A GIS-based approach to explore the factors contributing towards Urban residential land development and re-development (LDR): a case of Rajshahi City Corporation area

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ABSTRACT

Urban Residential land development and redevelopment intensity (LDR) act as an essential index to understand magnitude of urban livability and sustainable development. Recent urbanization pattern of Rajshahi city has made a rising demand for land, which made it a precious commodity. As a result of it, Rajshahi City Corporation (RCC) area is undergoing significant residential LDR in recent years. The understanding of factors influencing this residential LDR has great importance in real estate development as well as overall housing situation of the city. For this purpose, this study tries to explore the spatial characteristics of LDR. Relative Operating Characteristics (ROC) test statistics (>0.5) with improve hedonic model are set out to identify the internal drivers of LDR. Finally, geostatistics is explored by integrating methods of Geographic Information System (GIS) and SPSS regression analysis to analyze the correlation between LDR and driving factors. The spatial distribution of residential LDR has shown a strong distance decline law. One of the most exciting findings was that increase in distance to Central Business District (CBD) from the residential land has a slight influence on LDR. The outcomes of the paper will be beneficial for investors and policy-makers in their development decision-making processes.

Introduction

Land and people are the vital components of every nation, while in urban areas, demand for urban land is driven by the growth in both economic development and population (Lambin et al., 2001). In a developing country, the demand for urban residential land inevitably increases over a long period. Bangladesh as a developing country is undergoing rapid urbanization that causes immense pressure on urban residential land (Addae-Dapaah, 1999). Urban expansion and higher intensive land use are the two primary ways and best-practised solution to accommodate the growth that occurred due to economic development (Molotch, 1976). However, urban expansion is not always apparent as it causes loss of agricultural land and the provision of municipal facilities in the expanded area often tricky. The commonly accepted concept of solving this problem is increasing land-use intensity. Rajshahi City Corporation (RCC) area is not an exception to it. This area has experienced substantial land development and redevelopment over the last 15 years (Hassan, 2017). People actively developed land, and they use their raw land to accommodate their infrastructure. Also, through redevelopment, people are allowed to carry out more intense land development. The land has been hanged from a traditional resource to a capital, becoming the most considerable assets of local governments (Zhu, 1999). However, there exists an eternal conflict between humankind and land. Demands for any form of land use are invariably higher than land supply. And with the accelerated development of urbanization, urban land resources are becoming increasingly scarce (Deng et al., 2009). As a result, one of the most effective solutions is to reuse land and accommodate changing demands. This might be in the form of vertical expansion or by changing the use of existing land (Bullen, 2007). The government and private enterprises should work together to revitalize and optimize stocked land, playing the most important and influential roles in land development and redevelopment (LDR) (Verburg et al., 2009).

LDR is influenced by many factors. During residential decision-making, stakeholders, governments, and enterprises are concerned about different factors and economic interests (Zhou et al., 2017). These factors which influence LDR have both positive and negative impact on LDR (Cavailhès & Wavresky, 2003). So, it is crucial to understand which factors are directly or indirectly contributing to urban land development and re-development. There has been an increasing
interest in identifying and understanding the effects of the driving factors on urban land development and redevelopment. This knowledge is crucial to develop spatial models and also to put effective urban planning and management strategies (Zhang & Chui, 2018). Identifying the driving factors of LDR is of most considerable interest among researcher and academia. LDR can be described by the complex interaction of structural, political and property factors associated with the demand, technological capacity, social relations, and the nature of the environment (Verburg et al., 2009). Hedonic model is considered to be the most common approach towards land valuation, where land rent is considered as the dependent variable. However, in this study, we have considered LDR as the dependent variable, which makes this study distinct in one way. Taking into consideration, this study aims (1a) to explore the spatial characteristics of residential Land Development and Redevelopment (LDR); (2b) to identify the external drivers of LDR; and (3c) to detect and evaluate the correlation between LDR and driving factors.

**Literature review**

Nowadays, land development and redevelopment becomes a common phenomenon in developing countries. Where land development means conversion of raw land into construction, ready housing, commercial, or industrial building sites. Redevelopment occurs when real estate in a neighbourhood or city is enhanced through new construction or substantial renovation of existing structures (Hao et al., 2011). LDR intensity reveals spatio-temporal dynamism in the city. Here, the intensity of land development is the degree of compactness to which land is taken for use. The intensity of land development has been measured by computing the density of land parcel development (Brown & Vivas, 2005).

