



TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS

A THESIS REPORT ON
SPATIAL ANALYSIS FOR RESIDENTIAL DEVELOPMENT: A CASE OF
TULSIPUR SMC

BY
SUGAM GAUTAM
076/MSUrP/019

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE IN PARTIAL
FULFILLMENT OF THE REQUIREMENT FOR
DEGREE OF MASTER OF SCIENCE IN URBAN PLANNING

DEPARTMENT OF ARCHITECTURE
LALITPUR, NEPAL

SEPTEMBER, 2022

COPYRIGHT

The author has agreed that the library, Department of Architecture, Pulchowk Campus, Institute of Engineering may take this report freely available for inspection. Moreover, the author has agreed that permission for extensive copying of this project report for scholarly purpose may be granted by the professor who supervised the project work recorded herein or, in their absence, by the Head of the Department wherein the project report was done. It is understood that the recognition will be given to the author of this report and to the Department of Architecture and Urban Planning, Pulchowk Campus, Institute of Engineering in any use of the material of this project report. Copying or publication or the other use of this report for financial gain without approval of the Department of Architecture, Pulchowk Campus, Institute of Engineering, and author's written permission is prohibited.

Request for permission to copy or make any other use of the material in this report in whole or in part should be addressed to:

Head

Department of Architecture

Pulchowk Campus, Institute of Engineering

Lalitpur, Nepal

CERTIFICATE OF THESIS APPROVAL

This is to certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis report titled "**Spatial Analysis for Residential Development : A Case of Tulsipur SMC**" submitted by **Mr. Sugam Gautam (076-MSUrP-019)** in the partial fulfillment of the requirements for the degree of **Masters of Science in Urban Planning**.

Supervisor / Program Coordinator

Dr. Ajay Chandra Lal

Department of Architecture

IOE, Pulchowk Campus

External Examiner

Er. Kishore K. Jha

Senior Urban Planner

External Examiner

Ar. Yek Raj Adhikari

Joint Secretary (MOUD)

Date: 21st September, 2022

DECLARATION

I declare that this dissertation has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature for any degree. I state that this dissertation is result of my own independent work/investigation, except where otherwise stated. I, hereby, give my consent for my dissertation, if accepted, to be available for photocopying and understand that any reference to or quotation from my thesis will receive an acknowledgement.

.....

Sugam Gautam

076/MSUrP/019

September, 2022

ABSTRACT

This paper tries to analyze the suitability of residential areas in Tulsipur SMC. Urbanization is a shift in population from small rural settlements creating positive and negative impacts. The haphazard and unmanaged development in Tulsipur has brought about various problems in the city. If not intervened, this will only worsen. In recent decades, Tulsipur has observed unregulated shift in land-use, without certain policies. The unguided informal land development led by private land owners, a common practice, has aided in building construction purpose in random way. As a result, an intervention is crucial. Residential area suitability analysis using GIS based MCA is the process of finding 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, Hence a final raster equation was given in the GIS tool to generate a final suitability map according to development criteria which were integrated into the restricted map through which a final suitability map for residential development was carried out. In 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 favourable than high-rise apartments in the city due to cultural requirements and technological deficits.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my thesis supervisor Prof. Dr. Ajay Chandra Lal for his guidance in carrying out necessary studies and research work in preparation of this thesis report.

I am highly obliged to external jurors Kishor Kumar Jha, Yek Raj Adhikari for constantly guiding my work throughout different phases of presentations and helping me to be where I am.

I would also like to extend my profound gratitude to all the jury members of my presentation Dr. Kirti Kusum Joshi, Dr. Inu Pradhan Shalike for their valuable comments and suggestion and also to all the teachers of the department for their sincere teaching, intellectual help and encouragement.

I am also grateful to Ar. Aashish Shamsher Rana , Ar. Pukar Bhandari, Ar. Amir Duwadi, Ar. Achyut Bikram Thapa, Ar. Gaurav Nepal, Er. Dakshina Basnet, Er. Prabesh Ghimire, Ar. Rojina Shrestha, Er. Aashish Adhikari and Mr. Sulav Gautam for their encouragement and help during this thesis.

I would also like to thank my family and colleagues for directly or indirectly helping in the preparation of this thesis report.

ACRONYMS

AD: Anno Domini

ADSS: All Dilated Support System

AHP: Analytical Hierarchical Process

BC: Before Christ

CBD: Central Business District

CBS: Central Bureau of Statistics

DUDBC: Department of Urban Development and Building Construction

eBPS: Electronic Building Permit system

E.D: Executive Director

FAR: Floor Area Ratio

GIS: Geographic Information System

MCA: Multi Criteria Analysis

MCDM: Multi Criteria Decision Making

MCE: Multi-Criteria Evaluation

M.D: Managing Directo

MNSG: Malmesbury Neighborhood Steering Group

SMC: Sub Metropolitan City

UN DESA: United Nations Department of Economic and Social Affairs

UGF: Underground Fiber

VDC: Village Development Committee

TABLE OF CONTENTS

CERTIFICATE OF THESIS APPROVAL	ii
DECLARATION	iii
ABSTRACT.....	iv
ACRONYMS.....	vi
TABLE OF CONTENTS.....	vii
LIST OF TABLES.....	x
LIST OF FIGURES	xi
CHAPTER 1: INTRODUCTION	1
1.1 Background.....	1
1.1.1. Urbanization and Growth Trends in Nepal.....	1
1.1.2. Impact of Urbanization	4
1.2 Need of the research.....	5
1.3 Importance of the research.....	5
1.4 Problem Statement	6
1.5 Objectives	10
1.6 Scope and Limitations.....	10
CHAPTER 2: CONCEPTUAL FRAMEWORK AND METHODOLOGY	11
2.1 Research methodology.....	11
2.2 Methods	15
2.2.1. Literature Review.....	15
2.2.2. Data Collection	15
2.2.3. Data Analysis and Results.....	15
CHAPTER 3: LITERATURE REVIEW	17
3.1 Residential Area.....	17
3.2 Multi Criteria Decision Making (MCDM).....	18
3.3 GIS-Based MCA and Past Approaches	19

3.4	Site Selection Criteria	21
3.4.1.	Constraints.....	23
3.4.2.	Development Factors.....	26
3.5	Policy Review	30
	Local Government Operation Act, 2074	30
	Housing Act, 2074	31
	Land Acquisition, Rehabilitation and Resettlement Policy.....	31
	Land Use Act 2019.....	32
	KMC Heritage Home	32
	International Context.....	33
CHAPTER 4: STUDY AREA		34
4.1	Location	34
4.2	Demography.....	36
4.3	Regional Settings	37
CHAPTER 5: DATA COLLECTION		39
5.1	Primary Data Collection: Interview with the Experts and Questionnaire survey	39
5.2	Secondary Data Collection	41
CHAPTER 6: ANALYSIS AND FINDINGS		46
6.1	Existing Urban Expansion Pattern	46
6.2	Criteria for suitable residential development	54
6.3	Development of Suitability Index and Maps	56
6.4	Determination of Final Suitability Map	70
CHAPTER 7: DISCUSSION, CONCLUSION AND RECOMMENDATION		74
7.1	Discussion and Conclusion	74
7.2	Policy Interventions	76
7.3	Recommendation from the study	77
7.4	Recommendation for further studies.....	78

REFERENCES	80
ANNEX-A: QUESTIONNAIRE FOR EXPERTS' INTERVIEW	84
ANNEX-B: SITE PHOTOGRAPHS.....	88
ANNEX-C: COMMENTS	90
ANNEX-D: IOE GRADUATE CONFERENCE	91

LIST OF TABLES

<i>Table 1 Rural-Urban Population.....</i>	<i>2</i>
<i>Table 2 Population of Tulsipur SMC in different years.....</i>	<i>3</i>
<i>Table 3 Factors for residential development</i>	<i>22</i>
<i>Table 4 Upgraded ward of Tulsipur Sub Metropolitan City.....</i>	<i>35</i>
<i>Table 5 Ward-wise Population Distribution of Tulsipur Sub-Metropolitan City</i>	<i>36</i>
<i>Table 6 Secondary data, Data type and Data sources.....</i>	<i>42</i>
<i>Table 7 Existing Landcover of Tulsipur SMC.....</i>	<i>50</i>
<i>Table 8 Ward wise building permits record.....</i>	<i>53</i>
<i>Table 9 Total applications in different fiscal years.</i>	<i>54</i>
<i>Table 10 Input data for residential development suitability.</i>	<i>56</i>
<i>Table 11 Criteria and Assigned pixel value range.</i>	<i>57</i>
<i>Table 12 Restricted and Developable area of Tulsipur SMC</i>	<i>59</i>
<i>Table 13 Percentage area distribution for major road proximity suitability</i>	<i>60</i>
<i>Table 14 Percentage area distribution for water supply network</i>	<i>61</i>
<i>Table 15 Percentage area distribution for electric distribution line</i>	<i>62</i>
<i>Table 16 Percentage area distribution for telecommunication network.....</i>	<i>63</i>
<i>Table 17 Percentage area distribution for primary educational institutes.....</i>	<i>64</i>
<i>Table 18 Percentage area distribution for secondary educational institutes</i>	<i>65</i>
<i>Table 19 Percentage area distribution for college/university</i>	<i>66</i>
<i>Table 20 Percentage area distribution for health post</i>	<i>67</i>
<i>Table 21 Percentage area distribution for hospital.....</i>	<i>68</i>
<i>Table 22 Percentage area distribution for market centre proximity</i>	<i>69</i>
<i>Table 23 Percentage distribution of area for suitability map as per development criteria</i>	<i>71</i>
<i>Table 24 : Percentage distribution of area for final suitability map</i>	<i>73</i>

LIST OF FIGURES

<i>Figure 1 Built up Map of Tulsipur SMC</i>	<i>7</i>
<i>Figure 2 Google Image of Birendra Chowk, Tulsipur in 2004.....</i>	<i>8</i>
<i>Figure 3 Google Image of Birendra Chowk, Tulsipur in 2012.....</i>	<i>8</i>
<i>Figure 4 Google Image of Birendra Chowk, Tulsipur in 2016.....</i>	<i>9</i>
<i>Figure 5 Google Image of Birendra Chowk, Tulsipur in 2020.....</i>	<i>9</i>
<i>Figure 6 Flow diagram of MCDA (Eastman et al., 1991)</i>	<i>19</i>
<i>Figure 7 Integrated GIS / MCDA approach</i>	<i>20</i>
<i>Figure 8 Defination of Risk.....</i>	<i>25</i>
<i>Figure 9 Location Map of Tulsipur SMC.....</i>	<i>34</i>
<i>Figure 10 Inter Connectivity of Tulsipur SMC</i>	<i>38</i>
<i>Figure 11 Educational Institute Map.....</i>	<i>44</i>
<i>Figure 12 Road Network Map of Tulsipur SMC.....</i>	<i>44</i>
<i>Figure 13 Landuse Map of Tulsipur SMC</i>	<i>44</i>
<i>Figure 14 Electricity Distribution Line Network Map.....</i>	<i>45</i>
<i>Figure 15 Market Center Map</i>	<i>45</i>
<i>Figure 16 Health Institute Map</i>	<i>45</i>
<i>Figure 17 Built-up Map of Tulsipur SMC in 2004.....</i>	<i>47</i>
<i>Figure 18 Built-Up Map of Tulsipur SMC in 2013.....</i>	<i>48</i>
<i>Figure 19 Built-Up Map of Tulsipur SMC in 2022.....</i>	<i>49</i>
<i>Figure 20 Settlement Pattern (A: Grid iron Pattern; B: Leapfrogged/scatter Development; C: Strip/ribbon development pattern).....</i>	<i>51</i>
<i>Figure 21 Settlement Pattern (A: Small market centre at bijauri, B: Development in hills, C: Finger Development)</i>	<i>52</i>
<i>Figure 22 Bar chart of ward wise application.....</i>	<i>54</i>
<i>Figure 23 Slope Map of Tulsipur SMC.....</i>	<i>58</i>
<i>Figure 24 Land Suitability in terms of Slope</i>	<i>58</i>
<i>Figure 25 Land suitability in terms of Landuse</i>	<i>58</i>

<i>Figure 26 Final Constraint Map.....</i>	<i>59</i>
<i>Figure 27 Suitability map as per proximity to major roads.....</i>	<i>60</i>
<i>Figure 28 Suitability map as per proximity to water supply network.....</i>	<i>61</i>
<i>Figure 29 Suitability map as per proximity to electric distribution line.....</i>	<i>62</i>
<i>Figure 30 Suitability map as per proximity to telecommunication network.....</i>	<i>63</i>
<i>Figure 31 Suitability map as per proximity to primary educational institutes.....</i>	<i>64</i>
<i>Figure 32 Suitability map as per proximity to secondary educational institute.....</i>	<i>65</i>
<i>Figure 33 Suitability map as per proximity to college/university.....</i>	<i>66</i>
<i>Figure 34 Suitability map as per proximity to the health post.....</i>	<i>67</i>
<i>Figure 35 Suitability map as per proximity to hospital.....</i>	<i>68</i>
<i>Figure 36 Suitability map as per proximity to the market centre.....</i>	<i>69</i>
<i>Figure 37 Final Suitability Map as per Development Criteria.....</i>	<i>70</i>
<i>Figure 38 Pie chart representation for suitability index as per development criteria.....</i>	<i>71</i>
<i>Figure 39 Final Suitability Map for Residential Development in Tulsipur SMC.....</i>	<i>72</i>
<i>Figure 40 Pie chart representation for final suitability.....</i>	<i>73</i>
<i>Figure 41 Interview with Consultant Er. Santosh Bhattraï.....</i>	<i>88</i>
<i>Figure 42 Interview with Land Revenue Officer Mr. Khem Raj Sharma.....</i>	<i>88</i>
<i>Figure 43 Interview with head of DUDBC Dang, Er. Khadak Bahadur Chaudhary.....</i>	<i>88</i>
<i>Figure 44 Interview with Mayor of Tulsipur SMC Mr. Tika ram Khadka.....</i>	<i>88</i>
<i>Figure 45 Interview with NTC officer Er. Suresh Bhandari.....</i>	<i>89</i>
<i>Figure 46 Interview with Mr. Yam Kanta Bhandari, Chairperson of Tulsipur Watersupply.....</i>	<i>89</i>

CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1. Urbanization and Growth Trends in Nepal

Urban is defined in terms of the way of life of the people. However, urban areas and cities are spatial entities. They are characterized by high population density, infrastructure, and built environment. The process of urbanization, or "urban transition", describes a shift in population from one that is dispersed across small rural settlements with sufficient economy to the area where the population is concentrated in larger, dense urban settlements with a surplus economy (*United Nations, 2014*). Industrial and service activities basically characterize a surplus economy. Urbanization mainly refers to the expansion of urban built-up areas that change the existing ecosystem's process and structure and significantly affect the ecosystem's ability to provide services to people (*Yang et al., 2020*).

Rapid and uncontrolled urbanization and urban extension have positively and negatively impacted urban residents. The physical and environmental problems have also intensified due to the current trend as cities have become more prominent than ever. Urbanization is a complex spatial process that converts land from rural uses to urban uses and impacts the structure, function and dynamics of ecosystems, as well as the livelihoods of humans. A significant movement of people from rural to urban areas, and the physical changes that result, is referred to as urbanization. According to the United Nations, more than half (54%) of the world's population (4.2 billion people) presently lives in cities, with this number expected to rise to 6 billion by 2041 (*Kuddus et al., 2020*). Urban planning is concerned with land use development and planning at different levels on a city scale over time. The global community has been urbanizing at a rapid pace in recent years. This is evident in the context of Nepal as well.

The land is a valuable natural resource that benefits everyone. It is a scarce resource, particularly in cities. Zoning is a planning control tool which divides the land to ensure its complementary uses. The word "land use" represents the human use of land. Zoning can be characterized into four types, i.e. functional zoning, form-based zoning, intensity zoning and incentive zoning. Statistical analysis based on patterns and underlying processes is known as spatial analysis. Location analysis is a type of geographical analysis that elucidates patterns of human attributes and spatial appearance in geo statistics and geometrics. Site suitability analysis determines a spatial pattern for future land uses based on specific needs and preferences. In Nepal, urbanization is dominated by a few major and midsize cities, with an

overabundance of people concentrated in the Kathmandu Valley. The distribution of the urban population is uneven across the country.

In Nepal, the number of urban areas in the country has been small compared to the neighbouring countries. At the time of the first scientific population census in 1952/54, only ten urban areas were recognized, with an aggregate population of 238275. In July 2011, 72 additional municipalities were added, bringing the total number of municipalities to 133. The percentage of urban population has increased as the number of municipalities has increased from 133 to 191, then to 217, and now to 293 municipalities. Tulsipur was upgraded to Sub-Metropolitan City from a municipality like many other urban areas. The land is a valuable natural resource that benefits everyone. It is a scarce resource, particularly in cities. Zoning is a planning control tool which divides the land to ensure its complementary uses. The word "land use" represents the human use of land. Zoning can be characterized into four types, i.e. functional zoning, form-based zoning, intensity zoning and incentive zoning. Statistical analysis based on patterns and underlying processes is known as spatial analysis. Location analysis is a geographical analysis that elucidates patterns of human attributes and spatial appearance in geo statistics and geometrics. Site suitability analysis determines a spatial pattern for future land uses based on specific needs and preferences. In Nepal, urbanization is dominated by a few major and midsize cities, with an overabundance of people concentrated in the Kathmandu Valley. The distribution of the urban population is uneven across the country.

Table 1 Rural-Urban Population

Area	2068 B.S				2078 B.S	
	Population (Before Federal Structure)	Percentage (%)	Population (After Federal Structure)	Percentage (%)	Population	Percentage (%)
Urban	4,523,820	17.07	16,740,732	63.19	19,292,031	66.08
Rural	21,970,684	82.93	9,753,772	36.81	9,901,449	33.92
Nepal	26,494,504	100	26,494,504	100	291,922,480	100

The reports from UN-DESA and Worldometers show that the urban population percentage in Nepal has risen to 21.6% today. Still, per a Preliminary CBS report with a new structure of 753 local units in Nepal, this percentage has reached about 66%, with a total urban population of 19,292,031 today.

Although the context and applicability of the agenda vary with the morphology of cities that are different in different parts of the world, different cities across the world, such as Melbourne, Barcelona, Stockholm, etc., have been trying to incorporate the concept into their planning to create a more sustainable future. On a similar note, Tulsipur SMC might need to work on an index of its own, which is focused on measuring the connectivity of basic needs and amenities to the residents and housing areas. The population density of Tulsipur is 370/km² (higher than the Dang district density, 185 / km²). Interconnectedness to the capital city & many other cities, abundant resources, infrastructure development and pleasant climate accounts for its higher population density. The population density of Tulsipur SMC has increased from 300 / km² (2001) to 370 / km² (2011) within a decade. According to Population and Housing Census-2011 Database, CBS, 2014, 80.3 % of the population is originally from the Tulsipur Sub-Metropolitan city, while 19.7 % of the population has migrated to Tulsipur from other places.

Table 2 Population of Tulsipur SMC in different years.

S.N	VDC's	Years			
		1991	2001	2011	2021
1	Bijauri	9729	12064	13922	Final CBS report yet to be published
2	Duruwa	9721	13006	12979	
3	Halwar	8182	8754	10068	
4	Manpur	9962	12951	14864	
5	Pawannagar	11428	8270	8673	
6	Phulbari	4452	5446	5489	
7	Tarigaun	7685	10123	11135	
8	Tulsipur	13815	33876	51537	
9	Urhahari	8764	11269	12861	
TOTAL		83738	115759	141528	1, 80,734

The population of Tulsipur sub-metropolitan city was 83,748 in 1991, while it increased to 141,528 in 2011. From 1991 to 2001, the population growth rate was 3.28%, and during 2001-2011, the growth rate decreased to 2.03%, whereas the population growth rate was 2.77 during 2011-2021 as preliminary CBS report suggests the total population of Tulsipur SMC 180.

1.1.2. Impact of Urbanization

Urbanization often leads to population density increment where increased aggressive behaviour, disruption of normal mating, nesting, and maternal activities, and greater rates of disease and death can be the consequences. These trends could bring opportunities for economic and social development. However, at the same time, they can pose unintended food security, public health, and environmental risks (*Acosta & De los Santos-Montero, 2019*). Developing countries have witnessed a rapid increase in urban population over the last few decades (*Shirkhanloo, 2013*). This rapid speed of urbanization has led to uncontrolled urban development. Such physical change has occurred without considering various social, environmental, and economic impacts. Sprawling development and ever-expanding urban areas are the major phenomena. This phenomenon has been the primary concern faced by cities in developing countries. This has resulted in rapid urban growth haphazardly, and the planning approaches have not been able to address the problems. Because of changing administrative structure and lack of resources and capacity, Implementation of planning projects has been unsuccessful. Such is the condition of urbanization and population growth in Nepal.

Growing cities in the developing world like Nepal are trapped in the problems of unplanned sprawl. It is caused due to the spontaneous growth of urban regions. The same is the condition of Tulsipur SMC. Despite various land use inefficiency, environmental problems, and the decline of agricultural land, negligence towards this phenomenon persists. Urbanization frequently needs the acquisition of suitable land for engineering construction. Land use transformation from non-urban to urban services is usually always involved as a part of urbanization. Rapid urbanization has led to extensive land use change, particularly in developing countries. In line with the development of urbanization, arable land is decreasing dramatically, which presents a threat to the food security of human beings. It is, therefore essential to understand the level of impacts of urbanization on land use change (*Wu et al., 2011*). On the one hand, urbanization drives the overall development of the city's economy, culture, and society. On the other hand, human activities related to urbanization are changing the structure (*Yang et al., 2020*).

Tulsipur is one of Terai's rapidly developing municipalities, and the urban form is also constantly changing. The urban structure of Tulsipur SMC changes as we move further into the municipality. The city core is designed with iron grid 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 the city area as a result people

tend to live outside of the core areas. The core area, which was designed in iron grid pattern has helped to ease the navigation inside the municipality. The City area has not changed a lot recently because of the lack of vacant plots. The linear development in rural areas needs to be controlled by the municipality. Urban sprawl will only add externalities to the development of the municipality. Small market areas like Bijauri and Beljhundi can be developed as towns. The compact settlement must be promoted in new towns keeping the agricultural areas intact as much as possible. City core shows a tendency of people to live in a compact settlement at the junction of two or more roads. Roads have led to a linear growth pattern of built-up areas (esp. along the Tulsipur-Lamahi road section). More recent trends show increasing linear growth more than compact development. Increasing traffic flow and the development of commercial activities can be attributed to such a pattern. N-S Rapti highway is also another prominent axis showing linear growth along roads.

1.2 Need of the research

Tulsipur is one of the fast-growing cities of Nepal, with the growth rate of 2.77 as per census 2021. The haphazard and unmanaged development in Tulsipur has brought about various problems in the city. If not intervened, this will only worsen so it is necessary to find the means to stop sprawl. The existing land-use change pattern within the complex and intertwined socio-cultural and economic factors causing this phenomenon needs to be studied to explain the existing scenario. A holistic and credible explanation of the present scenario is a must to study the implications and address existing problems. Suitable site identification of residential development is one of the key issues for planning. Depending on the intended purpose for which the land is desired, land-use suitability can mean different things to different experts(*Puntsag, 2014*). The aim of the suitability analysis is to identify suitable spatial pattern for future land use. When an urban planner decides that an activity should be orientated in a specific area of land, it will have a significant impact in the future since it will push a pattern of such development. As a result, unpredictable and dangerous situations may occur if the decision is taken without any analysis or study of the situation. So a wise decision and careful consideration must be given to the scope and area of development.

1.3 Importance of the research

Identifying the root causes of urban sprawl and studying the effectiveness of existing planning approaches will help identify the growth management policy framework for Tulsipur Sub-Metropolitan City. When seen in context, the study's findings will assist city authorities in integrating strategic tools to increase attractive residential neighborhoods to solve various

future difficulties. The knowledge produced from this research will help the city planning authority propose strategic tools for urban development plans. This research can be used by the city planning authority as a credible reference to address existing problems regarding land-use and suitable areas for residential development. It will help city authorities to integrate strategic tools to cope with the haphazard growth of Tulsipur. Moreover, this research can be helpful for researchers to study similar physical phenomena in other growing cities.

1.4 Problem Statement

Tulsipur, an emerging city in western Nepal, is going through rapid and unregulated urban growth. In recent decades, Tulsipur has observed an unregulated shift in land use without certain policies. Rapid urbanization without a land-use plan has caused rapid depletion of natural resources, aiding in sprawling residential growth. Rapid and haphazard urban transformation, i.e. economy, land-use, settlement growth, has occurred in Tulsipur, and it is set to transform even more in coming years. This transformation has happened in an unplanned manner. Land price speculation by withholding land parcels has been a big problem for land management. Because of this, agricultural land on the city fringes, unsuitable for settlement, is being converted into housing plots. Such an urbanization trend has made it hard for the government to undertake development projects. The efficiency of the existing infrastructure has decreased, making them ineffective. The government has not been able to provide physical services i.e. road access, access to sewerage and water supply, and reliable public transport in areas of sprawling growth. This has increased the number of private vehicles, which is set to cause problems of traffic congestion and environment degradation. The city is intersected by Lamahi-Ghorahi-Tulsipur road, a section of feeder road. The congestion problem will worsen in this section if growth continues at the same rate.

