URP 3232: Regional Planning Studio

A Report on

Growth Prediction of Urban Areas: A Study on Khulna Metropolitan Area

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Chapter 01: Introduction

Khulna was the most vibrant industrial city in Pakistan period. After the construction of Padma bridge, it will generate the remarkable scope of creating more jobs, business opportunities, health and education facilities as well as other relevant things of economic growth and for this reason, urban growth will be started in this region at a significant rate. This study would be beneficial to understand the growth prediction of Khulna. By this study the predicted growth of various places of Khulna can be introduced.

1.1 Background of the project

Urban growth represents specific response to environmental, economic, and demographic conditions. Urban Growth is a major problem in the course of the urban development of the developing countries in the 21st century, most of the urban growth is considered to be the expansion of low density accompanied by a series of environmental and socio-economic issues (Triantakonstantis, Urban Growth Prediction: A Review of Computational Models and Human Perceptions, 2012).

Land development has been out of control and the construction land has kept expanding blindly, especially in the marginal areas of some metropolises. Nowadays urban areas experience fast growth due to enormous population growth, rapid industrialization, economic development and specific economic policies adopted by governments and immigration of people from villages to cities. Accelerated urban growth is usually associated with and driven by the population concentration in an area. The extent of urbanization or its growth drives the change in land use/cover pattern (Hussein D. et al 2014).

Khulna was the most vibrant industrial city in Pakistan period. After the construction of Padma bridge, it will generate the remarkable scope of creating more jobs, business opportunities, health and education facilities as well as other relevant things of economic growth and for this reason, urban growth will be started in this region at a significant rate. People from the surrounding semi-urban or rural areas had started to reside in Khulna city due to professional or educational purposes. Moreover, being an economically important area, people from other parts of the country has also been living here on a consistent basis. As a result the total population growth of Khulna city are now growing up very rapidly (Daily Sun, 2017). Khulna City has been developing rapidly after reform and opening-up since 2007 urban growth has emerged in some area (Zero point, Harintana). Land development has been out of control and the construction land has kept expanding blindly, especially in the marginal areas of this metropolitan city (Daily Sun, 2017).

The aim of this paper is to predict the urban growth considering different associated factor using GIS weighed overlay techniques. Analytic Hierarchy Process (AHP) is used to determine the weight of each factor.

1.2 Objective

To predict the urban growth of Khulna metropolitan area considering different associated factor.

1.3 Research Question

a. What are the influencing factors of urban growth?
b. Which are the most potential zones for future urban growth?
c. What will be the probable impact of predicted urban growth ?

1.4 Scope

This study is subjected to find to predict the urban growth considering different associated factors using GIS weighed overlay techniques. There are lot of factors which influence urban growth. But among them we only consider some factors for our analysis. The identification and analyzing of pre-expansion patterns helps in the effective planning of infrastructure in urban areas. In addition, understanding the behavior of urban sprawls could assist in achieving sound environmental planning and resource management. This study recommends a re-consideration of the city expansion strategies by decision makers in government in order to ensure ecological balance.

1.5 Limitations

1) There are lot of factors which influence urban growth. But among them we only consider some factors for our analysis.
2) No specific source is used for criteria selection. So, most of the criteria is selected based on our own assumption.
3) This analysis is based on secondary data source. Primary data can give more accuracy of the analysis.
4) Obsolete data are used for analysis.

Chapter 2: Literature Review

This chapter contains the definition of urban growth, the Analytic Hierarchy Process and other key terminologies. It also contains case studies related to urban growth prediction. It will also indicate the theoretical framework of the project.

2.1 Urban Growth

Urban growth can be defined as the rate at which the population of an urban area increases. This result from urbanization. It is the movement of people from rural areas to urban areas. Urban growth may lead to a rise in the economic development of a country. Urban growth is also referred to as the expansion of a metropolitan or suburban area into the surrounding environment. It can be considered as an indicator of the state of a country's economic condition as the effect of urban growth directly impacts the country's economic development. The more the metropolitan area grows, the more employment it generates, and in this way economic growth also takes place (Lu, 2002).

Urban growth leads to urbanization which in turn leads to some changes such as-

- Migration of rural people to urban areas.
- Employment opportunities in urban centers.
- Transport and communication facilities.
- Educational facilities.
- Increase in the standard of living.

Urbanization is an integral part of economic development. As the economy develops, there is an increase in per capita income and also demand for non-farm goods in the marketplace (Edward L. Glaeser, 2006).

