

Spatial Analysis for Residential Development: A case of Tulsipur SMC

Sugam Gautam ^a, Ajay Chandra Lal ^b

^{a, b} Department of Architecture, Pulchowk Campus, IOE, Tribhuvan University, Nepal

✉ ^a sugam.gtm19@gmail.com, ^b ajay@ioe.edu.np

Abstract

This paper tries to analyze the suitability of residential area in Tulsipur SMC. Urbanization is shift in population from small rural settlements creating positive and negative impacts. Due to haphazard growth, problem is arising, so an intervention is clearly required. Residential area suitability analysis using GIS based MCA is the process to intervene and find the solution. Literature review and KII helped to determine the restriction and development criteria for the residential development. A final map from restriction criteria was made. Each development criterion was produced as a GIS map before being normalized to a scale in raster maps, with 1, 2, 3, 4 and 5 denoting highly, moderately, low, very low suitable and unsuitable, respectively. Hence a final raster equation was considered in GIS tool to generate a suitability map according to development criteria which was integrated to the restricted map through which a final suitability map for residential development was carried out. At the end, it was suggested that places with great potential for residential development, such as colonial homes, be approved, while those with lower potential might still be used for residential construction with certain restrictions. Similarly it was recommended that low dense community housing was more favorable than high rise apartment in the city due to cultural requirements and technological deficit.

Keywords

Suitability analysis, Residential development, Restriction factor, Development criteria, GIS

1. Introduction

Urban is defined in terms of the way of life of the people. However, urban areas and cities are spatial entities. Urbanization can be understood as shift in population from small rural settlements towards concentrated larger, dense urban settlements with surplus economy[1]. Rapid and uncontrolled urbanization and urban extension have created both positive and negative impacts on the urban residents. It is therefore essential to understand the level of impacts of urbanization on the land use change.[2] On one hand, urbanization drives the overall development of the economy, culture and society of the city. On the other hand, human activities related to urbanization are changing the structure. According to the United Nations, more than half (54%) of the world's population (4.2 billion people) currently live in cities, with this number expected to rise to 6 billion by 2041.[3] The reports from UN-DESA and Worldometers shows that the urban population percentage in Nepal has risen to 21.6% till date but as

per Preliminary CBS report with new structure of 753 local units in Nepal, this percentage has reached about 66% with a total urban population of 19,292,031. Also CBS reports in different decades suggests the population of Tulsipur sub metropolitan city was 83,748 in 1991 while it has increased to 141,528 in 2011. During the period of 1991-2001, the population growth rate was 3.28% and during 2001-2011 the growth rate decreased to 2.03% and the population growth rate was 2.77 during 2011-2021. As preliminary CBS report suggests the total population of Tulsipur SMC is 180,734. Developing countries have witnessed a rapid increase in urban population over last few decades.[4] This rapid speed of urbanization has led to uncontrolled urban development. Such physical change has occurred without considering various social, environmental and economic impacts. Growing cities of developing world like Nepal are trapped in the problems of unplanned sprawl. Same is the condition of Tulsipur SMC. The city core is designed at grid iron pattern with named streets. But as we move into the rural

parts, settlement is linear alongside the road. The agricultural fields have been converted into housing plots. Land prices have increased in city area so that people are forced to live at the outskirts of the city resulting the urban sprawl.

2. Need of the study

- Tulsipur SMC is one of the fast-growing cities of Nepal with growth rate of 2.77 as per census 2021.
- The haphazard and unmanaged development in Tulsipur SMC has already brought various problems in the city.
- If not intervened, this will only worsen and it will push a pattern of haphazard development.

3. Importance of the study

- Identification of the root causes of haphazard growth.
- To assist city authorities in integrating strategic tools to increase attractive residential neighborhoods.
- To address existing problems regarding land-use and suitable areas for residential development.