Builtup Map of Tulsipur in 2022

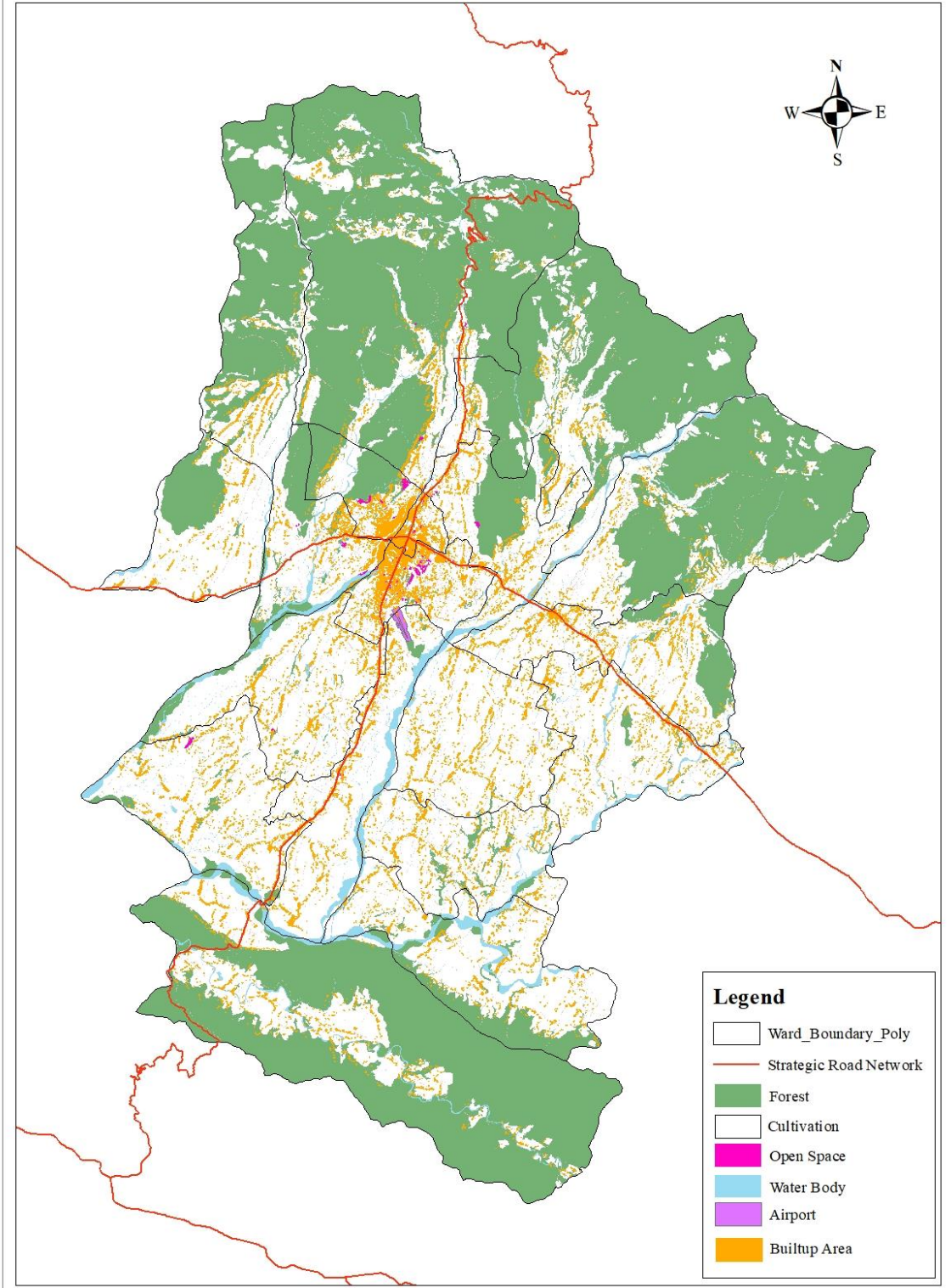


Figure 1 Built up Map of Tulsipur SMC

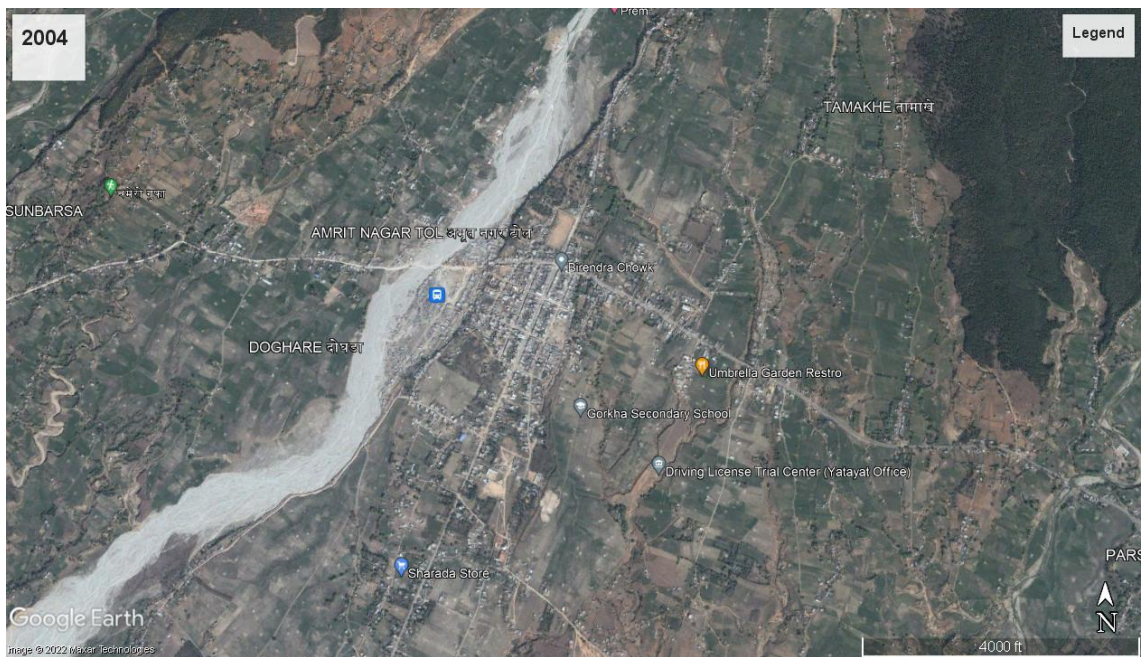


Figure 2 Google Image of Birendra Chowk, Tulsipur in 2004

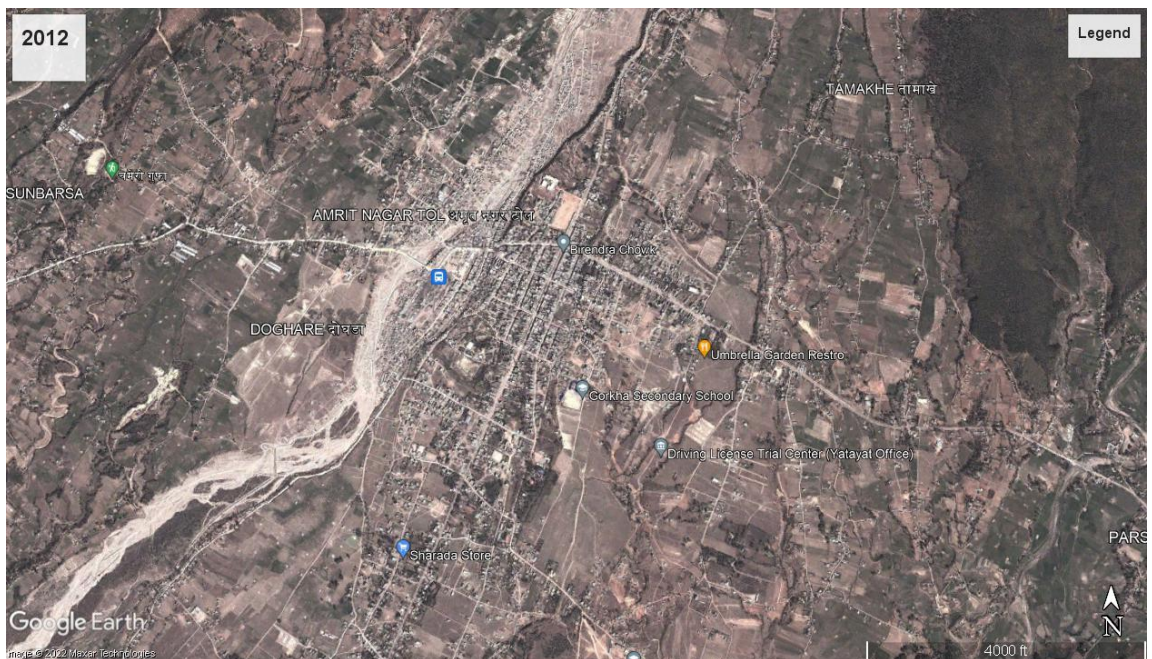


Figure 3 Google Image of Birendra Chowk, Tulsipur in 2012

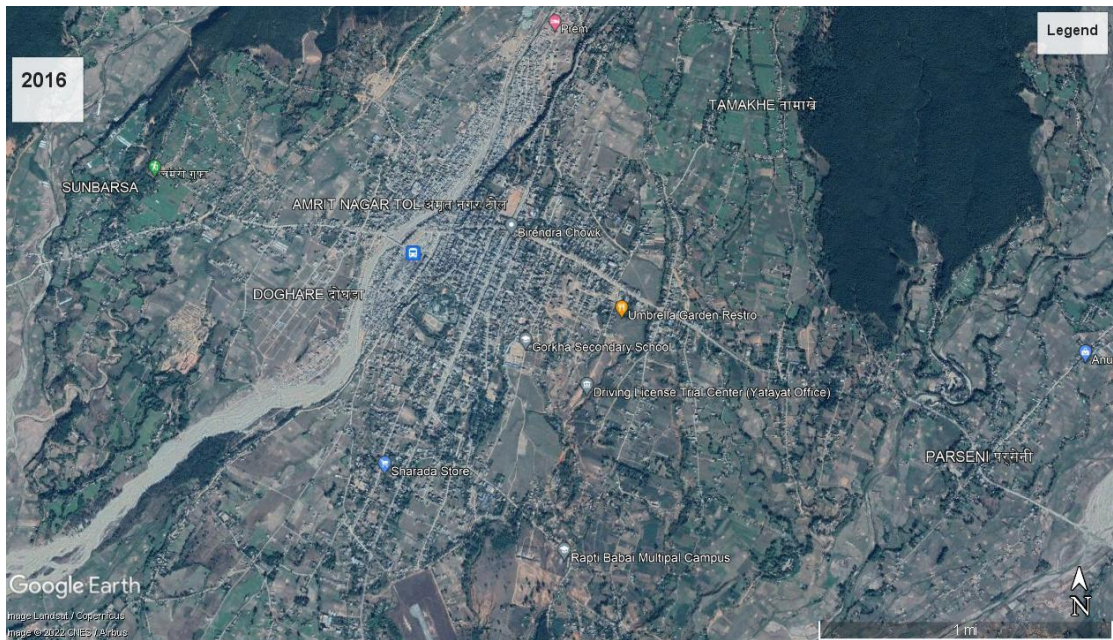


Figure 4 Google Image of Birendra Chowk, Tulsipur in 2016

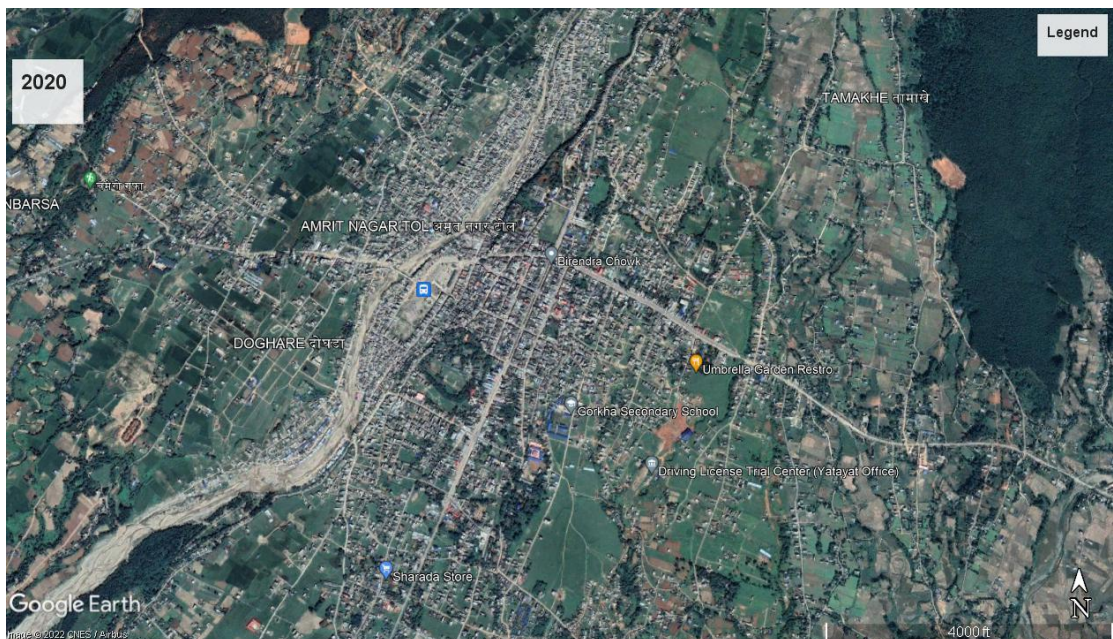


Figure 5 Google Image of Birendra Chowk, Tulsipur in 2020.

Over time, we can see the urbanization trend of leapfrog development at Birendra chowk, tulsipur. The above picture clearly indicates that the land has been acquired by the buildings in a random manner for different purposes, mainly for residential development. The sequence of images shows that the city's core area has reached a maximum density and that the process is continuing, leaving no or very few spaces. Encroachment of riverbanks by the people has triggered unplanned settlement growth. The unguided informal land development led by

private land owners, a common practice, has aided in randomly building construction purposes. 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 to slow the city's progress toward unintended consequences. Hence, the study will be useful to the local government of Tulsipur Sub-Metropolitan City and new people looking for a suitable area/location.

1.5 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:

1. How is the urban expansion occurring in Tulsipur SMC?
2. What governing factors determine the development suitability of residential areas?
3. What policy intervention can be done to encourage residential development in the identified areas?

1.6 Scope and Limitations

The research is limited to the Tulsipur-Sub metropolitan city. As a result, the criteria proposed for the analysis are entirely context based. As a result, the research findings may not apply to other regions. However, the findings might be extended to places with a similar setting. The research is limited to Tulsipur's new municipal boundary. Because surrounding municipalities now operate as distinct local authorities, similar to Tulsipur SMC, their area has not been included in the research. Also, the research is entirely tool based, where public participation is not taken into account; hence, the tool-based evaluation may not be practical in real life. Multi-criteria decision-making can benefit infrastructure development since risks can be adequately addressed. The research can also be expanded to include the use of several multi-criteria tools to determine suitable residential zones. Also, the research does not see the high flood level while using river buffer and does not talk about transportation mobility while taking the development factors.

CHAPTER 2: CONCEPTUAL FRAMEWORK AND METHODOLOGY

The conceptualization of the research is based up on a relativistic approach. This research focusses on understanding the research problem as a unique and complex entity (Ponterotto, 2005). The way knowledge is researched and interpreted is influenced by paradigms. The research's goal, motivation, and expectations are determined by the chosen paradigm. There is no foundation for following choices in technique, procedures, literature, or research design without first naming a paradigm.

2.1 Research methodology

The research approaches in its earlier stage largely followed the positivist paradigm that looked at truth as something external to the mind. Today, this field has grown with the emergence of various other research paradigms over time. Merriam-Webster defines a paradigm as a theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed to support them. In its early stages, research methods generally followed the positivist model, which viewed reality as something external to the mind. With the advent of numerous other research paradigms over time, this field has evolved today. A paradigm provides a conceptual framework for seeing and making sense of the social world. A paradigm consists of four parts: ontology, epistemology, methodology and methods. Ontology is the study or concern about what kinds of things exist and what entities exist in the universe. Ontology is the departure point of all research, while epistemology deals with the sources of knowledge. Epistemology concerns possibilities, nature, sources and limitations of knowledge in the field of study. It deals with the nature of the relationship between the knower and the known. Paradigm is Basic Belief Systems Based on Ontological, Epistemological, and Methodological assumptions (*Guba & Lincoln, 2013*).

Kuhn defines a research paradigm as the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed (*Kuhn, 2020*). A research paradigm is a way of describing a worldview guided by certain philosophical assumptions about the nature of social reality (ontology), ways of knowing (epistemology) and the science of obtaining that knowledge (methodology). Paradigm governs a belief about the nature of knowledge, a methodology and criteria for validity (*Mackenzie & Knipe, 2006*). The research paradigm is selected considering the following three factors i.e.

- Assumptions about the nature of reality and knowledge

- Theoretical framework, literature and research practice
- Value systems and ethical principles.

From the definition of different theoreticians about research paradigms, it can be noted that a paradigm is a set of beliefs that provides a firm base and guides the research according to the research purpose. The choice of research paradigm needs to be made for carrying out research. The research paradigm directs the research on the correct path, whereas choice is guided by the purpose of the research or the ontological position, 'the way a certain problem is seen or perceived'. Locating research in a certain paradigm is an important step of research. The research paradigm gives the basis for the choice of methodology, which then guides the methods, and explains the validity of the methods (*Mackenzie & Knipe, 2006*).

The ontological position of the researcher for specific research determines research paradigms (*Slevitch, 2011a*). Ontological position describes what entities exist or is assumed to exist by the researcher (*Guba & Lincoln, 2013*). This ontological position leads a researcher to the knowledge 'epistemology' process, which is concerned with the nature and scope of knowledge (*Slevitch, 2011b*). Epistemology is concerned with the study of knowledge, knowledge acquisition, and the relationship between the researcher (*Ponterotto, 2005*). Then the researcher goes on to the theoretical and philosophical system that structures research (*Slevitch, 2011b*).

Scientific investigation can be characterized by a set of philosophical and meta-theoretical assumptions concerning the nature of reality (ontology) and knowledge (epistemology), the principles regulating scientific investigation (methodology), as well as by techniques or tools regarding the practical implementation of the study (research methods)(*Slevitch, 2011b*). According to the theory of science, relationships among these constructs are as such: ontology defines epistemology, which in turn defines methodology, which then determines applied methods (*ibid*). The researcher's belief about reality defines what they perceive as legitimate knowledge and the ways to obtain it, which then defines the principles of scientific research, which subsequently define the research technique to be applied (*Slevitch, 2011b*).

In Tulsipur, there has been an increasing trend of unplanned residential housing construction. It was recently promoted to one of Nepal's eleven sub-metropolitan cities. This would also result in a more significant 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 spaces, and water bodies such as ponds. Hence, this will be the ontological position for my research.

The site observations provide information on the current land use. As a result, we must study, analyze and comprehend the pulling aspects for residents in the city's core. This requires a survey of the area and close interaction with the key informants of the city involved in corresponding governmental as well as other agencies. Understanding the past spatial trend of city growth will also be required. As a result, 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 Positivist paradigm holds that the scientific method is the only way to establish truth and objective reality (Thomas, 2010). August Comte, a pioneer of positivism in social science, insists that observations and reasoning are the best means of understanding human behaviour (Thomas, 2010). Positivism is based on rationality and tends to look at social science just like natural science (Mackenzie & Knipe, 2006). Social science positivists promoted value-free research, created social laws using rhetorical neutralities to get to the generalizations free of time and context (Burney, 2008). This positivist paradigm cannot be used to describe the phenomenon of residential development in Tulsipur. The truth cannot be described as a nomothetic result or a universal phenomenon. The ontological position of the research lies within a social reality which is never value and context free. None of the research objectives will be fulfilled by researching under this paradigm.

Post-positivist paradigm replaced positivism after World War II (Mackenzie & Knipe, 2006). It opts for social research to be less strict than positivism but employs similar methods of investigation (*ibid*). Post positivists assume that research is influenced by several factors other than the ones being tested (Mackenzie & Knipe, 2006). There is room for error and a chance for modification and refinement of the theory. Social realities are not certain and are not value and context-free. Social reality can only be approximated, and only the most possible explanation can be obtained. However, objectivity can be maintained using multiple measures and observations and triangulating the data to gain a clearer and more valid picture of reality.

The transformative paradigm emphasises the lives and experiences of marginalized people and minorities (Romm, 2015). It came forth as the response to the social realities constructed by the white, able bodied male perspective and based on male subjects (Mackenzie & Knipe, 2006). This paradigm intends to change the participants' lives, the institutions they are associated with, and the researcher's life (*ibid*). It intends to eradicate social inequality and advocates for justice using mixed method strategies involving the community to some degree of methodological

decisions(Romm, 2015) . The research of feminism or marginalized group may be conducted in transformative paradigm. This research is not about the marginalized region. It rather intends to create knowledge of the sprawling development and the ways to contain it. Transformative paradigm is not applicable for this research.

Pragmatism is not committed to any system of philosophy or reality but is rather related to 'what' and 'how' of the research(Mackenzie & Knipe, 2006). Pragmatist believe in using whatever method that works to answer the research question. Both objective and subjective enquiry best try to produce the knowledge to represent reality (Feilzer, 2010). Pragmatism tries to use the attributes of quantitative and qualitative methods but accepts that they are not different in ontological and epistemological level. This research doesn't fall under pragmatism as different processes fulfil different objectives. Both qualitative and quantitative method is not applied to describe the single objective.

The interpretivist or constructivist paradigm suggests that social reality is constructed. This paradigm tries to generate a theory or a pattern of meanings(Mackenzie & Knipe, 2006). This paradigm relies upon the view of participants about the situation or reality. Theorists believe that multiple constructed social realities generate different meanings for different individuals, which can be interpreted by a researcher (Burney, 2008). A constructivist researcher is more likely to rely on qualitative data collection methods and analysis or a combination of both qualitative and quantitative methods or mixed methods (Mackenzie & Knipe, 2006). In this research, quantitative data can be utilized to support and expand upon the qualitative data so that the social reality can be described in a holistic way. The reality will be constructed from within the society and interpreted through the researcher's lens.

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. The study's outcome could be unique to the context I'm researching. Data from key informant interviews may show some alternative criteria that should be weighted higher than those established in the literature for a similar scenario. During the study, new unique criteria determinant of some other reasons than simply physical and environmental reasons may be generated. It is clear that sustainability is a big necessity today. So, my 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 to Tulsipur city.

2.2 Methods

2.2.1. Literature Review

A thorough study of literatures of a similar study was carried out. Various books, articles and journals, maps, and related documents were studied to understand how the similar context was analyzed and how and what the solutions have been referred. A desk study was done to preliminarily analyze the city's urbanisation trend. Land use maps as well as Google maps study of different time provided idea of how the settlements are being laid in that spatial area of the city.

2.2.2. Data Collection

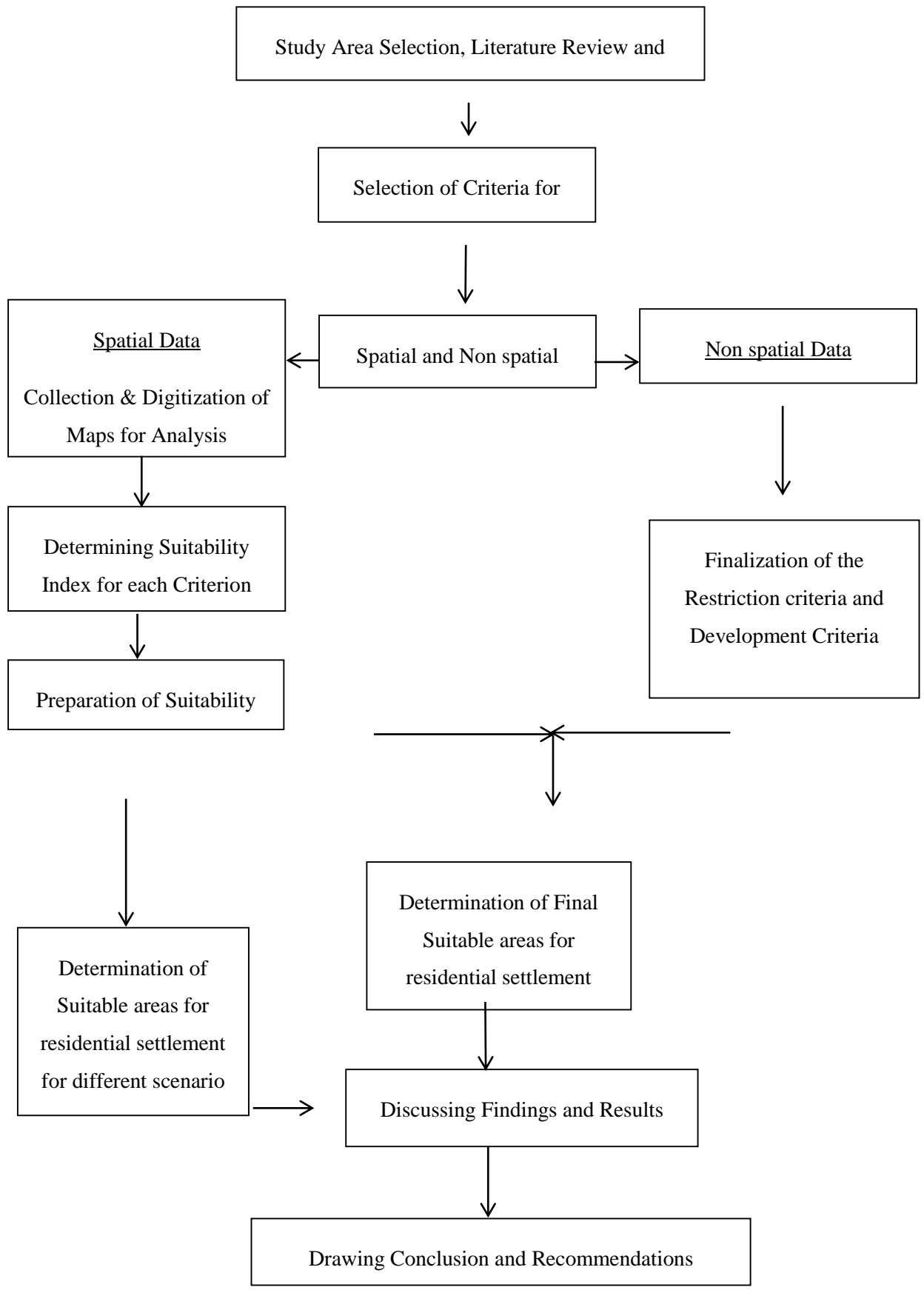
Data collection was of both types, i.e. primary as well as secondary. The primary data were the interviews with the key informants who are the experts studying and working in similar related fields either from governmental sides as in the municipal office, DUDBC office or from the private sides as ones involved in land development or housing development in the city.

The secondary data was required for performing spatial analysis work, which involves models or maps of the study area. These secondary data sources were referred from departments like the Department of Mines and Geology, Department of Survey, DUDBC, Municipal office of Tulsipur SMC and so on. Data may be in the form of hardcopy of maps which was scanned to prepare the digital copy or may be the digital copy itself. This helped in the exposure of the study results.

2.2.3. Data Analysis and Results

To fulfil the primary objective, the analysis started from the map study. Studying and analyzing the urbanization trend and how the residential pattern has been increasing in the city with time. This study was verified, and data were added through interviews with related agencies in the city. The assessment is a multi-criteria decision-making problem, and the MCA method for classifying and weighing criteria was applied. First, the data collected from the literature studies of similar spatial contexts was discussed with the experts. Then the important portion of the data analysis involved results from the interaction and interviews with the experts. Also, data acquired from interactions with the residents was used with those collected from the experts. Finally, GIS was used as a spatial analysis tool to prepare the results in maps.

The following summarizes the various steps that was followed during the study.



CHAPTER 3: LITERATURE REVIEW

3.1 Residential Area

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 systematically. The land that is used for barn, bhakari, garage, dug well, garden, or similar work attached or not attached to the house also falls within this area. Although this area is designated for the construction of houses, other services and work opportunities linked to the settlement are permissible. Since the widespread adoption of automobile transportation, major cities in the world started measuring the efficiency of transportation in terms of 'Level of Service' or 'Auto mobility'.

The rising concerns over air pollution and climate change have led to further innovation in city planning. The one-minute city in Sweden, superblocks in Barcelona, Melbourne's 20-minute neighbourhoods, etc., are some examples of such innovative takes on future sustainable cities. Improving walking for transportation, like going to the store, seems like a great action plan. The presence of sidewalks, aesthetics (e.g. trees) and some facilities like shops and parks and safety are essential. The conversion of residential buildings for urgent commercial purposes "seems to have become the norm" in most urban centers. The "public good" inherent in good planning tends to be eliminated when market forces are vigorously followed as a primary driver in property development in urban centres. This is because of either poor planning or ineffective planning management. Even worse would be if such a force were permitted to enter "Planned Residential Areas (PRA)," which serve as both a metaphor for and a blueprint for urban expansion. It might allow for both high and low-density land uses. The FAR (floor area ratio) for residential zoning is typically lower than that for business, commercial, or industrial/manufacturing zoning.

Agriculture is the primary and major source of the economy of Tulsipur. Most people depend on agriculture for their livelihood. Almost all the farmers in the rural areas are small holder farmers. Smallholders sell to private traders at the farm, local village markets, and the markets in urban areas. Most of the land in Tulsipur is dedicated to agricultural purposes. A lot of potential agro-based small as well as medium-scale industries can be established to boost up the economy. Furthermore, various problems or issues are also encountered in the agricultural sectors. Because there is a large fragmentation of the available agricultural land in Tulsipur SMC in contrast to the size distribution of the existing population, the large amount of difficulty

arises for a large number of the farm population/farmers to be provided with infrastructure and services.

3.2 Multi Criteria Decision Making (MCDM)

MCDA, or Multi-Criteria Decision Analysis, is a useful tool that may be used to make a variety of complex decisions. It can also be understood as a method used to prioritize, rank or choose from various alternatives based on multiple criteria. The method is objective and compares the alternatives to determine the options' priority value. The optimal alternative is found and selected as the option to meet the decision objective based on the priority value. The MCDM techniques are widely applied and used to solve various decision-making, optimization and predictive problems (*Majumder & Saha, 2016*).

At its core MCDA is helpful for:

- Dividing the decision into smaller, more understandable parts
- Analyzing each part
- Integrating the parts to produce a meaningful solution (*MCDA, 2011.*)

In essence, MCDA / MCDM involves the following four elements:

- Alternatives (or individuals) to be ranked or chosen from
- Criteria by which the alternatives are evaluated and compared
- Weights representing the relative importance of the criteria
- Decision-makers and potentially other stakeholders whose preferences are to be represented (*What Is MCDA / MCDM? | 1000minds, n.d.*)

Many professions, including planning, require many decisions to be made every day. However, it is not as easy in professions like planning, which do not have a complete solution. Instead, it has a range of subjective solutions and alternatives based on various criteria and variables that account for the solution itself. As such, Multi-Criteria Decision Making (MCDM) or Analysis (*Cheng & Wei, 2020*) referred to the past works of literature and studied the location selection of bike-sharing parking as a multi-dimensional analysis that includes users' interests and stakeholders, as well as environmental and safety issues. They ended up proposing multi-criteria decision-making (MCDM) model, including the analytic hierarchy process (AHP) and the weight-restricted data envelopment analysis (DEA) method to evaluate and determine the optimal bike-sharing parking points in the context of Beijing, China.

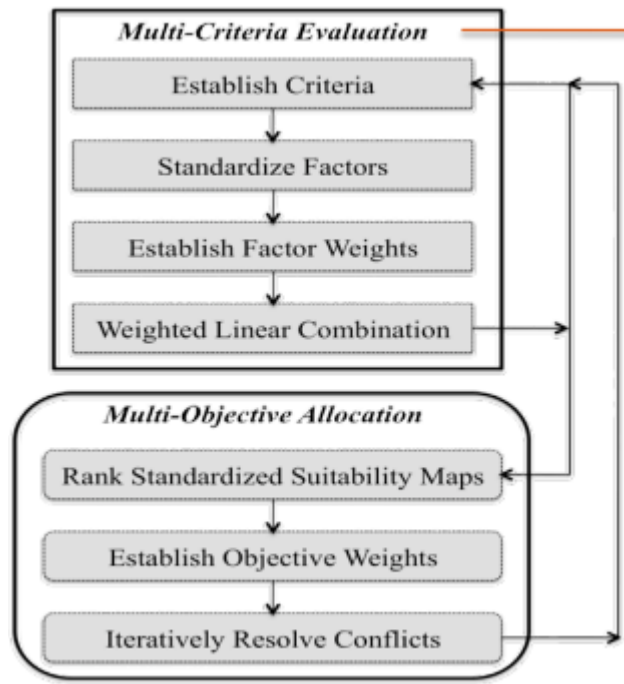


Figure 6 Flow diagram of MCDA (Eastman et al., 1991)

(MCDA) is a method that has been developed over time to aid the decision-makers in accounting for multiple variables, criteria, and alternatives. The MCDA helps determine a compromised solution by dividing the decision into smaller yet understandable parts and analyzing them individually. Finally, it integrates the components to produce a meaningful and balanced solution among those initial alternatives. Many MCDM methods developed over the years vary from one another. Each method is suitable for specific applications while others are not (Velasquez & Hester, 2013).

