. The Kappa coefficient represents the degree of agreement between the frequencies of two sets of data gathered on two different times in a test-retest situation (Yu, 2005).

2.4 Data Analysis

Using Land Changing Modeler, the change detection of land classes from 1990 to 2000, 2000 to 2010, and 2010 to 2020 was calculated to prove the hypothesis and to prove whether Khulna is expending on west side. The probability of transition between two years in each class was generated using the variables, and the influence level of each variable on the transition of each class was calculated. The CA-Markov model was used to predict land uses for 2010,2020, and 2030. The prediction for 2010 and 2020 were done to determine the difference between the actual and predicted scenario. The CA-Markov model is a combination of the Cellular Automata and the transition probability matrix created by the two different images cross tabulation. It offers a comprehensive approach to spatial-temporal dynamic modelling which means the CA-Markov chain can model two-way transitions between any numbers of categories, and can predict any transition between any numbers of categories (Hamad et al., 2018).

2.5 Corridor Assessment

A transport corridor is a generally linear area characterized by one or more forms of transportation that share a common path and cross the boundaries of more than one country, such as highways, railroads, or public transit (Ward et al., 2020). In order to evaluate the bypass road's role on the development of Khulna city and its west region, a 2 km and 4 km buffer were created alongside the bypass road. Using a supervised image, the expected and actual values of land uses were calculated. Then the difference between the actual and projected 4 km buffer values was calculated. By doing so, how much change occurred before the bypass and how much change occurred after the bypass road was built were measured.

2.6 Expansion or Reduction Intensity Index

The major indicator used to characterize the degree or intensity of the effects of highway building on land use changes is the expansion/reduction intensity index (EI or RI). The Index of Intensity of Expansion computes the average annual growth area standardized by the total area of a particular spatial unit (equation 1).

$$\text{EII/RII} = \frac{(\text{LUAi,t+n} - \text{LUAi,t})/\Delta t}{\text{TLAi}} \times 100 \quad (1)$$

$LUA_{i,t+n}$ indicates the land use area at time t+n and $LUA_{i,t}$ indicates the land use area at time t. TLA_i is the total land use area and Δt is the study time period (Akubia et al., 2019). Using the equation, EI or RI was calculated for each land use on 1to 5 km buffer for all period.

2.7 Single Dynamic Degree

The annual variation rate of the area of land use type, which is an essential metric of land use change, is shown by the single dynamic degree. The formula for single dynamic degree is given below (equation 2):

$$D_c = \frac{\text{At2} - \text{At1}}{\text{At1}} \times \frac{1}{t2 - t1} \times 100\% \quad (2)$$

Here, D_c is the single dynamic degree, A_{t1} represents the area of a land use type at initial time of the study t_1, A_{t2} represents the area of the same land use type in research period, t_2 (Hong et al., 2011).

2.8 Comprehensive Dynamic Degree

The degree of comprehensive land use dynamics can aid in the assessment of overall change in different land use types in a given region during a certain time period. The comprehensive dynamic degree is expressed as (equation 3):

$$LC = \frac{\Sigma \Delta LUi-j}{\Sigma \text{LUi}} \times \frac{1}{t} \times 100\% \quad (3)$$

LC refers to the comprehensive dynamic degree, LU_i is the area of the i-th land use type at the beginning of the monitoring period, ΔLU_{i-j} represents the area in which the i-th land use type is converted into the j-th land use type during monitoring, and t is the length of monitoring period (Zheng et al., 2021).

2.9 Difference-in-Difference Estimation

A simple comparison of land use changes before and after the road's establishment is not sufficient to prove the effect of the road on land use changes. A Difference-in-Difference (DID) model was adopted to identify the effect with more robust conclusion. The main concept of DID is to determine the "treatment effect" by using a cross-sectional and time-series double difference brought about by the exogenous implementation (Abadie, A., 2005). The sample area was divided into two groups, the treatment group that is affected by the bypass road (Bypass served area: Batiaghata, Dumuria and Khan Jahan Ali thana) and the control group that is not affected by the bypass road (bypass unserved area: KCC, Phultala). The DID model can determine the overall impact of the bypass road on Land use changes by comparing the change in land cover area between the treatment group and control group, before and after the bypass roads' establishment. To measure the difference, two dummy variables were generated. Dpost dummy variable for the time period of the bypass. As the road was established in the early period of year 2008, it was assumed that the road was in effect for the whole year. Dtr dummy variable was generated for the treatment group. The values of the dummy variables are shown in Table 1. DID is the treatment effect of bypass road on land use changes. In order to ensure the robustness of the estimation equation, several control variables were taken to control the influence on land use changes. The control variables were Population of the areas, distance from CBD, total length of roads and household data. To measure the influence, the estimation was calculated for 2000 and 2010 (before and after the bypass road), for 2010 and 2020 (after the establishment of bypass) and 1990 and 2000 (before the establishment of the bypass road). In 2000 and 2010, the coefficient value was calculated to measure the effect on land use changes before and after the roads' establishment. Using all control variables, robustness error and fixed effects (land, state and year) in regression equation of DID, the coefficient values and their significance were calculated. For further exploration of the effect of the bypass road on land use changes, using value of year 2010 and 2020, another DID estimation was calculated. By doing so, how much the road affected the land use change after its establishment was measured. If the coefficient values are positive and significant at 10% significance level or better, it indicates that establishment of bypass has significantly contributed to the LULC changes of the study area.

Table 1: Value of the dummy variables.

Condition	Dummy Variable	
	Dpost	Dtr
Year ≥ 2008	1	------
Year < 2008	0	------
Treatment Group	------	1
Control Group	------	0

3. ANALYSIS AND FINDINGS

3.1 Change Detection & Accuracy

It can be visually interpreted that within the period of 1990 to 2000 (Figure 2), the built-up area increased in the south west and middle part of the Khulna city. From 1990 to 2000, vegetation to built-up transition is the highest, which is 7.206 sq. mile (Figure 4 (a)). From 2000 to 2010, it can be said that the amount of change is less compared to previous period. The amount of built-up land use expended to Batiaghata and beside the Bhairab River. It can also be interpreted that compared to 2000, in 2010, the amount of built-up land use increasing can be seen alongside the bypass road. But considering the internal transition of land uses, agriculture to vegetation transition is the highest, which is 5.827 sq. mile (Figure 4 (b)). From the image of 2010 to 2020 (Figure 3), the newly constructed rail line and bypass road became more distinguishable.

The amount of built-up land use in the west side of the bypass has also increased more than 2010. More agricultural land turned into built-up land, especially in Batiaghata and the west side of KCC. From 2010 to 2020, vegetation to built-up transition is the highest, which is 5.53 sq. mile (Figure 4 (c)). Considering overall growth trend of land uses, built-up land use exhibited a trend of increase over time (Table 2).

Table 2: Area of supervised images based on land uses (sq. mile).

Land use type	1990	2000	2010	2020
Waterbody	5.60	5.55	5.74	5.50
Agriculture	48.05	50.50	43.75	39.04
Vegetation	27.33	16.91	21.49	21.81
Built-up	5.32	13.33	15.32	19.82

As, transportation can influence the uses of lands, to measure the transition potential of land uses, three variables (Variable 1 roads, 2 railway and variable 3 river) were determined. The road has major influence on the transition of land uses, while the river has least influence. It can be explained as the main road and the bypass road influences the land use changes in overall study area. From the Table 4, it can be seen that the transition potential of land uses is almost equal.