A study by Pollakowski and Wachter (1990) conducted in Cincinnati, United States, suggests that the combination of impact of urban location, neighbourhood and other individual factors on urban land prices was addressed in the early land hedonic price model. And these factors could explain 83% of urban land development changes. Garrod and Willis (1992) examined neighbourhood or environmental characteristics of countryside land parcels in the United Kingdom using a hedonic model. The result shows the picturesque sight (of woodlands, for example,) and the presence of water was essential amenity attributes in their resident. Geoghegan (2002) developed a hedonic model to predict probability associated with converting undeveloped land to developed lands. Colwell and Munneke (1999) wanted to find the relation between land development and redevelopment patterns in the CBD to the land development and redevelopment surrounding the CBD. The assumption was that the LDR pattern for CBD is less concave than other area. This result explains that the intensity of LDR in CBD is more than the other places. In his research, Colwell also found that the effect of the coefficient on the distance is negative and significant to the CBD (Colwell & Munneke, 1999).

Correspondingly, effects of Light-Rail Transit (LRT), subways and highways on land development have also been quantified in hedonic model (Haider & Miller, 2000). Amin (2009) used a sample of 235 properties and observed a favourable capitalization of the vicinity to LRT stations for houses within 500 m of actual walking distance. He argued that proximity to LRT improves resident’s accessibility to CBD and other urban areas with employment opportunities.

Des Rosiers et al. (1996) also analyzed the effects of size and proximity of shopping centres on surrounding residential land development. The study examined the impact of 87 shopping centres of varying sizes on the development of approximately 4000 residential properties developed between January 1990 and December 1991 in Quebec, Canada (Des Rosiers et al., 1996). The linear and semi-log functional forms along with Hedonic price regression were used to model the data. The study found a positive relationship between shopping centre size and residential land development. Besides, the study concluded that the optimal distance to a neighbourhood shopping Centre is approximately 215 m.

Seago (2013) tested the effect of the Northgate Mall, situated in Montgomery County, USA and corroborated the findings of Colwell et al. (1985). More specifically, the study applied the hedonic model to 250 residential housing estates and found that houses situated within a radius of 800 m were negatively affected by the presence of the Northgate Mall. However, houses that were located outside of this buffer, but still within a 3200-m radius experienced statistically significant positive impact (Seago, 2013). Bolitzer and Netusil (2000), in their study, stated that open spaces such as public parks, natural areas and golf courses might influence the sale of residential land property close to those resources. Traffic congestion and noise are some of the negative externalities that could outweigh the net effect of open space proximity.

Hedonic model is a well-established method used to construct the factor system that has both positive and negative influences on residential land development and redevelopment. The hedonic approach is a revealed preference technique, and it is based on an early theory of the market for miscellaneous goods developed by Rosen (1974). In his approach, residential properties are characterized as a set of sophisticated heterogeneous products. At the same time, each feature consists of an essential bundle of homogeneous attributes that differ in values and characteristics. The
The underlying theory for the market of miscellaneous goods states that the development of land is a function of the levels or value of each attribute in the bundle. In the housing market, these attributes are usually structural and site characteristics of a property. Moreover, characteristics of the neighbourhood area, quality of local services, and locational attributes such as accessibility to transportation systems or centres of activity are also part of the bundle of homogeneous attributes.

Verburg (2004) has included some driving factors of land development, such as population growth, migration, and economic issue. Development and land use of any region are not independent, which depends on various factors like conditions of the neighbouring environment and distant locations, economic, cultural, and political relations effect on the development of land. Distance to the nearest location of employment or facility affects more on land development. His study only put emphasis upon the neighbouring characteristics of land development. The ROC values were 0.67 and 0.65 of residential land and industrial or commercial land, respectively. In this case, he was less successful in explaining residential and commercial land development influencing factors. Here, the Relative Operating Characteristic (ROC) method in land use or cover change modelling is used to measure the relationship between simulated change and real change (Pontius & Schneider, 2001). This method is known as a threshold-independent method because there is no need to define the threshold value for generating a simulated land use map (Beguería, 2006). The ROC values range from 0 to 1. ROC equals to 1 when a prediction map has perfect suitability, while ROC equals to 0.5 when a prediction map has random suitability values (Pontius, 2000). The ROC is based on a curve relating to the true-positive proportion and the false-positive proportion. Liu et al. (2012) showed that the spatial distribution of all Urban Land Development Intensity (ULDI) gradients could well be explained by the selected driving variables as indicated by the high Relative Operating Characteristics (ROC) test statistics (>0.6).

After reviewing several studies, this research adopted ROC test statistics and hedonic model to select the significant variables which have an impact on residential land development and redevelopment.