3.3 GIS-Based MCA and Past Approaches

GIS can be understood as techniques & procedures that have an essential role to play in analyzing decision problems. It is recognized as a decision support system involving the integration of spatially referenced data in a problem-solving environment. GIS-based MCA can be thought of as a process that transforms & combines geographical data & value judgments (the decision-maker's preferences) to obtain information for decision-making.

MCA and GIS have various applications in aiding site selection decision-making, and the methods used in various planning projects are comparable. (Meng et al., 2011) 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.

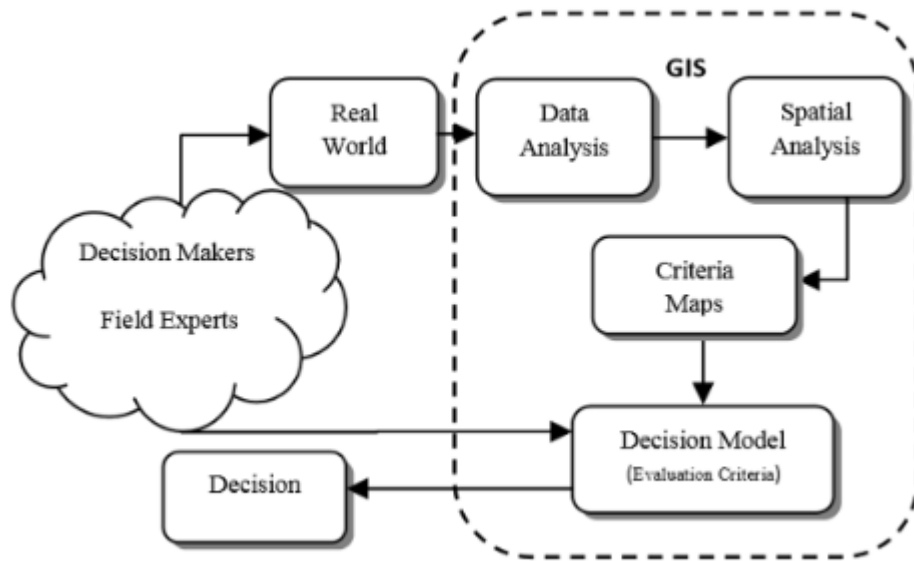


Figure 7 Integrated GIS / MCDA approach

In the context of multi-criteria decision analysis (MCDA), geographic information systems (GIS) are utilized as a potent tool in the process that combines and transforms geographic data (input criteria) and value judgments (decision makers' preferences) to obtain an overall assessment for selecting between alternative actions or ranking prioritized suitable lands for proposed land uses (Velasquez & Hester, 2013). In recent years, GIS-based MCDA has been widely used for site suitability analysis for natural resource management (Eastman et al., 1991), solar energy plants (Majumder & Saha, 2016), Industrial site selection (Rikalovic et al., 2014), agricultural land (Özkan et al., 2020) 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 land suitability was mapped using the weighted sum overlay analysis in the ArcGIS software. A Residential area suitability map was created after the predicted weights were assigned to the relevant layers and the raster maps were layered on top of one another. Two steps were followed to produce a site suitability map:

- (1) Finding suitable factors to use in the analysis,
- (2) Enervating a land suitability map for residential development

Many kinds of literature have attempted to define the urban design framework and identify the features that make a better-built environment in the last couple of decades. Prominent of them (Cervero & Kockelman, 1997) standardized the 3D: Density, Diversity and Design that would make a desirable built environment which was later expanded to 5D with the addition of

Distance to Transit and Destination Accessibility (*Ewing & Cervero, 2010*). Although attempts have been made to include adjustment of scores by block length and intersection density, it still largely fails to incorporate the five urban qualities related to walkability.

In a GIS-based multi-criteria site suitability analysis, applicable parameters are represented geographically and categorized according to their relative significance. It is incredibly challenging to determine the relative importance of the various elements that site analysis uses to determine the best locations for different land uses.

3.4 Site Selection Criteria

Site suitability is the process of comprehending the attributes of the current site and the elements that will determine where a specific activity will take place. Since all three factors, i.e. social, economic, and environmental, support the identification of viable sites for residential development at any location, the studies must take into account the actual urban situations of the research region to ensure the highest social benefits.

MadurikaH (2017), explains that residential areas are moving to periphery areas in cities. As land is scarce and has economic value, finding the best locations for residential housing schemes in Greater Matara Region has become a pressing issue. A similar need has been realized in the case of Tulsipur SMC's case. Previously, site selection was nearly entirely dependent on economic and technical criteria. A higher level of sophistication is demanded nowadays.

Various environmental, climate, proximity and social criteria must also be satisfied for site selection enforced by government regulations and legislation (*Rikalovic et al., 2014*). For residential development in a developing country like Nepal, the criteria must look up to different practices in the world such as 15 minutes city, green city, safer city, sustainable city etc. Data collection allows for the generation of a possible residential area that may be grouped, where using certain criteria and various iteration narrows down the choice.

(*Siqing, 2016*) established five objectives for the selection of suitable areas in Bendigo:

- A connected city 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 highlights the importance of proximity to existing resources, infrastructures and facilities in the urbanized core area.

(Weldu, 2016) explains that housing development suitability emphasized the prioritization of suitability criteria and influencing weights computation as the most critical step in site suitability analysis. The real urban situations of the study area with eleven economic and environmental factors were identified. Such a study serves as a spatial decision-supporting system with enormous potential to address the uncertainty about where the additional house should be developed in the city. (Dong et al., 2008) considered eleven criteria under different factors, which were incomplete for integrated development. Since this study is related to residential development, site suitability analysis must consider the community services like hospitals, schools and recreational areas or parks and include utility services like water supply. Some of the criteria adopted by Dong were the railway proximity which is totally out of context for this study. (Tudes et al., 2010) also considered different factors related to buildings, industrial, and landfill sites, which comprise environmental conditions like slope, elevation, geology, groundwater, etc. As Tulsipur is one of the fastest growing cities in Nepal, the city's immediate need is to develop the housing in a planned way in the form of residential development. The current unplanned city lacks open spaces, parks, and outdoor recreational activities where conserving the agricultural land for the food sustainability should also be taken into account (Ullah & Science, 2014).

Selection criteria can be categorized into two groups, i.e. restricted criteria which restrict development, such as conservational area, religious area, hazard-prone zones etc. and assessment criteria which assess suitability and promotes development. Hence, for this study, by using GIS for the suitability of residential development, it is better to analyze from two perspectives, one by generating constraints and the other by developing factors. The constraints will have zero values and will not be considered for the suitability analysis or residential development. The constraints would be Hazard, Slope, Forest, and Roads. Existing buildings, Water bodies (Da Wei and Yijie Ding, 2015).

Table 3 Factors for residential development

Development factors	Constraints
Proximity to Road	Forest

Proximity to Electricity and telecommunication	River/ water bodies
Proximity to Water supply	Airport and open spaces
Proximity to Education	Risk zones: Slope, fault line
Proximity to Health	
Proximity to Market centre	

3.4.1. Constraints

- **Forest:**

Any place completely or partially covered with trees and plants that does not come under one other described area is referred to as a "forest area," including public, private, community, and other sorts of forest areas. The government's declaration and designation of a region for the expansion of forestland is also referred to by this term. Forest area protection is crucial. Forest area is taken as a constraint for future urban development so that the greenery can be maintained in the long run.

The review shows that before 1957 the Nepalese government focused on converting forestlands to farmlands and extracting timber for export. After the nationalization of the forests from 1957 until 1976, policy-making efforts were oriented toward national control of forests through stringent laws and expansion of the forest bureaucracy (*FECOFUN, 2022*). The Forest Act of 1993 categorized national forests into five sub-categories: community forest, leasehold forest, government-managed forest, religious forest, and protected forest. According to (*The-Forest-Act, 2019*), No Forest area containing trees shall be used for settlement or resettlement.

In the case of Tulsipur SMC, almost 37% of the total area is covered by forest, which will be totally restricted for residential development.

- **River/ Water Bodies**

A river is a body of water that looks like a ribbon and moves downward under the influence of gravity which may be both large and deep, or it may be only shallow enough to wade across. In the case of Nepal, water bodies refer to rivers, streams, lakes, ponds etc.

As per the municipal bye-laws of Tulsipur SMC and interview with municipal engineer Er. Akhil Pokhrel and Shreenarayan Chaudhary, 50m buffer were chosen on either side of the river

where no development can happen as they can be considered as flood prone zone. River and water bodies cover 4.07 % of the total land cover of Tulsipur SMC.

The potential location for a residential housing area should not pose a risk of river flooding during the rainy season from a safety perspective. According to the city's structural plan, no development is allowed within a 30-meter radius on each side of the river and in the floodplain (*Weldu, 2016*). So, areas far from river courses are more suitable for housing.

- **Airport and Open Spaces**

Public open space is defined as an open piece of land, both green space or hard space to which public access exists. Any open spaces (publicly or privately owned land) could potentially be used as open spaces for evacuation and rescue-relief during such events. Tulsipur has high potential for the development of recreational facilities. Temples and religious ponds are considered socially valuable. They must be preserved up to a certain buffered region around it to create more free spaces required during important occasions for gathering. Lakes, ponds, public open spaces, and community buildings within the Sub-Metropolitan City currently serve as sources of recreation in the area. Most wards possess temples, rivers, lakes ponds, community forests and parks that could be developed into recreational and potential tourist spots. For instance, Chamere cave in ward number 4, with ancient archaeological importance, could be the major attraction of the Sub-Metropolitan City. There are seven lakes and ponds identified in the Sub-Metropolitan City. These lakes and ponds are the major sources of recreation for the people. Likewise, more than 100 religious spots have been identified are the major source of potential religious tourism and recreation. Almost all the wards have at least a temple. There are a number of open spaces available; however, most are under the ownership of schools and colleges. So these locations are restricted for developing residential area.

An airport is a facility where aircraft, such as aeroplanes and helicopters, can take off and land. The city accommodates the only airport in the Dang district, commonly serving Salyan, Rukum and Rolpa, including adjacent rural municipalities and Ghorahi SMC. Thus, airport zone is also restricted for developing the residential area.

- **Risk zones**

Risk is uncertainty about how an action will affect or implicate something people value, frequently focused on unfavourable, unpleasant outcomes. Also, any probability, high or low, that a hazard will cause harm to someone is a risk. Risk is further categorized into slopes and fault lines since flood-prone zones are already mentioned as a constraint above.

Disaster risk is the likelihood of loss of life, injury or destruction and damage from a disaster in a given period. The most typical way to think about risk comes from vulnerability, exposure, and hazard.



Figure 8 Definition of Risk

1. Slope

Steep slopes could be dangerous for urban growth. One of the most expensive geo hazards to infrastructure is slope failure. Development on steep slopes (slope greater than 33 %, i.e. 30 degrees) poses a high risk of erosion and helps to increase the risk of landslides both during and after construction (*County 2013*). Terrain instability in slopes and hillsides results in each year in soil and rock mass wasting that, in turn, produces great material losses and considerable infrastructural and environmental damage, creating complex emergencies that are not only difficult to manage but difficult to prevent. The most frequent manifestations of instability are landslides.

According to Settlement Development, Urban Planning and Building Construction Bye-laws 2072, precautions to be taken to avoid landslides: When choosing a place, flat land or a sloped area of less than 30 degrees should be chosen, and the building will be allowed only by leaving at least 3 meters from the bottom of the slope. However, even if there are less than 30-degree steep areas, there is no settlement in the areas which the Department has notified of Mines and Geology in the gazette. Still, in the areas with hard rock more than 30 degrees steep, settlements will be given according to the advice of experts.

2. Fault Line

“A fault is a fracture in the Earth’s crust. The opposite sides of the fracture are held together by pressure and friction, but as stress builds up, a fault may suddenly rupture. In a large rupture,

shock waves cause the earth to shake violently and produce an earthquake. An active fault is a fault that has ruptured repeatedly in the past, and whose history indicates that it is likely to rupture again. An active fault creates a fault hazard risk.”(Kerr et al., 2003).

A fault avoidance zone is formed by building a buffer zone on either side of the known fault trace. Twenty meters was chosen because, within this distance from the primary plane of the fault rupture, intense deformation and secondary ruptures are frequently experienced as a result of fault movement (Kerr et al., 2003). In the event of a fault rupture, structures within a fault avoidance zone, especially those that intersect active faults, are very prone to experience damage.

In the case of Tulsipur, the fault line was digitized from the hard copy of “Geological Map of Western, Central and Mid-Western and Far Western Region of Nepal” by the department of mines and geology and “Geological Map of Petroleum exploration block no. 2,3,4 and 5” by petroleum exploration promotion project.

3.4.2. Development Factors

Some of the development factors considered for the development of residential development are:

1. Road Infrastructure

Road transportation plays a dominant role in the development of the physical infrastructure of the nation. The social-economic status of a country is well reflected by the existing volume of road network in the country. Growth of other developmental sectors, like trade, commerce, industry, health, agriculture, education etc., is impossible without developing a proper road network in the country. The road would be a major necessity for better services to the road users in Tulsipur. The road is useful to facilitate the access, making, distribution and development of Tulsipur as an area of influence for people. It also attempts to develop different kinds of structures/infrastructures. The major road linkage includes Strategic roads identified by DTMP, viz. east-west road connecting Ghorahi- Tulsipur- Purandhara- Botechaur and the north-south highway connecting Tulsipur with the east-west highway to the south and Salyan to the north. The city has been formed around the intersection of these roads.

One significant factor in determining a site's suitability for facilitating mobility and linking settlement sites is its road accessibility. Therefore, when choosing a good location for housing, evaluation of accessibility to public infrastructure in terms of distance from a certain location using a particular mode of transportation must be taken into account. In any case, the most crucial consideration is road accessibility, and any residential development project must be contained within a 1–5 km radius. Road proximity would not have a significant impact on a potential site; rather, the closer to the street the site is, the more probable it is to be acceptable for a residential house because of easy access to transportation (*Weldu, 2016*). The most convenient access to major roads is probably within a range of 0–400 meters, and it's unlikely to be more than 1000 meters where the least accessibility for major roadways were considered, and maximum accessibility to major roadways is not used (*Madurika H, 2017*).

2. Water supply

Whether water is utilized for drinking, domestic use, food production, or recreational activities, the public's health must have access to safe, readily available water. It is essential to all basic human needs, including food, drinking water, sanitation, health, energy and shelter, yet, millions of people have no access to safe drinking water. Tulsipur SMC is no more different for this case. Since Tulsipur is spread over 364 sq. km, a water supply facility is more or less provided to the core city area. Urban sprawl has made life in Tulsipur more difficult. Infrastructure development for those sprawled houses is very difficult, so a designated zone is a necessity for Tulsipur SMC, where infrastructure would be provided.

Water for household purposes both in rural and semi-urban areas depends on municipality tap water. It is clear from statistics that residential area has a significant impact on water supply and services. Water supply and services are enormously varied between rural and semi-urban areas. According to National Population & Housing Census 2011, the primary source of drinking water in Tulsipur Sub-Metropolitan city is tap/piped water, on which 48 % of the total household depend. 18% of total households depend upon covered well/kuwa & other 18% depend upon uncovered well/kuwa for water. Similarly, 6% of total households depend upon tube wells/handpump for drinking water. The availability of groundwater resources makes Tulsipur a good location with sufficient attributes of water supply resources.

According to Plan Norms and Standards, 2015, at least 80% should have piped water supply. Guided by the target of delivering equitable access to safe, adequate, affordable and sustainable water supply and sanitation services, hence, to attend these objectives and goals, proper

necessary activities must be approached. The strategic vision of the water supply must be guided by safe, affordable and accessible water supply to all.

3. Electricity and Telecommunication

The municipality must ensure that electricity is available without disturbance and universal access to affordable, reliable and modern energy services. The challenge for the municipality is to expand the electricity network throughout the municipality's settlements as there is a lot of urban sprawl and urban fringe in the municipality. The present condition of electricity inside Tulsipur SMC is unsatisfactory. Due to the presence of extremely rural areas and uneven/rugged topographical and geological conditions, electricity-related infrastructures are very hard to establish. According to Planning Norms & Standards 2013, power access for any sub-metropolitan city should be such that it has 100% coverage over the city. Solar Home System standards for the sub-metropolitan city as alternative energy (panels, battery). On average, more than 80% of the wards have electricity access. To summarize the present condition, electricity or facilities relating to electricity are not available to all the households inside Tulsipur SMC. As per the data collected from NEA, almost more than 90% of households in all wards have access to electricity except for Ward 7 (40%) and Ward 9 (70%). Although transformers are there in all wards, the voltage is deficient. The sub-station is located in Tulsipur & Ghorahi.

Communication facility is available in the municipality in the form of land line phones and mobile phones. Communication facilities are provided by both government and private telecommunication facilities. With the primary goal of providing communication service to each individual in the town, a telecommunication plan is basically focused on optimising resources in the distribution of communication services. According to Planning Norms & Standards 2013, the status of communication in a Municipality should be such that landline/mobile should have 100% coverage, and a Public/ Community Telephone booth (TB) (standard booth) should be for two neighbourhoods. Inside Tulsipur, Mobile Service (2G, 3G) has reached all wards except Ward No. 1, 9 and 19. Landline service is not present in any of the wards except for Ward No. 12 and 18. Almost none of the wards have proper internet facilities. Internet Connections are available in Ward No 7 and 18 but the quality, consistency and speed of these connections are considerably poor. Major telecommunication providers are NTC and Ncell, whereas ISP is world link.

4. Health

According to Planning Norms and Standards 2013 issued by the Department of Urban Development & Building Construction, Ministry of Urban Development, the standard requires the number of district hospitals to be 1 per 50,000 populations (25-50 beds) and one zonal hospital per 100,000 populations (50–100 beds). In Tulsipur sub-metropolitan city, there is one zonal hospital (Rapti Zonal Hospital), one zonal Ayurvedic Hospital, one regional Ayurvedic Hospital & 1 zonal eye hospital (Rapti Eye Hospital), which is in accordance with the standard required for health institutions as prescribed by Planning Norms & Standards 2013. Still, the health post is not up to mark and are deprived of capable human resource and technology. However, Wards 2, 7, 12 and 14 lack basic health centres. Since the health institutions are not properly distributed throughout the SMC, some wards are found to have limited accessibility to health services. While the health centres are distributed evenly in the SMC, people still have to travel to the city core from the wards on the fringe for major health problems.

5. Education

The total literacy rate (among the population aged five and above) in Tulsipur SMC, as per 2011 National Census, was 74.52%. However, gender disparity can be noticed with female literacy of 66.91% compared to male literacy of 83.22%. Out of all the VDCs and municipalities, Tulsipur SMC has the highest literacy rate at 80.65 %. All other VDCs have a similar literacy rate with a gap in the literacy rate of males and females. According to Jilla Sikshya Karyalaya Dang's saikshik bulletin 2073/074, a total of 156 schools have been identified. Out of 156 schools, 82 are community, and 74 are institutional schools. Furthermore, 64 primary levels, 21 pre-primary levels, 54 secondary levels, and 17 higher secondary level schools are present in the Sub-Metropolitan City. Tulsipur has various government, public-private and private educational institutions. Nepal Sanskrit University, NSU (formerly Mahendra Sanskrit University) is the only Sanskrit university and 2nd oldest University of Nepal promoting the Sanskrit language, Vedic Astrology, and Nepali literature in Nepal.

As per Planning Norms and standards, 2013, there should be a primary school between 400 and 800m. The primary schools are concentrated in wards 5 and 6 along East west Tulsipur-Ghorahi road. Primary school accessibility considers the lack of primary educational institutions per the norms in various parts of the SMC in sprawling and near hilly areas. Higher Secondary school is required for 1 per 7500 populations at a distance of 30min in public transportation. The secondary and higher secondary schools are sufficient in all parts of Tulsipur. There should be at least 1 Graduate/Post-graduate college for 25,000 populations at a distance of 45min in public

transportation as per planning norms and standard, 2013 in a SMC. There are several colleges in Tulsipur SMC. Also, there should be one university (specialties) per 40,000 population at a distance of 1 hour in public transportation.

6. Market Center

In general, the city needs an eight-kilometre buffer from the mean urban centre to be covered, and places closer to already-developed territory are better suited than those farther away. Therefore, as the distance from the urban centre continuously increases, the suitability factor for house development will drop. (Weldu, 2016). Central city sites score highly in terms of transit accessibility and low driving costs but lag in neighbourhood socioeconomic characteristics (high educational attainment and incomes for surrounding households, low crime risk, low poverty levels). (<http://www.shimberg.ufl.edu/research/housing-suitability-model>).

The market centre of a city is where most of the businesses and offices are located. It is typically near the intersection of the city's transportation networks. Good land values and hence intense land usage result from high accessibility. Tulsipur is regarded as the second most developed Sub-Metropolitan City after Ghorahi in terms of urbanization with growing market centres. Market centres have developed on the road intersection of East west Tulsipur- Ghorahi road and North-South road. The market centres like Parseni, Bijauri, and Beljhundi are developed on the East-west Tulsipur-Ghorai road.

3.5 Policy Review

For the practicality of the plan, it must follow certain legislations, policies and guidelines. The government of Nepal has formulated various acts, rules and regulations for different sectors to enhance the Nation's national, provincial, and local development. In this concern, the following acts, regulations, policies etc. reviewed for study have been listed below:

Local Government Operation Act, 2074

After the promulgation of a new constitution and reforming the governance system from a constitutional monarchy to a federal state structure, local governments are expected. They are made legally much more powerful than any time earlier. A decentralized system of governance is one of the fundamental policies to achieve the objectives outlined in the constitution. The Local Government Operation Act has shouldered the local governments a true power of self-governance. They are empowered to formulate their Acts and regulations concerning planned

development, taxation, resource mobilization, local administration and overall local governance. Being a new Act and the Act itself being practised in a new environment, capacity building of local governments to fully understand and implement the provisions of this Act is of utmost necessity and challenge

Housing Act, 2074

It aims to make proper arrangements for a safer housing facility for Nepali citizens. It is oriented towards an ownership-based model. It also includes rental housing with a glaring gap of absence of required provision. Section 7 provides those housing facilities to people lacking a house or land under one's family. To make housing affordable, housing should be understood in terms of dimensions like habitability, availability of services, materials, facilities & infrastructures, Accessibility, Location & Cultural Adequacy (*Act, 2018*). This act does not create specific obligations to prevent people but can address the underlying cause to have a proper assessment of situations & responsibilities to the situation. The recommendation for the act is to amend to improvise the problem of homelessness, specifying measures by the state to address housing needs & to create statutory obligations for all tiers of government. The other recommendation is to an amendment to clarify the roles & responsibilities if each tier of government. The other recommendation is to provide immediate accommodation to homeless people until permanent housing facilities is provided.

Land Acquisition, Rehabilitation and Resettlement Policy

This policy facilitates to acquisition of land for an infrastructure project. This policy is provisioned only when the installation of transmission lines, telephones & underground drinking water pipelines affect livelihoods and shall be entitled to compensation. The expenses related to land acquisition, compensation & implementation shall be added to the project cost. The team of a 5-member committee shall play a role in determining & deriving compensation amounts close to the market rate. The people not satisfied with the land acquisition process can lodge complaints at the project office or hearing office at the district & regional level or appellate court. The key provision for it is to ensure the livelihood of the affected person or household, to emphasize the project development agency for meaningful consultation, accomplished compensation payment & efforts, land acquisition through negotiation, land-based compensation & resettlement (*Commission, 2015*). The major inclusive programs for enhancement of socio-economic development for disadvantageous groups should be enhanced. There should be the provision of subsidized rates to the project-affected persons. For the physically displaced groups, additional assistance should be provided like residential, goods,

and relocation. House rental etc. Also, employment opportunities & livelihood restoration to project-affected livelihoods should be ensured & project development agency should ensure the allocation of resources.

Land Use Act 2019

Nepal Government has full right to make land use plan for the appropriate use of any land with prior Public notice. Land use Areas could be categorized as follows:

1. Agricultural Area
2. Residential Area
3. Commercial Area
4. Industrial Area
5. Mineral and Mine Area
6. Forest Area
7. Stream, River, Lake, Marshy area
8. Public land area
9. Cultural and Archeological area
10. Other areas as allocated by Nepal Government

Ministry of land management, Cooperatives and Poverty alleviation must prepare a land-use area plan for the Local Government and hand over the plan within a year of the commissioning of the act. Such plans must clearly identify and show disaster-prone and risk areas. The local government can prepare individual Land use area plans for rural and urban areas. They must also provide a land ownership certificate showing the allocated land use area if any land owner is not satisfied with the allocation of the land use area in their plot, they can complain, giving an application to the District Court within thirty-five days of notice.

- Local land use Council
- Provincial Land use Council
- Federal Land use Council

KMC Heritage Home

Conservation/renovation of traditional style private and institutional buildings of historical, archaeological, and architectural importance within the Kathmandu Metropolitan City area, reusing the materials used in the said building during the repair and reconstruction of the outer covering, preservation, and reconstruction of the building using original materials. In addition

to setting specific standards to be done, the house owners are encouraged to build buildings of the traditional original form by providing incentives for such buildings.

It is believed that the metropolitan city gives up to Rs. 32 lakhs for the cultural house. Those important buildings are categorized in different categories, and the incentives are provided accordingly. (*KMC, 2021*)

International Context

The official authorities in these global south nations typically preferred to turn a blind eye to the sprawl of informal settlements for a few decades after the Second World War. During that time, they began spreading and growing more quickly in many global South cities (*Chiodelli, 2016*). Talking about France, To ensure that low-income households and households in fragile financial situations have access to good homes, the government must intervene in the housing market (*Trannoy & Wasmer, 2013*).

CHAPTER 4: STUDY AREA

4.1 Location

Tulsipur Sub-Metropolitan City (area-384.63 sq. km) is located in the Dang district in Lumbini Province. The study area designated for the residential development is limited to Tulsipur SMC. Ghorahi Sub-Metropolitan surrounds the Sub metropolitan city 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 the population census 2011, it is the second most populous city next to Ghorahi in Dang district. With an area of 384.63 km² (148.51 sq. mi). It spreads from the Mahabharata Range to Chure Range in the South. Along with the announcement of a new local level structure in 2017, Tulsipur was upgraded to Tulsipur Sub-Metropolitan City by restructuring its units.