Urbanization can yield positive effects if it takes place up to a desirable limit. Extensive urbanization or indiscriminate growth of cities may result in adverse effects like-

- The problem of overpopulation, the growth of slums, etc.
- The disintegration of the Joint family
- Cost of living

- Increase in Crime rates
- Impersonal relations
- Problem of Pollution
- Stress

Most of these changes have a direct impact on the country's economic development (Edward L. Glaeser, 2006).

Hence, the level of urbanization is regarded as an index of economic development, as financial growth results in the shift in demand and therefore to a reallocation of resources –land, labor and capital- out of agriculture into manufacturing and services.

2.2 Characteristics of Urban Growth

i. Economic Development:

- The level of urbanization is considered as an index of economic development.
- Economic growth results in the shift in demand and therefore to a reallocation of resources –land, labor, and capital- out of agriculture into manufacturing and services (RODWIN, 2014).

ii. Industrialization and Density:

- The relative importance of manufacturing and services the does not just characterize an urban settlement but more importantly, by a high density of population. Much of manufacturing is cheaper when produced on a large-scale because of the economies of scale.
- Economies of scale and cost of transportation cause concentration of production and people in a specific location.
- Industrialization leads to urbanization but not vice versa.
- The bigger cities have one advantage. Most businesses are subject to fluctuations. In big cities, one may switch from one employer to another in case of need or any other reason since there is a wide choice. In that way, a wage laborer is better off in migrating to a big city rather than a small city, where (big city) he is likely to be more fully

employed. All these factors increase the density of population in the cities (RODWIN, 2014).

2.3 Growth Pole Theory

The growth pole theory was developed by French regional economist, Francois Perroux, in 1955. He was concerned with the phenomenon of economic development and with the process of structural change (Parr, 2013).

He attempted to explain how modern process of economic growth deviated from the stationary conception of equilibrium growth. His arguments were based on Schumpeter's theories of the role of innovations and large-scale firms.

In Schumpeter's analysis, development occurs as a result of discontinuous spurts in a dynamic world. The cause of discontinuous spurts is the innovative entrepreneur whose activities take place in large- scale firms. These firms are able to dominate their environment in the sense of exercising reversible and partially reversible influences on other economic units by reason of their dimension and negotiating strength, and by the nature of their operations (Parr, 2013)

The growth pole theory received a specific geographical and regional importance because of Boudeville. He defined a regional growth pole as a "set of expanding industries located in an urban area and including further development of economic activity throughout its zone of influence." The place where these 'expanding' or 'propulsive' or 'dominant' industries are located in the region becomes the pole of the region and agglomeration tendencies are promoted (Darwent, 2008).

2.4 The Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s (L.S.Ganesh, 2009).

Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions (L.S.Ganesh, 2009).

Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem-tangible or intangible, carefully measured or roughly estimated, well or poorly understood-anything at all that applies to the decision at hand (Darwent, 2008).

Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to each other two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, but they typically use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations (Triantaphyllou, 2011) .

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision-making techniques (Edward L. Glaeser, 2006)

In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action (Triantaphyllou, 2011).

2.5 Case Study

Case Study-1

Title

Monitoring and Prediction of Urban Growth Using GIS Techniques: A Case Study of Dohuk City Kurdistan Region of Iraq.

Objective

- To support application modules namely built up area, green and recreational areas.
- To represent specific response to environmental, economic, and demographic conditions.

Outcome

1. This case represents about 234% growth in built-up area over the first place, and 302% growth in the second pace.
2. Thus over the six years of study period population grew by 300% in the first place, and by 254% in the second pace.
3. As a total growth, the built-up area grew by 1247% over the entire period, while population grew by 1316%, just slightly higher than the growth of the built-up area.
4. With respect to green space, it is obvious that in 2004 there was no green space available.
5. However, in 2007 about 0.7 hectares occurred which is a very small percentage, comparing to the available built-up area.
6. Nonetheless, it has increased to about 2.9 hectares in 2010. Yet, it is still a very low percentage according to the built-up lands.
7. The census data indicate that the main phase of population growth as well as built-up area growth in Masik district occurred between 2007 and 2010.
8. The main cause of this growth was the growth of the city of Duhok, which means the growth of the city has reached Masik district in 2004 and started growing very fast.
9. Population census of Duhok give that the population of Masik in 2003 was zero.
10. As stated before, growth direction of Duhok city is to the west due to the mountain ranges that surround the city from north, south and east. However, there is a space available in the east for growth, but it is very small comparing to the available space in the west (Mohammed & A. Ali, 2014).