**Materials and methods**

**Study area profile**

The study area selected for this research is Rajshahi City Corporation (RCC) area (Figure 1), which is located along the river Padma, between 24°20’ and 24°24’ north latitudes and in between 88°32’ and 88°40’ East longitudes. The area comprises 95.56 sq. Km (36.895922 sq. mile) of land with 0.39 million populations in 2001, 0.45 million populations in 2011 and 0.85 million populations in 2016 (Abdullah Al-Muyeed, 2018). It is a divisional city and the most significant urban centre in the northern region of Bangladesh (Clemett et al., 2006). The Rajshahi Master Plan Project 2004, carried out by the Rajshahi Development Authority (RDA) identified that the city is expanding in a northward direction along a major road named “Noahata Road” (Development Design Consultants Limited, 2004). However, a recent study conducted by Ashaduzzaman (2017) states that the physical growth of the city took place along the north-east direction. Most of the urban expansion is taking place along the major transportation network, giving a conical shape to the city. According to them, one of the primary reasons for the northward expansion is the accessibility impacts of the development and expansion of the major arterial road, i.e. Noahata road running towards the north.

![Figure 1](image-url). Location of Rajshahi City Corporation (RCC) area (a) in Bangladesh and Rajshahi District (b) RCC ward boundary, Land use and Zoning Boundary.

Source: (a) Banglapedia, National Encyclopedia of Bangladesh, 2012, and (b) Rajshahi Development Authority (RDA), 2010.
The rate of urbanization and population growth is meager in Rajshahi City compared to other major cities of the country. The population density of the RCC area is only 8891.21 persons per sq. Km (Abdullah Al-Muyeed, 2018). Between 1981 and 1991, the population has increased at a rate of 63.36%, about .00000114 million. However, during 1991–2001, it has increased only 0.00000088 million, accounting for a 30.25% rise (Development Design Consultants Limited, 2004). The urbanization rate of the northern region (i.e. Rajshahi Division) remained the same throughout the last decade, which was 17.3%. The country’s annual growth rate of population in the period 1991–2001 was the lowest in Rajshahi SMA (1.87%) and fastest in Dhaka SMA (4.26%). Every year the capital city Dhaka absorbs an additional population equivalent to the current population of RCC area (Development Design Consultants Limited, 2004).

**Determination of spatial characteristics of LDR**

Developed and redeveloped land have been identified through land development permission data from RDA. This data contains mouza name, plot number of permitted land parcel. It also contains the owner’s name and current state of land of the land parcel. Then, Mouza maps are collected from UDD Rajshahi. Mouza map is digitized to identify the location of Developed and redeveloped plot in mouza map. Then, a comprehensive visual inspection at the field level is conducted to cross-check the data. As mentioned earlier, GIS has been used as a tool in this study. First of all, the centroid of LDR is determined. A mobile GPS is used to add X and Y coordinates of the polygon (surveyed LDR) centroids to the corresponding GIS attribute table. Study adds two new fields, named X-coordinates and Y-coordinates, and fills the respective fields with the X and Y coordinates of the polygon centroids. As the theme was projected in the Bangladesh Transverse Mercator (BTM) projection, the output coordinates have also been projected accordingly. The point locations of the residential properties surveyed in Rajshahi City have been presented in Figure 2. Finally, the map of spatial characteristics of land development and redevelopment is constructed.

**Selection and explanation of independent variables**

One of the main objectives of this study is to detect and evaluate the correlation between LDR and driving factors. To do this, identifications of various variables that influence LDR is important. A set of variables are chosen based on preliminary research related to this study as well as expert knowledge. It is assumed that (1) Parcel characteristics (2) Location Characteristics (3) Neighborhood characteristics and (4) Political characteristics have influence on LDR.

**Parcel characteristics**

The characteristics of parcels generally meant physical elements, meaning the pre-development floor area ratio (FAR) (Waddell, 2002). These attributes don’t disturb by external factors. If there were no buildings or structures before the original parcels were developed, the FAR will be zero (Irwin & Bockstael, 2002). However, most urban land has already been developed in the process of urbanization in Rajshahi, but the efficiency of use and economic benefits are low. Because of that, people think to redevelop it to get more benefit on land use. With the concept of land-use intensification and sustainable development based on smart urban growth that attempts to balance growth while fulfilling economic, social, and environmental needs, and a large amount of urban stock land has been redeveloped (Godschalk, 2004). Thus, the concept of pre-development FAR was realized. The construction of new structures will be hampered to some extent if there were structures or buildings on the original parcels. In that case, the pre-development FAR is 1. That directly results in a greater difficulty of redevelopment of the parcels. Based on the reasons above, this paper chooses pre-development FAR as the main feature variables of parcels (Table 1).

With a topographical map, you can determine where your property should be constructed. Topographic maps are also used by governments to zone land for development. If an area is very steep, then it’s not often zoned for commercial or residential use. While lower areas are a great place to build large malls, schools, and more. So, contour is chosen as an important factor.