Using Kappa coefficient, the acquired kappa index of the supervised classified images (Figure 2 and Figure 3) and the overall accuracy is shown in Table 3.

Table 3: Accuracy assessment of image classification.

Year	Overall Accuracy	Kappa Index
1990	80.59%	0.7911
2000	88%	0.8866
2010	85%	0.8252
2020	82.54%	0.8056

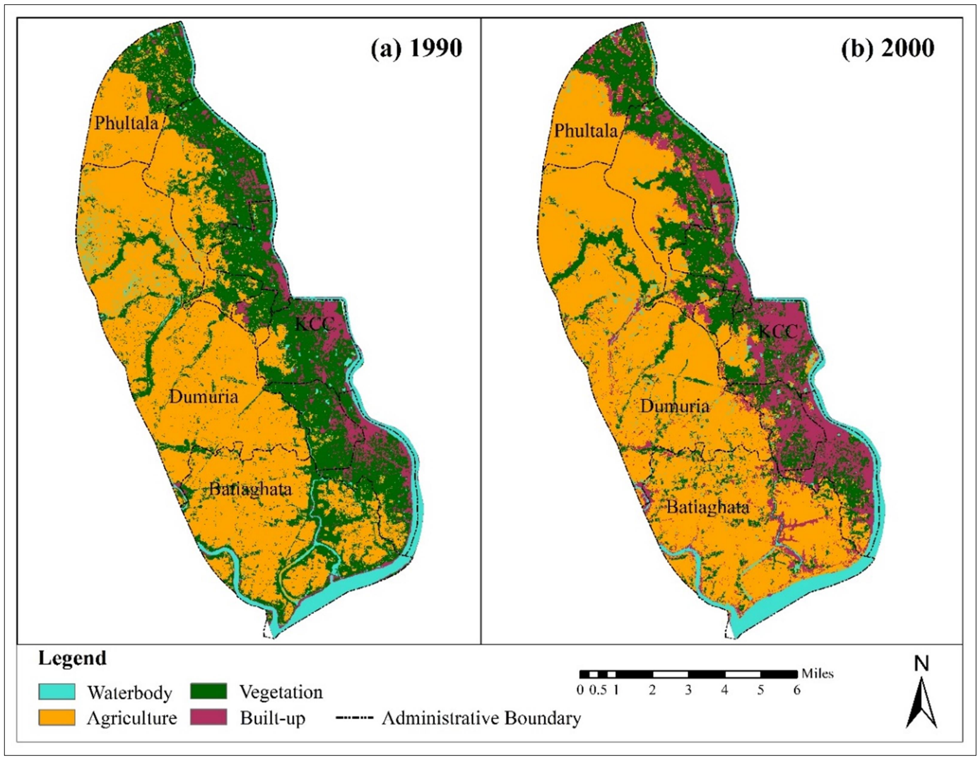

Figure 2: Supervised classified land use maps of 1990 and 2000.

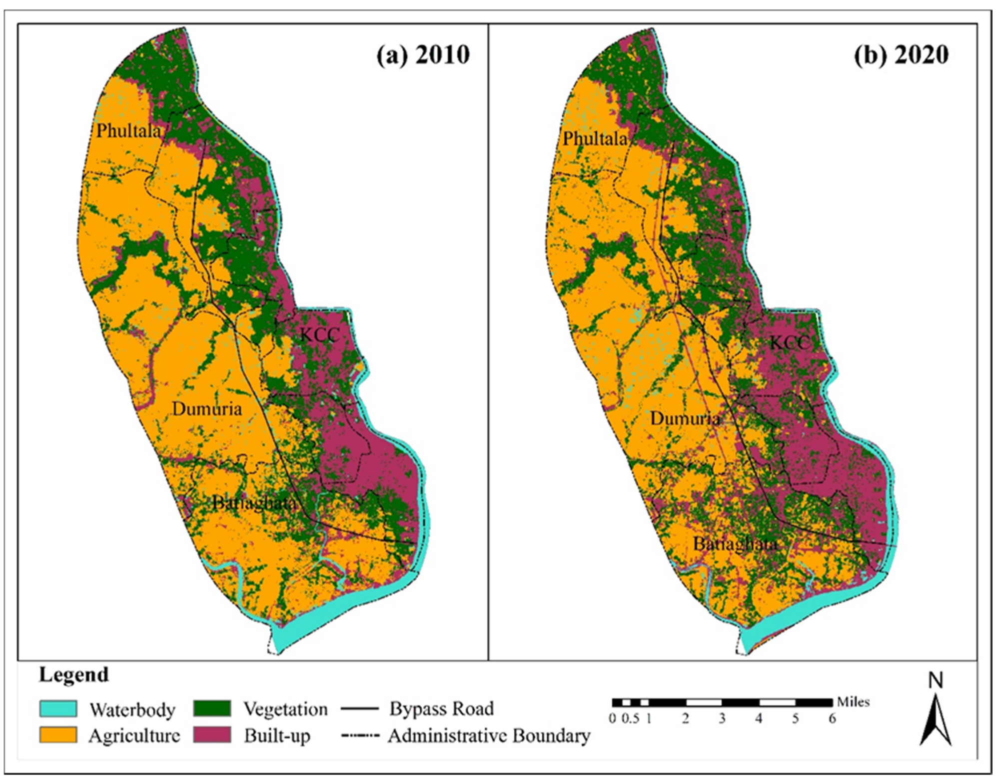

Figure 3: Supervised classified land use maps of 2010 and 2020.