Case Study-2

Title

Urban Growth Prediction: A Review of Computational Models and Human Perceptions

Objective

To begin gap by analyzing results from a survey investigating developer and user perceptions from the modelling and critically discusses existing urban growth prediction models.

Outcome:

- A total of 156 manuscripts is identified. Analysis of aggregated statistics indicates that cellular automata are the prevailing modelling technique, present in the majority of published works.
- There is also a strong preference for local or regional studies, a choice possibly related to data availability. There is an overwhelming response in the potential of UGPMs (98% positive), however respondents are split on whether UGPMs currently reach that potential in practice (43% positive).
- The survey found a strong recognition of the models' potential in decision making, but also limited agreement that these models actually reach that potential in practice.
- Modelers are found to create models that are not easy to understand (72% negative, with almost identical responses from the planners (74%) and surprisingly the modelers community (71%)), while planners do not identify clear expectations (81% negative with the mod elders being slightly more negative (87%) than the planners (79%)).
- On the question regarding whether UGPMs reach their potential in practice, respondents with no policy experience agreed or strongly agreed at a lower percentage than respondents with policy experience (37% vs. 53%) (Triantakonstantis & Mountrakis, Urban Growth Prediction: A Review of Computational Models and Human Perceptions, 2012).

Chapter 03: Methodology

In this chapter, the overall working procedure of the study is described in brief. Collection of required data and the method of predating urban growth is described in this chapter. To predicting urban growth based on multi criteria analysis using GIS, different criteria was fixed. Analytic Hierarchy Process (AHP) is used to determine the influence of each factor.

Total Workflows

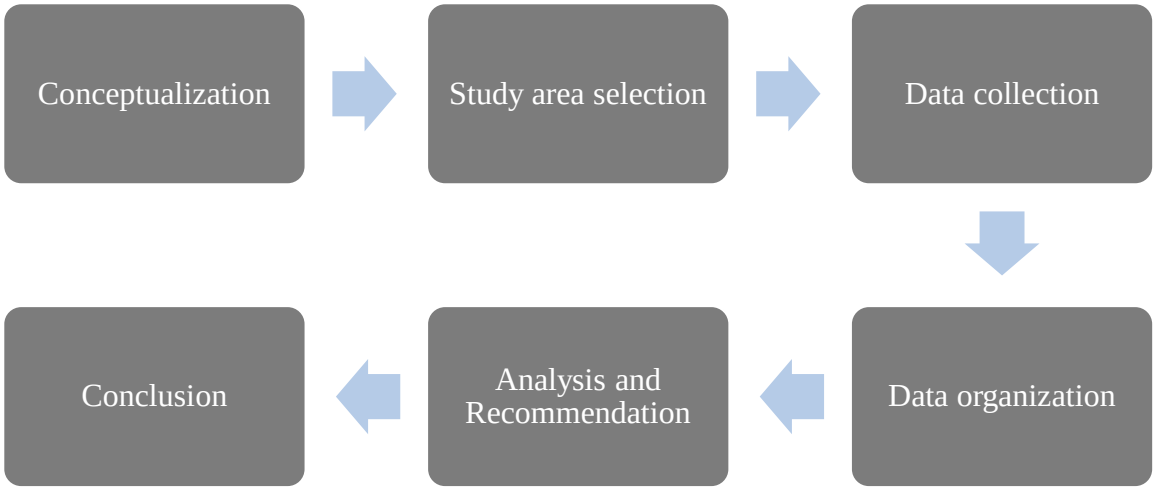


Figure 1: Total workflows of methodological process

3.1 Conceptualization

Firstly, various kinds of urban growth-related study have been reviewed to enrich the knowledge level. Such as definition of urban growth, growth pole theory, factors affecting the urban growth from different books, reports and journals.

3.2 Study area selection

After the literature review study area has been chosen. Khulna Metropolitan area (Figure 3.1) is being chosen as study area for this research. Khulna Metropolitan area 40.79 sq. km, located in between 24°45' and 24°54' north latitudes and in between 89°28' and 89°35' east longitudes. It is bounded by dighalia upazila and khan jahan ali thana on the north, batiaghata' upazila on the south, rupsa and Dighalia upazilas on the east and dumuria upazila on the west.