4. Problem Statement

Tulsipur, an emerging city of western Nepal, is going through rapid and unregulated urban growth. In recent decades, Tulsipur has observed unregulated shift in land-use, without certain policies. Over a period of time urbanization trend of leapfrog development can be seen at Tulsipur. The land has been acquired by the buildings in random manner for different purposes, mainly for residential development. As a result, an intervention is crucial, particularly in relation to residential activities. So, it is necessary to make local government and allied agencies aware of these facts, analyze them, and propose appropriate solutions in order to slow the city's progress toward unintended consequences. Hence, the study will be useful to the local government of Tulsipur Sub-Metropolitan City as well as new people looking for a suitable area/location for residential purpose.

5. Objectives

The main objective of the study is: - Identify, analyze and determine the areas suitable for residential development in Tulsipur SMC. The general research questions are as following:

- How is the urban expansion occurring in Tulsipur SMC?
- What governing factors determines the development suitability of residential areas?

6. Scope and Limitations

The research is limited to the Tulsipur-Sub metropolitan city. The criteria proposed for the analysis are entirely context based. As a result, the findings of my research may not apply to other regions. However, the findings might be extended to any place with a similar setting. The research is limited to Tulsipur's new municipal boundary.

7. Conceptual Framework and Methodology

Research paradigm is a way of describing a world view guided by certain philosophical assumptions about the nature of social reality (ontology), ways of knowing (epistemology) and science of obtaining that knowledge (methodology). Paradigm governs a belief about the nature of knowledge, a methodology and criteria for validity.[5] Ontological position describes what entities exist or are assumed to exist by the researcher. In Tulsipur, there has been an increasing trend of unplanned residential housing construction. As a result a greater influx of citizens from adjacent regions to the city's center areas, resulting in the loss of numerous valuable spaces such as open spaces, green space, and water bodies such as ponds. Hence, this will be the ontological position for my research. Epistemology is concerned with the study of knowledge, the acquisition of knowledge and the relationship between the researcher.[6] Software and spatial analysis tools such as GIS will be used to comprehend the problem and determine the solution, which will remain the epistemological position of my research. The context of the place influences the social reality of the research to some extent. It's possible that the answers won't apply to all spatially similar places. So, the research is based on the post-positivist paradigm and includes some

quantitative geographical data analysis utilizing GIS as a tool. The study uses deductive logic with a case study approach of Tulsipur city.

Methodological approach

The project will be mainly focused on creating a map that demonstrates the various degrees of suitability for residential development in Tulsipur SMC. This shall be carried out in the following four steps:

- Literature Review: Contextual identification of necessary development criteria and restriction criteria.
- Data Collection: Collection of appropriate geospatial dataset of those criteria in ESRI Shapefile format.
- Raster Overlay: The iso-distant buffers of different categories would be converted to raster images and appropriately overlaid on one another to create a composite that demonstrates the proximity to various amenities and suitable area for residential development within the boundary of Tulsipur SMC.

8. Literature Review

Residential areas are parts of a city that have been designated for homes. It can accommodate one or more families, apartments, houses, flats and private garages. The residential area is determined with the objective of increasing population density by developing settlements in a systematic manner. Although this area is designated for the construction of houses, other services, work opportunities linked to the settlement is permissible. The MCDM techniques are nowadays widely applied and used to solve various decision making, optimization and predictive problems.[7] At its core MCDA is useful for:

- Dividing the decision into smaller, more understandable parts
- Analyzing each part
- Integrating the parts to produce a meaningful solution

There are many MCDM methods developed over the years that vary from one another. Each of these methods is suitable for specific applications while others are not. Meng and Velasquez proposes a multi criteria decision analysis approach based on a Geographic Information System (GIS) for mapping

accessibility patterns of housing development sites in Canmore, Alberta [8][9]. In recent years, GIS based MCDA is widely used for site suitability analysis for natural resource management [10], solar energy plant [7], industrial site selection [11], agricultural land [12] and many more. The use of GIS and multi-criteria decision analysis methods for creating maps of residential development priorities in Tulsipur SMC is specifically highlighted in this study. The residential areas are moving to periphery areas in cities and as land being scarce and having economic value, it has become a pressing issue to find the best locations for residential housing scheme in Greater Matara Region.[13] Similar need has been realized in the case of Tulsipur SMC as well. Previously, site selection was nearly entirely dependent on economic and technical criteria. A higher level of sophistication is demanded nowadays. Siqing established five objectives for the selection of suitable areas in Bendigo [14]:

- A connected city: It considers sustainable transport and connectivity thus encouraging growth along transport corridors.
- A city of equality: It considers areas in proximity to education institutions and health services.
- An ecological city: It supports the protection of reserved forests and vegetation.
- A safe city: It encourages areas that are not vulnerable to threats and disasters.
- A compact city: It highlights the importance of proximity to existing resources, infrastructures and facilities in the urbanized core area.