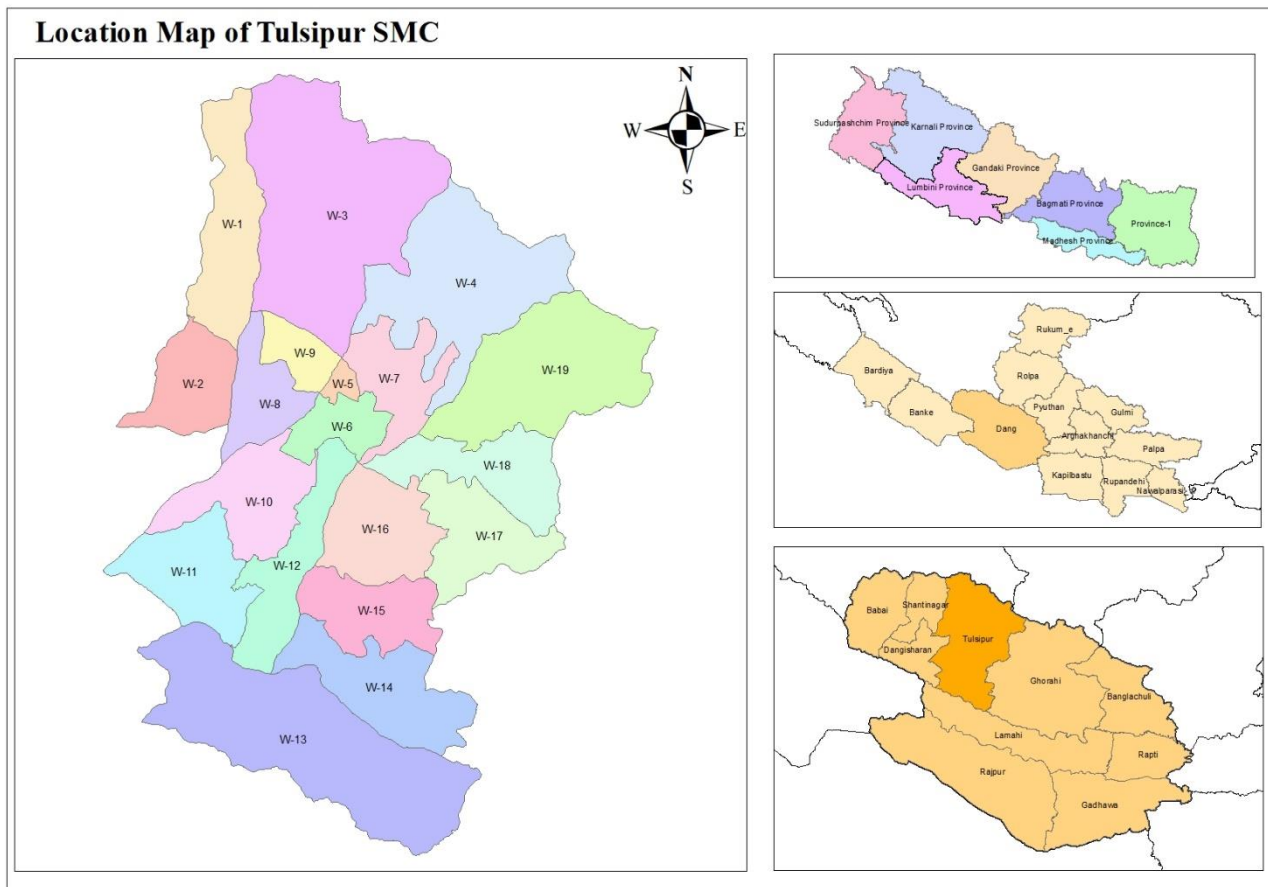


Figure 9 Location Map of Tulsipur SMC

Table 4 Upgraded ward of Tulsipur Sub Metropolitan City

Ward. No.	Former VDCs/Municipalities	Erstwhile Ward No.
1.	Pawannagar	1-4
2.	Pawannagar	5-9
3.	Tulsipur	1, 7, 10
4.	Tulsipur	2, 16, 17
5.	Tulsipur	5
6.	Tulsipur	6
7.	Tulsipur	3, 4, 15
8.	Tulsipur	8, 11
9.	Tulsipur	9
10.	Tulsipur	13, 14
11.	Tulsipur	19, 20
12.	Tulsipur	12, 18
13.	Phulbari	1-9
14.	Duruwa	2, 3, 8, 9
15.	Duruwa	1, 4-7
16.	Manpur	2 - 6
17.	Manpur	1, 7-9
18.	Bijauri	1, 3-5, 7
19.	Bijauri	2, 6, 8, 9

(Source: Ministry of Federal Affairs and Local Development, 2018)

Located at the bank of Paatu Khola, the city accommodates the only airport in the Dang district and the Rapti Zonal hospital. The only airport of Dang district, Tulsipur Airport, lies two km south of the town centre in Tarigaon. Roads go north into Salyan District and all the way to Rukum (also known as Rapti-Babai Highway), giving its connectivity to Midhill Highway. It is the major transit point of southern and western Dang, Salyan, Rolpa and Rukum districts and serves as the transportation hub of the whole Rapti zone. The interconnectedness of Tulsipur with other cities and Kathmandu, Nepal's capital, enhances the prospects of planned development. It is the major transit point of southern and western dang, Salyan, Rolpa and Rukum districts and serves as the transportation hub of the whole Rapti zone. Almost all the major transport companies of Dang and Rapti are headquartered here.

4.2 Demography

The municipality is divided into 19 wards. Since the detailed report of Census 2021 is yet to be published, the Preliminary CBS report 2021 suggests the total population of Tulsipur SMC stood at 1, 80,734. In terms of population density as of the National census of 2011, Ward No. 5 is the densest ward, with a density of 7190.12 persons/sq. Km. The largest market of the municipality, Tulsipur Bazar, is situated in Ward No 5.

Table 5 Ward-wise Population Distribution of Tulsipur Sub-Metropolitan City

New Ward	Household	Total Population	Male	Female	Area (SQ KM)	Density (person per sq. km)
1	993	4361	1962	2399	19.88	219.4
2	905	4312	2089	2223	13.05	330.4
3	1663	7479	3494	3985	55.63	134.4
4	1816	8126	3647	4479	36.38	223.4
5	2786	11648	5761	5887	1.62	7190.1
6	3313	12969	6301	6668	7.52	1724.6
7	2425	10817	5005	5812	12.74	849.1
8	1229	5641	2748	2893	10.73	525.7
9	1169	4925	2340	2585	5.97	825
10	1347	6497	3017	3480	17.26	376.4
11	1794	8661	4061	4600	17.29	500.9
12	1771	8838	4247	4591	15.77	560.4
13	1227	5489	2522	2967	52.3	105
14	1266	6040	2781	3259	20.57	293.6
15	1469	6939	3178	3761	14.32	484.6
16	1535	7603	3554	4049	17.11	444.4
17	1553	7261	3372	3889	16.07	451.8
18	1657	7671	3676	3995	16.24	472.4
19	1325	6251	2920	3331	34.2	182.8
Total	31243	141528	66675	74853	384.65	367.9

(Source: Census 2011)

As per the census 2011, the major ethnic/caste group of Tulsipur Sub-Metropolitan City is Chhetree, whose population is 45,013 and occupies about 31.80% of the total population. The second major ethnic/caste group is Tharu, whose population is approximately 35,343 and occupies about 24.97% of the total population. Similarly, the other major ethnic/caste groups

are Brahman-Hill, Magar, Kami, Damai/Dholi, Sanyasi/Dashnami, Sarki, Thakuri, Newar, Musalman, Gurung, Badi, Haluwai, Kumal and so on.

4.3 Regional Settings

Tulsipur has developed as a common hub for trading and commerce in the Dang district. As an emerging city of the Dang district, the sub-metropolitan city has been the gateway town for Salyan District and other nearby Villages for decades. Tulsipur Bazar is the major market centre for many adjacent municipalities and even for the district as a whole. 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 Sub-Metropolitan City for trade, health services, and other purposes.

Inter Connectivity

Tulsipur is connected with other parts of Nepal through National Highway (North- South Rapti highway) and feeder roads. National highway i.e. Rapti Highway, connects Tulsipur not only to the Hilly regions like Salyan and Rukum but also to the East-west highway at the south making Tulsipur the center to collect and distribute goods and services from either side. The products imported from India and Kathmandu are dispatched all around market places of hill region. Similarly, Feeder road Tulsipur- Bijneta- Kalche- Botechaur is another important road that connects Tulsipur with Hekuli, Shrigaun, Dhanauri, Purandhara in the west. This strategic road makes possible for the transport of goods and agricultural products from Tulsipur bazaar and nearby rural municipalities and vice-versa. Another important feeder road is Lamahai-Ghorahi-Tulsipur road which connects Tulsipur Bazaar with Ghorahi SMC and Lamahi Municipality, making import and exports of goods and services from Ghorahi, Kathmandu and India easier. This road also caters to the settlements like Bijauri, Dudras, Beljhundi, Hemantapur.

Tulsipur along with adjoining Ghorahi SMC has also become a hub for education, health, trade and commerce for the whole region. Exchange of such goods and services which is common amongst nearby districts and within Dang district, has direct impact in the economic development of the region. The SMC is about 444 km. (around 11 hr.) far from Kathmandu, National capital. It is linked through E-W highway and then Lamahi-Tulsipur feeder road or E-W highway and then Rapti Highway. Similarly, it is 126 km North-East (3 hrs. time distance) from Nepalgunj and about 171 km (4 hrs. time distance) North West from Butwal, the two

major cities in the west. The nearest link is with Ghorahi SMC at a distance of 25 km where a linkage on daily or a regular basis is carried out. This linkage is related to the markets for daily needs, education or other basic needs and services. A little farther but important linkage is with Rukum and Salyan. Salyan and Rukum are linked with Tulsipur for education, health and connectivity with country's capital city Kathmandu. The linkage with Kathmandu and Nepalgunj (Rupaidiya of India) and Butwal is seen in bulk level. Tulsipur is linked with these cities for mostly health facilities and trade. Similarly, the SMC is also with Kathmandu for education facilities.

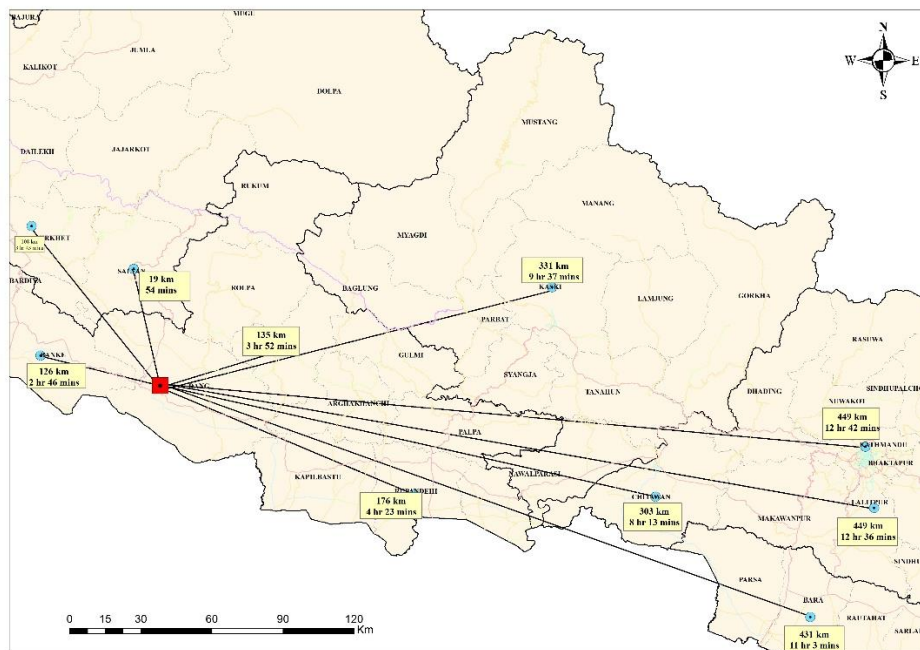


Figure 10 Inter Connectivity of Tulsipur SMC

Intra Connectivity

Most of the market centres in Tulsipur lie along East-West Ghorahi- Tulsipur road, feeder roads and at the junction points between Rapti highway and other side roads. This has made the goods and services easier to transfer to the market centres from the hinterlands. Wards 5, 6, 7, 9 and 18 have most of the market places. This cluster is connected with National Highway, feeder road, and other link roads. Raikhaliyan bazar at the southern part is connected to this cluster by the district road as well as other link roads. Tulsipur bazar, being located at the junction of the national highway and feeder road, is the densest market in the Sub-Metropolitan City. The dense network of roadways in most of the wards has made it easier to access market goods and agricultural products for sellers and consumers, as well as transport goods and agro-products from agricultural farms within the Sub-Metropolitan City.

CHAPTER 5: DATA COLLECTION

5.1 Primary Data Collection: Interview with the Experts and Questionnaire survey

A short questionnaire survey was conducted to know the context of the study area, i.e. Tulsipur, and non-spatial data was collected. The key informant interview was taken with some key experts and the officials of some offices directly or indirectly related to the study. The interview was taken with Er. Khadak Bahadur Chaudhary, Head of Provincial Urban Development and Building Construction, Dang on 5th of Shrawan, 2079, Mayor of Tulsipur SMC Mr Tika Ram Khadka, Civil Engineer of Tulsipur SMC Er. Shree Narayan Chaudhary, Head of Survey Department, Er. Bhakta Bahadur B.K, Head of Land Revenue office Mr Khem Raj Sharma on 3rd of Shrawan and Chairman of water supply office, Tulsipur Mr Yam Kanta Bhandari, Supervisor Ganesh Bhandari, Civil Engineer of Nepal Electricity Authority, Tulsipur. Er Padam Pokhrel and Engineer at Nepal Telecom, Tulsipur Er. Suresh Bhandari on 4th of Shrawan. Also, for more information about the residential development, open discussion with land valuator Er. Sagar K.C, M.D of Vaastu Enginnering solution, M.D of Kaal Bhairav C.P nirmaam sewa Er. Suvash Chandra Gurung, E.D of A and B consultants Er. Santosh Bhattraai was conducted on the 6th of Shrawan.

Three sections made up the questionnaire. The first section was created to discuss and verify the restricted and Developable criteria with key experts, asking them to what degree they were appropriate for my study's analysis given the setting. Similarly, the second section was for the government bodies where the discussion was done on the topic of an existing urban pattern of Tulsipur SMC, the current scenario of buying and selling of land, Issues and challenges for new residential development, current/ pipeline policies if there were any and policies intervention for new residential development. A series of open-ended questions and discussions were included in the final section to discuss previous tools and approaches for residential development in Tulsipur. Additionally, it covered the views of different people, experts on the city's planned residential areas in the future.

Er. Khadak Bahadur Chaudhary, Head of Provincial Urban Development and Building Construction, Dang, noted that they had been planning for land pooling in Tulsipur using a similar methodology and that this style of the study was an excellent way to approach such studies in the city. The method, however, was discussed and met with by urban planners and

decision-makers rather than being recorded in written form. He stated that a recent trend in the city was the development of land plots by private organizations for commercial purposes. Additionally, he clarified that communal housing styles that are widely dispersed would be more advantageous for the city than high-rise residences. The reason is that there are still many culturally distinct neighbourhoods in the city, and most families still favour communal housing due to their religious convictions. Additionally, the city has a large amount of land, and there is little demand for it to transition to high-density apartment buildings. He added that designated residential development areas might demand physical and social infrastructures, and the main problem for the development is land ownership of people all over Nepal. He further added and suggested categorizing the designated residential area in different zoning as well. He was not involved in the city for a very long time, so he was unaware of the planning interventions that had been applied to residential developments, which the Municipality must do, but he stated law and policies must be intervened strictly as such to conserve public land since encroachment of land in Tulsipur is in increasing trend. This is due to not incorporating the poor in urban policies. According to the urban development act, 10% of the land must be designated for the poor, but the main concern is identifying the urban poor of Tulsipur SMC.

In the following interview with the Mayor and engineers of the municipality, they talked about some pipeline projects which may give a slight edge in deciding the suitable area for residential development. Ribbon development is not only the trend of Tulsipur SMC but the nation's trend; settlement eventually needs accessibility to other amenities, so road infrastructure must be the priority. The significant buying and selling of land are happening in Bijauri, Manpur, Basgadhi, Beljhundi and Rakshyachaur areas. The major problem of the municipality is that agricultural land is being used for different purposes. The price escalation will be the greatest threat in future if a designated residential zone is identified. The main concern for the mayor was to conserve agricultural land since the government had invested a lot in constructing canals and agricultural fields. He denied the fact that policies in Nepal or the local level are so effective, so he did not put forward the policies that the municipality could bring, but he assured the experts' advice that the municipality would do everything possible to make the city beautiful and have systematic development. He added it would be more accessible to the municipality to discuss this study and policy once the designated residential development area is finalized. The major preference for the municipality would be Ghorahi-Tulsipur highway corridor for residential development since most of the infrastructure has already been built. Also, it was an approach for the city to intrude the residential development from outward to inward rather than compacting within the centre only.

Er. Bhakta Bahadur B.K, head of Survey Department, addresses the most fragmentation of land is happening in wards 7, 8 and 12, where the big plots are available. Since ward no. 5 and 6 is understood as the city's most developed and dense area, the land has already been fragmented. Khem raj Sharma Land revenue office gave a different perspective about buying and selling land. He addressed the core city area, i.e. ward 5 and 6, as the most buying and selling wards, followed by Lahure chaur, dogharre, Tarigaun, Maanpur. He also added the plot developer buys a chunk of land and sells fragmented land, which is the major concern for urban sprawl. They firstly buy the land where the price is low and sells with the minimum facilities, which is helping the urban sprawl concern of the city.

The next day, Interview with Er. Suresh Bhandari and the team of Nepal Telecom were held where the Fibre cable network, Aerial cable network, ADSS network and UGF network was traced on a map of Tulsipur and information related to telecommunication was gathered. Similarly, Er. Padam Pokhrel traced the Distribution line of electric network and the discussion with Ganesh Bhandari and Yam Kanta Bhandari traced the water supply network of Tulsipur city. These data were further digitized as GIS .shp file.

Furthermore, Er. Sagar K.C, Valuator, denied giving the specific land price of the settlement or a particular ward. He added that land price is the most fluctuating thing all over Nepal. The government price has been set up, but no one follows the price. He says by the time we finish this interview or by the time this study is completed, a drastic change in land price may occur since it is a city. Er. Santosh Bhattraai added the process of designing residential houses is continuously increasing since he is involved in his company. Er. Suvash Chandra Gurung says the construction of the building is growing rapidly and the scope is even more since the municipality was upgraded to Sub Metropolitan City.

5.2 Secondary Data Collection

Similarly, the rest of the data were secondary, i.e. in the form of digital or hard copy maps such as Land use maps of Tulsipur, Road maps, Building maps, River and pond (water bodies) maps, Maps of educational institutes, Religious Places, health services, Market Centre, Open Spaces etc. Most of the maps were in the form of GIS .shp files, which could be directly used during the analysis, while some of the map was in the form of hardcopy, which was first scanned and digitized into softcopy geo-referenced to form required .shp format. These maps were collected from various sources like DUDBC, Babarmahal Kathmandu, and the Survey Department, Min Bhawan. GIS maps are better than hard copy maps because they carry attribute tables in them

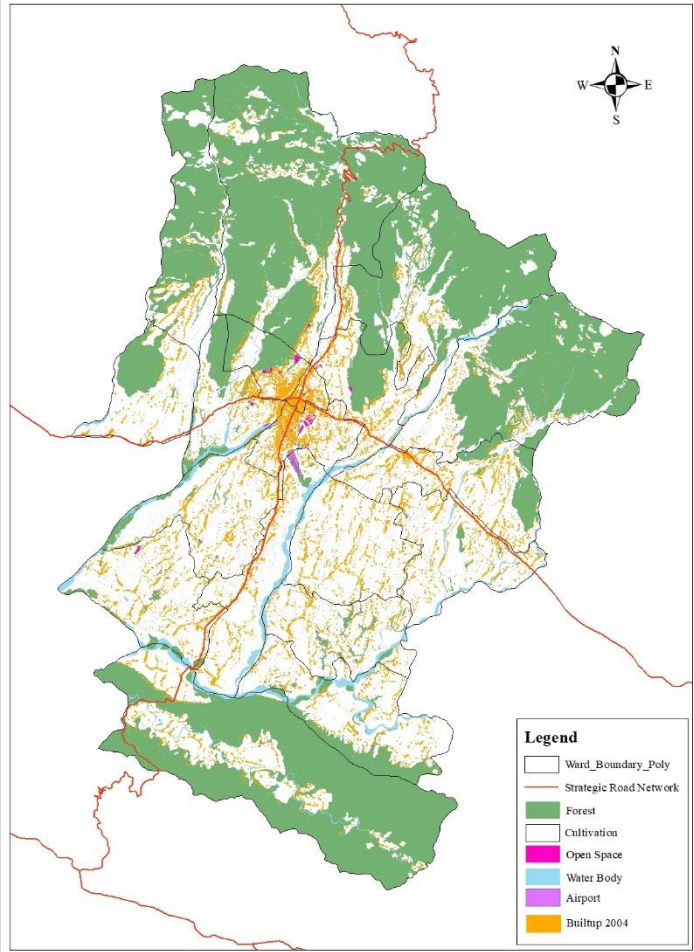
which can be helpful in various forms during analysis. The detailed description of secondary data and its sources are as follows.

Table 6 Secondary data, Data type and Data sources

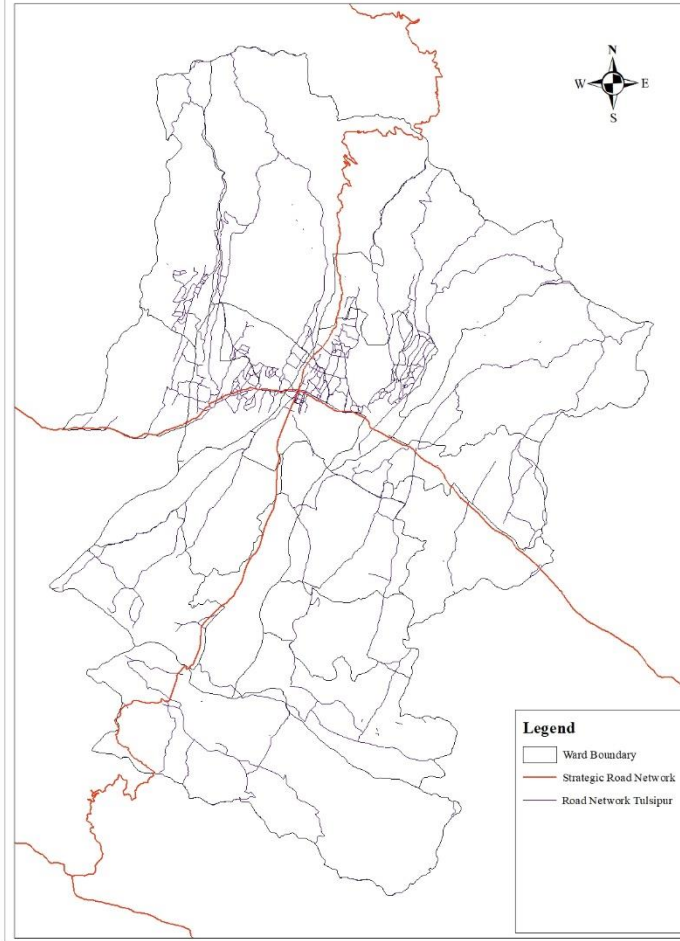
SN	Secondary Data Detail	Type/Format	Source
1	Ward map and Municipal map of Tulsipur	GIS .Shp File	Survey department, Minbhawan
2	Land Use Map,	GIS .Shp File	Survey department, Minbhawan
3	Existing Builtup Maps	GIS .Shp File	Digitized from Google Earth
4	Fault Line	Hard Copy	Department of Mines and Geology, Lainchaur, Kathmandu
5	Existing Road Network	GIS .Shp File	DUDBC, Kathmandu
6	Health Institutes	GIS .Shp File	DUDBC, Kathmandu
7	Educational Institutes	GIS .Shp File	DUDBC, Kathmandu
8	Open spaces	GIS .Shp File	DUDBC, Kathmandu
9	Religious Places	GIS .Shp File	DUDBC, Kathmandu
10	Market Center	GIS .Shp File	DUDBC, Kathmandu
11	Electric Distribution Line	GIS. Shp File	
12	Water Supply Line	Hardcopy	
13	Telecommunication Line	Hardcopy	

The key data and maps collected for Tulsipur's residential development study are listed below.

LandUse Map of Tulsipur SMC



Road Network Map of Tulsipur SMC



Educational Institute Map of Tulsipur

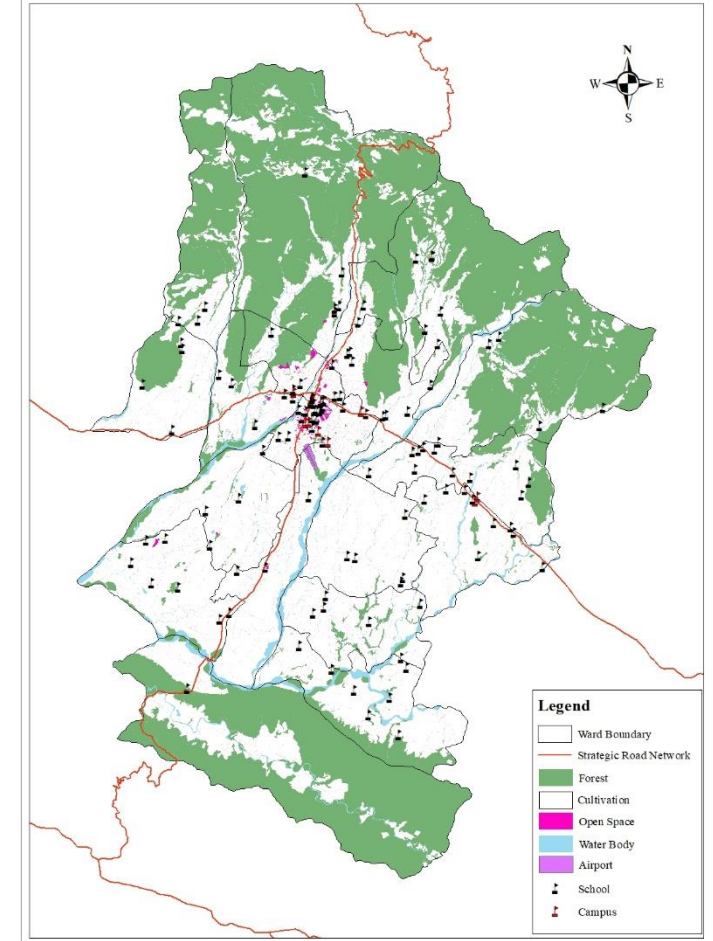


Figure 13 Landuse Map of Tulsipur SMC

Figure 12 Road Network Map of Tulsipur SMC

Figure 11 Educational Institute Map

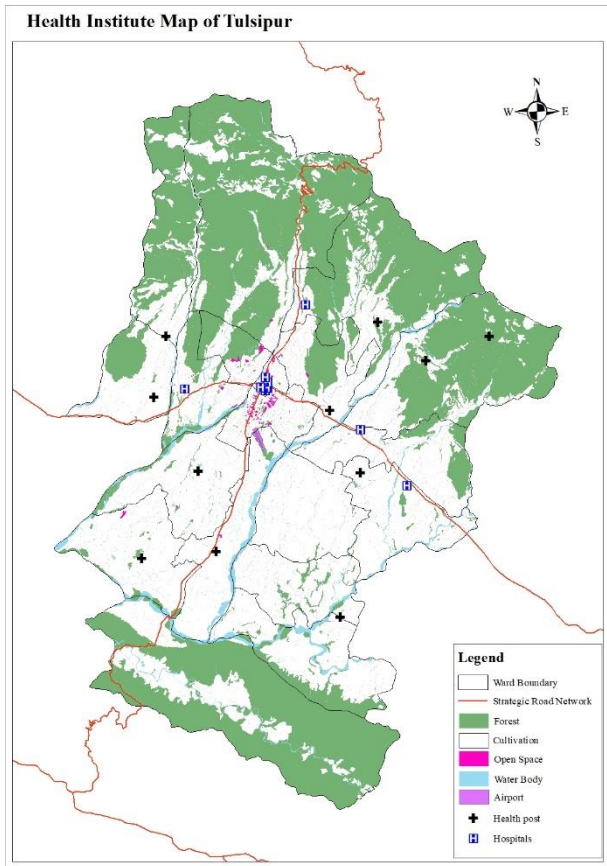


Figure 16 Health Institute Map

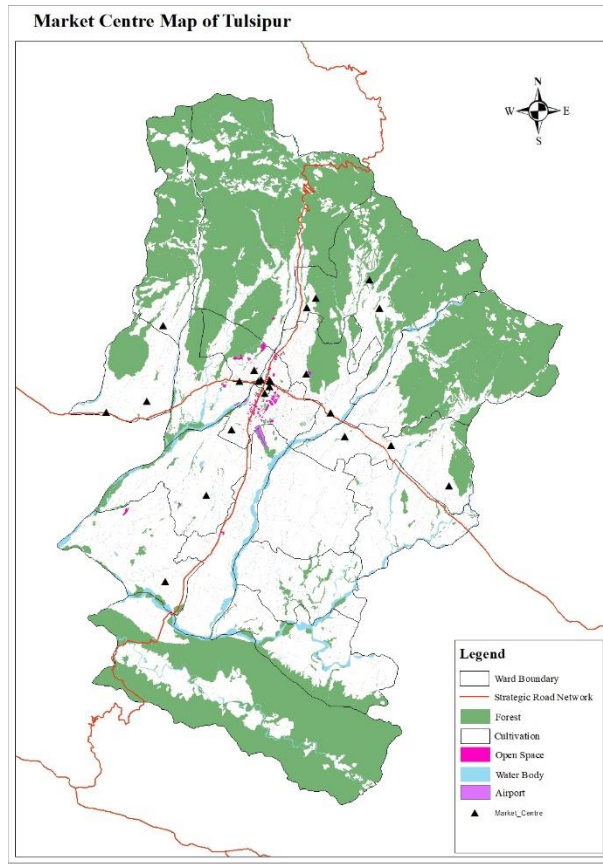


Figure 15 Market Center Map

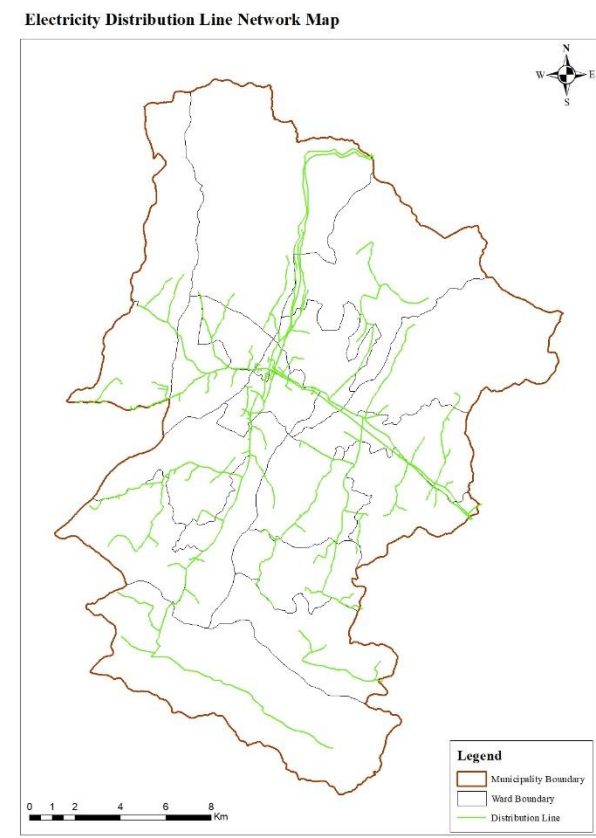


Figure 14 Electricity Distribution Line Network Map

CHAPTER 6: ANALYSIS AND FINDINGS

6.1 Existing Urban Expansion Pattern

Market places have been developed at the junction of highways. In Tulsipur, the major built-up is concentrated at the intersections of National Highway and Feeder Road (Ghorahi- Tulsipur- Purandhara- Botechaur) and along North-South Rapti Highway. As Tulsipur is the second largest Sub- Metropolitan City after Ghorahi in the Dang district, the built-ups have been developing along the Tulsipur-Ghorahi road at present, with larger agglomeration at various junctions like Birendra Chowk, Haati khauwa, Motipur, Rajapur, Parseni, Bijauri, Hemantapur and Dudhras. The expansion has also been expanded along the National highway i.e. B.P. Chowk, Barauwagaun, Dumrigaun, Rajaura, Glauri up to Urahari in the South and Rakschachaur in the North. Similarly, Doghare, Amritpur, Balapur, and Kamalgadhiare major built-ups along the feeder road Tulsipur- Purandhara-Botechaur.