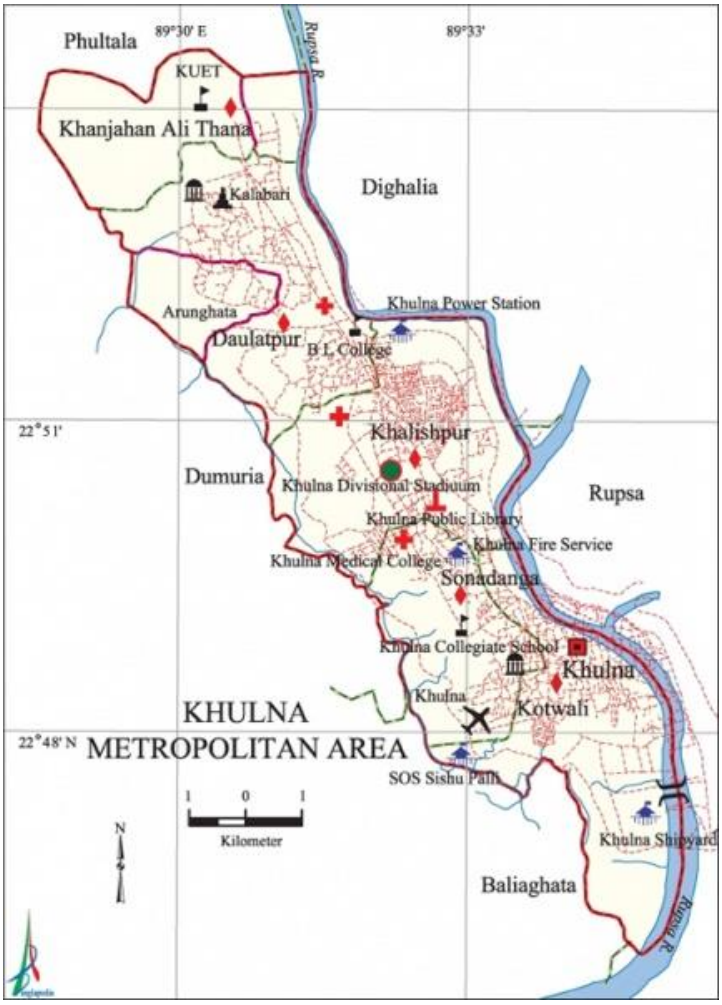


Figure 2: Study Area (Source: Banglapedia)

3.3 Data collection

To predicting urban growth based on multi criteria analysis using GIS, different criteria was fixed. Here only secondary data of each criteria is used for analysis purpose. This data is collected through various secondary source. A list of all data sources is given below.

Table 1: Data sources of different criteria for regionalization

Data	Format	Source
KCC Boundary	Shape File	KDA DAP
Road	Shape File	KDA DAP
Existing Structure	Shape File	KDA DAP
Major Growth Center	Point Shape	Google Earth
Slope	Raster File	Open contour website

3.4 Data organization

After the data collection, data is organized by using various statistical software like Microsoft excel. ArcGIS 10.3 is also used for data organization.

3.5 Analysis and Findings

Various spatial analysis is done by using ArcGIS 10.3 software. In this section firstly each criterion is singly analyzed by using Euclidean distance and slope. After the analysis of all criteria, various suitability analysis is done by using weighted overlay tools. Before the overlay, data has been normalized by using reclassify tools. Influence of various criteria are given on basis of Analytic Hierarchy Process (AHP). The process of establishing influence using AHP method is described below.

AHP Rating Scale

Value - Interpretation

9 - Extreme Preference/ Importance A over B

7 - Very Strong Preference/Importance A over B

5 - Strong preference/importance A over B

3 - Moderate preference/importance A over B

1 - Equal preference/importance A and B

1/3 - Moderate preference/importance B over A

1/5 - Strong preference/importance B over A

1/7 - Very strong preference/importance B over A

1/9 - Extreme preference/importance B over A

Intermediate numerical ratings of 2, 4, 6, and 8 can be assigned. If someone could not decide whether one criterion (alternative) is moderately more important than the other one or strongly more important than the other one, 4 (moderately to strongly more important) can be assigned.

AHP method has some steps to be completed.

Step-1: Some criteria have to be defined and alternatives of these criteria has to be identified.