As Tulsipur is one of the fastest growing city in Nepal, the immediate need of the city is to develop the housing in planned way in the form of residential development. The current unplanned city lacks open spaces, parks, outdoor recreational activities where conserving the agricultural land for the food sustainability should also be taken into account.[15] Selection criteria can be categorized into two group i.e. restricted criteria which restricts the development.

Constraints

- Forest
- River/ water bodies
- Airport and Open spaces
- Risk zones: Slope, Fault line

Development Factors

- Proximity to major roads
- Proximity to electricity and telecommunication
- Proximity to water supply
- Proximity to educational institutes
- Proximity to health institutes
- Proximity to market centers

9. Study Area

Tulsipur Sub-Metropolitan City (area-384.63 Sq. km) is located in Dang district in Lumbini Province. The Sub metropolitan city is surrounded by Ghorahi Sub-Metropolitan in the east, Dangisaran and Santinagar Rural Municipality in the west, Salyan and Rolpa district in the north and Lamahi municipality in the South direction. As per population census 2011, it is the second most populous city next to Ghorahi in Dang district. With an area of 384.63 km². The municipality is divided into 19 wards. Preliminary CBS report 2021 suggests the total population of Tulsipur SMC stood at 1, 80,734. Ward No. 5 is the densest ward with a densest ward with a density of 7190.12 persons/sq. km. Tulsipur has developed as one of the common hub for trading and commerce in the whole Dang district. The sub-metropolitan city has been the gateway town for Salyan District and other nearby Villages for decades. Tulsipur has developed as a common hub for trading and commerce in the Dang district. The only airport of the Dang district lies in Tulsipur city, commonly serving Salyan, Rukum and Rolpa, including adjacent rural municipalities and Ghorahi SMC. The life of people living in neighbouring municipalities and districts is directly associated with Tulsipur SMC for trade, health services, and other purposes.

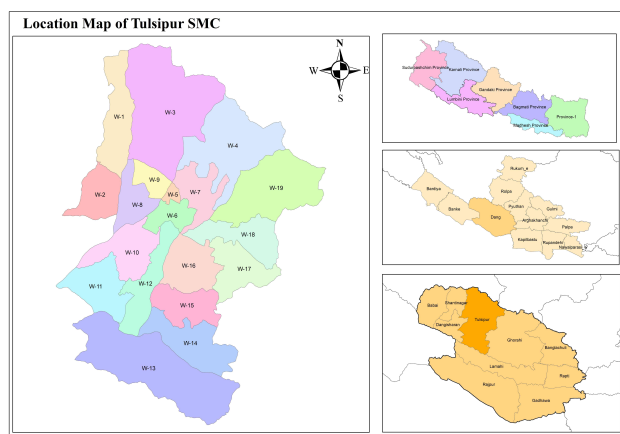


Figure 1: Study Area

10. Analysis and Findings

10.1 Existing Urban Expansion Pattern

Different literature was analysed from past to present to identify the main walkability indexes and indicators used in the framework. The analysis yielded five different indicators. Market places have been developed at the junction of highways. Ribbon development along the road is predominant in Tulsipur SMC. The development usually takes place along the main road and then along the roads connected to the main road. Built up change clearly shows much changes have happened since 2012. The land-cover of Tulsipur Sub-Metropolitan City is tabulated below. Almost 52% of area of Tulsipur Sub-Metropolitan City consists of cultivable land and 8% of total land is built-up. Tulsipur has 37% of forest. Settlements have spread in most parts of the municipality in a scattered pattern in plains. Agricultural land has been encroached by settlement. Similarly strip/ribbon development pattern can be witnessed along the major roads as well as urban roads.