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. Ribbon development is seen along district roads, feeder roads and national highways. A dense ribbon settlement is formed on Beluwa road that originates from Tulsipur- Purandhara road towards the north.

Market places in Tulsipur have developed along the district roads and village roads. Health post- Thatigaun- Abhidhara road radiates towards the north from the district road, Pawannagar- Shantinagar-Baghmare-Purandhara. Major settlements in wards 8 and 1 like Aswara, Bhamke, and Hapurkot are formed in and around this road. Village road Doghare- Damagarun-Dadakhutti- Aambas-Nalle-Makhantakuri Road in ward number 3 connects village settlements like Damagarun-Dadakhutti-Aambas-Nalle-Makhantakuri lying far north with the east-west road. Major markets in ward 4 are developed along the road of Rakschachaur and Khadre. Raikhaliyan in ward number 10 along the district road is another dense settlement. The expansion of the market places along the National Highway (Rapti Rajmarg) has developed a grid-iron network of access roads with linear urban fabrics (buildings connected along sideways).

Ward nos.1, 3, 4, 10, 13, 14, and 19 are comparatively sparsely populated and have fewer built-ups, with most of the areas being used as agricultural land. Most of the population are concentrated within ward 5, 6, 7, 8 and 9. The flat belt of Tulsipur has great potential for planning. However, Tulsipur SMC does not show any definite pattern and direction of growth

except a fair grid-iron pattern along the newly developed areas. Most land fragmentation has been noted in wards 6, 8, 9, 17 and 18. Although the flat belt of Tulsipur has great potential for planning, Tulsipur Sub-Metropolitan City does not show any definite growth pattern. The highest concentration of agglomeration can be witnessed along the National Highway and east-west feeder road starting from Birendra Chowk. Apart from the market centre, the area is predominantly rural with untouched barren land, providing a great opportunity for planned development.

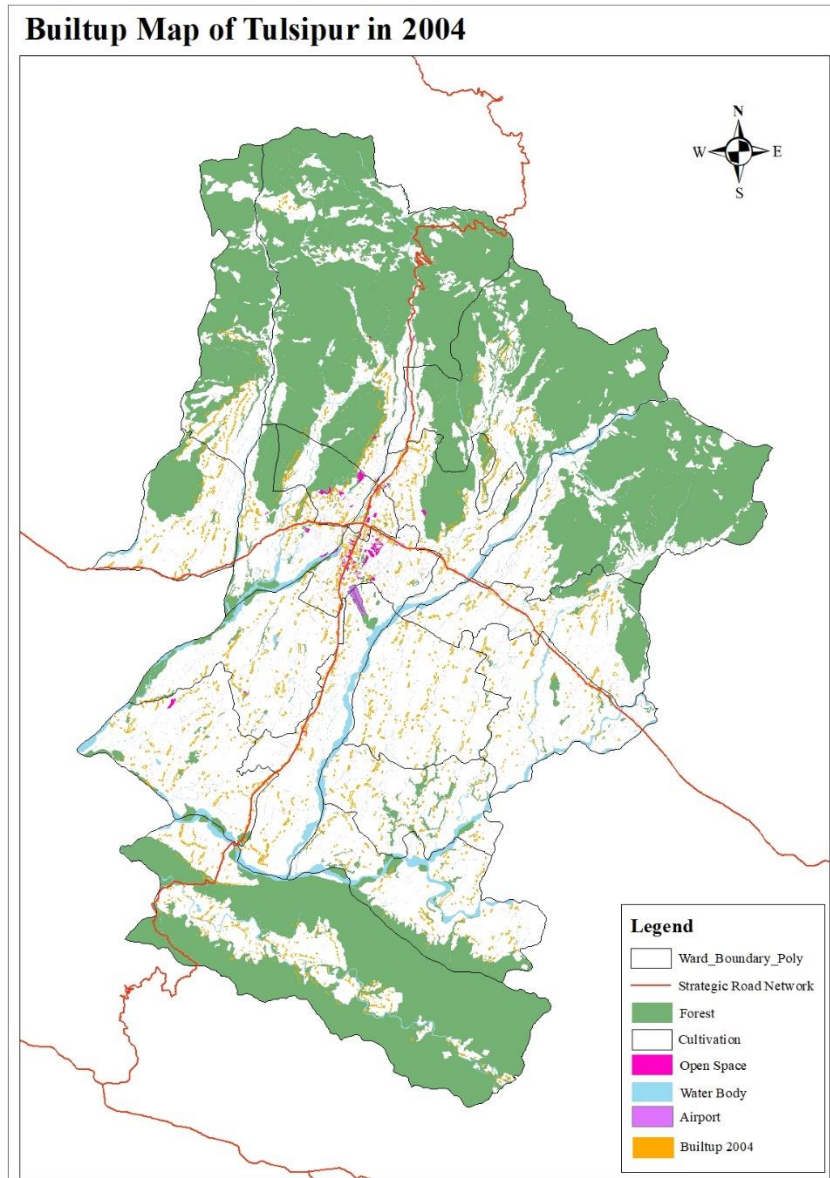


Figure 17 Built-up Map of Tulsipur SMC in 2004

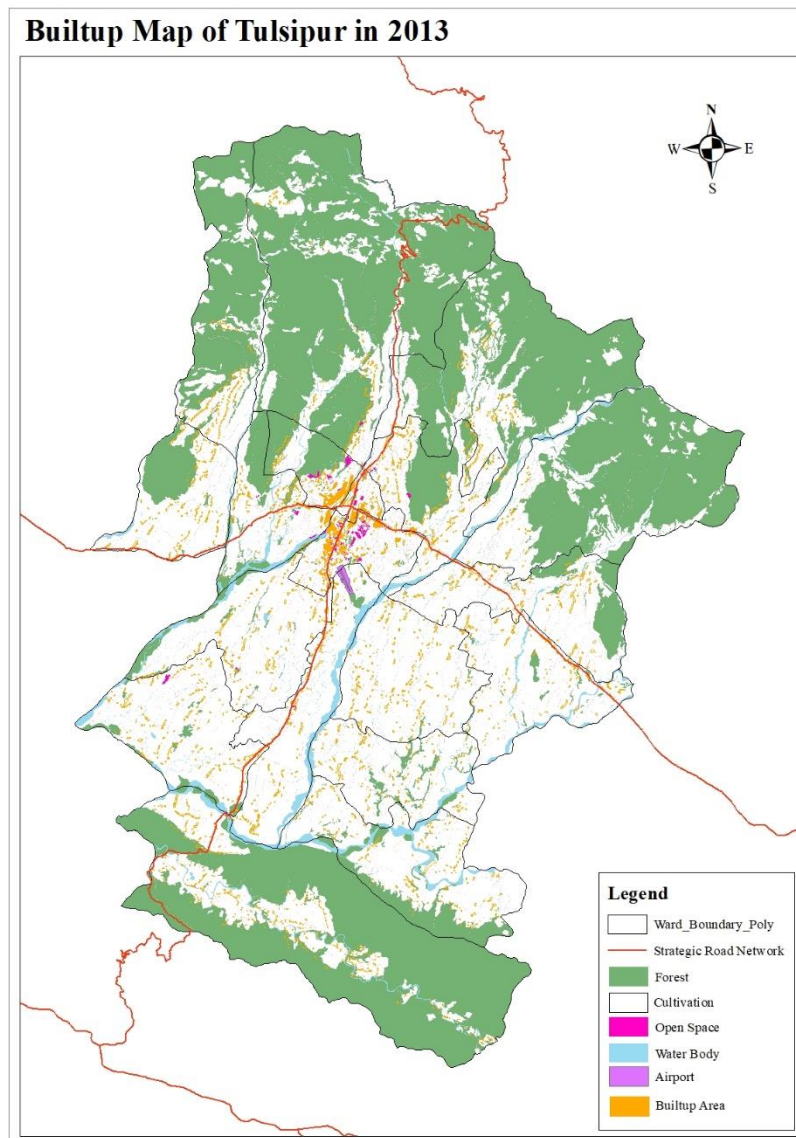


Figure 18 Built-Up Map of Tulsipur SMC in 2013

Built-up change clearly shows much changes have happened since 2012. Much growth can be seen around Tulsipur Bazar, located at the junction of E-W Tulsipur-Lamahi feeder road and Rapti Highway. This area has seen radiating growth. The development of relatively small market centres along E-W Lamahi Tulsipur road can also be noticed in the built-up change map. Similarly, the southern part of Rapti highway also shows the increased built-up density. Likewise, recent built-ups have developed areas previously used for agricultural purposes.

The northern and southern parts of the city are covered with forest and have high terrain compared to the central region, where the land topography is plain. Development is also concentrated in the central part. The sub-metropolitan city also hosts regional headquarter

of security, army and health facilities. With increasing demand from the growing population, the city is expected to have growth in infrastructures like roads, water supply, drainage, etc. In this cultivating stage of urbanization, it is crucial to deal with effective planning control mechanisms and incorporate innovative measures to systematize urbanization for a smarter future.

The land cover of Tulsipur Sub-Metropolitan City is tabulated below. Almost 52% of the area of Tulsipur Sub-Metropolitan City consists of cultivable land, and 8% of the total land is built-up. Tulsipur has 37% of forest

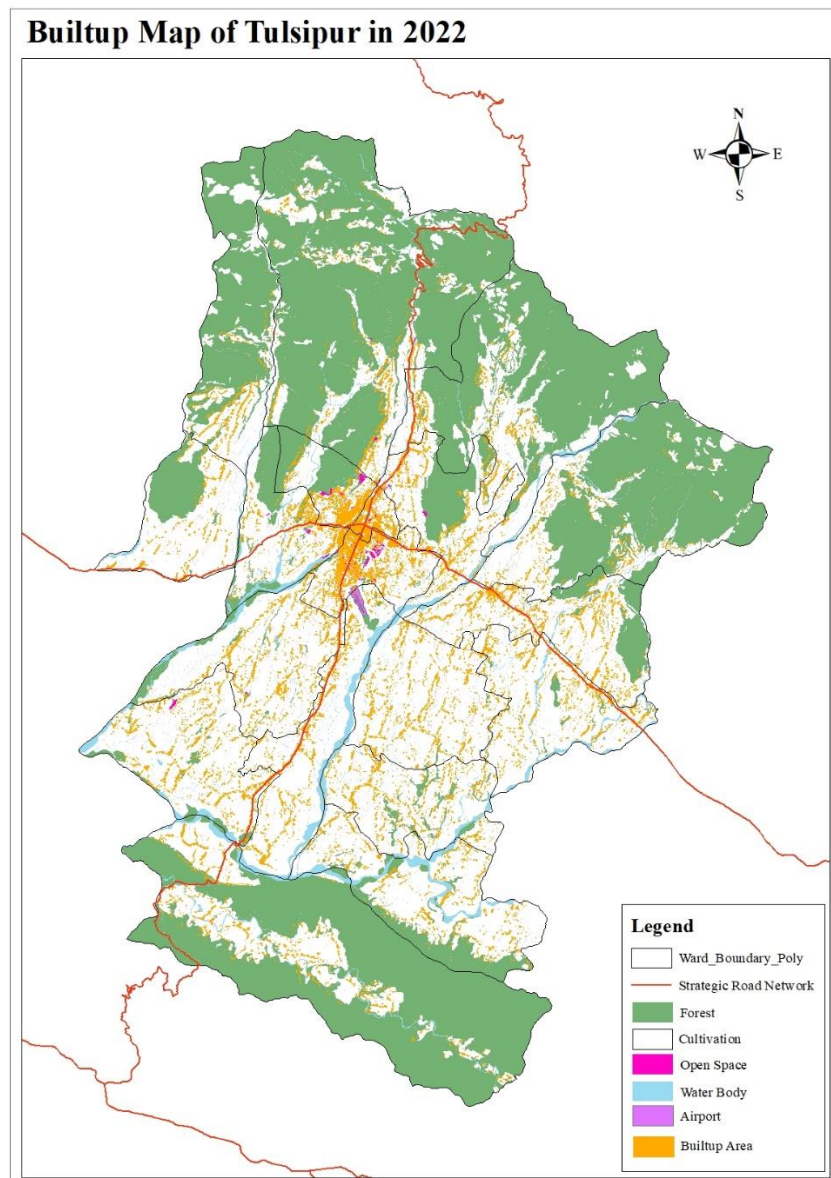


Figure 19 Built-Up Map of Tulsipur SMC in 2022

Table 7 Existing Landcover of Tulsipur SMC

S.N	Landuse	Area	Percentage
1	Barren Land	4.384	1.14%
2	Built Up	8.099	2.11%
3	Bushes	12.259	3.19%
4	Cultivation	201.386	52.34%
5	Forest	141.664	36.82%
6	Grassland	1.295	0.34%
7	Water Bodies	15.652	4.07%
Total		384.739	100.00%

Settlements have spread in most parts of the municipality in a scattered pattern on plains. Agricultural land has been encroached on by settlement. Similarly, strip/ribbon development patterns can be witnessed along the major and urban roads. However, a small market centre can be seen after a certain distance. Most of the settlements are observed on the southern plains rather than the northern hills. The settlements seem to be elongated as they have developed along the roads. The densest and biggest one is Tulsipur Bazar (city centre), which radiates (spreading out) from the central core. The city core shows a grid iron pattern of settlement.



Figure 20 Settlement Pattern (A: Grid iron Pattern; B: Leapfrogged/scatter Development; C: Strip/ribbon development pattern)

Tulsipur has developed as one of the common hubs for trading and commerce in the whole Dang district. Tulsipur Bazar is the primary market centre for many adjacent municipalities and even for the district as a whole. The life of people living in neighbouring municipalities and districts is directly associated with Tulsipur Sub-Metropolitan City for trade, health, and other purposes. The dense network of roadways in most wards has made it easier to access market goods and agricultural products for sellers and consumers and to transport 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 a residential area. It is necessary to encourage further development in existing settlements and discourage isolated small lots in rural zones. Due to the rapid Urbanization, many productive agricultural lands are being excessively exploited.

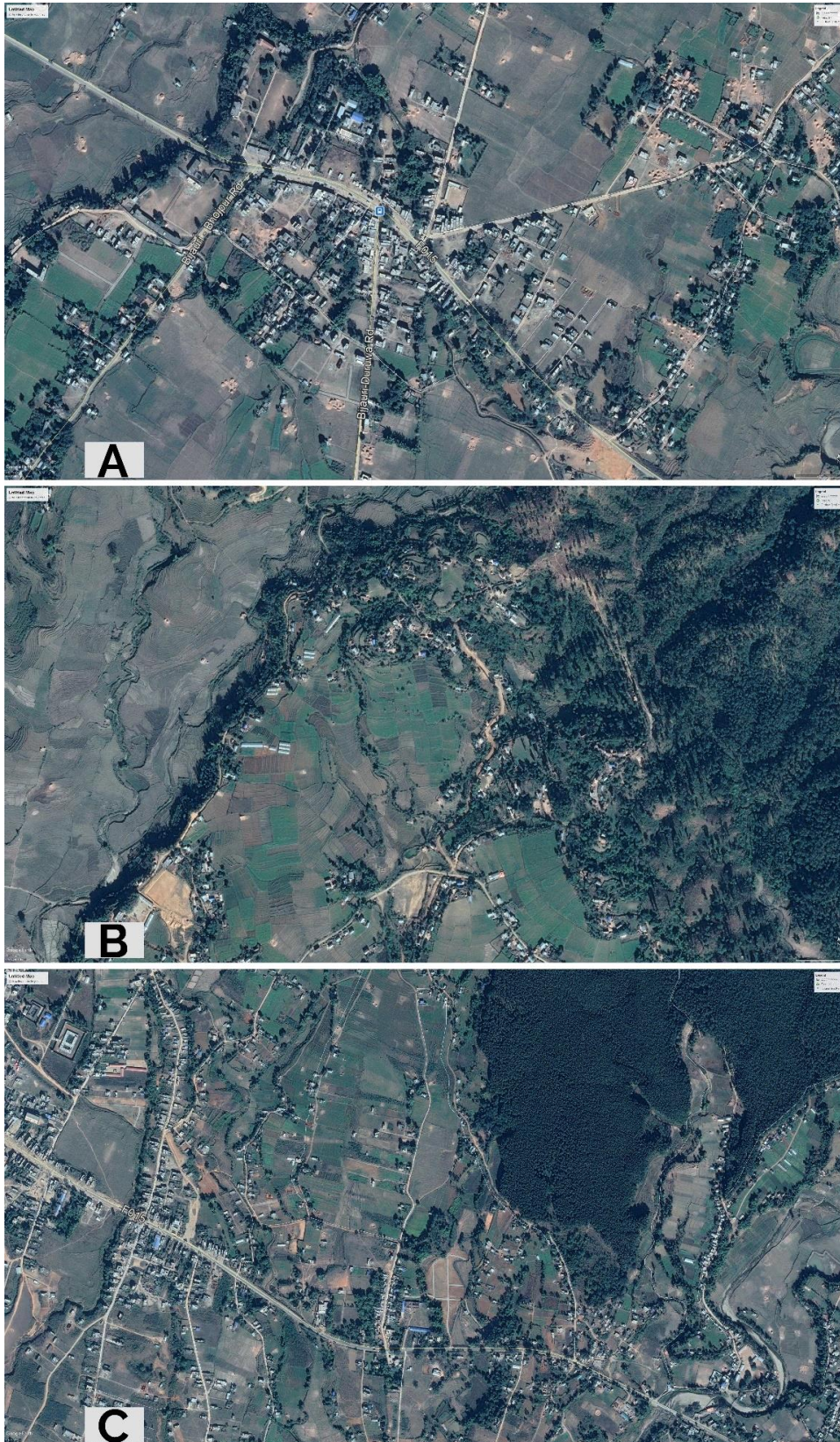


Figure 21 Settlement Pattern (A: Small market centre at bijauri, B: Development in hills, C: Finger Development)

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 have been recorded and still counting. Buildings are of different purposes like residential, commercial, and mixed use, but as per the data, the residential building permits dominate.

Table 8 Ward wise building permits record

Ward No.	Building Permit
1	7
2	10
3	3
4	17
5	27
6	193
7	105
8	84
9	72
10	16
11	5
12	17
13	3
14	2
15	4
16	8
17	64
18	50
19	35
Total	722

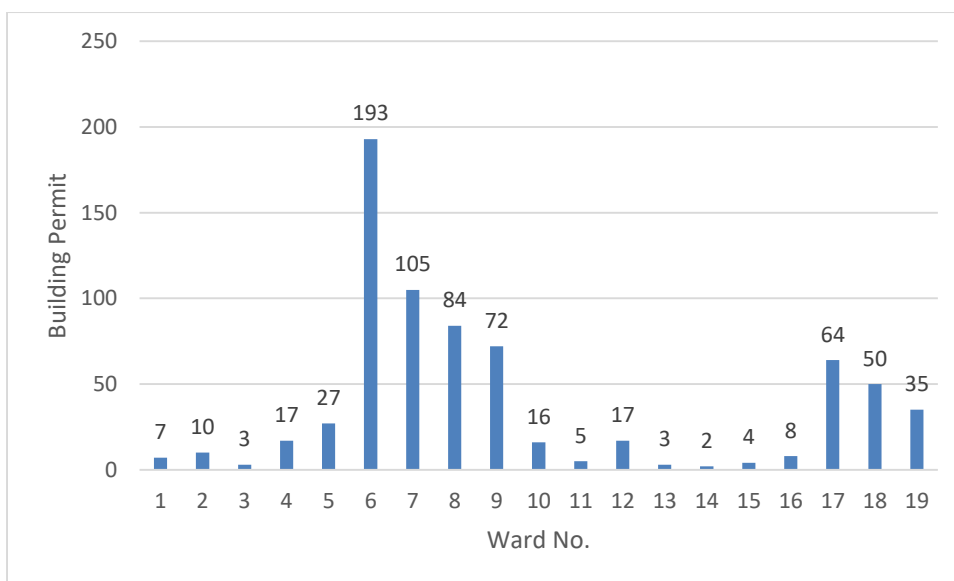


Figure 22 Bar chart of ward wise application

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.

Table 9 Total applications in different fiscal years.

S.N	Fiscal Year	Total Application
1	2076/77	–
2	2077/78	137
3	2078/79	541
4	2079/80	8

6.2 Criteria for suitable residential development

Several aspects affect how a residential area is developed; for example, land suitability analysis by multiple criteria evaluation process. These parameters must be determined under varied circumstances from various spatial and non-spatial, qualitative and quantitative data. Firstly, relevant data collection that is required for generating suitability maps is divided into two parts i.e. restriction factors and development factors. The restriction factors entirely restrict the development, and the remaining area is further analyzed for the suitability with degree of suitability with respect to the elements. The factors in terms of the study are developed from

the study of various literatures with similar context. As per the study the development criteria are classified as five planning criteria.

- **Connected City**

The initial planning objective is to consider the advantages and possibilities that the current infrastructure provides for the city and the community. Tulsipur has set goals for a well-developed public transportation system, paved roads, and a connected road network that will enhance connectivity in the city and the trunk lines of urban utilities like water supply, Telecommunication, and Electric lines. Tulsipur is served by urban transport roads, which represent an opportunity for growth and densification and act as attractors of investment. In contrast, the presences of roads increment the possibilities of public transport provision. The Euclidean distance analysis identifies the areas proximal to the road network and urban utilities (*Siqing, 2016*).

- **City of Equality**

Additionally, a fundamental planning objective is to situate future expansion zones near facilities for health and education, two necessities for everyone's daily existence. Future development is projected to be close to areas for education and health, which are also important sources of employment in Tulsipur. The reclassification of Euclidean distance denotes the areas that are benefited from the mentioned amenities.

- **An Ecological City**

Since biodiversity is one of the most crucial visions for the city's sustainable growth, this planning goal supports the preservation of protected forests, rivers, and native plants. The uniqueness of Tulsipur can be its complex urban system integrating with green ecosystems. More strategic, inventive, and forward-looking measures are needed to establish a livable, resilient, ecologically sound, and sustainable city while preserving its priceless environment and distinctive culture. Forests and Rivers represent a valuable natural resource within Tulsipur, accommodating a wide range of recreational activities that benefit locals and visitors.

- **Safe city**

Future developments should avoid specific locations sensitive to flood, landslide, and earthquake hazards. The three most serious risks for the city in recent years. This aim acknowledges that natural threats and disasters can influence the area.

- **Compact City**

This goal emphasizes the value of proximity between urban developments to utilize the resources, infrastructure, and services already present in the urbanized city centre and lower the overall cost of housing development. Due to abundant land available and a relatively small city population, many cities suffer from the adverse effect of urban sprawl, such as increased traffic and demand for mobility and increased investment in infrastructure (Ewing & Cervero, 2010). Tulsipur’s urban area offers various services and activities, including retail, education, health, and business. Future growth areas will be located in proximity to consolidated urban zones to increment to provision of accessible facilities and employment and reduce the negative impact of urban sprawl (Siqing, 2016).

A comprehensive assessment of land-use suitability for urban growth in Tulsipur SMC is carried out in this study. The selected areas are located in areas not prone to natural disasters and proximity to established neighbourhoods, jobs, education and health services, and major roads and train facilities.

Table 10 Input data for residential development suitability.

Planning Criteria	Criteria	Layers
Connected City	Proximity to major roads	Major roads
	Proximity to urban utilities	Water supply, Telecommunication and Electric distribution line networks
City of Equality	Proximity to Health Services	Health posts and Hospitals
	Proximity to Educational Institutes	Primary school, Secondary school and colleges
Ecological City	Restrict development in Rivers, Forest and significant landscape areas	Forest and Rivers
Safe City	Avoid flood-prone zones, landslide areas, earthquake fault line buffer	Slope, River buffer, Fault line buffer
Compact City	Proximity to market neighbourhoods	Market centres

6.3 Development of Suitability Index and Maps

Following the interview, the criteria were determined, and the suitability ranges and indices were set following 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, we 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 area respectively.

Table 11 Criteria and Assigned pixel value range.