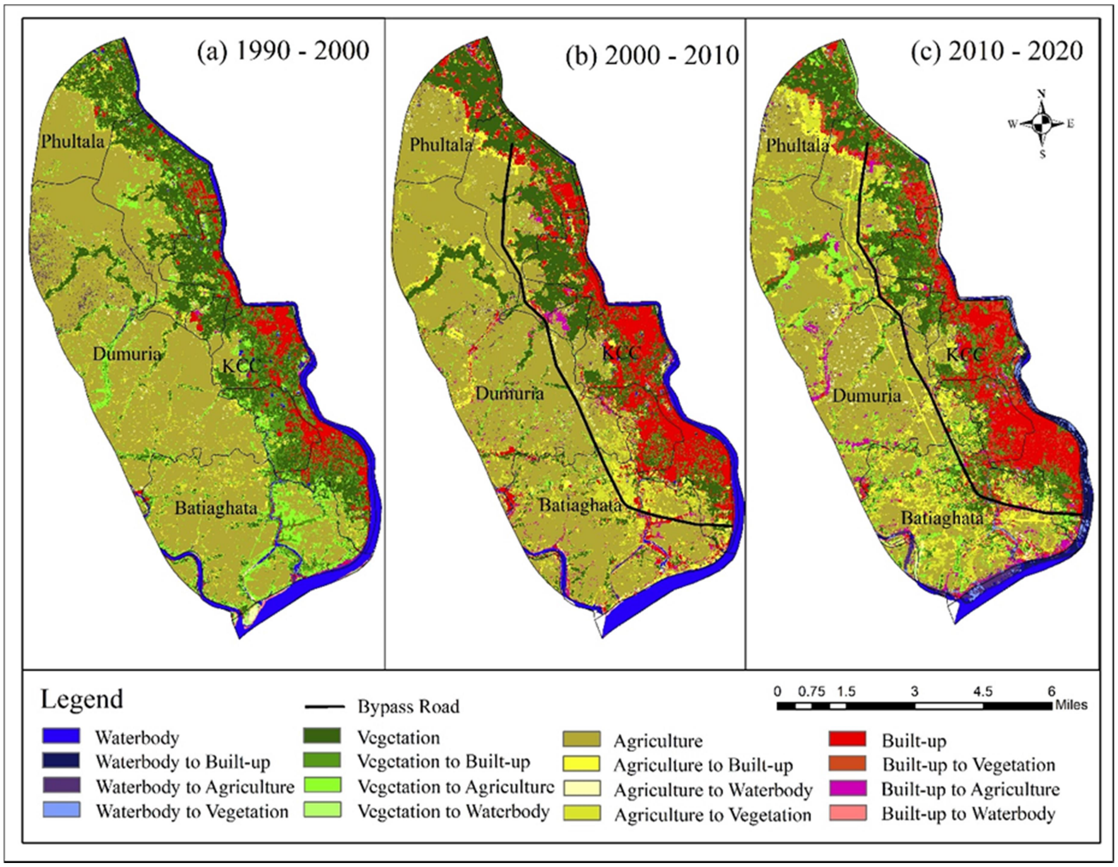

Figure 4: Transition of land uses in the study area (1990 to 2020).

Table 4: Transition potential (sq. km) between land uses from 1990 to 2020.

	1990-2000				2000-2010				2010-2020			
Land Use	Water body	Agric ulture	Vegeta tion	Built-up	Wate rbody	Agric ulture	Vegeta tion	Built-up	Water body	Agr icul ture	Vegeta tion	Bui lt-up
Waterb ody	1.10%	1.08%	1.09%	1.09%	1.09%	1.09%	1.10%	1.08%	1.07%	1.09%	1.09%	1.09%
Agricu lture	1.10%	1.10%	1.09%	1.07%	1.09%	1.09%	1.09%	1.09%	1.09%	1.08%	1.09%	1.09%
Vegeta tion	1.09%	1.09%	1.09%	1.09%	1.09%	1.08%	1.09%	1.09%	1.09%	1.10%	1.09%	1.09%
Built-up	1.10%	1.09%	1.09%	1.10%	1.08%	1.07%	1.07%	1.08%	1.10%	1.09%	1.09%	1.09%

3.2 Change Prediction

From probability matrix of 1990 to 2000 (Table 5), it is found that built-up land use has the highest probability to remain as it is. Vegetation has the most probability of changing to built-up, which is 33.81%. This result corresponds to actual transition scenario, where the amount of vegetation to built-up land use change is the highest. In the period between 2000 to 2010, agriculture to vegetation transition probability is highest, which is 34.51% (Table 5). This value corresponds to actual transition where the amount of transition between agriculture to vegetation is highest in 2000 to 2010. The probability matrix of 2010 to 2020 (Table 5) doesn't match the actual scenario where the amount of agriculture to vegetation transition had the highest amount. It shows waterbody to built-up land use change has the highest probability of change which is 37.75%.

Table 5: Markov Transition Probability (Percentage) Matrix from 1990 to 2020.

	1990-2000				2000-2010				2010-2020			
Land Use	Water body	Agricu lture	Vege tatio n	Built -up	Water body	Agricu lture	Veget ation	Buil t-up	Water body	Agricu lture	Vege tatio n	Buil t-up
Water body	78.7	15.3	2.7	3.3	81.1	13.1	1.4	4.4	21.3	23.4	17.5	37.8
Agricu lture	5.0	57.8	25.9	11.4	5.1	42.0	34.5	18.4	4.5	36.1	36.1	23.3
Veget ation	1.5	30.9	33.8	33.8	0.8	10.5	68.1	20.6	3.1	26.6	39.5	30.8
Built-up	4.1	5.7	4.9	85.4	1.6	12.6	19.0	66.8	2.3	15.0	32.2	50.6

Using CA Markov model and Markov transition probability matrix, prediction of land uses in year 2030 (Figure 6), and to validate the actual land use change, prediction of year 2010 (Figure 5) and 2020 (Figure 6) were done. From the comparison (Table 6), it can be stated that the amount of projected value and actual value differs the most for built-up land use. As the actual value is much higher than projected value, it can be stated that the increased built-up land use may be due to the development resulting from bypass road.

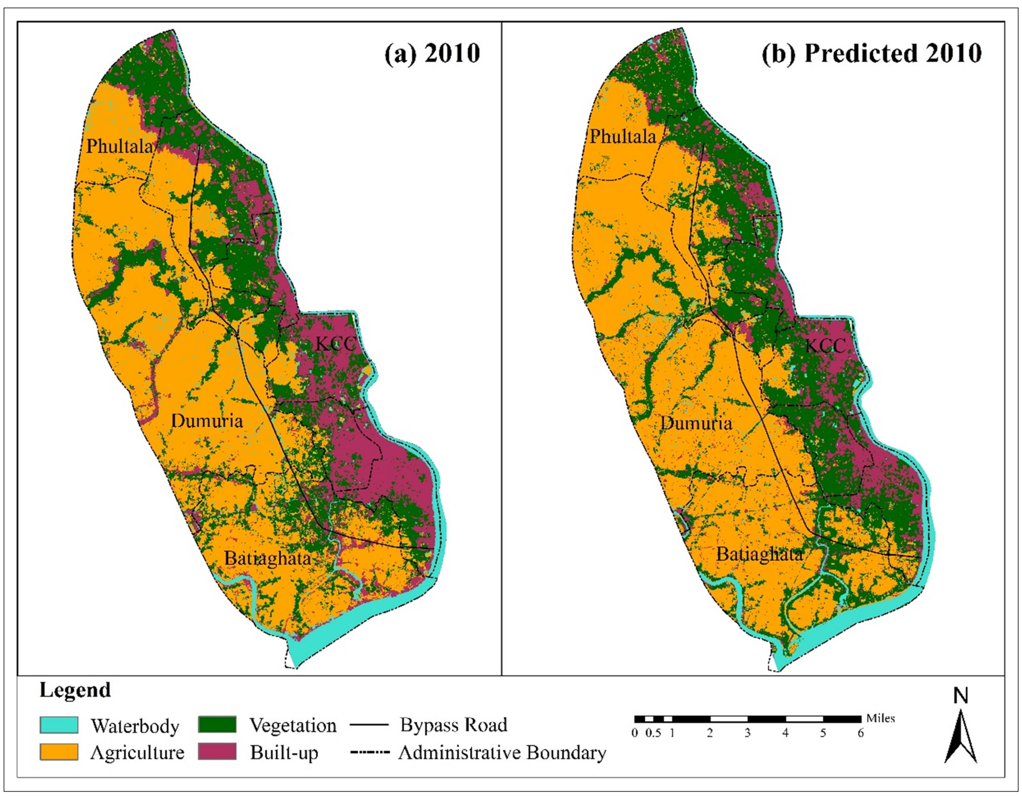

Figure 5: Actual and Predicted Land use Image of 2010 of the study area.