In this paper, shape index is also introduced as indicator that reflects landscape characteristics. A plot is the basic unit of the Land, irregular in shape, and usually defined according to its land-use type, ownership, and natural and administrative boundaries (Deng et al., 2009). The area of each parcel was computed directly, and the shape index has been defined as (Equation (1)) (Xie et al., 2005)

\[
\text{Shape Index} = \frac{4\sqrt{A}}{L}
\]  

(A is the area, and L is the perimeter of the parcel. Shape index reflects the deviation degree of a parcel from a square with the same area. The larger the shape index, the more regular the parcel’s shape, and vice versa. The value of shape index ranges from 0 to 1.)

**Location characteristics**

The influence of location characteristics on LDR is conspicuous. Habib (2004) selected the
accessibility to the Central Business District (CBD) as a locational attribute for developing the hedonic price model. The other locational attributes include accessibility to the major roads (city arterials from the individual residential properties at Rajshahi), distance to airport and railway. The downtown area has a significant influence on LDR. Usually, the downtown area facilitated with basic civic facilitates more than other areas. The transportation system has a significant impact on the residential LDR of an urban area. It is a significant factor that can deflect and revamp how and where people live, work, shop and travel. Thus, distance from major arterial roads, airport and railways have a significant influence on LDR (Table 1).

**Neighbourhood characteristics**

A set of demographics, land use and amenities at the neighbourhood level are the measure of neighbourhood quality and neighbourhood-level externalities. Since these are expected to influence LDR, these factors are included in the study. Natural conditions of land parcels, such as near coastline or river, are symptomatic of commencing project development. Cheshire thought that open spaces often direct to the possibility of development because of its bland features (Cheshire, 2007).

Human-made facilities like school, hospital, and park are important example of neighbourhood characteristics. (Kain & Quigley, 1970) compared the relationships between the quality of different schools and urban land prices. The studies by Richardson et al.
**Table 1. Descriptive statistics of the independent variables.**

| Variable | Definition | Expectation |
|----------|------------|-------------|
| Parcel   |            |             |
| PDFAR (X1)| Pre-development FAR | + |
| Shape_Index (X2) | Shape Index | + |
| Contour (X3) | Contour |             |
| Location |            |             |
| DISTCBD – distance to central business district in meters (X4) | A block unit’s Euclidean distance to CBD, in meters, static variable | - |
| DISTROAD – distance to Major Arterial-roads in meters (X5) | A block unit’s Euclidean distance to Major-road, in meters, static variable | - |
| DISTSHOPPING – distance to shopping center in meters (X6) | A block unit’s Euclidean distance to shopping center, in meters, static variable | - |
| DISTRIVER – distance to river in meters (X7) | A block unit’s Euclidean distance to river, in meters, static variable | - |
| DISTWHOLESALE – distance to wholesale markets in meters (X8) | A block unit’s Euclidean distance to wholesale markets, in meters, static variable | - |
| DISTDRAINAGE – distance to drainage networks (X9) | A block unit’s Euclidean distance to drainage, in meters, static variable | - |
| DISTRAILWAY – distance to railway in meters (X10) | A block unit’s Euclidean distance to railway, in meters, static variable | - |
| Neighborhood |            |             |
| DISTRIVER – distance to river in meters (X11) | A block unit’s Euclidean distance to river, in meters, static variable | - |
| DISTSCHOOL – distance to school in meters (X12) | A block unit’s Euclidean distance to school, in meters, static variable | - |
| DISTPARK – distance to park in meters (X13) | A block unit’s Euclidean distance to park, in meters, static variable | - |
| Political |            |             |
| Land PropertyRights(14) | Stated owned Land, Private Land |         |

Source: Prepared by Authors, 2018.

(1974) showed that hospitals have a positive impact on urban land prices. As for studies related to parks (Richardson et al., 1974) found that land prices near parks were higher than in other areas. Therefore, this paper chooses the rivers, schools, hospitals and parks as important variables in the neighbourhood characteristics (Table 1).

**Political characteristics**

The issue of property attributions, the first land development ownership belongs to the government. However, the core of land redevelopment is the reconstruction of land development rights, which allows property to transform land exploitation from a lower-yield to a higher-efficiency, or to enhance land-use intensity for more revenue. That’s why ownership of the land takes as one of the important variables in the political characteristics (Belsky et al., 2006).

**An improved hedonic model**

A hedonic price model is applied to develop a factor system that influences urban land development and redevelopment (Malpezzi, 2002). The land value is the main reason for the development and redevelopment of land, while the measurement of land value usually adopts the hedonic model. The traditional hedonic model is mainly based on the construction of the real estate market (Sirmans et al., 2005).