S. N	Criteria	Pixel Value Assign				
		1=High Suitable	2=Moderately 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 centres	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

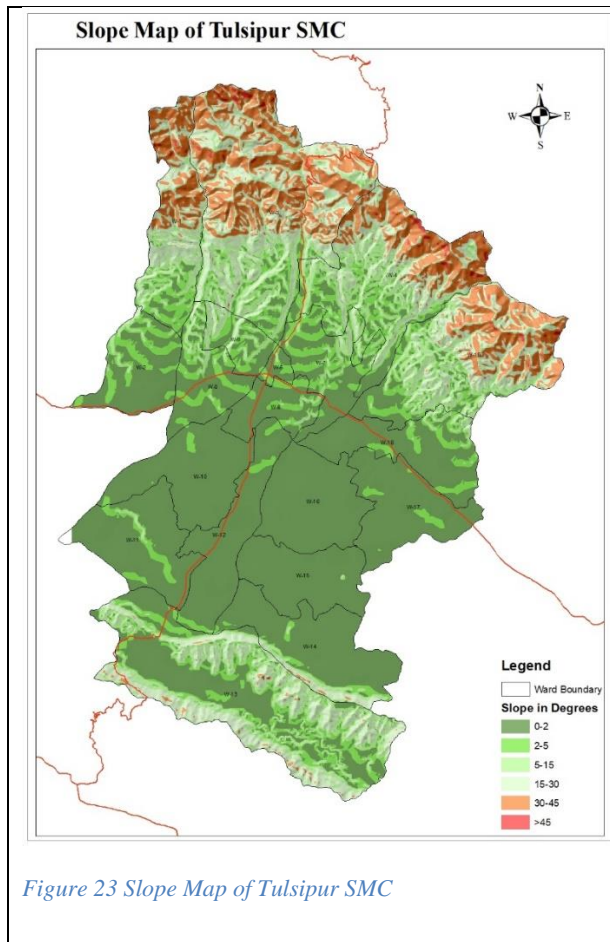


Figure 23 Slope Map of Tulsipur SMC

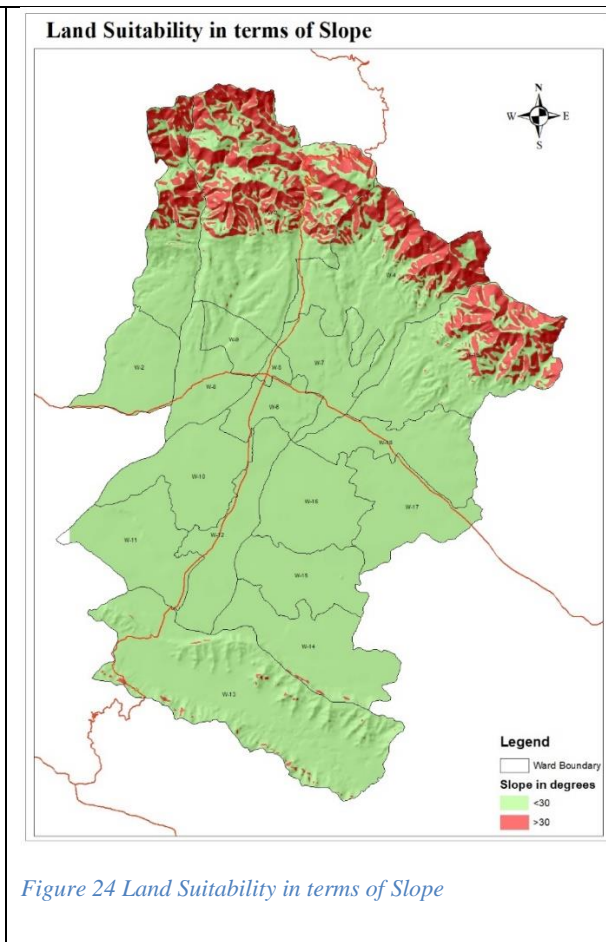


Figure 24 Land Suitability in terms of Slope

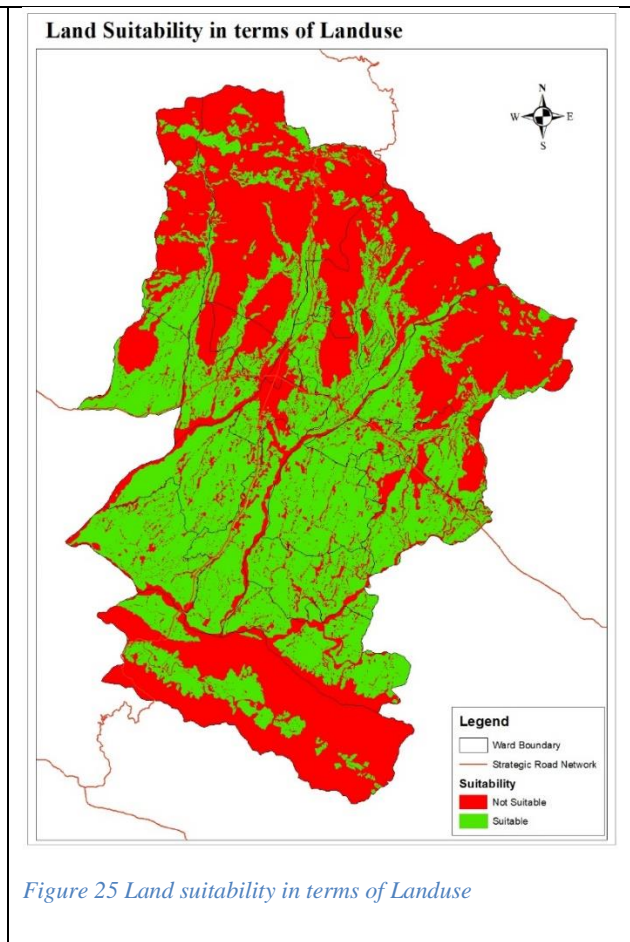


Figure 25 Land suitability in terms of Landuse

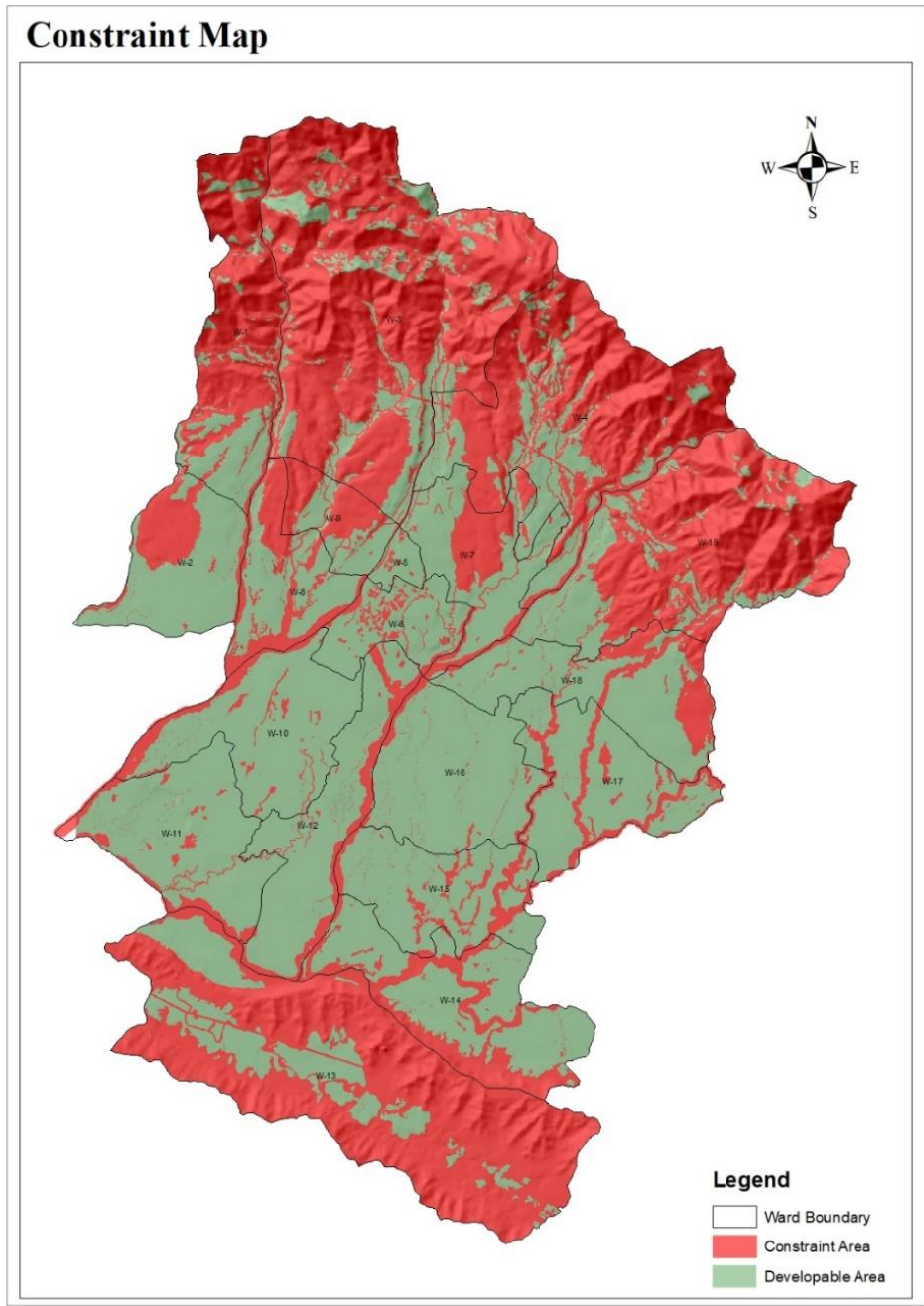


Figure 26 Final Constraint Map

Table 12 Restricted and Developable area of Tulsipur SMC

Suitability	Area	Percentage
Restricted area	18363.58	47.76%
Developable area	20089.13	52.24%

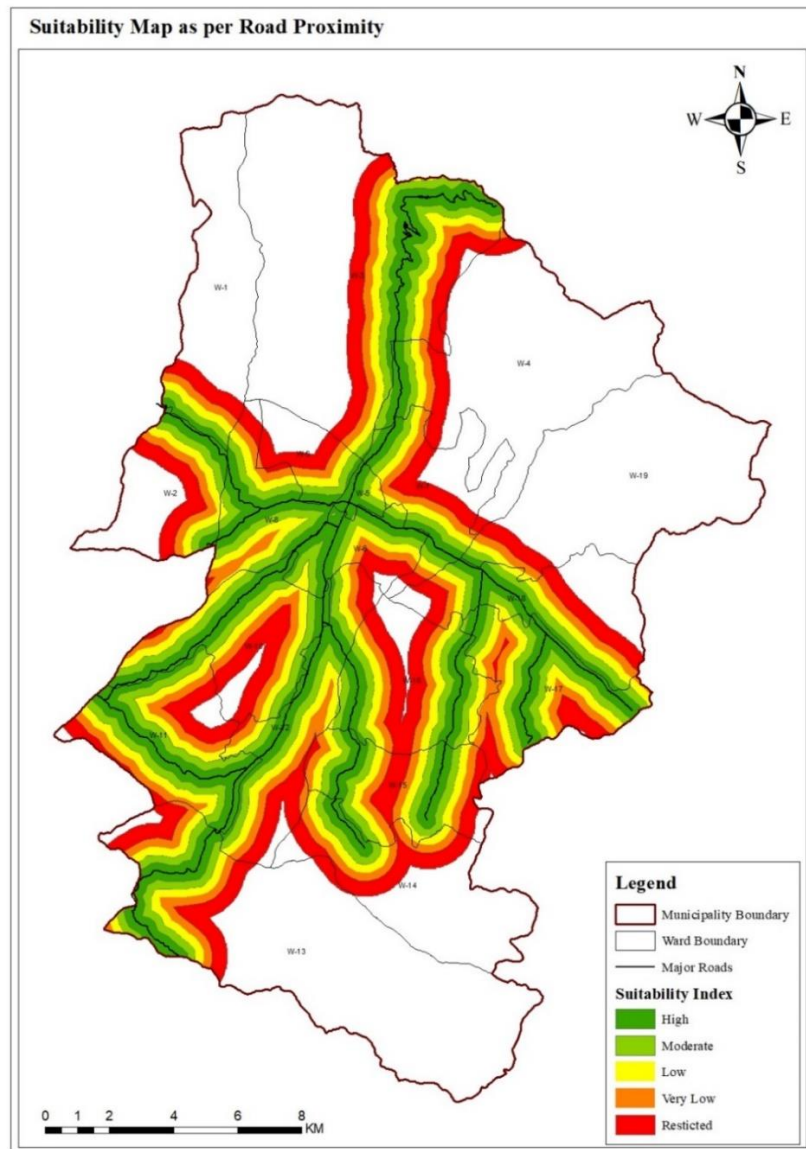


Figure 27 Suitability map as per proximity to major roads

Table 13 Percentage area distribution for major road proximity suitability

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-250m	1	High	4534.497	11.79%
2	251-500m	2	Moderate	3986.726	10.37%
3	501-750m	3	Low	3668.346	9.54%
4	751-1000m	4	Very Low	3248.152	8.45%
5	>1000	5	Restricted	23014.99	59.85%
Total				38452.71	100.00%

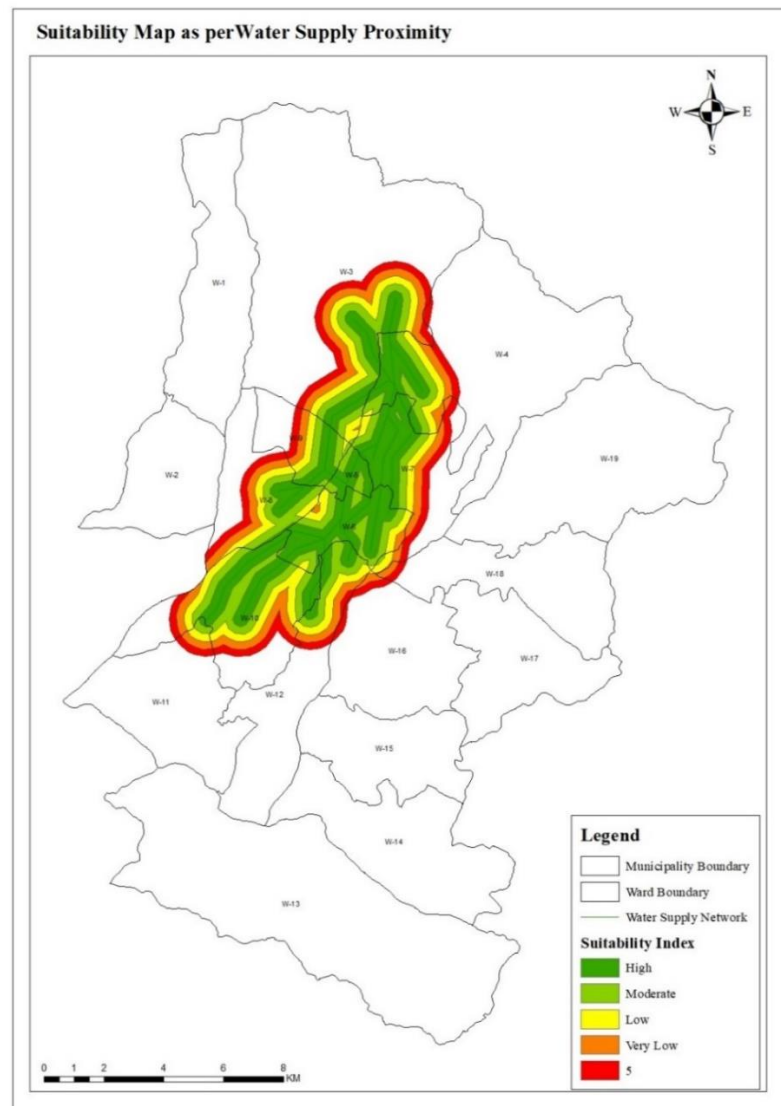


Figure 28 Suitability map as per proximity to water supply network

Table 14 Percentage area distribution for water supply network

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-250m	1	High	2213.533	5.76%
2	250-500m	2	Moderate	1489.078	3.87%
3	500-750m	3	Low	1117.647	2.91%
4	750-1000m	4	Very Low	963.8538	2.51%
5	>1000	5	Restricted	32668.6	84.96%
Total				38452.71	100.00%

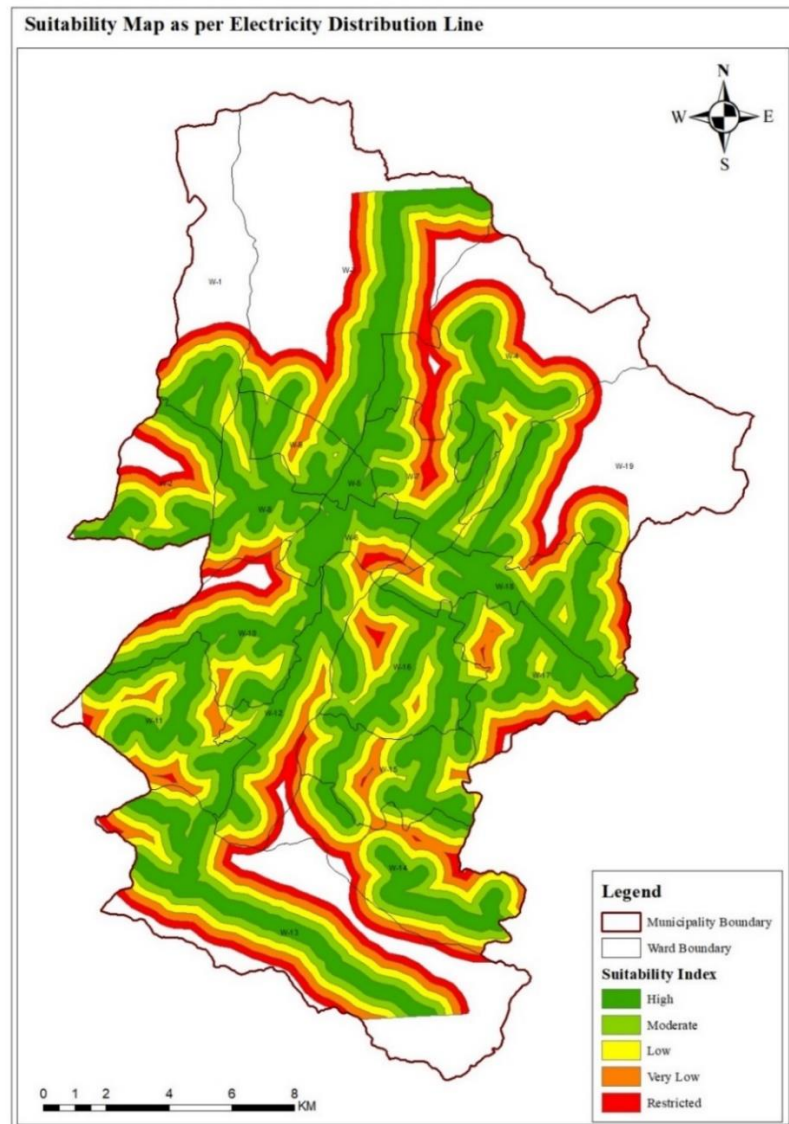


Figure 29 Suitability map as per proximity to electric distribution line

Table 15 Percentage area distribution for electric distribution line

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-250m	1	High	9633.306	25.05%
2	250-500m	2	Moderate	7243.231	18.84%
3	500-750m	3	Low	5587.593	14.53%
4	750-1000m	4	Very Low	3867.347	10.06%
5	>1000	5	Restricted	12121.23	31.52%
Total				38452.71	100.00%

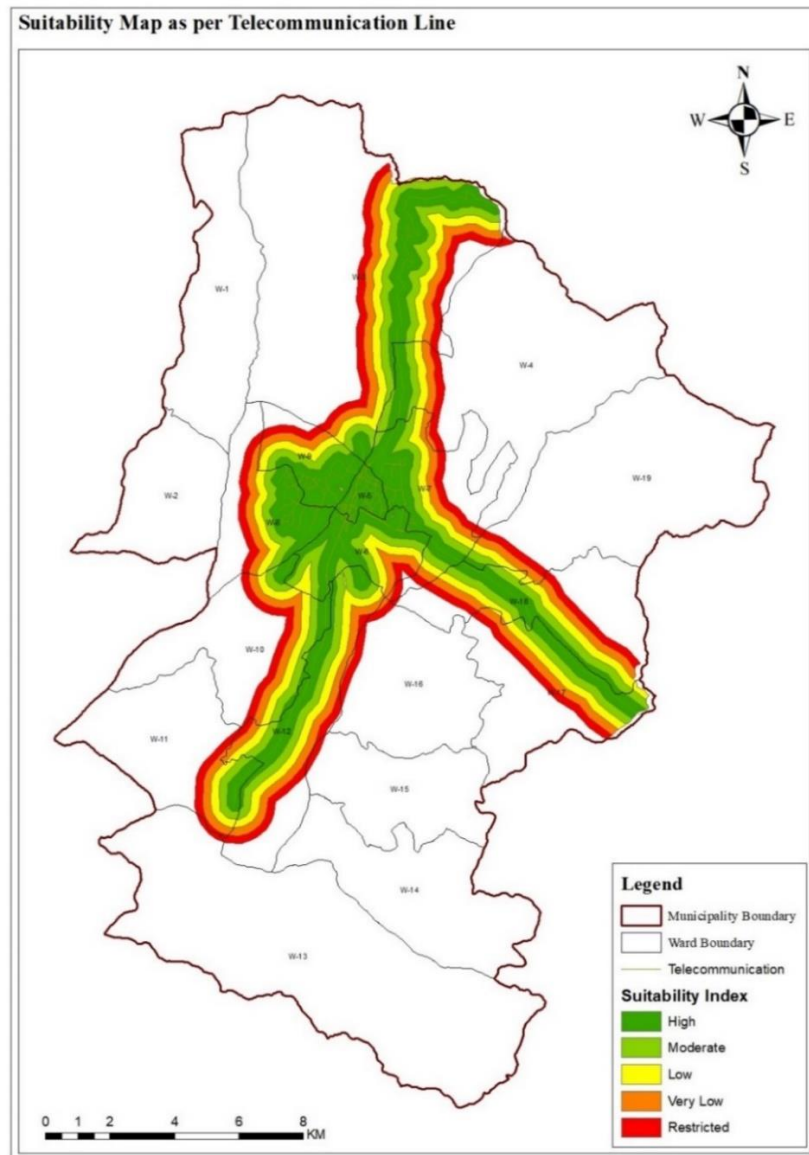


Figure 30 Suitability map as per proximity to telecommunication network

Table 16 Percentage area distribution for telecommunication network

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-250m	1	High	2848.24	7.41%
2	250-500m	2	Moderate	1940.939	5.05%
3	500-750m	3	Low	1762.96	4.58%
4	750-1000m	4	Very Low	1639.5	4.26%
5	>1000	5	Restricted	30261.07	78.70%
Total				38452.71	100.00%

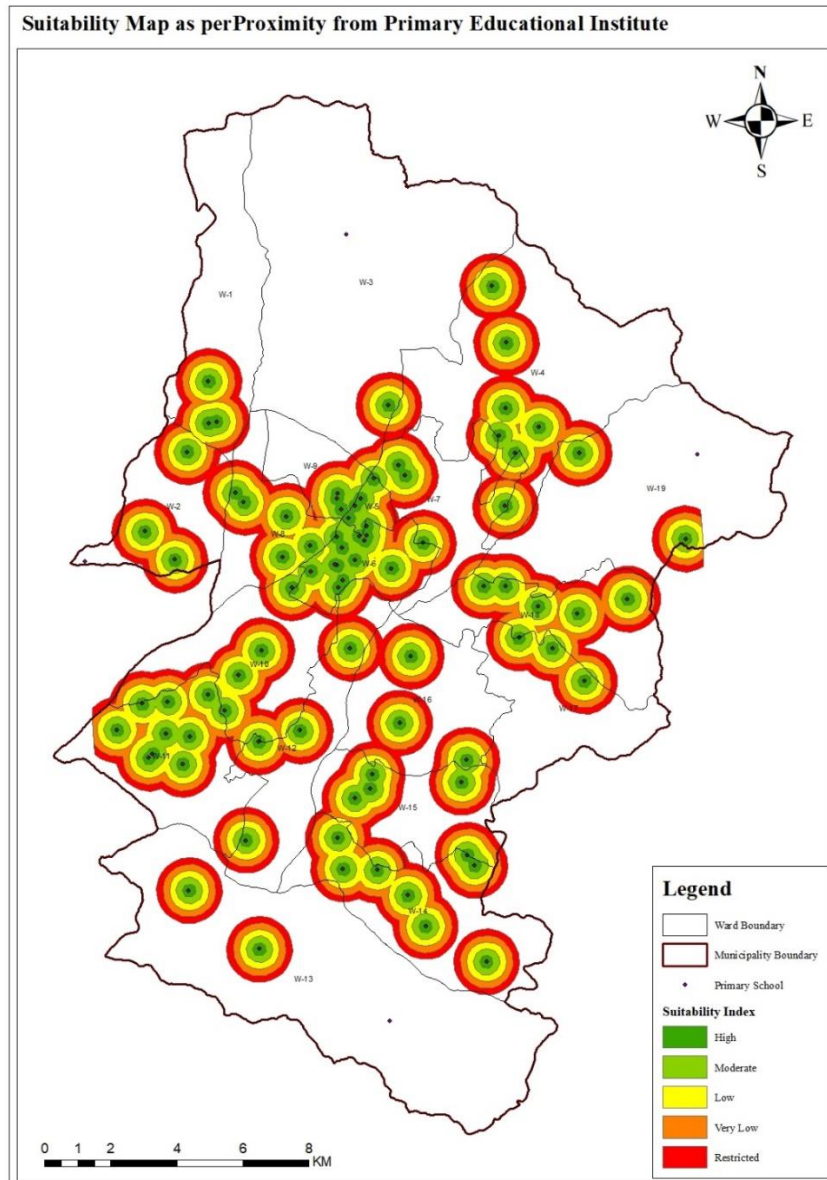


Figure 31 Suitability map as per proximity to primary educational institutes

Table 17 Percentage area distribution for primary educational institutes

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-200m	1	High	996.6989	2.59%
2	201-400m	2	Moderate	2699.438	7.02%
3	401-600m	3	Low	3744.275	9.74%
4	601-800m	4	Very Low	3857.777	10.03%
5	>800	5	Restricted	27154.52	70.62%
Total				38452.71	100.00%

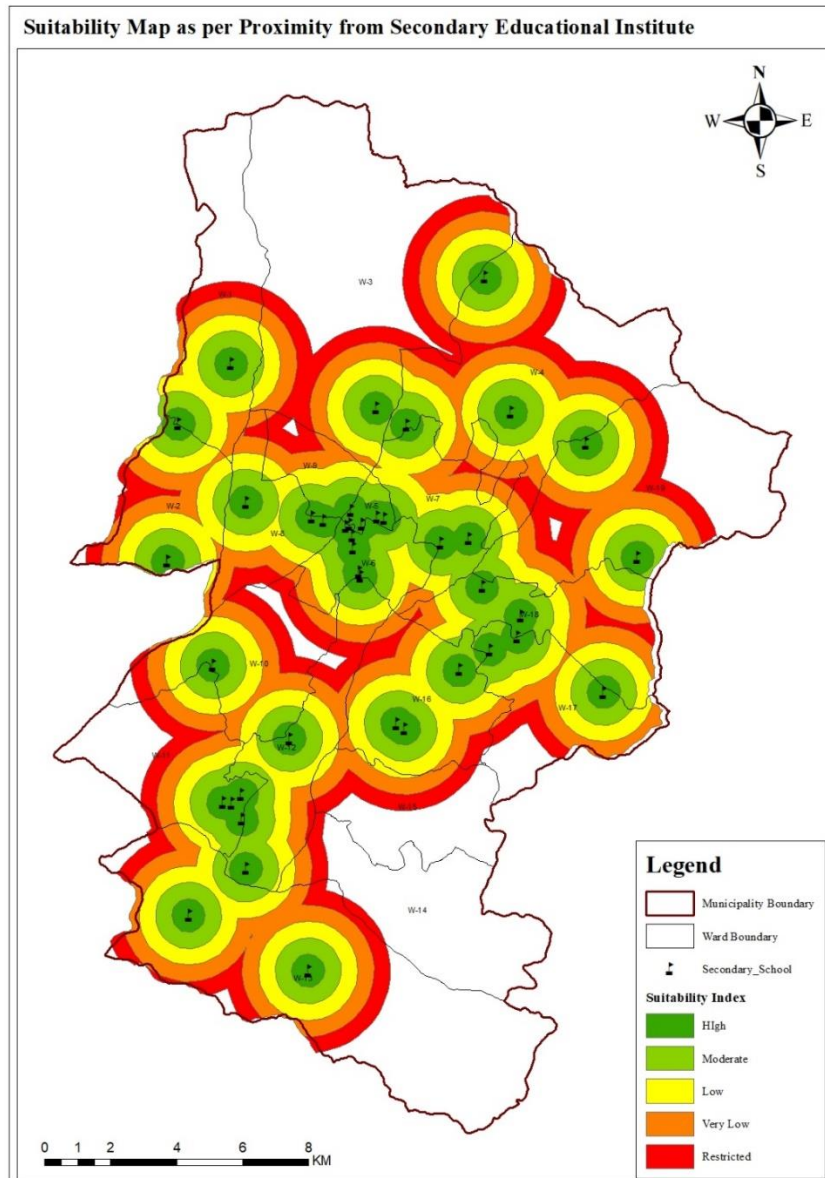


Figure 32 Suitability map as per proximity to secondary educational institute

Table 18 Percentage area distribution for secondary educational institutes

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-500m	1	High	2544.468	6.62%
2	501-1000m	2	Moderate	5678.064	14.77%
3	1001-1500m	3	Low	7268.518	18.90%
4	1501-2000m	4	Very Low	6943.116	18.06%
5	>2000	5	Restricted	16018.54	41.66%
Total				38452.71	100.00%

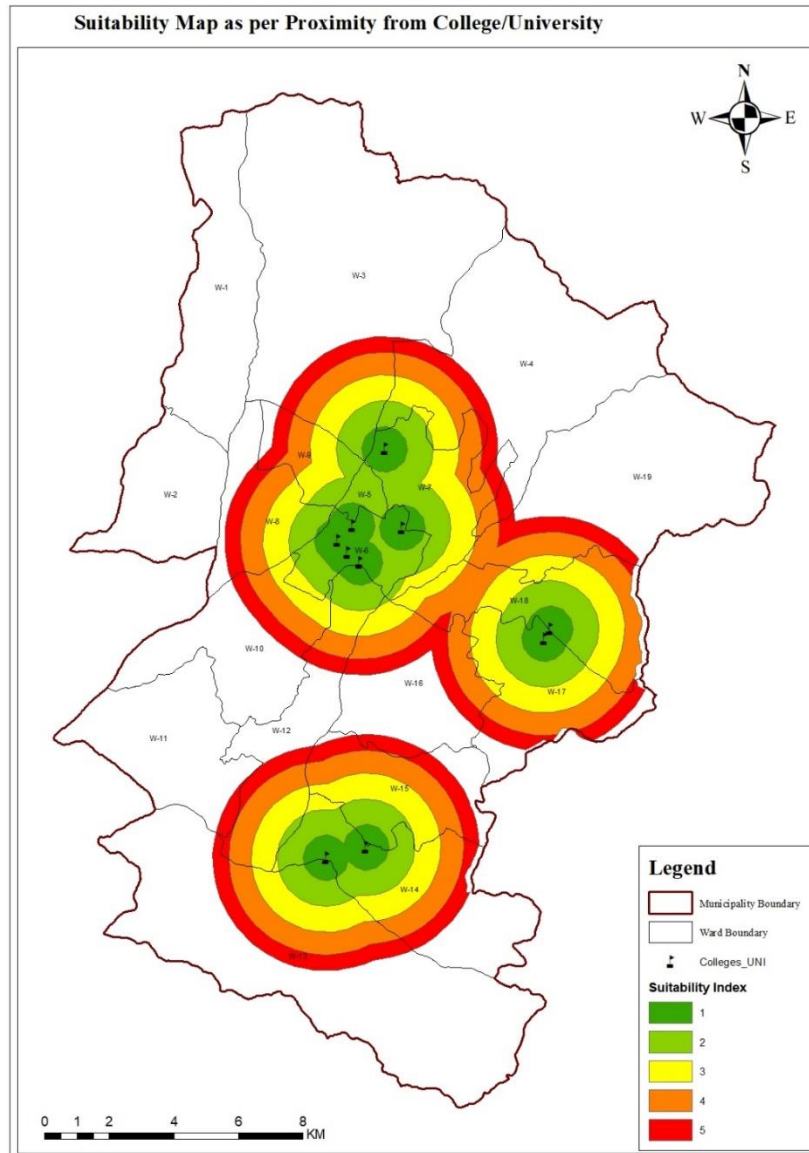


Figure 33 Suitability map as per proximity to college/university

Table 19 Percentage area distribution for college/university

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-700m	1	High	1183.2	3.08%
2	701-1500m	2	Moderate	2868.471	7.46%
3	1501-2300m	3	Low	3860.319	10.04%
4	2301-3000m	4	Very Low	4209.354	10.95%
5	>3000	5	Restricted	26331.36	68.48%
Total				38452.71	100.00%