3.3 Corridor Assessment

To relate the frequency of change to the bypass road proximity, a 2 km and 4 km buffer (Figure 7) were applied to the study area. If all class changes were uniform throughout the study area for all years, the 2 km buffer would be doubled accordingly in the 4 km buffer area. However, the change was not uniform. To analyze the growth amount of land uses adjacent to the bypass, year 1990-2000 values were also calculated. By doing so, we can understand the land use transition before and after the bypass road.

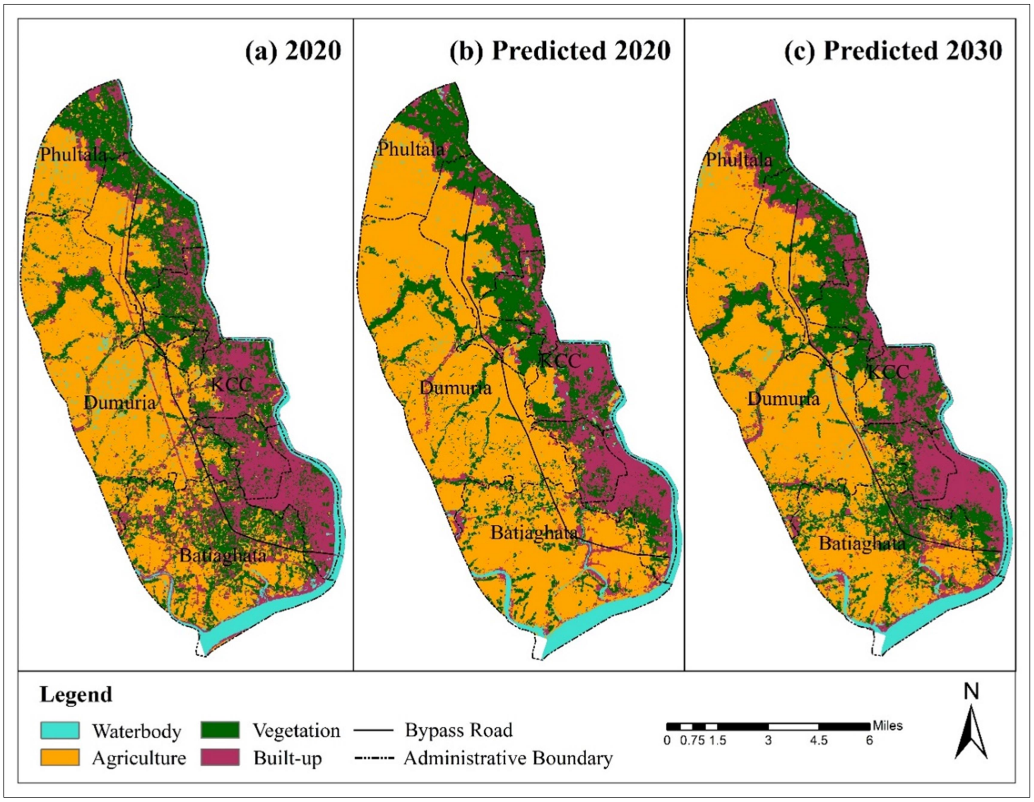

Figure 6: Actual and Predicted Land use image of 2020 and 2030 of the study area.

Table 6: The comparison between projected image and actual image area.

Land Class	Projected 2010	Actual 2010	Difference (projected-actual)	Projected 2020	Actual 2020	Difference (projected-actual)
Waterbody	5.85	5.74	0.11	4.74	5.50	-0.76
Agriculture	46.72	43.75	2.97	48.23	39.04	9.19
Vegetation	24.86	21.49	3.37	17.53	21.81	-4.28
Built-up	8.86	15.32	-6.46	14.16	19.82	-5.66

Table 7 shows all transition in both the 2 km buffer and 4 km buffer zone on both side of the bypass from 1990 to 2020. The projected 4 km buffer areas' value serves as a comparison to the actual 4 km buffer areas' value. The negative value represents that the projected change is greater than the actual change in the buffer zone. From the data, we can see that the changes are not uniform. Within 2 km and 4 km buffer areas, the amount of built-up land use was increased more than was projected.

As bypass was established in 2008, by doing the corridor assessment from 2000 to 2010, the built-up land use changes were measured. The difference in number of other classes to built-up was mostly positive, which means the development of built-up land use happened more than expected. From 2010 to 2020, the ratio of other land use to built-up is negative, which indicates that the expected development didn't happen within 4 km buffer.

To determine whether the Khulna city is expanding on the west side of the bypass, 2 and 4 km buffer zone were created to assess the land use changes in these buffer zones. From the Table 8, it can be observed that from 1990 to 2000, the difference number of other classes to built-up was mostly positive except vegetation to built-up. From 2000 to 2010, it was found that the difference number of other classes to built-up were all negative, which indicated that the projected transition didn't occur within 4 km buffer zone. A similar scenario is found for 2010-2020. According to projected scenario, the land use transition didn't occur in the west side of the bypass road.

Table 7: 2 and 4 km corridor frequency according to class changes (both side of the bypass) from 1990 to 2020.

Land Use	Difference (actual – projected)		
	1990|2000	2000|2010	2010|2020
Waterbody | Waterbody	2.045	2.23	1.822
Agriculture | Waterbody	-0.122	-0.395	0.096
Vegetation | Waterbody	0.101	-0.02	-0.267
Built-up | Waterbody	0.131	0.025	0.225
Waterbody | Agriculture	0.152	-0.165	-0.128
Agriculture | Agriculture	-8.67	-5.246	3.546
Vegetation | Agriculture	-5.02	-0.107	-3.033
Built-up | Agriculture	-0.156	-1.131	0.094
Waterbody | Vegetation	-0.09	-0.005	0.303
Agriculture | Vegetation	-1.83	-6.026	-2.837
Vegetation | Vegetation	-2.76	-6.696	-6.541
Built-up | Vegetation	0.245	-0.497	1.41
Waterbody | Built-up	0.068	0.094	-0.041
Agriculture | Built-up	-1.05	-2.035	-2.271
Vegetation | Built-up	3.544	2.38	-0.899
Built-up | Built-up	5.850	10.015	9.803