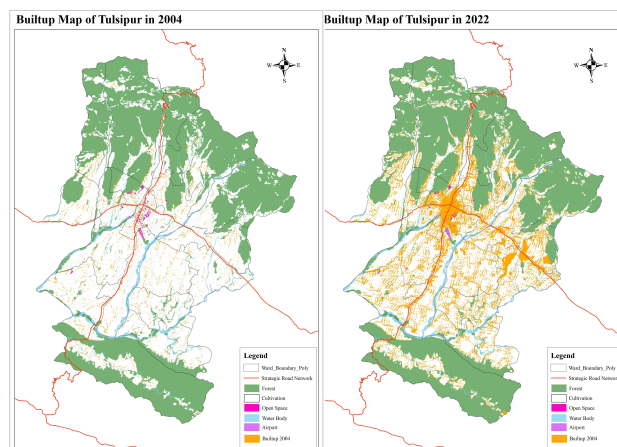


Figure 2: Built up Map of Tulsipur SMC

Tulsipur has developed as one of the common hubs for trading and commerce in the whole Dang district. Tulsipur Bazar is the major market center for many adjacent municipalities and even for district as a whole. The life of people living in adjacent municipalities and district is directly associated with Tulsipur Sub-Metropolitan City for trade, health, and other purposes. The dense network of roadways in most of the wards has made easier to access market goods and agricultural products for seller and consumers as well as with transporting goods and agro products from agricultural farms within the

Sub-Metropolitan City. There is a trend of rapid acquisition of agricultural land and its transformation into residential area.



Figure 3: Development pattern

Figure: 3(A) indicates Grid iron Pattern; Figure: 3(B) indicates Leapfrogged/scatter Development and Figure: 3(C) indicates Strip/ribbon development pattern.

The settlement pattern is shown where Figure: 4(A) indicates Small market center at Bijauri, Figure: 4(B) indicates Development in hills, Figure: 4(C) indicates Finger Development.