Step-2: Pair wise comparison has to be made and the relative importance between each pair of criteria and alternatives have to be rated. AHP uses 1-9 scale for the prioritization process.

	Slope	Road	Growth Center	Structure
Slope	1	7	9	3
Road	1/7	1	4	1/6
Growth Center	1/9	1/4	1	1/8
Structure	1/3	6	8	1
	1.587	14.250	22.000	4.292

Here, column sum has been determined to continue the synthetization.

Step-3: The results have to be synthesized to determine the best alternative. The final reults have to be obtained.

Slope	Road	Growth Center	Structure	Row Sum	Criteria Weight
0.630	0.491	0.409	0.699	2.229	0.557
0.090	0.070	0.182	0.039	0.381	0.095
0.070	0.018	0.045	0.029	0.162	0.041
0.210	0.421	0.364	0.233	1.228	0.307
					1.000

Here, row sum has been determined and then the row some has been multiplied into the initial importance values of criteria to determine the criteria weight. The sum of the weights should be 1.00.

The output of AHP is the set of priorities of the alternatives.

Now, it will be the matter of consistency to check.

Consistency Index= $[Lamda_{(max)} -n]/(n-1)$

Here, Lamda is the result of (weighted sum/criteria weight)

Lamda $_{(max)}$ is the average value of all criteria's Lamda

n= No. of criteria

Slope	Road	Growth Canter	Structure	Weighted Sum	Lamda
0.557	3.901	5.016	1.672	11.147	15.000
0.009	0.007	0.017	0.004	0.036	0.381
0.003	0.001	0.002	0.001	0.007	0.162
0.064	0.129	0.112	0.072	0.377	1.228
					4.193

Then the Consistency Index= (4.193-4)/ (4-1)