The standard hedonic price function for the sale of a building is given by the Eq. 2:

\[ P = (X_i, Y_j, Z_k, U_1) \]  \hspace{1cm} (2)

where \( P \) represents the sales price of an existing building, \( X_i \) represents the building characteristic at number \( i \), \( Y_j \) represents the location characteristic at number \( j \), \( Z_k \) represents the neighbourhood characteristic at number \( k \), \( U_1 \) represents other variables that influence the sales price, and \( f(*) \) denotes the idiographic function.

This paper denotes other variables as land property rights.

**Relative operating characteristics (ROC)**

To define the ROC, ROC curve plots the rate of true-positives on the vertical axis versus the rate of false-positives on the horizontal axis for each of the various scenarios selected by hedonic model. Each scenario corresponds to a point in the plotted space. The ROC statistic is the area under the curve that connects the plotted points. Equation (3) uses integral calculus’ trapezoidal rule to compute the area, where \( x_i \) is the rate of false positives for scenario \( i \), \( y_i \) the rate of true positives for scenario “i”, and “n” the number of suitability groups:

\[ \text{Area under curve} = \sum_{i=1}^{n} \left[ \frac{x_i + 1}{2} - \frac{x_i}{2} \right] \]  \hspace{1cm} (3)

If the variables have the suitability values match perfectly the sequence in which real LDR has occurred, then ROC equal to 1, because as the influence of the variables increases from 0% to 100%, the ROC curve begins at the origin, goes up the horizontal axis to the point (0, 100%), then passes to the right to the point (100, 100%). More generally, ROC equal to 1 for any variable for which the locations that experience LDR have a larger influence. Note several different suitability maps could have ROC of 1. This study considered those variables that have ROC value more than 0.5 as the most significant variables for LDR.
Regression analysis

Regression is a method to discover the empirical relationships between dependent and several independent categorical and continuous variables (Harrell, 2015). In this paper, the logistic regression model is used to characterize the influence factors of LDR and identify critical impacts. The conventional regression models include linear regression, variant linear regression, and logistic regression, which are widely used in the research of influencing factors and mechanisms of urban development (Hosmer et al., 2013). When compared with linear regression and variant linear regression, the application of logistic regression in the socio-economic field is more advantageous. The logistic regression model is used to evaluate the possibility of one land type being converted to another type by constructing the correlation between the various influencing factors and various types of land (Pontius & Schneider, 2001). The dependent variable is the development and redevelopment possibility of land of RCC area, and two levels of qualitative variables are developed (=1) and not developed (= 0). However, for a complex socio-economic system and the factors influencing the development of cities, often conventional assumptions cannot be made. These factors are composed of continuous variables and categorical variables. Logistic regression can express these variables and construct regression models. The basic expression of the logistic regression model is as follows (Equation (4)):

\[ P(y = 1|x) = \frac{e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n}}{1 + e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n}} \] (4)

In this formula, \( P \) represents the probability of land development and redevelopment and \( x \) represents the factors influencing land development. \( \beta_0, \beta_1 \ldots \beta_n \) are for regression coefficients whose values represent the contribution of each argument to the dependent variable \( y \), using the weighted least squares, or Newton Raphson method (Ypma, 1995), to solve each regression coefficient. A linear expression can be obtained by changing the Formula.

\[ y = \ln \left( \frac{1 - p}{p} \right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n \] (5)

Then, \( p \) is:

\[ p = \frac{e^y}{1 + e^y} \] (6)

In the logistic regression model, the dependent variable can be a nonlinear function of the independent variable. The probability \( p \)-value changes with \( y \) and further characterize the significance of the independent variable.

**Results and discussion**

**Initial GIS operations results**

Euclidean distance is the distance between two points in Euclidean space. Euclidean distance mapping was conducted to visualize the relative location of particular factor and LDR location. Figure 2 shows the results of Euclidean distance mapping. Then, to calculate distance and additional proximity information between the input features (location of LDR) and the closest feature in another layer (factors, e.g., distance from roads) proximity toolset of ArcGIS is used. That is important to conduct final regression analysis.

**Driving forces of residential LDR**

Logistic regression was estimated for different variables to reach the highest possible relative operating characteristic (ROC). Probability values vary in the range between 0 and 1, which state the possibility of an event as a proportion of both incidence and non-incidence (Fang et al., 2005). The spatial distribution of all LDR could well be explained by the selected driving variables, as indicated by the high Relative Operating Characteristics (ROC) test statistics (>0.5). To select the optimum variables, it had to reach the highest ROC value, which verifies the validity of the hedonic model. Mainly ROC assesses how well the changes can be described with the selected variables (Hu & Lo, 2007).