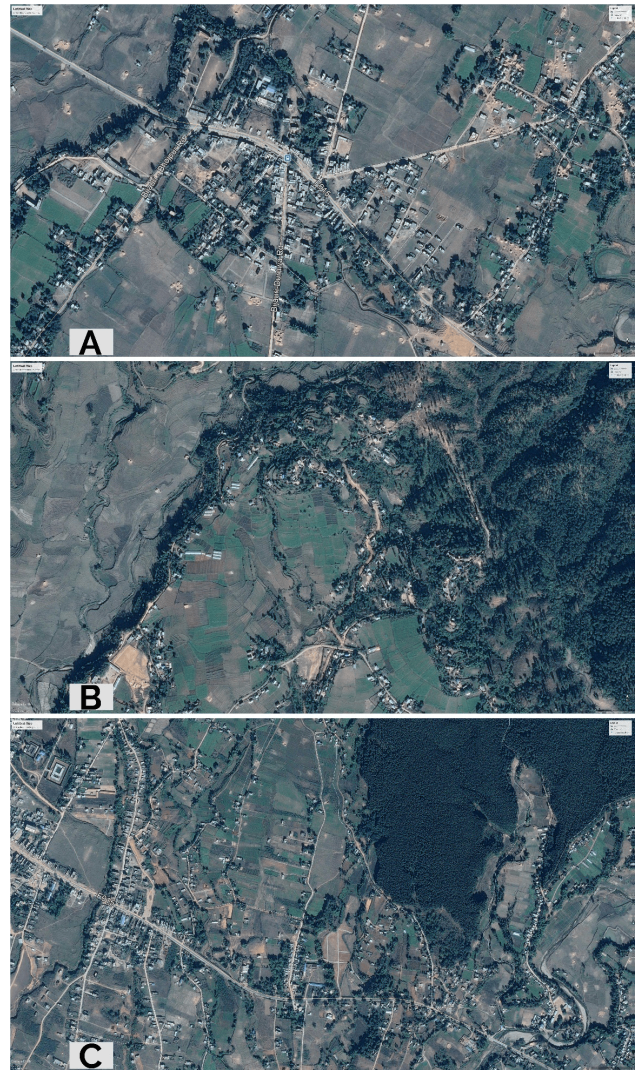


Figure 4: Settlement pattern

10.2 Building Permits of Municipality

The Building permit of Tulsipur SMC was recorded digitally only after the fiscal year 2077/78 B.S so the data before that are not available. The eBPS suggests in the fiscal year 2077/78 137 building permits were recorded, in 2078/79 541 building permits were recorded and in 2079/80 44 buildings has been recorded and still counting. Buildings are of different purposes like residential, commercial, mixed use but as per the data the residential building permits dominates. The above data suggest that the most dominating ward for building permits is ward no.6, followed by 7, 8, 9, 17, 18, and 19, respectively. The fewer building permit applied is at ward no. 14, 13, 3, 15 and 11. This shows the expansion is occurring near the market vicinity.

10.3 Development of Suitability Index and Maps

Following the interview, the criteria were determined, and the suitability ranges and indices were set in accordance with the various literature studies. Similar to this, each criterion has a range of suitability in absolute values. Therefore, all of the maps were converted to similar pixel values during GIS analysis so that they would all depict or function at the same scale. As a result, the study used the pixel values listed below to represent various appropriateness ranges across all of our maps. Hence using GIS as an analysis tool, above mentioned criteria were generated in the form of raster maps in which all had discrete pixel values from 0 to 4 representing highly suitable to very low suitable and restricted areas respectively.

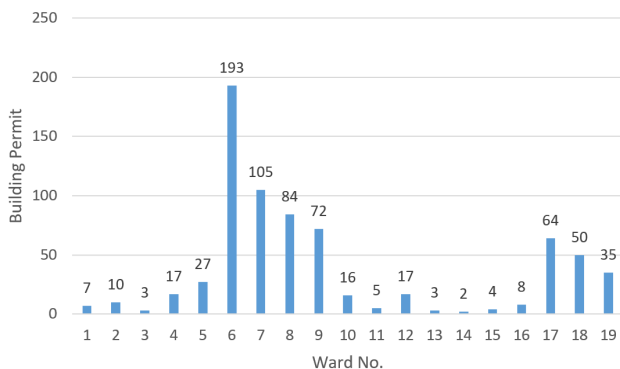


Figure 5: Building permits

S. N	Criteria	Pixel Value Assign				
		1=High Suitable	2=Moderate ly suitable	3=Low Suitable	4=Very Low Suitable	5=Restricted
Connected City						
1	Proximity to Major Roads	0-250m	251-500m	501-750m	751-1000m	> 1000m
2	Proximity to Water Supply Network	0-250m	251-500m	501-750m	751-1000m	> 1000m
3	Proximity to Electricity Line Network	0-250m	251-500m	501-750m	751-1000m	> 1000m
4	Proximity to Telecommunication	0-250m	251-500m	501-750m	751-1000m	> 1000m
City of Equality						
5	Proximity to Primary School	0-200m	200-400m	400-600m	600-800m	>800m
6	Proximity to Secondary School	0-500m	500-1000m	1000-1500m	1500-2000m	>2000m
7	Proximity to College/University	0-700m	701-1500m	1501-2300m	2301-3000m	>3000
8	Proximity from Health Post	0-500m	500-1000m	1000-1500m	1500-2000m	>2000m
9	Proximity to Hospitals	0-700m	701-1500m	1501-2300m	2301-3000m	>3000
Compact City						
10	Proximity to urban centers	0-2000m	2001-4000m	4001-6000m	6000-8000m	>8000m
Ecological City						
11	Forest/ Water bodies					Restricted
Safe City						
12	Slope				<30 degree	>30 degree
13	Fault Line	Other than buffer zone of the fault line				20m from the fault line

Figure 6: Suitability ranges and index

11. Discussion and Conclusion

The outcomes of the residential land suitability analysis were situation-based. Only appropriate selection criteria were used in the analysis. These criteria were broadly classified into their major categories namely safe city, ecological city, compact city, city of equality and connected city. The major discussion occurs on why was the highly suitable area determined less. It was because an area can't have equal accessibility to every urban amenities and safe from the restriction criteria as well. The data shows only 0.15% of total area is highly suitable, 5.71% moderate suitable, 16.24% low suitable and 26.19% very low suitable for residential development in the city as per development criteria adopted for the study. About 51.71% area resulted to be unsuitable/restricted lying in peripheral region of the city.