=0.064

If the no. of criteria is 4, the value of Random Consistency Index is 0.9

The Consistency Ratio=Consistency Index/ Random Consistency Index

=.0.064/0.9

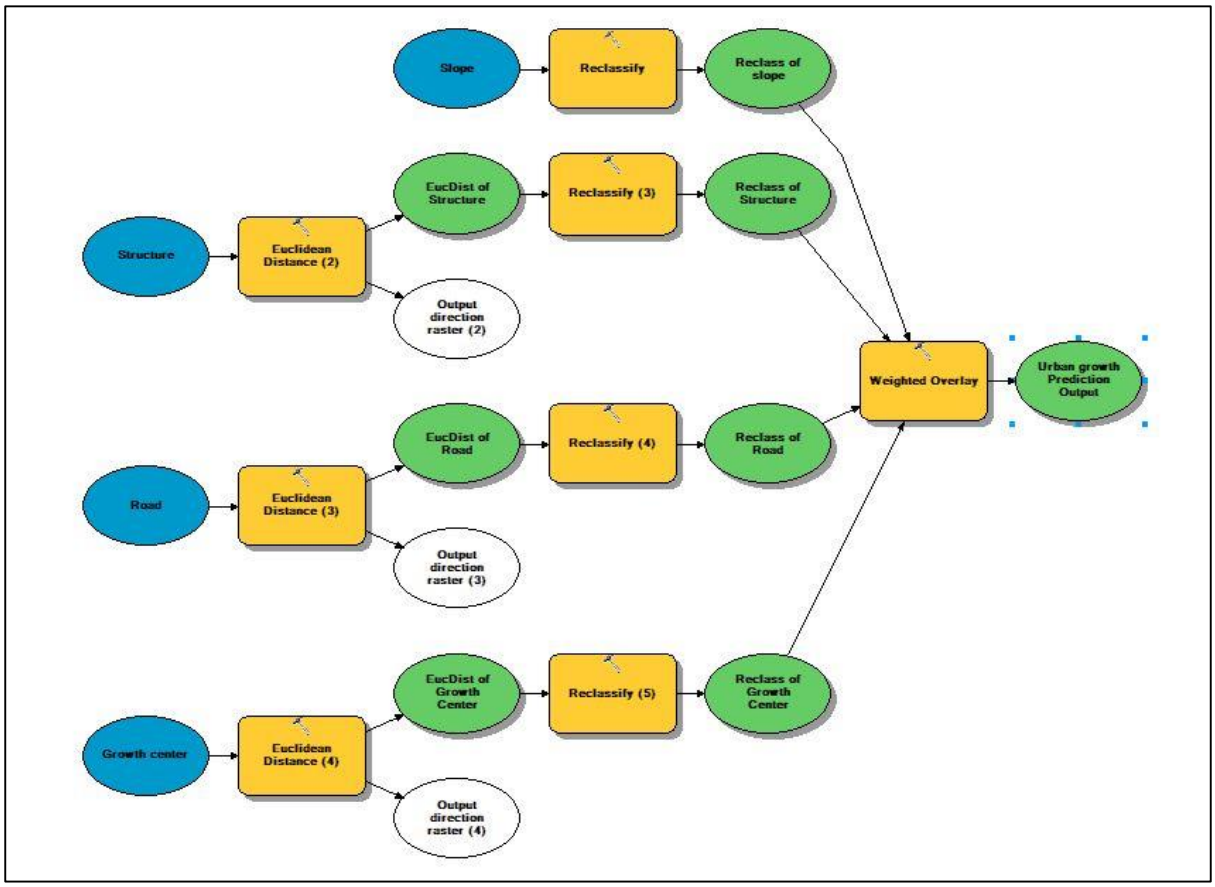
=0.071<0.1

If the Random Consistency Index value>0.1, it is inconsistent and if the Random Consistency Index value<0.1, it is consistent.

So, this model is consistent.

The output table after giving the rating is given below.

The weighted overlay table and model of different regionalization process is given below.



Chapter 4: Analysis and Findings

In this chapter, the future urban growth of Khulna City Corporation(KCC) is predicted using GIS analysis. Influence of various criteria are given on basis of Analytic Hierarchy Process (AHP). As we can notice that the existing urban growth is near the south-east portion of Khulna city corporation. In most cases roads and transportation facilities are highly enriched on that area and land topography is also suitable there. As a result, urbanization is increasing in full swing on those areas. On the contrary, future urban growth will also be on higher side there because usually urbanization process spreads out rapidly around established urban area where necessary urban life elements such as roads, transport, utility services etc. are better achievable.

4.1 Factors considered for future urban growth

The analysis is based on four factors, Major Urban Growth Center of KCC area, Existing Road of KCC, Existing settlement of KCC area and Existing Topographic condition of KCC.

Urban growth is an important part of detecting and predicting future urban scenario. Usually future urban growth take place around existing urban growth center and settlement. Moreover, transportation facilities also play a vital role for future urban growth. That is why we consider this factor also.

Topographic condition was also considerable because land topography is a vital part of urban growth. Usually flat topographic region is suitable for Urban Growth.

The major urban growth center of Khulna cities are Fulbarigate, Daulatpur, Notun Rasta, Boyra, Shib Bari, Dakbangla, Sonadanga etc. In most cases, rate of urban growth is high around those areas.
Existing road facilities is better on the southern side. Land topography is high on the south and pretty low on the north and peripheral areas. As a result, Urbanization is taken place at a slower rate in those places.

Another fact is that, most of the existing settlement is also on the southern side due to better road facilities and higher land topography.

4.2 Urban growth prediction for KCC Area

The following map shows a resemble of future urban growth prediction for KCC Area. On the map Light Blue color indicates the existing settlement, Red color indicates the future.