Necessarily ROC = 1 indicates a perfect fit and ROC = 0.5 indicates a random fit. From Table 2, it is clear that distant to road, railway, streams, park, school, shopping centre, wholesale markets, shape index and contour influence land development and redevelop-

**Table 2. Relative operating characteristics of explanatory variables.**

| Variable                               | Relative Operating Characteristic (ROC) |
|----------------------------------------|---------------------------------------|
| Distance to CBD                        | 0.442                                 |
| Distance to Road                       | 0.809                                 |
| Distance to Railway                    | 0.522                                 |
| Distance to River                      | 0.307                                 |
| Distance to Streams                    | 0.556                                 |
| Distance to Open Space                 | 0.680                                 |
| Distance to Nearby City                | 0.322                                 |
| Population Density                     | 0.142                                 |
| Distance to School                     | 0.502                                 |
| Distance to Hospital                   | 0.519                                 |
| Shape Index                            | 0.826                                 |
| Drainage                               | 0.780                                 |
| Distance to Cultural facilities        | 0.315                                 |
| Distance from Waste Disposal           | 0.239                                 |
| Facilities                             |                                       |
| Shopping Centre                        | 0.682                                 |
| Wholesale Market                       | 0.782                                 |
| Distance to Nearby Bank                | 0.443                                 |
| Distance to Nearby University          | 0.231                                 |
| Distance from Stadium                  | 0.412                                 |

Source: Prepared by Authors, 2018.
ment. So, those variables are selected for further analysis. As CBD is one of the critical factors of land development and redevelopment, it is also taken for further analysis.

**Logistic regression analysis**

Several types of data pre-processing and logistic regression analysis were conducted, and the regression model results have been shown in Table 3. According to the results, overall Percentage represents the overall accuracy and if the value is higher than 80%, the better the effect of the logistic regression model. In this paper, the Overall Percentage value is 84.7% (Table 4). If the p-value is less than 0.01, which means the results are significant. According to the regression result, the p-value is 0.005. The estimator is significant. It can be seen that the overall accuracy is high, and the model fits the sample data well.

The coefficients and their significance are stable in several operations, which reflect the scientific nature and credibility of the hedonic model (Witte et al., 1979). The coefficients and significance level of model variables are presented in Table 3. B is the coefficient of every independent variable. The estimated equation performs satisfactorily in terms of goodness of fit. The likelihood-ratio chi-squared value for the model is 243.78, and the estimated model is highly significant, with a p-value of less than 1%. More importantly, most coefficients are statistically significant at the 1% level, and their signs are mostly consistent with expectations. The estimated results suggest that several factors influenced the probability of Land development and redevelopment. The influencing factors include plot’s location, parcel characteristics, accessibility and physical elements.

**Parcel characteristics**

As expected, the regression coefficient of the pre-development FAR is negative. That means that the higher the pre-development FAR, the more difficult it is for the land to be developed and redeveloped. The coefficient on contour is positive and significant. Hedonic model shows, the development of low lying area at the periphery and other areas within RCC area is boosting. When contour decrease by one unit, the probability of LDR increases by about 17.4%. Due to rapid urbanization, people perceive that urban development is likely to shift from city core to urban periphery, most of the urban periphery is characterized by low lying area. Owing to limited restrictions on peripheral development and having good access, people are interested in investing in urban fringe area development. All these factors have been instrumental in triggering off the emergence of development in the periphery (Keivani & Mattingly, 2007).

Globalization has broached this entire process of land-use, and livelihood transformation along the urban fringes (Keivani & Mattingly, 2007) as transnational capital has been found to favour locations in and around the most important cities

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### Table 3. Estimation results of the model for land development and redevelopment.

| Model Independent Variables | B   | Standard Error | Wals    | Df | Sig. | Exp (B) |
|-----------------------------|-----|----------------|---------|----|------|---------|
| **Parcel Characteristics**  |     |                |         |    |      |         |
| PDFAR (X₁)                  | -0.763 | 0.345          | 9.349   | 1  | .001 | 0.466   |
| Shape Index (X₂)            | 0.113 | 0.003          | 0.021   | 1  | .001 | 1.119   |
| CONTOUR (X₃)                | 0.174 | 0.002          | 1.771   | 1  | .001 | 1.900   |
| **Location Characteristics**|     |                |         |    |      |         |
| DISTCBD (X₄)                | -0.007 | 0.001          | 6.866   | 1  | .001 | 0.993   |
| DISTTRUNKROAD (X₅)          | -0.765 | 0.001          | 7.141   | 1  | .000 | 0.465   |
| DISTSHOPPING (X₆)           | -0.020 | 0.014          | 4.878   | 1  | .027 | 0.980   |
| DISTRIVER (X₇)              | 0.009 | 0.001          | 6.866   | 1  | .009 | 1.009   |
| DISTWHOLESALE (X₈)          | -0.031 | 0.000          | 1.905   | 1  | .168 | 0.9694  |
| DISTDRAINAGE (X₉)           | -0.059 | 0.001          | 7.141   | 1  | .008 | 0.9427  |
| DISTRAILWAY (X₁₀)           | -0.001 | **0.001**      | 4.878   | 1  | .007 | 0.999   |
| **Neighborhood Characteristics** |     |                |         |    |      |         |
| DISTPARK (X₁₁)              | -0.012 | **0.001**      | 4.924   | 1  | .001 | 0.988   |
| DIStHOSPITAL (X₁₂)          | -0.011 | 0.000          | 0.001   | 1  | .970 | 0.9890  |
| DISTSCHOOL (X₁₃)            | 0.033 | 0.001          | 2.287   | 1  | .130 | 1.033   |
| **Political Characteristics**|     |                |         |    |      |         |
| Land Property Rights (X₁₃)  | 0.001 | 0.000          | 1.905   | 1  | .168 | 1.001   |
| CONSTANT                    | 19.615| 17.404         | 1.798   | 1  | 1.2  | 0.441   |