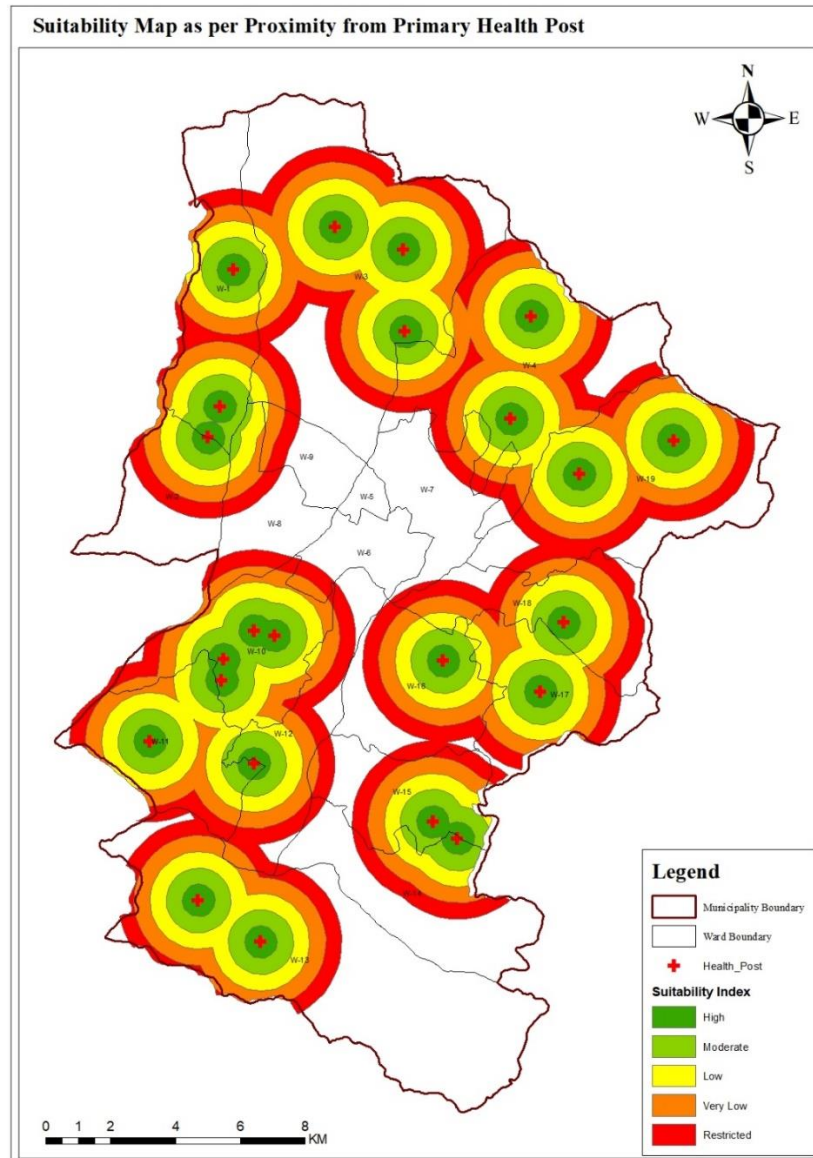


Figure 34 Suitability map as per proximity to the health post

Table 20 Percentage area distribution for health post

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-500m	1	High	1764.783	4.59%
2	501-1000m	2	Moderate	4741.756	12.33%
3	1001-1500m	3	Low	6928.831	18.02%
4	1501-2000m	4	Very Low	7158.375	18.62%
5	>2000	5	Restricted	17858.96	46.44%
Total				38452.71	100.00%

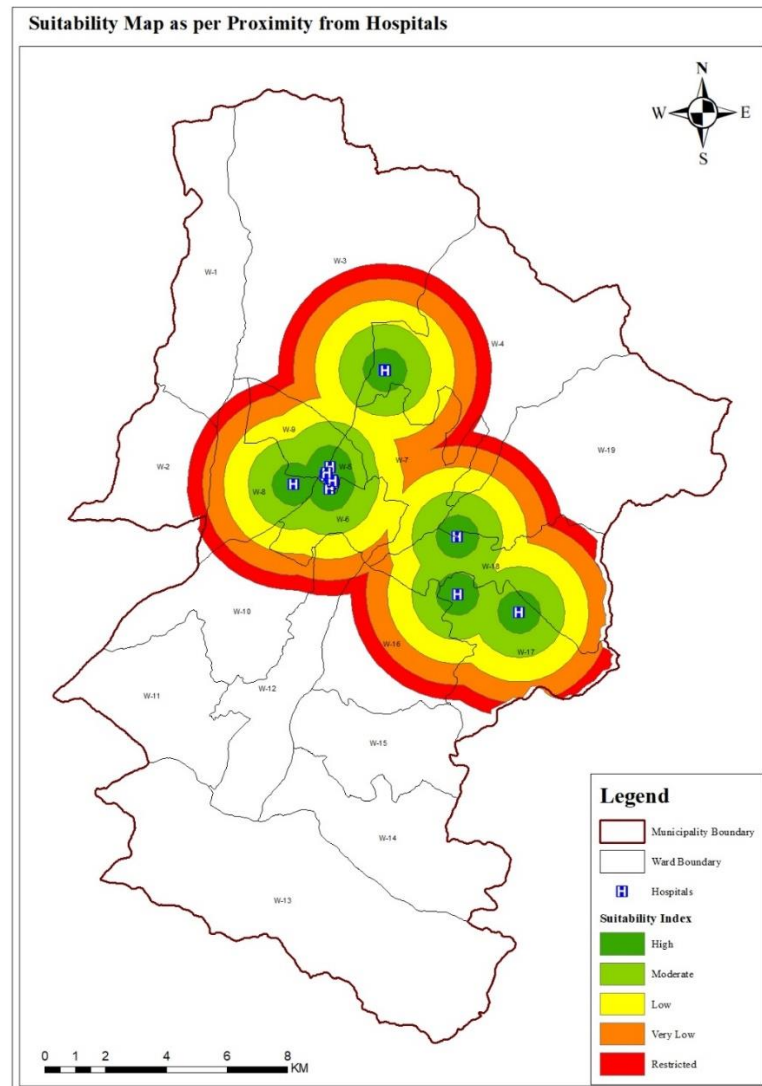


Figure 35 Suitability map as per proximity to hospital

Table 21 Percentage area distribution for hospital

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-700m	1	High	1030.044	2.68%
2	701-1500m	2	Moderate	2746.7328	7.14%
3	1501-2300m	3	Low	3613.9563	9.40%
4	2301-3000m	4	Very Low	3168.717	8.24%
5	>3000	5	Restricted	27893.258	72.54%
Total				38452.708	100.00%

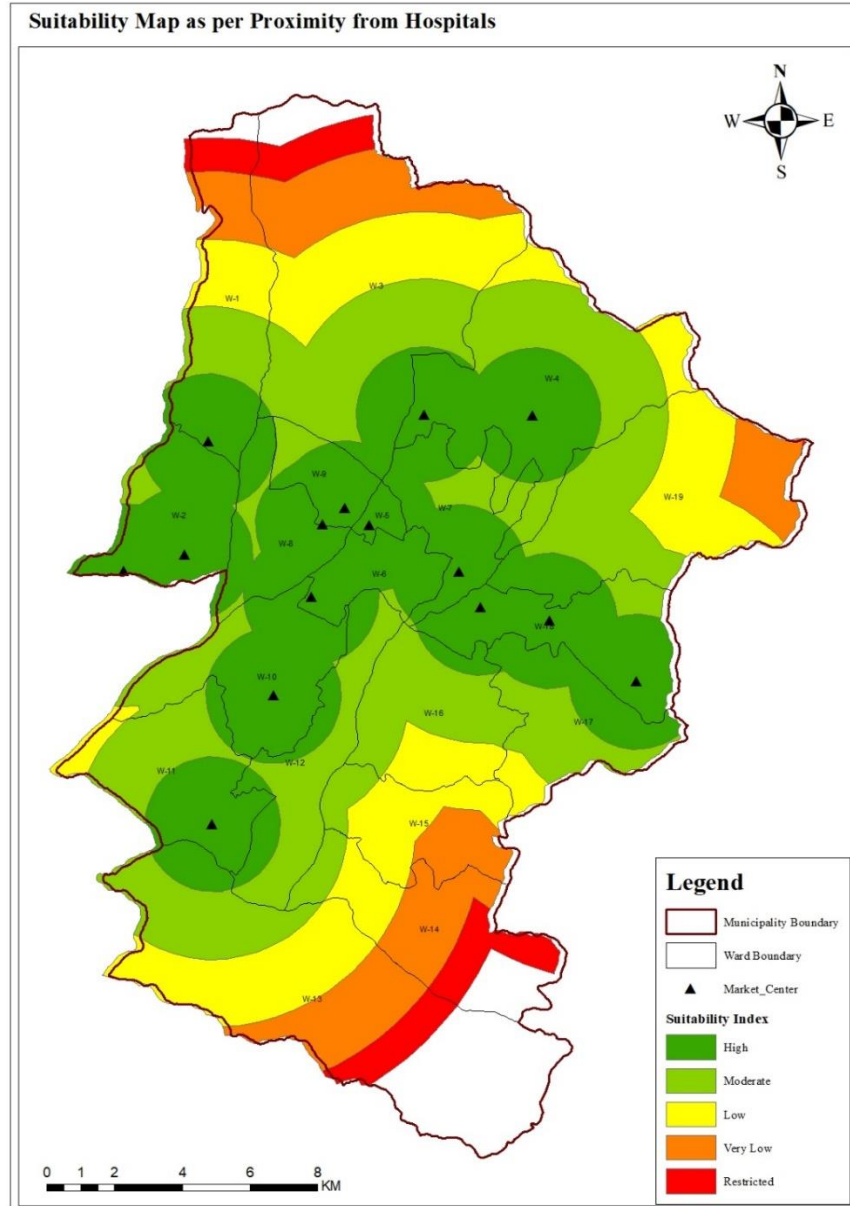


Figure 36 Suitability map as per proximity to the market centre

Table 22 Percentage area distribution for market centre proximity

S.N	Proximity Distance Range	Pixel value	Suitability Index	Area(Ha)	Percentage
1	0-2000m	1	High	12778.251	33.23%
2	2001-4000m	2	Moderate	11243.4175	29.24%
3	4001-6000m	3	Low	6788.59764	17.65%
4	6001-8000m	4	Very Low	4018.98224	10.45%
5	>8000	5	Restricted	3623.45967	9.42%
Total				38452.708	100.00%

6.4 Determination of Final Suitability Map

Firstly, we need to find a suitable map for the developable criteria. Then we integrate the final constraint map with the developable criteria suitability map to get the final suitability map for the residential area of Tulsipur SMC.

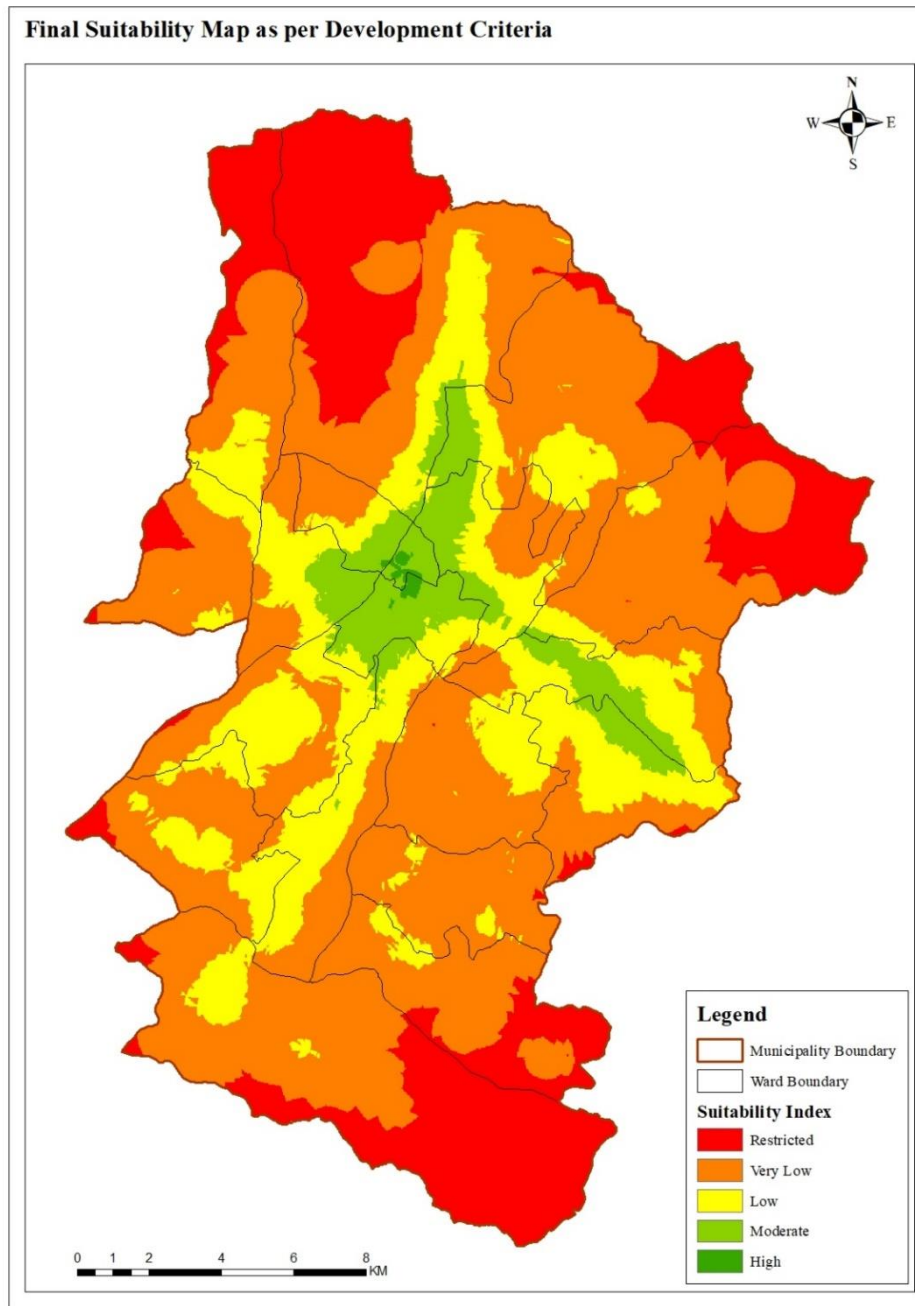


Figure 37 Final Suitability Map as per Development Criteria

Table 23 Percentage distribution of area for suitability map as per development criteria

SN	Suitability	Area (Ha)	Percentage
1	High	68.470417	0.18%
2	Moderate	2470.6606	6.43%
3	Low	8003.3807	20.81%
4	Very Low	19246.323	50.05%
5	Restricted	8663.8752	22.53%
Total		38452.71	100.00%

The data shows only 0.18% of the total area is highly suitable, 6.43% moderate suitable, 20.81% low suitable and 50.05% very low suitable for residential development in the city as per the development criteria adopted for the study. About 22.53% of the area was unsuitable in the city's peripheral region.

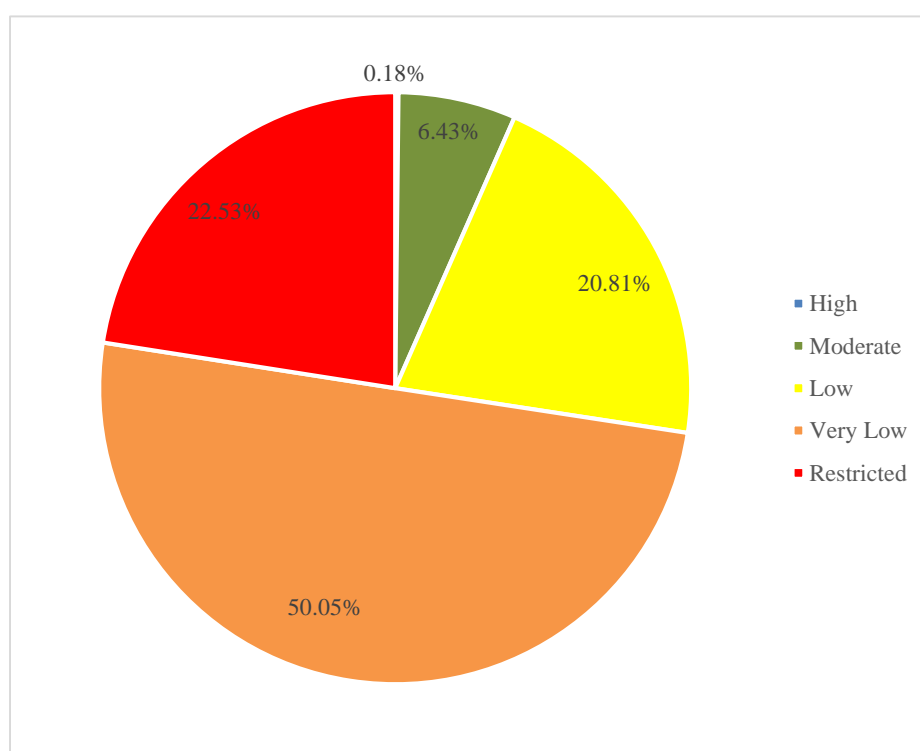


Figure 38 Pie chart representation for suitability index as per development criteria.

Furthermore, the development criteria should consider the constraints for the final suitability for residential development in Tulsipur SMC. So by integrating this final suitability map and constraint map, the final suitability map is understood to be developed.

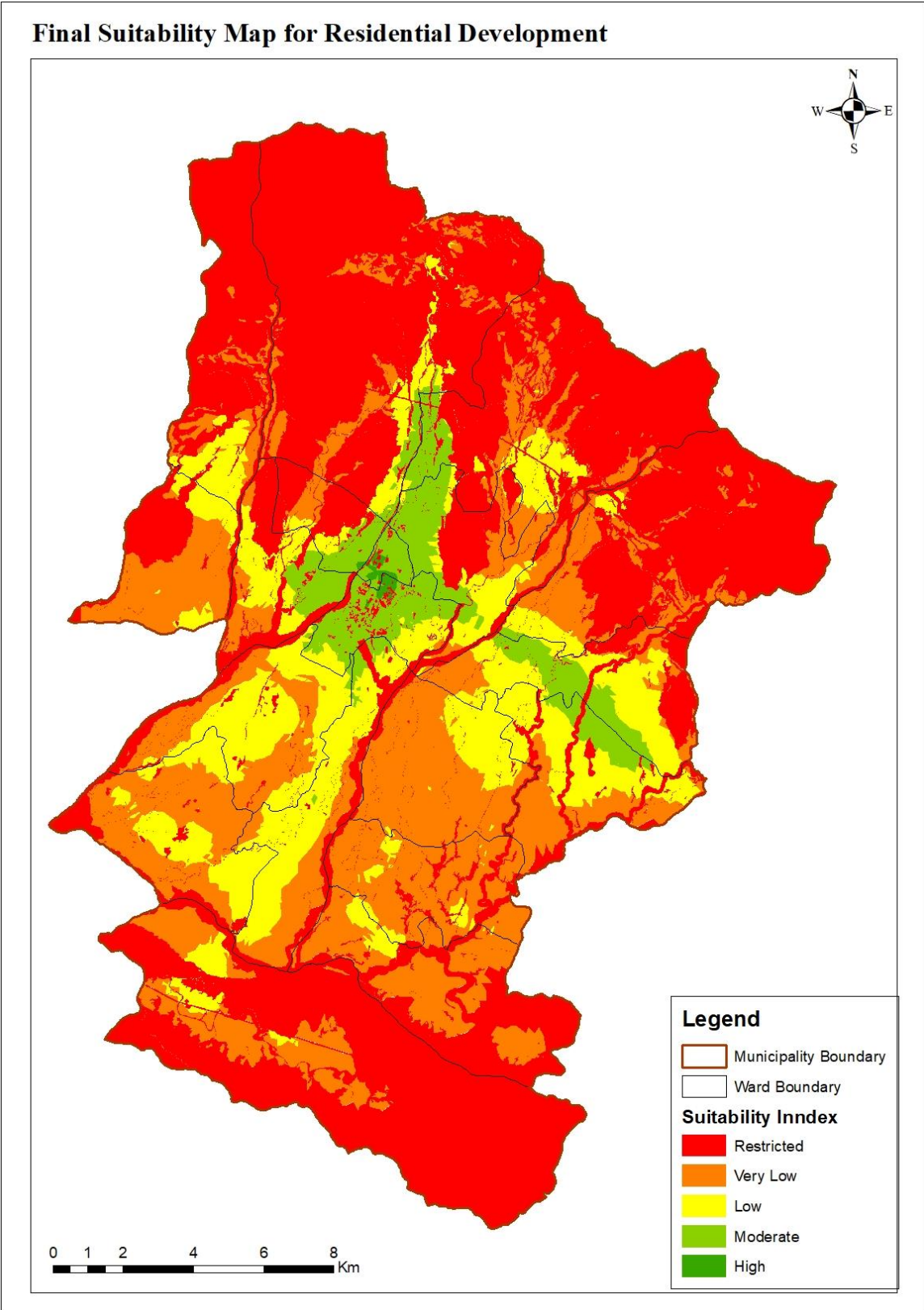


Figure 39 Final Suitability Map for Residential Development in Tulsipur SMC

Table 24 : Percentage distribution of area for final suitability map

SN	Suitability	Area (Ha)	Percentage
1	High	58.645263	0.15%
2	Moderate	2196.421015	5.71%
3	Low	6243.936494	16.24%
4	Very Low	10069.77572	26.19%
5	Restricted	19883.93151	51.71%
Total		38452.71	100.00%

The data shows only 0.15% of the 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 the development criteria adopted for the study. About 51.71% are resulted to be unsuitable/restricted lying in the peripheral region of the city.

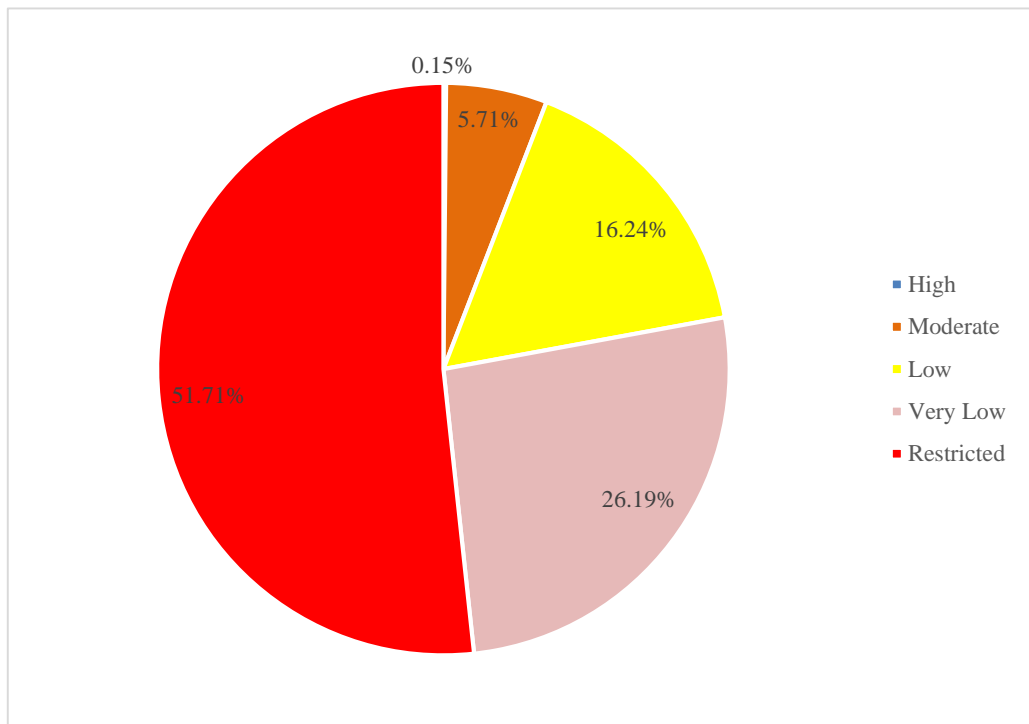


Figure 40 Pie chart representation for final suitability

CHAPTER 7: DISCUSSION, CONCLUSION AND RECOMMENDATION

7.1 Discussion and Conclusion

Built-up areas in Tulsipur SMC have changed from 2004 to the present (2022). Between 2004 and 2022, the built-up areas in Tulsipur SMC increased significantly, from 1.08 sq. km to 8.09 sq. km. We can see the grid iron pattern in Birendra chowk, the core area of Tulsipur SMC planned in the past. We can sense that there is no area designated for the urban expansion zone which is causing urban sprawl all over the nation. This study might help to plan about the future expansion area. which implies the other area suitable from the analysis is also very crucial to be designed as a residential area to overcome the future problem due to urbanization. The maps of restricted factors and development factors were overlaid to investigate their spatial relationships. The analyses focused on risk-related trends between the present and future. Given the absence of data necessary to generate credible estimates, we assumed that social vulnerability in municipalities would remain unchanged in the future. However, prior to research indicates that social exposure/ vulnerability is not anticipated to change considerably over time.

Hence, analysis for residential development resulted in the site suitability of the residential area in Tulsipur SMC. Since the research was entirely context-based, the factors were divided into two major groups, namely restricted criteria and development criteria. Only useful criteria were broadly selected for the analysis. They were furthermore divided into five major planning criteria, i.e. safe city, connected city, ecological city, compact city and city of equality. GIS tool was to generate the final suitability map for residential development. The outcomes of the residential land suitability analysis were situation-based. The primary discussion occurs on why was the highly suitable area determined less. It was because a place can't have equal accessibility to every urban amenities and is safe from the restriction criteria. The data shows only 0.15% of the 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 the development criteria adopted for the study. About 51.71% area resulted to be unsuitable/restricted lying in the peripheral region of the city as per the current location of existing urban amenities and physical infrastructures and trunk lines of water supply, electricity and telecommunication.

Since the restricted area, i.e. safe city and ecological city, covers 47.8 percentage of the total area clearly defines the suitable area for development reduced to almost half the total area considering the environmental aspect.

Scenario	Wards	Dominant featureso
Suitable and Growth	6,7,8	Vacant Land, No earthquake risk, Close to utility services
Unsuitable and Growth	9,19	Own land, Low Land price, constraint factors.
Suitable and Less Growth	5	Homestead, Very less land available, High Land price
Unsuitable and Less Growth	1,3,4,13,14	Forest and Vulnerable areas

Looking at the final suitable map generated above and the growth trend through the building permits of the past two years of Tulsipur. Wards 6,7 and 8 are considered as suitable area where the trend of growing houses is also high, which might be due to the low-risk zone and high facilities within the core-periphery. Ward no. 5 can be seen as a highly suitable area with very few building permits since the ward is the city's core area, and significantly less land is available for further development. Also, being the city's core area and accessibility to almost every amenity, the land price was the main concern for fewer building permits. Ward 9 and 19 can be seen as an unsuitable area for development, but a high number of building permits can be seen due to the land ownership and low land price of that area, motivating people to take the risk. Ward 1,3,4,13, and14 were found to be unsuitable areas, and the number of building permits is also very low since these wards fall under restricted and remote areas. The core area, understood as a planned area, also lies in the suitable area found in the study, which also means that the areas planned before were not vulnerable to risks. Although this kind of study were not held in the past, people in the past are believed to make the core area in a very suitable area. The main concern arises when some part of the core city still lies in unsuitable area because of the river's encroachment and building construction.

The suitable area with more building permits needs no interventions, which may lead to a compact city, and the suitable regions with fewer building permits should be encouraged for development. As a result, an infill development would happen, which can help to control urban sprawl. These areas should be used for urban residential areas to facilitate new housing

development. Also, if we can increase the development /growth towards the already built infrastructures and urban amenities, the initial investment for the new construction of other urban amenities can be saved and the infrastructure budgeting plan for the municipality will also be more efficient. Unsuitable areas with high building permits should be highly discouraged from development since it will lead to urban sprawl and the development at risk areas which may affect in the long term. The unsuitable area with fewer building permits must restrict further development in the area and be used for other recreational purposes. There shouldn't be any significant development in these locations. The area's lands lie near fault lines. Therefore, there is a risk of earthquakes in certain areas. Talking about the control of sprawl seen dominantly in Tulsipur SMC would lead the municipality to phase-wise infrastructure construction.