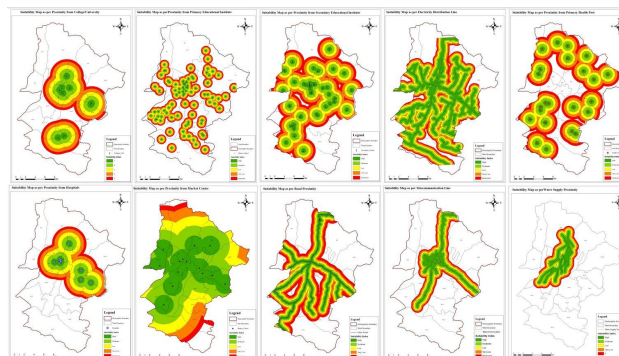


Figure 7: Suitability map of urban amenities

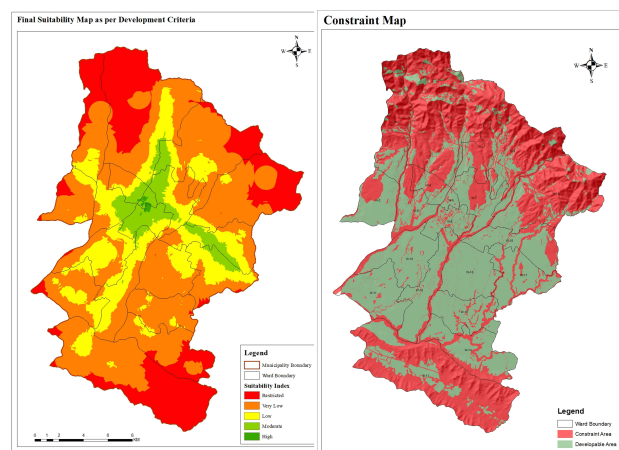


Figure 8: Suitability map as per Development criteria and Constraint

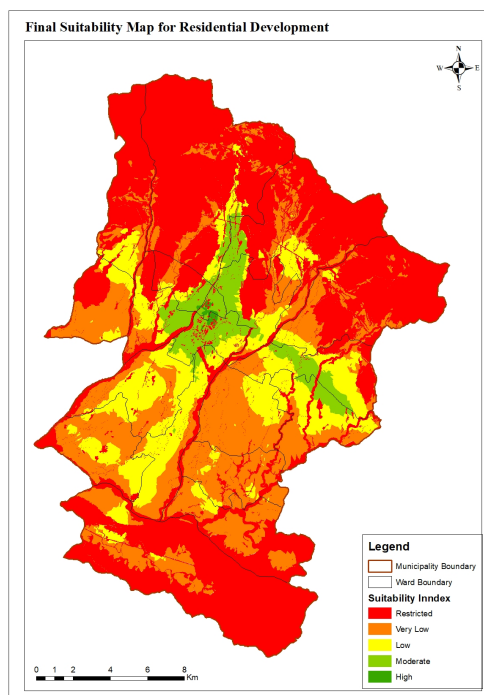


Figure 9: Suitability map for Residential Development

12. Recommendation

Planners and Policy makers can utilize the results as well as method of this study in many ways. This method is highly preferable for the site suitability analysis in international context. The results of my study can be utilized by policy makers in developing policies regulating land uses in the city. The areas within highly suitable can be used for complete residential activities like colony housing where only residential activities will be allowed. Similarly, area lying in moderately suitable region can be permitted for residential development mixed with commercial activities. Similarly, some incentive can be given for the houses to be built in the designated residential area where as discouraging policies like increase in tax, delay in development of urban facilities could be done in the unsuitable area. Also these considerations can be taken,

- Suitable area having more building permits needs no interventions.
- Unsuitable area having more building permits should be discouraged.
- Suitable area having less building permits should be motivated for infill development.
- Unsuitable area having less building permits must be restricted and can be used for other purposes.

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