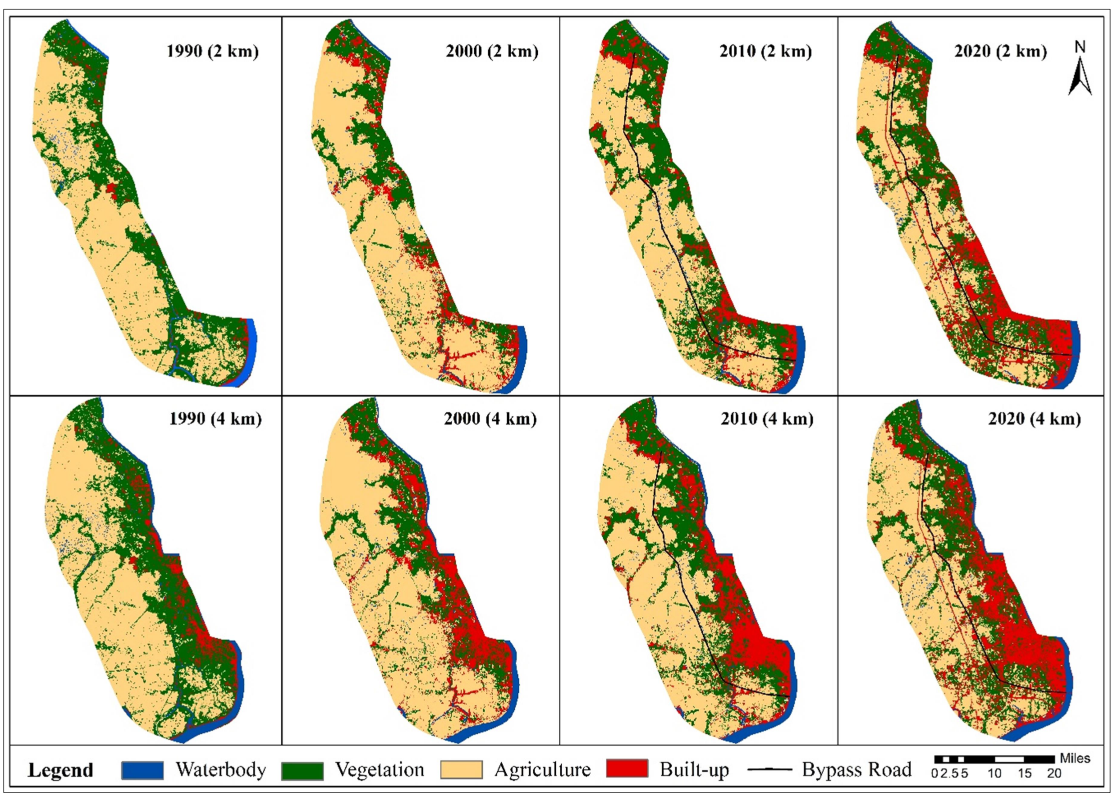

Figure 7: 2 km and 4 km buffer map of the study area.

Table 8: 2 km and 4 km corridor frequencies according to the class changes (west side of bypass) from year 1990 to 2020.

Land Use	Difference (actual – projected)		
	1990|2000	2000|2010	2010|2020
Waterbody | Waterbody	1.181	1.377	0.889
Agriculture | Waterbody	0.104	-0.039	0.214
Vegetation | Waterbody	0.033	-0.028	0.134
Built-up | Waterbody	0.089	0.015	0.081
Waterbody | Agriculture	0.205	0.073	0.687
Agriculture | Agriculture	5.945	7.288	11.977
Vegetation | Agriculture	-0.880	0.228	-0.374
Built-up | Agriculture	-0.002	0.042	0.192
Waterbody | Vegetation	-0.031	0.007	-0.068
Agriculture | Vegetation	-0.112	-1.375	0.494
Vegetation | Vegetation	0.545	0.232	0.199
Built-up | Vegetation	-0.003	-0.206	-0.338
Waterbody | Built-up	0.033	-0.051	-0.209
Agriculture | Built-up	0.091	-0.606	-0.528
Vegetation | Built-up	-0.662	-0.034	-0.665
Built-up | Built-up	-0.149	-0.537	-0.548

3.4 Expansion or Reduction Intensity Index

The result (Table 9) shows a significant difference in the rate of change as well as intensity across different time on both side of the bypass road. In 1990-2000, 1-3 km built-up gradually increased. For 2000-2010, the same scenario was seen. 1-3 km, the expansion rate increased and after that the reduction rate increased. The speed of expansion of built-up differed with the buffer distance. In 2010-2020, the speed of expansion within 2 km buffer increased drastically. But after 3 km the speed of expansion decreased.

Table 9: Expansion or reduction intensity index on both side of bypass road (1 to 5 km buffer zone).

Land use type	1km			2km			3km		
	1990 - 2000	2000 - 2010	2010 - 2020	1990 - 2000	2000 - 2010	2010 - 2020	1990 - 2000	2000 - 2010	2010 - 2020
Waterbody	0.006	0.091	-0.080	-0.002	0.031	-0.023	-0.002	0.024	-0.036
Agriculture	0.426	-1.43	-1.229	0.375	-1.156	-2.822	0.322	-1.389	-1.155
Vegetation	-1.16	1.204	0.213	-1.228	0.977	-0.086	-1.344	0.938	-0.055
Built-up	0.736	0.137	1.077	0.855	0.149	2.917	1.023	0.427	1.225

	4km			5km			------		
	1990 - 2000	2000 - 2010	2010 - 2020	1990 - 2000	2000 - 2010	2010 - 2020	------	------	------
Waterbody	-0.003	0.015	-0.006	-0.006	0.022	-0.027	------	------	------
Agriculture	0.282	-0.82	-0.671	0.284	-0.782	-0.546	------	------	------
Vegetation	-1.29	0.543	0.027	-1.207	0.536	0.037	------	------	------
Built-up	1.016	0.265	0.633	0.928	0.236	0.521	------	------	------

As for the west side of the bypass road (Table 10), in 1990-2000, 1-2 km built-up land use gradually decreased. Then in 3 km, the built-up faced an increase in expansion rate. For 2000-2010, 1-2 km, the expansion rate increased and after that the reduction rate increased. In 2010-2020, the speed of expansion decreased gradually. But within 1 km buffer zone, built-up experienced the most amount of expansion in 2010-2020. It can be assumed that after the establishment of the bypass road, the built-up land use was influenced greatly compared to other land uses. With the establishment of accessibility, built-up land use increased within 1 km buffer zone of the bypass road on its west side. People are willing to move to rural area with the condition of greater accessibility.

Table 10: Expansion or reduction intensity index on west side of bypass (1 to 5 km buffer zone).

Land use type	1km			2km			3km		
	1990 - 2000	2000 - 2010	2010 - 2020	1990 - 2000	2000 - 2010	2010 - 2020	1990 - 2000	2000 - 2010	2010 - 2020
Waterbody	-0.03	0.09	-0.06	-0.01	0.03	-0.01	-0.01	0.02	0.00
Agriculture	0.48	-1.31	-1.32	0.29	-1.06	-1.03	0.23	-0.86	-0.93
Vegetation	-1.01	0.99	0.30	-0.77	0.77	0.28	-0.64	0.63	0.27
Built-up	0.56	0.23	1.08	0.49	0.27	0.75	0.43	0.22	0.64

	4km			5km			------		
	1990 - 2000	2000 - 2010	2010 - 2020	1990 - 2000	2000 - 2010	2010 - 2020	------	------	------
Waterbody	-0.01	0.02	0.00	-0.01	0.03	-0.03	------	------	------
Agriculture	0.20	-0.79	-0.79	0.22	-0.76	-0.61	------	------	------
Vegetation	-0.60	0.57	0.25	-0.64	0.56	0.19	------	------	------
Built-up	0.41	0.20	0.53	0.43	0.17	0.43	------	------	------

3.5 Dynamic Degree

3.5.1 Single dynamic degree

The single dynamic degree was calculated for both side and west side of the bypass for 1-5 km buffer zone as this degree represents the speed of changes in the land uses of the study area. The variation direction of built-up land cover is always positive throughout the buffers and years, indicating that the urban area developed rapidly in these periods. The negative to positive changes indicate that transfer out land class increased initially then transfer in increased later, but change speed increased. The dynamic degree of land uses on both side of the bypass road (Figure 8) shows that for built-up land use, the speed of change increased from 1 to 2 km buffer in 1990-2000. Then gradually the speed decreased from 3 to 5 km, which means, as the distance from a potential accessibility point increased, the speed of change in land use gradually started to decrease. But in 2010-2020, in 2 km buffer zone, the speed of land use change increased sharply compared to other buffer zones. After the establishment of the bypass road, within 2 km buffer zone, the change of built-up land use was seen the highest. For the west side (Figure 9), as the distance from the bypass road increased, the speed of changes of built-up decreased over the time.