The whole analysis was carried out to achieve the study's primary objective. It is observed that the GIS is a tool that offers more flexibility and precision for land suitability assessments in urban settings. Although similar tasks have been carried out manually by urban planners in the past, this study may be helpful in the decision-making process for land use planning. It may also aid in the sustainable urban development of Tulsipur SMC. Determining whether land should be developed right away or preserved for future development is crucial for planners. To create urban growth policies and strategies for a city, planners and policymakers can use the technique to monitor urban land development. People's tendency to invest in land, believing it to be both rewarding and safe, increased swiftly as a result of the rapacious rate of urbanization and the ensuing swift growth in land value. Buying and selling of land have been taking place in a large scale. However, the amount of money that should have gone to the government did not rise accordingly. This reflects the significant discrepancy between the government-set guidelines and the actual prices at which sales have been occurring.

7.2 Policy Interventions

Publishing numerous plans by different bodies has created wider gaps and confusion among the implementing body. Land use planning is not adequately linked with risk reduction. Earthquake Prone and possible liquefaction area are found to have been used for intense development. Building Permits issued under pressure without complying with Building Bye-laws is also an issue.

One of the significant interventions could be the Incentives; As KMC provides incentives for heritage home construction up to 32 lakhs, we can apply similarly for the houses to be constructed in that designated zone for residential development. The incentive would be an

initial investment, Tax discount, and Material supply from the municipality side. Another policy could be Force/Freeze the area. It can be understood as forcing people to develop the residence only in the residential area found in the study or freezing the construction of residential houses rather than the designated area. Since Nepal is a democratic country with a dual land ownership system, where Forcing and freezing seem to be difficult but can be done with certain awareness and motivation.

The next policy would be rental of the houses. Construction of those rental houses can be done either by the municipality or public-private and people partnerships. This policy was considered in France but could be totally different in the South Asian context, especially in western Nepal. Also the policy has a drawback regarding housing affordability for young and underprivileged people.

The municipality would recommend people with the information that the utility services and bigger investment projects would be taken into priority only in the designated residential zone so that if anyone decides to construct a residential house away from the designated zone may be deprived of the municipal and urban services such as physical and socio-economic services. The information could be given at the municipal portal, local newspapers and local media. Afterwards, it would be a calculated risk if anyone decides to go against the information. Impact fees can be a valuable tool for guaranteeing adequate infrastructure to handle expansion where and when it is predicted when they are based on a thorough plan and used in conjunction with a strong capital improvement plan. Communities should rely on zoning and other land use laws that align with a comprehensive plan to control growth patterns and better anticipate the demand for new infrastructure. Impact fees, however, might be seen as growth facilitators in places where development moratoria are in place due to a lack of suitable public infrastructure rather than growth stoppers. Impact fees shouldn't be used to "halt growth" or as a magic solution for financing general capital projects. The two are incompatible. Impact fees are now being used more frequently by many local municipalities to pay for various public facilities. These taxes are mainly used for roads, parks, and water and sewer infrastructure. The United States practices this.

7.3 Recommendation from the study

Planners and policymakers can use the study's methodology and findings in various ways. This method is strongly favoured for investigating a site's suitability in an international context. Thus, current generation planners can use this technology and GIS as a tool to save a ton of time over old ways. Similar to how the analysis will be more effective and simple with this

procedure, the results are typically displayed in the form of informative, indicative and publicly faced maps that are easy to comprehend by all types of readers. As

Decision-makers can use the study's findings to create regulations governing land usage in the city. Four nominal suitability categories, namely highly suitable, moderately suitable, low suitable, and very low suitable, were used to categorize the results. Highly suitable areas can be utilized for entirely residential activities, such as colony housing, where only residential activities are permitted. Similar areas in generally appropriate regions can be approved for residential and commercial development. Low-suitability zones may allow for residential construction with some restrictions, such as requiring that only 40% of the plot be used for housing and 60% be used for landscaping and vegetation. It can be agreed with the thoughts of experts that low-density community housing would be more appropriate for the city in the same context as the type of residential plan in the city. There are two leading causes for it. The first is that the city is populated mainly by cultural families who place a higher value on communal cohesion than on economic prosperity. The city's lack of contemporary technology is the second factor, as it may make mistakes when responding to emergencies such as fire escapes from high-rise apartments and other scenarios. Looking at the growth trend of the city, certain areas must be separated for future generations and high-rise building designated zone must be separated. As of now, low rise and low dense, culturally combined community housing type of residential plans would be a more favourable option for the city.

So the major recommendation of the study is to develop the residence only in the designated zone found in the study. This study also recommends not to use that designated area for any other purpose.

7.4 Recommendation for further studies

The development factors and restriction factors were chosen based on a literature review and consultations with a selected group of specialists due to various restrictions. Therefore, in future research, planners can perform FGD with experts and, using the opinion of several specialists in related fields, calculate the weightage of each criterion precisely and effectively. This will strengthen the effects and increase their potency. Furthermore, the 2011 census data sets were included in the investigation. Therefore, the new researcher can use the most recent CBS 2022 datasets for a more detailed and accurate analysis.

Also, in further research, the unsuitable area found in this research would be suitable for any other purpose than residential development. For example, ward no. 1,3,4,13,14 are near to the forest area, so the area could be suitable for Tourism, or Agricultural/ cultivation, which can be

identified with further research. Furthermore, Suitability with probability of every development factors can be determined.

REFERENCES

- Acosta, A., & De los Santos-Montero, L. A. (2019). What is driving livestock total factor productivity change? A persistent and transient efficiency analysis. *Global Food Security*, 21(November 2018), 1–12. <https://doi.org/10.1016/j.gfs.2019.06.001>
- Act, T. R. to H. (2018). The Right to Housing Act , 2075 (2018). *An Act Made To Provide for Right to Housing, 2075(12)*, 1–11.
- Burney, A. (2008). Inductive and Deductive Research Approach. *Research Approach, March*, 22. <https://doi.org/10.1177/0266666903192004>
- Cervero, R., & Kockelman, K. (1997). Travel Demand and The 3Ds. *Transport and Environment* , 2(3), 199–219.
- Cheng, M., & Wei, W. (2020). An AHP-DEA Approach of the Bike-Sharing Spots Selection Problem in the Free-Floating Bike-Sharing System. *Discrete Dynamics in Nature and Society*, 2020. <https://doi.org/10.1155/2020/7823971>
- Chioldelli, F. (2016). International Housing Policy for the Urban Poor and the Informal City in the Global South: A Non-diachronic Review. *Journal of International Development*, 28(5), 788–807. <https://doi.org/10.1002/jid.3204>
- Da Wei and Yijie Ding. (2015). *Selecting Housing Development Sites using Multi-Criteria Decision Analysis (MCDA)*, Msc Thesis. July. <http://www.diva-portal.org/smash/get/diva2:911865/FULLTEXT01.pdf>
- Dong, J., Zhuang, D., Xu, X., & Ying, L. (2008). *Integrated Evaluation of Urban Development Suitability Based on Remote Sensing and GIS Techniques \226 A Case Study in Jingjinji Area, China*. 5975–5986. <https://doi.org/10.3390/s8095975>
- Eastman, R., Jin, W., Kyem, P. A. K., & Toledano, J. (1991). *for Procedures Raster Decisions Multi-Criteria*. January 1995.
- Ewing, R., & Cervero, R. (2010). Travel and the built environment. *Journal of the American Planning Association*, 76(3), 265–294. <https://doi.org/10.1080/01944361003766766>
- FECOFUN. (2022). *A review of forest policies, community forestry and women in Nepal*. *Jtrcf 2001*. [http://fecofun.org.np/downloads/A Review of Forest Policies, Community Forestry](http://fecofun.org.np/downloads/A%20Review%20of%20Forest%20Policies,%20Community%20Forestry)

and Women in Nepal pdf.pdf

- Feilzer, M. Y. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of Mixed Methods Research*, 4(1), 6–16. <https://doi.org/10.1177/1558689809349691>
- Guba, E. ., & Lincoln, Y. . (2013). *10-Guba_Lincoln_94.Pdf* (p. 13). http://steinhardtapps.es.its.nyu.edu/create/courses/3311/reading/10-guba_lincoln_94.pdf
- Kerr, J., Nathan, S., Van Dissen, R., Webb, P., Brunsten, D., & King, a. (2003). *Planning for Development of Land on or Close to Active Faults: A guideline to assist resource management planners in New Zealand*. 124 pages.
- KMC. (2021). *KMC, Heritage Home*.
- Kuddus, M. A., Tynan, E., & McBryde, E. (2020). Urbanization: A problem for the rich and the poor? *Public Health Reviews*, 41(1), 1–4. <https://doi.org/10.1186/s40985-019-0116-0>
- Kuhn, T. (2020). The structure of scientific revolutions. In *Knowledge and Postmodernism in Historical Perspective: Vol. II* (Issue 2). <https://doi.org/10.5840/philstudies196413082>
- Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research*, 16(2), 1–11. <https://doi.org/Retrieved from ERIC>
- MadurikaH. (2017). GIS Based Analysis For Suitability Location Finding In The Residential Development Areas Of Greater Matara Region Demarcation of GN Divisions' Boundary of Sri Lanka View project Tsunami Housing Reconstruction Project View project Gis Based Analysis For Su. *Article in International Journal of Scientific & Technology Research*, 6(02), 96.
- Majumder, M., & Saha, A. K. (2016). Feasibility model of solar energy plants by ANN and MCDM techniques. In *Springer Briefs in Energy* (Issue January 2018). <https://doi.org/10.1007/978-981-287-308-8>
- MCDA. (n.d.). Retrieved June 15, 2022, from <https://projects.ncsu.edu/nrli/decision-making/MCDA.php>
- Meng, Y., Malczewski, J., & Boroushaki, S. (2011). A GIS-Based Multicriteria Decision

- Analysis Approach for Mapping Accessibility Patterns of Housing Development Sites: A Case Study in Canmore, Alberta. *Journal of Geographic Information System*, 03(01), 50–61. <https://doi.org/10.4236/jgis.2011.31004>
- Özkan, B., Dengiz, O., & Turan, İ. D. (2020). Site suitability analysis for potential agricultural land with spatial fuzzy multi-criteria decision analysis in regional scale under semi-arid terrestrial ecosystem. *Scientific Reports*, 10(1), 1–18. <https://doi.org/10.1038/s41598-020-79105-4>
- Ponterotto, J. G. (2005). Qualitative research in counseling psychology: A primer on research paradigms and philosophy of science. *Journal of Counseling Psychology*, 52(2), 126–136. <https://doi.org/10.1037/0022-0167.52.2.126>
- Preliminary CBS Report*. (2021).
- Puntsag, G. (2014). Land Suitability Analysis for Urban and Agricultural Land Using Gis : Case Study in Hvita To Hvita , Iceland. *UNU Land Restoration Training Programme*, 1–19.
- Rikalovic, A., Cosic, I., & Lazarevic, D. (2014). GIS based multi-criteria analysis for industrial site selection. *Procedia Engineering*, 69, 1054–1063. <https://doi.org/10.1016/j.proeng.2014.03.090>
- Romm, N. R. A. (2015). Reviewing the Transformative Paradigm: A Critical Systemic and Relational (Indigenous) Lens. *Systemic Practice and Action Research*, 28(5), 411–427. <https://doi.org/10.1007/s11213-015-9344-5>
- Shirkhanloo, N. (2013). *Analyzing the Effects of Urban Sprawl on the Physical Environment in the case of Kyrenia. August*.
- Siqing, C. (2016). Land-use suitability analysis for urban development in Regional Victoria: A case study of Bendigo. *Journal of Geography and Regional Planning*, 9(4), 47–58. <https://doi.org/10.5897/jgrp2015.0535>
- Slevitch, L. (2011a). Qualitative and quantitative methodologies compared: Ontological and epistemological perspectives. *Journal of Quality Assurance in Hospitality and Tourism*, 12(1), 73–81. <https://doi.org/10.1080/1528008X.2011.541810>
- Slevitch, L. (2011b). Qualitative and quantitative methodologies compared: Ontological and

- epistemological perspectives. *Journal of Quality Assurance in Hospitality and Tourism*, 12(1), 73–81. <https://doi.org/10.1080/1528008X.2011.541810>
- The-Forest-Act, G. (2019). *The-Forest-Act2-076*. 2019(12), 1–38.
- Thomas, P. . (2010). Research Methodology and Design. *Research Methodology and Design*, 291–334. <https://doi.org/10.1515/9783110215519.82>
- Trannoy, A., & Wasmer, É. (2013). La politique du logement locatif. *Notes Du Conseil d'analyse Économique*, 10(10), 1. <https://doi.org/10.3917/ncae.010.0001>
- Tudes, S., Duygu, N., Ame, Á., & Sig, Á. (2010). *Preparation of land use planning model using GIS based on AHP : case study Adana-Turkey*. 235–245. <https://doi.org/10.1007/s10064-009-0247-5>
- Ullah, K. M., & Science, E. (2014). *URBAN LAND-USE PLANNING USING GEOGRAPHICAL INFORMATION SYSTEM AND ANALYTICAL HIERARCHY PROCESS : CASE STUDY DHAKA CITY*. 35.
- United Nations. (2014). *World Urbanization Prospects: The 2014 Revision, CD-ROM Edition*. 1–20.
- Velasquez, M., & Hester, P. (2013). An analysis of multi-criteria decision making methods. *International Journal of Operations Research*, 10(2), 56–66.
- Weldu, G. (2016). *Identification of Potential Sites for Housing Development Using GIS Based* *International Journal of Sciences : Identification of Potential Sites for Housing Development Using GIS Based Multi-Criteria Evaluation in Dire Dawa City , Ethiopia*. January 2016.
- What is MCDA / MCDM? | 1000minds*. (n.d.). Retrieved June 15, 2022, from <https://www.1000minds.com/decision-making/what-is-mcdm-mcda>
- Wu, Y., Zhang, X., & Shen, L. (2011). The impact of urbanization policy on land use change: A scenario analysis. *Cities*, 28(2), 147–159. <https://doi.org/10.1016/j.cities.2010.11.002>
- Yang, Y., Jun, Z., Sui, X., & He, X. (2020). Study of the spatial connection between urbanization and the ecosystem—A case study of Central Yunnan (China). *PLoS ONE*, 15(9 September), 1–14. <https://doi.org/10.1371/journal.pone.0238192>

ANNEX-A: QUESTIONNAIRE FOR EXPERTS' INTERVIEW



TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS

Checklist and Interview with the Experts and Officials

This checklist questionnaire has been developed as a requirement during the master's thesis study in urban planning under Department of Architecture and Urban Planning, Pulchowk Campus, Lalitpur, I.O.E., T.U.

Title of the Thesis: Land Suitability Analysis for Residential Development in Tulsipur

Objective: The major objective of my thesis is to determine the suitable land area for residential development in Tulsipur SMC. So there will be use of GIS application for the analysis and the study will need some of your opinions based on your past experience and knowledge related to the study area.

Date and Time of Interview: _____

Name of the Student/Interviewer: Sugam Gautam

Name of the Supervisor: Dr. Ajay Chandra Lal

Name of the Key Informant/Expert to be interviewed: _____

Working Profession/Field of the Expert: _____

Name of the Office: _____

Address: _____

PART-I: VERIFICATION OF DEVELOPED CRITERIA FOR RESIDENTIAL DEVELOPMENT IN TULSIPUR SMC

After the thorough study of literatures, following suitability criteria for residential land development in Tulsipur SMC city has been developed. So, I would like to request you to

review them and provide your valuable suggestions in removing or adding any criteria that would be useful in my analysis.

Following are the list of criteria that I have developed

Rejection of Constraints

- Forest
- River
- Risk Sensitive Areas

Then For the selection of Residential development, Proximity to

- Health (Hospital, health center)
- Education (School, college)
- Culture (Religious places, community center)
- Recreation (Open spaces, parks, sport arena)
- Market center are taken.
- Proximity to Highway/Major Roads.

PART-II: KII FOR GOVERNMENT BODIES

Name:

Organization:

Position:

1. What is the trend of urban pattern in Tulsipur?

(Urban sprawl/ Ribbon development/Pocket development)

2. What are the factors that are driving the development pattern?

(Road, infrastructures, land price, proximity to services)

Validate what happens first

3. In the current scenario, where are people buying land and settling?

(Land fragmentation: where and frequency)

Why are they buying in that particular area?

4. Are there any policies (Municipal) regarding the development of new residential settlement? (Upcoming/Pipeline)

5. What criteria should be taken into consideration for development of new residential settlement?

(Risk sensitive areas, Proximity to services/urban amenities)

6. What could be the issues/ challenges for new residential development?

7. What interventions can be taken to make people go to the selected area?

(Tax exemption, Incentives, Urban facilities)

PART-III: INTERVIEW WITH LOCAL PEOPLE

1. Information about unsuitable and suitable area for residential area from the study.

2. What is the main factor you chose this area for residence?

(Land value, Own Land, Relatives nearby))

Observation checklist

Infrastructure:

Road condition, Settlement pattern

Proximity to existing settlements

Existing Urban Patterns

Urban Amenities and Services

Problems (Price escalation)

Building Permits past 2 years (Ward No.)

Land Fragmentation (Ward No.)

ANNEX-B: SITE PHOTOGRAPHS



Figure 41 Interview with Consultant Er. Santosh Bhattra



Figure 42 Interview with Land Revenue Officer Mr. Khem Raj Sharma



Figure 44 Interview with Mayor of Tulsipur SMC Mr. Tika ram Khadka



Figure 43 Interview with head of DUDBC Dang, Er. Khadak Bahadur Chaudhary



Figure 45 Interview with NTC officer Er. Suresh Bhandari



Figure 46 Interview with Mr. Yam Kanta Bhandari, Chairperson of Tulsipur Watersupply

ANNEX-C: COMMENTS

S.N	Phase	External Jury	Major Comments	Page No.
1	Preliminary	KKJ sir	Less writeup about world population and urbanization	2
			Add about Tulsipur in Introduction	3
		YRA sir	Revise Methodology	
		YRA sir	More about Urban Expansion Pattern	16
2	Mid term	KKJ sir		
		YRA sir	Limitations about mobility and flood zone	10
			Photographs in Data collection to be placed in Annex	87
		Was Past planned area lies in suitable area?	73	
3	Final Defence	KKJ sir	Questionnaire must be written as Checklist	85
			Add graphics in presentation	
		YRA sir	Regional settings	38
			Report Formatting	
			Recommendation for further studies	77

NOTE: Regular Consultation with Supervisor Dr. Ajay Chandra Lal was carried out and report was done accordingly throughout the study. This study is finalized with the guidance of the supervisor.

ANNEX-D: IOE GRADUATE CONFERENCE



त्रिभुवन विश्वविद्यालय
Tribhuvan University
इन्जिनियरिङ अध्ययन संस्थान
Institute of Engineering

डीनको कार्यालय OFFICE OF THE DEAN

GPO box- 1915, Pulchowk, Lalitpur
Tel: 977-5-521531, Fax: 977-5-525830
dean@ioe.edu.np, www.ioe.edu.np
गोश्वारा पो ब न- १९१५, पुल्चोक, ललितपुर
फोन- ५५२१५३१, फ्याक्स- ५५२५८३०

Date: October 11, 2022

To Whom It May Concern

This is to confirm that the paper titled “*Spatial Analysis for Residential Development : A Case of Tulsipur SMC*” submitted by **Sugam Gautam** with Conference ID **12139** has been accepted for presentation at the 12th IOE Graduate Conference being held in October 19 – 22, 2022 at Thapathali Campus, Kathmandu.

Khem Gyanwali, PhD
Convener,
12th IOE Graduate Conference



Spatial Analysis for Residential Development: A case of Tulsipur SMC

Sugam Gautam, Dr. Ajay Chandra Lal,

^a Department of Architecture, Institute of Engineering, Pulchowk Campus, Kathmandu, Nepal

^b Program Coordinator MSc Urban Planning, Institute of Engineering, Pulchowk Campus, Kathmandu, Nepal

Corresponding Email: sugam.gtm19@gmail.com, 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.

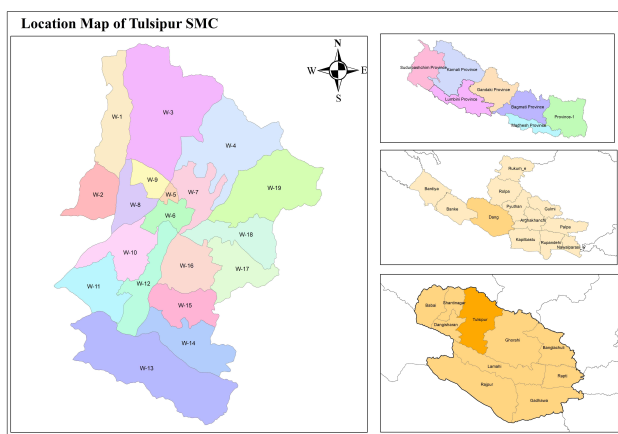


Figure 1: Study Area

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.

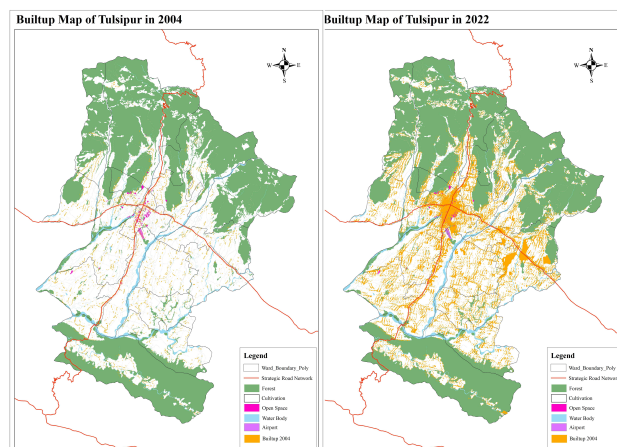


Figure 2: Built up Map of Tulsipur SMC

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.

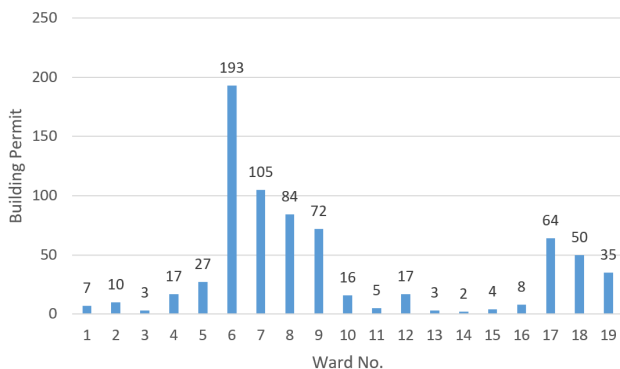


Figure 5: Building permits

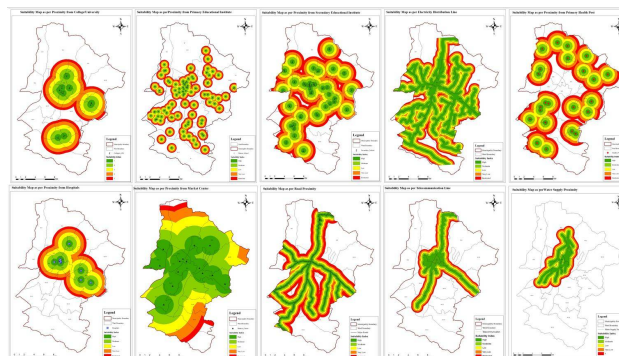


Figure 7: Suitability map of urban amenities

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

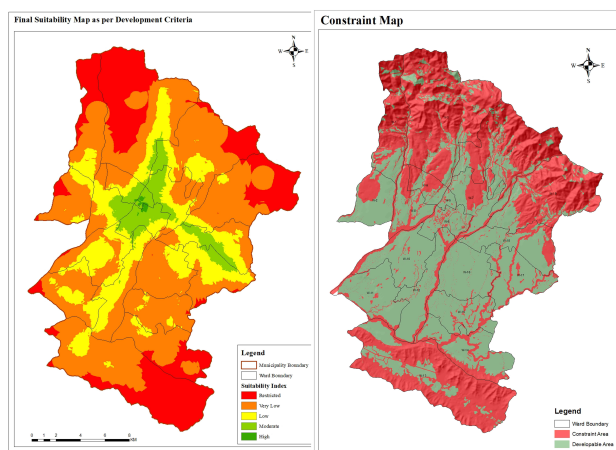


Figure 8: Suitability map as per Development criteria and Constraint

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.

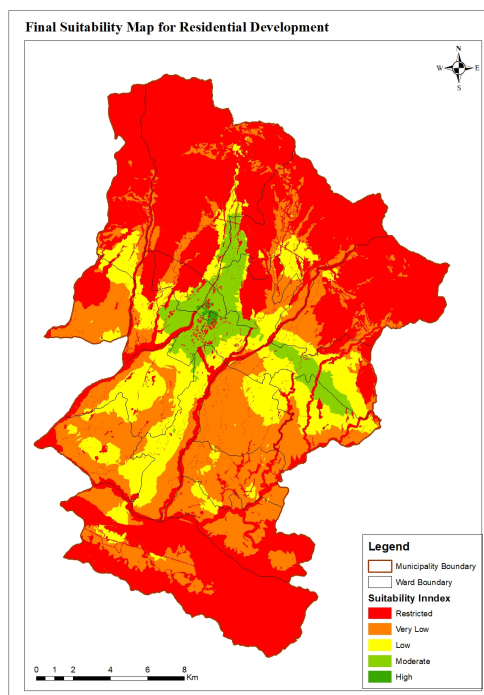


Figure 9: Suitability map for Residential Development

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.

Acknowledgments

The authors are very grateful to Institute of Engineering, Pulchowk Campus, Particularly Department of Architecture and Urban Planning for helping to make good progress and achievement as far as academic knowledge is concerned. The authors are thankful to different people directly or indirectly involved in the study.

References

- [1] United Nations. World Urbanization Prospects: The 2014 Revision, CD-ROM Edition. pages 1–20, 2014.
- [2] Yuzhe Wu, Xiaoling Zhang, and Liyin Shen. The impact of urbanization policy on land use change: A scenario analysis. *Cities*, 28(2):147–159, 2011.
- [3] Md Abdul Kuddus, Elizabeth Tynan, and Emma McBryde. Urbanization: a problem for the rich and the poor? *Public health reviews*, 41(1):1–4, 2020.
- [4] Nina Shir Khanloo. *Analyzing the Effects of Urban Sprawl on the Physical Environment in the case of Kyrenia*. PhD thesis, Eastern Mediterranean University (EMU)-Doğu Akdeniz Üniversitesi (DAÜ), 2013.
- [5] Noella Mackenzie and Sally Knipe. Research dilemmas: Paradigms, methods and methodology. *Issues in educational research*, 16(2):193–205, 2006.
- [6] JG Ponterotto. Foundational elements of qualitative methodology. *Journal of Counseling Psychology*, 52(2):126–136, 2005.
- [7] Mrinmoy Majumder and Apu K Saha. *Feasibility model of solar energy plants by ANN and MCDM techniques*. Springer, 2016.
- [8] Yunliang Meng, Jacek Malczewski, Soheil Boroushaki, et al. A gis-based multicriteria decision analysis approach for mapping accessibility patterns of housing development sites: a case study in canmore, alberta. *Journal of Geographic Information System*, 3(01):50, 2011.
- [9] Mark Velasquez and Patrick T Hester. An analysis of multi-criteria decision making methods. *International journal of operations research*, 10(2):56–66, 2013.
- [10] Ronald Eastman, Weigen Jin, Peter AK Kyem, and James Toledano. for procedures raster decisions m multi-criteria. *Photogramm Eng Remote Sens*, 61:539–547, 1995.
- [11] Aleksandar Rikalovic, Ilija Cosic, and Djordje Lazarevic. Gis based multi-criteria analysis for industrial site selection. *Procedia engineering*, 69:1054–1063, 2014.
- [12] Barış Özkan, Orhan Dengiz, and İnci Demirağ Turan. Site suitability analysis for potential agricultural land with spatial fuzzy multi-criteria decision analysis in regional scale under semi-arid terrestrial ecosystem. *Scientific reports*, 10(1):1–18, 2020.
- [13] HKGM Madurika and GPTS Hemakumara. Gis based analysis for suitability location finding in the residential development areas of greater matara region. *International Journal Of Scientific and Technology Research*, 6:96–105, 2017.
- [14] Chen Siqing. Land-use suitability analysis for urban development in regional victoria: A case study of bendigo. *Journal of Geography and Regional Planning*, 9(4):47–58, 2016.
- [15] Kazi Masel Ullah. Urban land-use planning using geographical information system and analytical hierarchy process: case study dhaka city. *LUMA-GIS Thesis*, 2014.