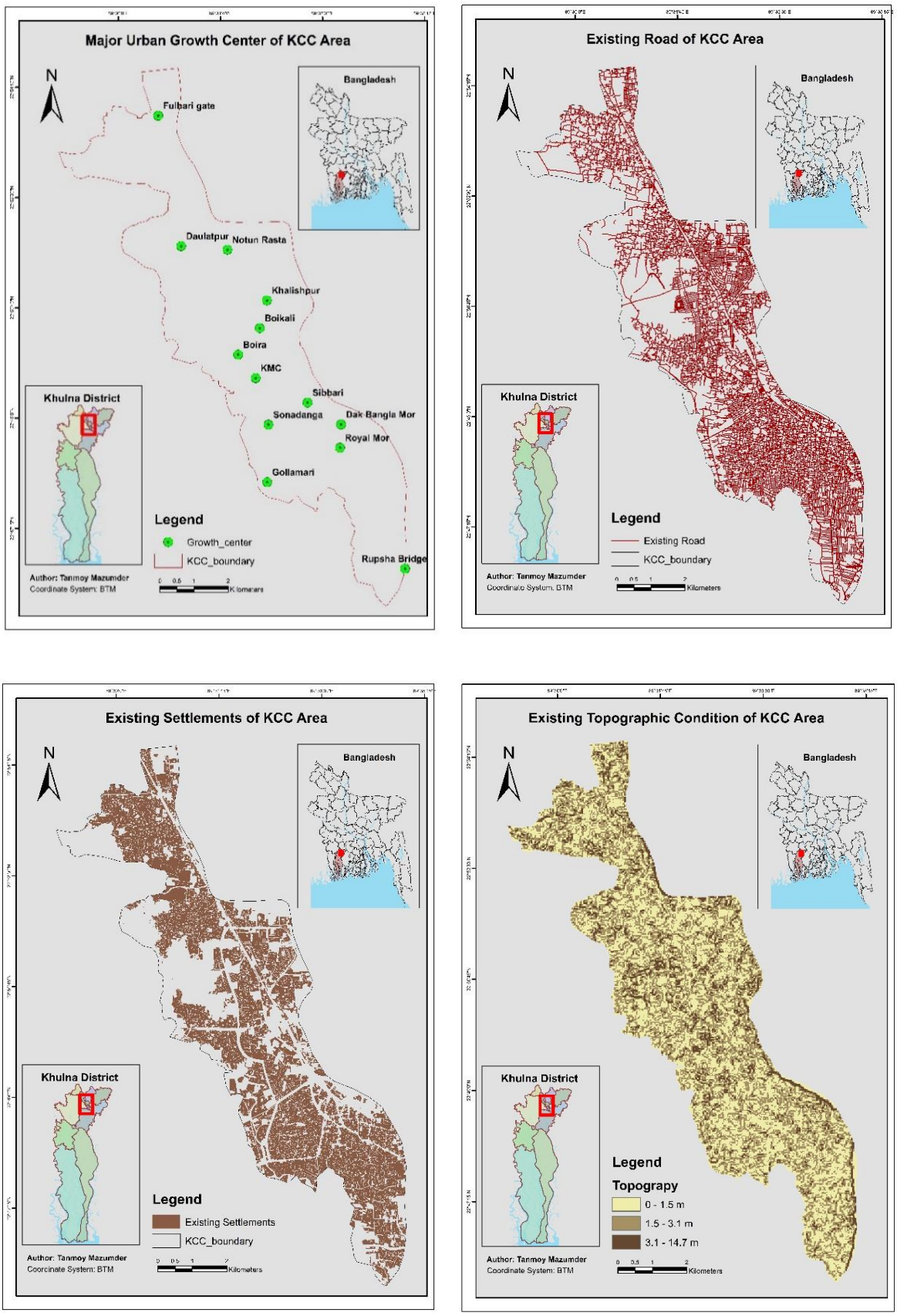


Figure 3: Map of all factors considered for urban growth prediction

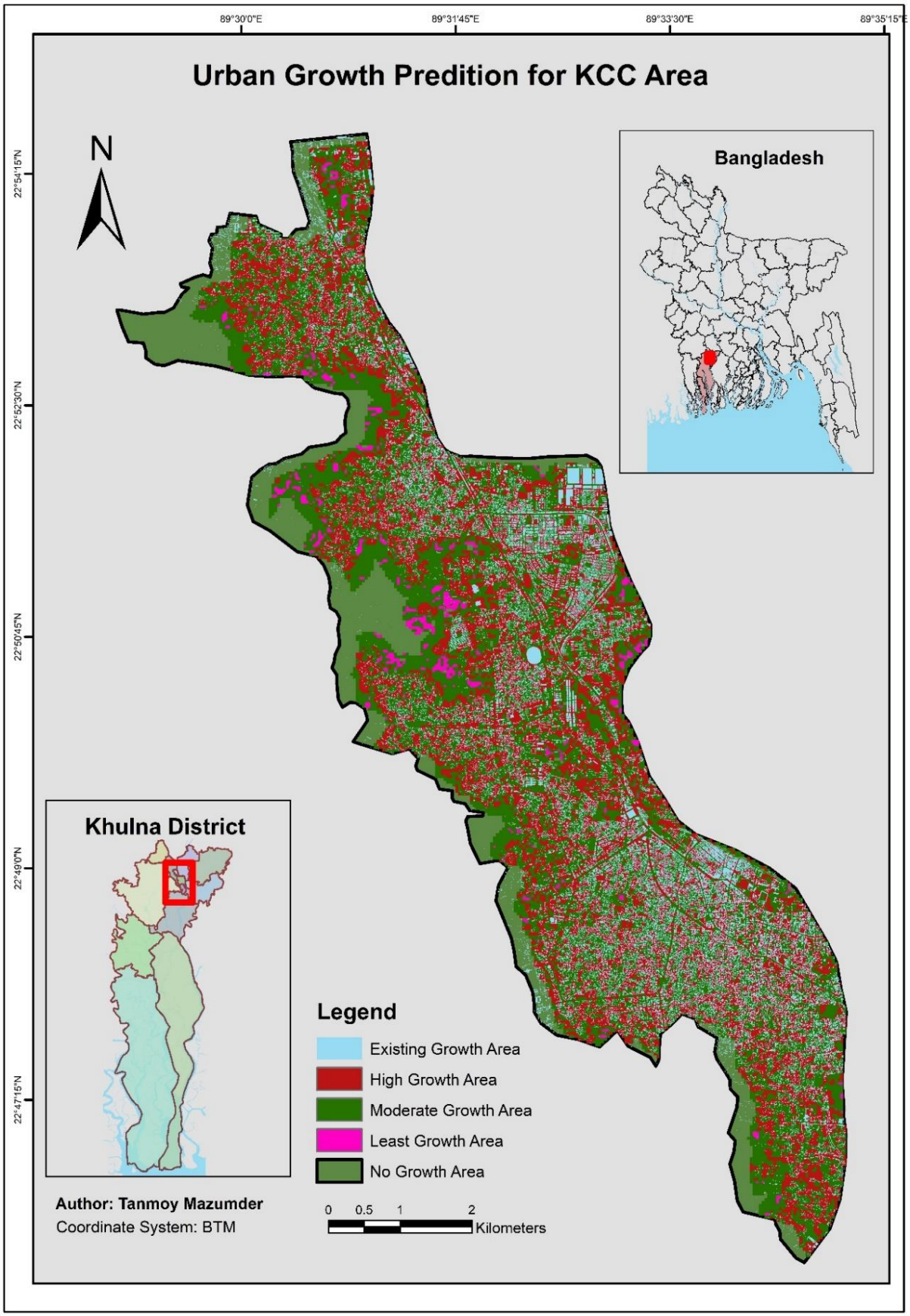


Figure 4: Urban growth prediction model of KCC area

Up growing area, bottle green marked area symbolizes moderately growing area and the pink marked area indicates very less growing area.

As we can notice that the existing urban growth is near the south-east portion of Khulna city corporation. In most cases roads and transportation facilities are highly enriched on that area and land topography is also suitable there. As a result, urbanization is increasing in full swing on those areas. On the contrary, future urban growth will also be on higher side there because usually urbanization process spreads out rapidly around established urban area where necessary urban life elements such as roads, transport, utility services etc. are better achievable.

On the other hand, north-west portion will be moderately urbanized. One of the reasons behind that is comparatively unsuitable topographic condition and transportation or road facilities. But there are lots of closed industries in that area, if those can be re-opened, urban growth on that area may get refueled.

There is another inspection from our map that, on the peripheral area where land topography is very low is unsuitable for future urban growth. At present, the periphery of kCC is using as agricultural land or vacant low land for fish cultivating. Due to low topographic condition and lack of transportation facilities there mayn't be any urban growth.

Chapter 05: Conclusion

Urban Growth is a major problem in the course of the urban development of the developing countries in the 21st century, most of the urban growth is considered to be the expansion of low density accompanied by a series of environmental and socio-economic issues. For supporting application modules and beginning gap by analyzing results from a survey investigating developer and user perceptions, many models have been created, like- logistic regression, fractal model, decision trees model, cellular automata model, AHP etc. AHP is an important model for the prediction of urban growth. Analytic Hierarchy Process is most useful where teams of people are working on complex problems, especially those with high stakes, involving human perceptions and judgments, whose resolutions have long-term repercussions. It has unique advantages when important elements of the decision are difficult to quantify or compare, or where communication among team members is impeded by their different specializations, terminologies, or perspectives. As we can notice that the existing urban growth is near the south-east portion of Khulna city corporation. In most cases roads and transportation facilities are highly enriched on that area and land topography is also suitable there. As a result, urbanization is increasing in full swing on those areas. On the contrary, future urban growth will also be on higher side there because usually urbanization process spreads out rapidly around established urban area where necessary urban life elements such as roads, transport, utility services etc. are better achievable.

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