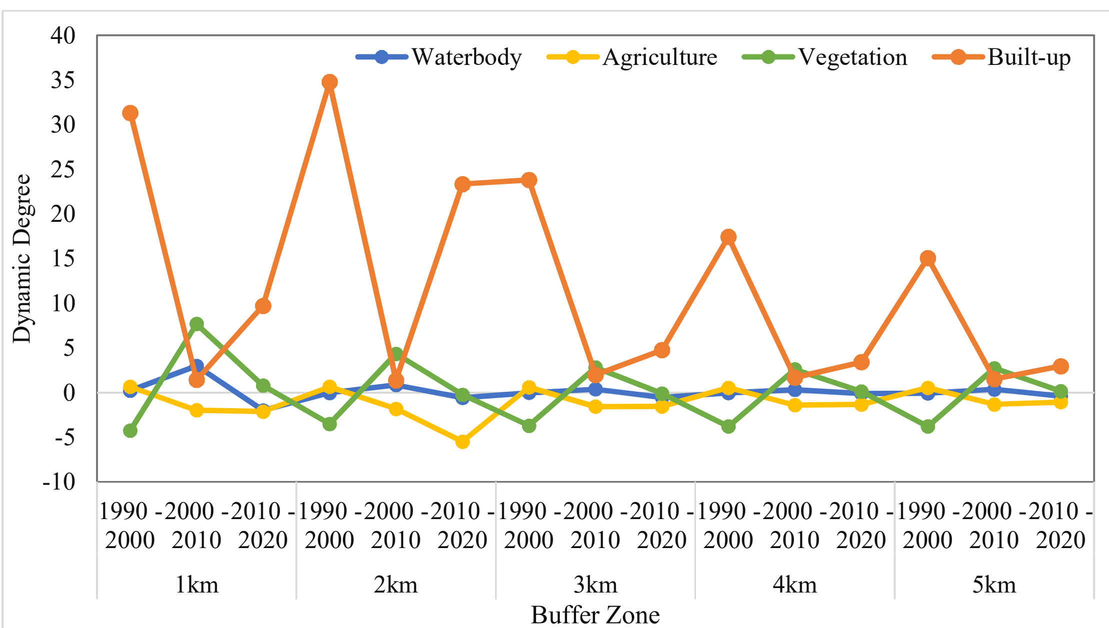

Figure 8: Single land use dynamics in buffers of the study area (both side of bypass road).

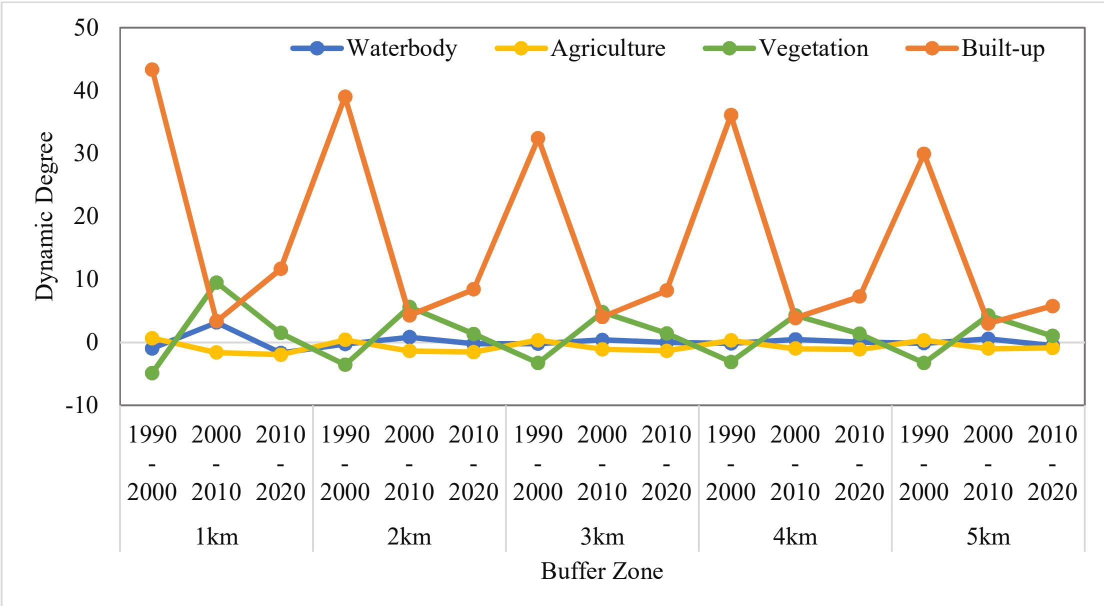

Figure 9: Single land use dynamics in buffers of the study area (west side of bypass road).

3.5.2 Comprehensive *Dynamic Degree*

From all of the buffer zones that the land use transfer for was highest in 2010-2020 (Figure 10). The dynamic degree of comprehensive changes in land use decreased with the increase in the distance from the road. In 1 km zone, land use changes increased gradually until 2010. After 2010, the degree showed sharp increase which was after the establishment of the bypass. Within 1 km of bypass, after the establishment, land use changes experienced sharp growth. In the 3-5 km buffer zone, the change in 2000-2010 was less than previous years, but in 2010-2020, the land use dynamic exceeded previous years' value by huge difference. From this, it can be said that although the change is less compared to 1 km buffer zone, after the bypass roads' establishment, the land uses experienced sharp changes.