Source: Prepared by Authors, 2018.

Dependent variable: Whether land is developed and redeveloped; *** Significance at the 1% level; ** Significance at the 5% level.
(Chakravorty et al., 2003). It is therefore not difficult to understand that following the reforms, the urban fringes of the city are emerging as hot spots of economic activities that convey severe implications for the people residing there as the economic base is continually exposed to radical transformations. Land uses in the fringe area of RCC are being continually exposed to competition from urban uses resulting in escalation of land development in the periphery. Shape Index also influence land development and redevelopment. The estimated coefficients for area and shape index are both significantly positive. This suggests that the possibility of being LDR is higher for parcels with larger size and more regular shape. And increase by 11.3% for each unit increase in the shape index between area and perimeter. This suggests that parcels with different characteristics share different LDR trends.

**Locational characteristics**

The coefficients of the independent variable DISTCBD are not of statistical significance in the model. The results suggest that for every kilometre increase in distance to city centre, the probability of being residential LDR increases by 0.07%. This suggests that land development and redevelopment is not being influenced by the CBD area. The development rate at the CBD area is same as LDR in outskirts area. This phenomenon could be explained by the scenario of city expansion since these parcels of land are usually located in low lying area and have not previously developed. But due to urbanization, the importance of those lands is increasing day by day. In other words, economic development has increased the need for spaces where people can work and live, so a large amount of land around city periphery areas has borne the brunt of being land development and redevelopment. Smart growth theory holds that urban development should be relatively concentrated and should reduce the distance from workplace to home, making good use of the infrastructure and restraining unreasonable urban sprawl (Durand et al., 2011). The estimated coefficient of DISTROAD is negative and statistically significant. The hedonic price of DISTROAD (−0.765) highlights the fact, all other conditions being the same, an additional unit distance from the block results in a − 0.765-unit decrease in the natural log of unit land price. This makes sense because the core assumption is that households are willing to trade off purchases of accessibility, land area, and other attributes. When accessibility levels of an area increase that stimulate changes in land use patterns (Kantartzis et al., 2006).

People like to construct their houses close to road to get better access to other facilities. Investment in infrastructure plays an important role in addressing economic deprivation. Mainly, investment in road infrastructure development carries significant importance for the integrated development of a country. New road infrastructure brings other facilities in the locality. So that together increases value of land (Hilling, 2003). One of the most important factors that cause significant residential LDR over the past few decades is the increase in the number and size of retail shopping centres situated in, or close to, residential areas. In the hedonic model, the existence of a shopping centre within 1 km of a residential property (land) is estimated to increase the value of LDR by 2%. In the hedonic model, the existence of Wholesale markets within 1 km of a residential property (land) is estimated to increase a value of land by 3.1%. Wholesale market provides opportunity for trading. Streams are essential for irrigating arid land, so parcels close to the streams have a lower probability of LDR. This is rational because streams help to generate agricultural activity.

It is also worth noting that the variable River is not significant. Unlike other cities like Haikou (China), Rajshahi is not developing along the river. Rajshahi is situated beside Padma River. But along the river, there is a lot of vacant lands and commercial activity. Not an ideal place for residential development. An essential part of buying most homes is investigating potential problems and hazards associated with the house and property. An easement on prospective home requires thorough investigation before signing a sale agreement. An assessment includes assessment of the existing drainage network. Drainage easements set aside land to carry water collected from neighbourhood streets and land parcels through a complex drainage network, thereby protecting homes and businesses from water damage (Weiss, 2002). That increases the importance of having drainage network close to land in LDR. In the hedonic model, the existence of a drainage network within 1 km of a residential property (land) is estimated to increase the value of land by 5.9%.