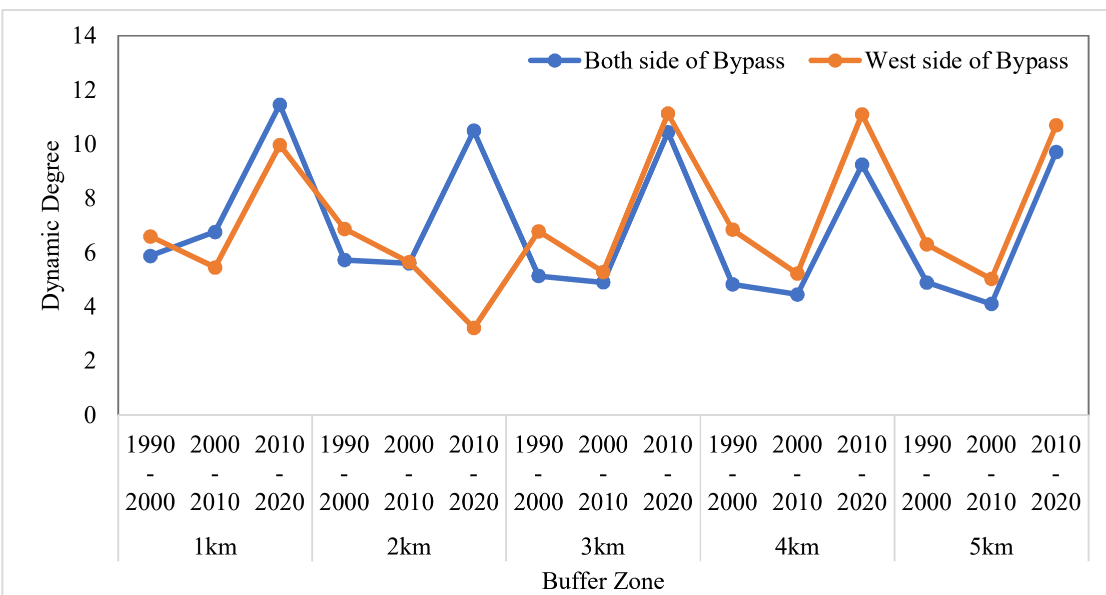

Figure 10: Comprehensive land use dynamics of the study area.

3.6 Difference-in-Difference Estimation

From Table 11, we can see that Dpost value is positive and statistically significant at 1%, which means that the bypass road has positive effect on the land use changes. The value of Dtr is negative and statistically significant at 1%, which indicates that the bypass has negative effect on area wise land use changes. DID value is positive and significant which indicates significant capitalization effect of 9.98%. For the effect of the control variables on land uses, Population and total area of road has positive effects. With the increase of population, land use changes increase too. Similarly, the convenience of transportation represents the change in land uses, transition to built-up land uses. For more accurate estimation of the impact of bypass road, a DID estimation was conducted with the data of 2010 and 2020. Dpost and DID value were omitted because of collinearity. The coefficient value of Dtr is positive and significant which means that the bypass road has positive effect on treatment group and control groups' land use changes.

As there can be some unobservable difference between treatment group and control group over time, the land use change may be caused by some unobservable factor beside the bypass. In order to eliminate potential variables for these unobservable factors, a placebo test with robustness was conducted. Placebo test is the test that applies an identification strategy or model in a context where it is expected to have no effect. If the effect is found, then the strategy or model's reliability is questionable. For this test, an additional DID estimation is performed using a "fake" treatment group, that is, a group that is not affected by the program. Here, the hypothesis was that bypass was opened twenty years before the actual opening in advance. From the Table 12, it is observed that Dtr variables are all insignificant and has no impact on land use changes. So, it is concluded that the impact observed in Table 11 was caused by bypass rather than some other unobservable factors. There is no systematic difference between the control group and treatment group before the bypass was actually established.

Table 11: Impact of bypass on land use changes (A multi stage DID estimation).

Variables	2000-2010	2010-2020
Dpost	0.240***	0
	(0)	(0)
Dtr	-11.68***	11.42**
	(1.30e-10)	(24.00)
DID	0.998***	0
	(0)	(0)
Population	9.16e-06***	-1.43e-08**
	(0)	(9.19e-06)
CBD	-0.266***	-1.149
	(0)	(1.832)
Road	0.00674***	-9.77e-05*
	(0)	(0.00140)
Household	-0.000129***	1.34e-07
	(0)	(2.97e-05)
Constant	20.52***	4.742
	(0.977)	(2.534)
Year fixed effect	Yes	Yes
State fixed effect	Yes	Yes
Land fixed effect	Yes	Yes
Observations	40	40
R squared	0.467	0.428

Notes: The t-statistics for the coefficients are reported in parentheses.

***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

Table 12: Impact of bypass on land use change: Placebo test.

Variable	(1)	(2)
Dtr1990	-87.90	
	(338.8)	
Dtr2000		48.87
		(316.4)
Population	-0.000335	0.000126
	(0.00129)	(0.000818)
Road	0.0548	-0.00354
	(0.183)	(0.0550)
CBD	-7.411	4.068
	(28.33)	(26.81)
Constant	218.9	-122.1
	(846.1)	(789.0)
Observations	20	20
R-squared	0.507	0.493
State fixed effect	no	no
Land fixed effect	yes	yes

4. DISCUSSION

From the analysis, it can be seen that in 2010-2020, the transition of other land uses to built-up is highest, which means due to the increase of some factors like population or development, the establishment of built-up land uses are increasing day by day. Despite the decrease in 2000-2010, the study area is facing an increase of built-up land cover due to some major factors. To understand the degree of changes in land uses, a 5 km buffer was generated focusing the bypass road. The changes were measured based on the distance from the bypass road to understand the establishments' influence on land use changes. On both side of the bypass, in 2010-2020, the speed of expansion within 2 km buffer increased drastically. But after 3 km buffer, the speed of expansion decreased. Again, on west side of the bypass, in 2010-2020, the speed of expansion decreased gradually. But within 1 km buffer zone, built-up experienced the most amount of expansion in 2010-2020. It can be assumed from this that after the establishment of the bypass road, the built-up land use was influenced greatly compared to other land uses. With the establishment of accessibility, built-up land use increased within 1 km buffer zone of the bypass road on its west side. In the 2 km buffer zone, the speed of land use change increased sharply compared to other buffer zones. After the establishment of the bypass road, within the 2 km buffer zone, the change of built-up land use was seen the highest. As for the west side, as the distance from the bypass road increases, the speed of changes of built-up decreases over the time. The dynamic degree of comprehensive changes in land use decreased with the increase in the distance from the road. In the 1 km zone, land use changes increased gradually until 2010. After 2010, the degree showed sharp increase which was after the establishment of the bypass. From above all, it was clear that the bypass has some influence on the land use changes of the study area. The most occurred changes happened within 1-2 km buffer of the bypass road. From the observed data, it can be said that the Khulna city is expending to its west side, but within 1 km of the bypass road. This is due to the fact that, staying within the 1 km buffer zone of the bypass road ensures accessibility to the road and the city center. As the distance increases from the road, the advantage of accessibility decreases.

To determine the influence of the bypass road on land use changes, Difference-in-Difference estimation was used. From the calculation, it is found that the bypass road has positive effect on the land use changes on overall study area. As there can be some unobservable difference between treatment group and control group over time, the land use change may be caused by some unobservable factor beside the road. In order to eliminate potential variables for these unobservable factors, a placebo test with robustness was conducted. It is observed that Dtr variables are all insignificant and has no impact on land use changes. So, it is concluded that the impact observed was caused by the bypass road rather than some other unobservable factors.

The land use change pattern of the study area is mostly focused on the west side of Khulna city. The data for land cover changes analyzed in classified image is almost same as previous studies (Moniruzzaman et al., 2018). The previous studies focused only on land use changes, while in this study, the impact of the bypass road on land use changes is also measured. The measurement technique is somewhat similar to previous study (Deng et al., 2019). Though the previous study focused on high-speed railway and population to determine the rails impact on population, using same principle, the impact of bypass road on land use changes was calculated.