**Neighbourhood characteristics**

In the hedonic model, the existence of open space within 1 km of a residential property (land) is estimated to increase the value of land by 1.2%. As in the logistic model, the distance of the open space has a negative and statistically significant influence on residential land development. This is relevant as urban green open spaces are valuable environmental resources often associated with positive influences for quality of life and property value. One category of non-market open space benefit is called use-value. Use values are related to seeing or using the open space and include having a scenic view, experiencing improved water quality, or viewing wildlife.
In contrast, nonuse value arises from merely knowing that open space exists. The estimated coefficient for distance from school is insignificant and positive. The value for the coefficient of DISTSCHOOL in the model is 0.033. That because Rajshahi is called educational city. There are many schools in this particular area. People quickly get accessibility to school wherever they find their residence in the city area. So, people don’t provide additional emphasis on proximity to school at the time of residential choice. Hospital has an impact on the local property market. Firstly, it could increase the demand for housing in the area, both from people who work at the hospital during or post-construction and from people who value living close to medical facilities. This research shows that the existence of a hospital within 1 km of a residential property (land) is estimated to increase a value of land by 1.1%.

**Political characteristics**

Although to a lesser extent, the provision of title of property ownership also positively affects residential land prices. Surprisingly, this research doesn’t find any significant influence of Land property rights on Land development and redevelopment.

**Conclusion**

With the new stage of urbanization, the land development pattern in RCC area has changed. Because of rising visible and invisible costs in land development and redevelopment, urban development has changed from dull incremental expansion to the parallel development model of incremental land development and stock land redevelopment. The influencing factors of urban LDR are mainly composed of four characteristics: parcel characteristics, location characteristics, neighbourhood characteristics, and political characteristics. Thus, selecting the significant factors, which can make comparisons with the market sale prices, is very important to model the residential land value. Within these characteristics, the locational features are particularly important at the land market in Rajshahi.

In this research, at first, the influence factors are selected as follows, based on literature and local knowledge of experts. These include – travel time to the city centre, neighbourhood quality, access to the main road, waterbody, access to amenity, travel time to school, distance to school, distance to post office, distance to market, convenient of the public transportation stop, land area, and so on. One of the most surprising and exciting findings of this study is, land development and redevelopment (LDR) doesn’t follow distance decline law from Central Business District (CBD). In the context of Bangladesh, the reverse case is expected in most of the cities. The estimated coefficient of DISTROAD is negative and statistically significant. In the hedonic model, the existence of open space within 1 km of a residential property (land) is estimated to increase the value of land by 1.2%. As in the logistic model, the distance of the open space has a negative and statistically significant influence on residential land development.

This study examines the impacts of different accessibility on residential properties using hedonic price model approach. The strength of hedonic price models could also be increased with the inclusion of employment and socio-economic data, which was not available for this study. Besides, negative externalities of variables could have been incorporated in the study. A more comprehensive approach to diagnosis spatial autocorrelation should also be employed. Moran’s I is sensitive in the presence of other forms of specification error, such as nonmorality and heteroscedasticity. Alternative tests like Lagrange, the multiplier should also be employed to evaluate the performance of Moran’s I.

Finally, cautions must be taken in the direct application of the findings from the value estimated in this study to other urban areas. The value can only be viable for the study area (Rajshahi City Corporation) concerned. Because this study solely relies on the estimation of the first hedonic stage. Full implementation of the hedonic methodology requires a second stage that deals with the estimation of demand or bid function for the attributes.

Based on the findings of the study, individual recommendations for Rajshahi City can be made for practical applications. As the Rajshahi Development Authority (RDA) is preparing the Rajshahi City Corporation Earthquake Contingency Plan, these recommendations may be useful for plan formulation and implementation as well. By determining the capitalization of positive accessibility effects, the localized evidence from this study provides tools for exploring the use of innovative land-based tax instruments. These results are expected to inform local planners and policymakers about the potential of public funding tools for infrastructure.

Therefore, first of all, an innovative land-based tax instrument could be introduced as the study determined the capitalization of positive transportation accessibility effects. Such an effort could support alternative capital cost recovery of the intended transportation infrastructure investments by the Rajshahi Development Authority. Second, the Rajshahi Development Authority (RDA) should take housing projects apart from the central business district (Saheb Bazar, Luxipur) as the study showed that LDR is also high at a distance away from the CBD at Rajshahi City. Last but not least, the transportation network, particularly the city arterials, should be planned in such
a way that the housing properties get maximum accessibility. Because, according to this study, moving closer to the city arterials tends to increase the LDR.

Disclosure statement
No potential conflict of interest was reported by the authors.

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