5. CONCLUSIONS

The main objective of the study was to analyze the LULC changes in the study area between 1990, 2000, 2010 and 2020 and evaluate the impact of the bypass road on the LULC changes in the west side of Khulna city. The study has provided a wide range of information on land use dynamic in the 5 km buffer zone which are useful for planning purpose. On the basis of information contained in the classified land use images, CA Markov model was used in order to specify the process and magnitude of land use changes and future expected land use changes for each land cover class. The result confirms our hypothesis that the Khulna city is expanding on the west side along the bypass road. The analysis provided us with the information about the changes in the diversity of land uses.

Though the city is facing decrease in population, due to the establishment of bypass road, people are willing to move outside the city due to accessibility and low cost. The area within 1 km buffer zone of the bypass road ensures accessibility to the bypass road easily which connects the Khulna city with its surrounding regions. Due to this factor, after the establishment of the bypass road, the population of Batiaghata upazila faced increasing trend, while Khulna city is still facing downward trend. As the upazila is the nearest to the city center and just beside the bypass road, the upazila is facing changes in land use the most. The built-up type land cover increased rapidly after the establishment of the bypass road in this upazila. Our study confirms our hypothesis that Khulna city is expanding on its west side and bypass road has major influence of the land use changes of the study area.

ACKNOWLEDGEMENT

The authors acknowledge the support received from the Department of Urban and Regional Planning, Khulna University of Engineering & Technology (KUET), Khulna-9203.

REFERENCES

Abadie, A., 2005. Semiparametric difference-in-differences estimators. *The review of economic studies*, *72*(1), 1-19.

Ahmed, B., 2011. Modelling spatio-temporal urban land cover growth dynamics using remote sensing and GIS techniques: A case study of Khulna City. *J. Bangladesh Instit. Plan*, *4*(1633), 43.

Akubia, J. E., & Bruns, A., 2019. Unravelling the frontiers of urban growth: spatio-temporal dynamics of land-use change and urban expansion in greater Accra metropolitan area, Ghana. *Land*, *8*(9), 131.

Archer, R. W., 1973. Land speculation and scattered development; failures in the urban-fringe land market. *Urban studies*, *10*(3), 367-372.

BBS., 2015. Statistical Pocketbook Bangladesh, 2015. *Bangladesh Bureau of Statistics (BBS).* Retrieved from Bangladesh Bureau of Statistics:
http://203.112.218.65:8008/WebTestApplication/userfiles/Image/SubjectMatterDataIndex/YearBook15.pdf

Corner, R. J., Dewan, A. M., & Chakma, S., 2014. Monitoring and prediction of land-use and land-cover (LULC) change. *Dhaka megacity: geospatial perspectives on urbanization, environment and health*, 75-97.

Day, K. L., 2006. *Assessing the impact of highway development on land use/land cover change in Appalachian Ohio* (Doctoral dissertation, Ohio University).

Deng, T., Wang, D., Yang, Y., & Yang, H., 2019. Shrinking cities in growing China: Did high speed rail further aggravate urban shrinkage?, *Cities*, *86*, 210-219.

Dewan, A. M., & Yamaguchi, Y., 2009. Using remote sensing and GIS to detect and monitor land use and land cover change in Dhaka Metropolitan of Bangladesh during 1960–2005. *Environmental monitoring and assessment*, *150*, 237-249.

Griffiths, P., Hostert, P., Gruebner, O., & van der Linden, S., 2010. Mapping megacity growth with multi-sensor data. *Remote Sensing of Environment*, *114*(2), 426-439.

Hamad, R., Balzter, H., & Kolo, K., 2018. Predicting land use/land cover changes using a CA-Markov model under two different scenarios. *Sustainability*, *10*(10), 3421.

Hong, Z., Hailin, L., & Zhen, C., 2011. Analysis of Land Use Dynamic Change and Its Impact on the Water Environment in Yunnan Plateau Lake Area—A Case Study of the Dianchi Lake Drainage Area. *Procedia Environmental Sciences*, *10*, 2709-2717.

Knight, R. L., & Trygg, L. L., 1977. Evidence of land use impacts of rapid transit systems. *Transportation*, *6*(3), 231-247.

Lambin, E. F., 1997. Modelling and monitoring land-cover change processes in tropical regions. *Progress in physical geography*, *21*(3), 375-393.

Macrotrends., 2020, July 27. *Khulna, Bangladesh Metro Area Population 1950-2020*. Retrieved from macrotrends: https://www.macrotrends.net/cities/20124/khulna/population

Moon Jr, H. E., 1987. *Interstate highway interchanges as instigators of nonmetropolitan development* (No. 1125).

Moniruzzaman, M., Roy, A., Bhatt, C. M., Gupta, A., An, N. T. T., & Hassan, M. R., 2018. Impact analysis of urbanization on land use land cover change for Khulna City, Bangladesh using temporal landsat imagery. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci*, *42*(5), 757-760.

Mustafa Shindaini, A. J., & Baqui, G. A. H., 2012. Impact of Shrimp Cultivation on Social Life in Rural Bangladesh: A Case of Bujbunia Village in Khulna District. *ASA University Review*, *6*(2).

Nahiduzzaman, K. M., 2006. Housing the urban poor: Planning, business and politics. *Unpublished M. phil thesis. Norway: Norwegian University of Science and Technology*.

Rahman, M. T., 2013. *Strategy for urban sector development in bangladesh.* Dhaka: Bangladesh Planning Commission. Retrieved from: https://www.theigc.org/sites/default/files/2015/05/1SouthAsiaRahman.pdf

Roy, S., Sowgat, T., Ahmed, M. U., Islam, S. T., Anjum, N., Mondal, J., & Rahman, M. M., 2018. Bangladesh: National urban policies and city profiles for Dhaka and Khulna. *GCRF Centre for Sustainable, Healthy and Learning Cities and Neighborhood (SHLC)*.

Sowgat, T., Wang, Y. P., & McWilliams, C., 2017. Pro-poorness of planning policies in Bangladesh: the case of Khulna city. *International Planning Studies*, *22*(2), 145-160.

The World Bank., 2007. Dhaka: Improving living conditions for the urban poor. Sustainable Development Unit, South Asia Region, Report No. 35824-BD. Retrieved from: https://documents1.worldbank.org/curated/en/938981468013830990/pdf/404240BD0Dhaka10ALSO03582401PUBLIC1.pdf

Yu, C. H., 2005. Test–Retest Reliability. *Encyclopedia of Social Measurement*, 777-784.

Ward, S. F., Taylor, B. S., Dixon Hamil, K. A., Riitters, K. H., & Fei, S., 2020. Effects of terrestrial transport corridors and associated landscape context on invasion by forest plants. *Biological Invasions*, *22*, 3051-3066.

Zheng, F., Huang, J., Feng, Z., & Xiao, C., 2021. Impact of the Kunming–Bangkok Highway on Land Use Changes along the Route between Laos and Thailand. *Land*, *10*(9), 991.