



Ethiopian Institute Technology-Mekelle

School of Architecture and Urban Planning

Program MSc. In Urban Planning and Development

LOCATIONAL SUITABILITY OF URBAN RESIDENTIAL AREAS-THE CASE OF ABIY ADI TOWN CONDOMINIUM HOUSING

By

Tsehay Kunu

A Thesis Submitted to Ethiopian institute of technology-Mekelle, School of Architecture and urban planning and to the institute of graduate Studies of Mekelle University in Partial fulfilment of the requirement for the Masters of Science Degree in Urban Planning and Development studies.

Advisor

Zemenfes Gebregziabher. (PhD)

Co-adviser

Filmon Gebrehitsan (MSc.)

September, 2025

Mekelle-Ethiopia

Mekelle University

Ethiopian Institute of Technology-Mekelle

School of Architecture and Urban Planning

Program: MSc. In Urban Planning and Development

Certification

As thesis research advisor, I hereby certify that I have read and evaluated this thesis prepared under my guidance, by Tsehaye Kunu, entitled that “**Locational suitability of urban residential areas-the case of Abiy Adi town condominium housing.**” I recommend that it to be submitted as fulfilling the Masters of sciences degree thesis requirement. Certified further, to the best of my knowledge the work reported here does not form part of any project report or thesis on the basis of which a degree or prize was conferred on an earlier time on this or any candidate.

Approved by Board of Examiners:

	Name	Date	Signature
Chair Coordinator:	<u>Tesfalebrhan FHSion</u>	<u>21/02/2026</u>	<u>[Signature]</u>
Advisor:	<u>Zemenfes Gebregziabher (PhD)</u>	<u>21/02/2026</u>	<u>[Signature]</u>
External Examiner:	<u>Kesate Estelzia (Dr.)</u>	<u>21/02/2026</u>	<u>[Signature]</u>
Internal Examiner:	<u>Golden Deste (PhD)</u>	<u>21/02/2026</u>	<u>[Signature]</u>



Acknowledgment

I would like to express my sincere Thanks to my advisor Zemenfes Gebregzabher (PhD) for his unlimited and continuous support, critical comments and guidance from the beginning to the success of the research. I am very much grateful for his encouragement, advice and friendship during my study and hardships.

I would like to acknowledge the participants of this study, whose cooperation and willingness to share their experience were essential to the research process.

My sincere thanks go to those officials who were happy and willing to share any data that supports my research: Abiy Adi municipal officers and related professionals for their discussion on the issue of this research.

Last but certainly not least, I would like to thank my family my for loving, encouraging and sharing all the difficulties with me. I finally would like to thank my friends and colleagues: for their constant encouragement and making my study time interesting.

Abstract

The locational suitability of urban residential developments is a critical component of sustainable city planning, particularly in rapidly urbanizing regions such as Ethiopia. This research evaluates the spatial and environmental suitability of the condominium housing project in Abiy Adi town, located in the Tigray National Regional State. The project site—situated near the confluence of the Tanqua and Gereb Shegalu rivers in the Da’Aba Dera area of Kebele 02—was analyzed using Geographic Information Systems (GIS), field observations, and stakeholder interviews. Key suitability factors such as slope, flood risk, proximity to services, soil conditions, and infrastructure access were assessed. The GIS-based spatial analysis revealed that the condominium site lies predominantly within high-risk flood and landslide zones and exceeds acceptable slope thresholds for safe and cost-effective construction. Qualitative findings from residents and key informants highlighted significant challenges including poor drainage, seasonal inaccessibility, limited access to healthcare and education facilities, and inadequate infrastructure. A composite suitability score of 1.85 out of 5 categorized the location as suboptimal for urban residential use. The researcher concludes that the Abiy Adi condominium housing development suffers from serious locational deficiencies that compromise both safety and livability. It recommends future residential developments be guided by scientific suitability analyses and integrated urban planning frameworks that prioritize environmental risk, infrastructure accessibility, and social service proximity. This research contributes to improved housing policy formulation and promotes evidence-based urban development practices in Ethiopian towns.

Keywords: *Urban suitability, GIS, Condominium housing, Flood risk, Spatial planning, Abiy Adi.*

Contents

Certification	i
Declaration	ii
Acknowledgment	iii
<i>Abstract</i>	iv
Chapter One	1
1 Introduction	1
1.1 Background of the Research	1
1.2 Statement of the Problem	2
1.3 Objectives of the Research	3
1.3.1 General objective	3
1.3.2 The Specific Objectives of the Research	3
1.4 Research Questions	3
1.5 Scope of the research	3
1.6 Significance of the research	5
1.7 Research Organization	5
Chapter Two	7
2 Literature review	7
2.1 Definition of Terms	7
2.2 Land Suitability Analysis	8
2.3 GIS-Based Land Suitability Analysis	16
2.4 Challenges of condominium housing	21
2.4.1 Suitability analysis, site location Land use and site analysis	21
2.5 Case Research	27
2.5.1 Land suitability location analysis for housing development using GIS in KOSOVO	27
Chapter Three	34
3 Description of the Research Area	34
3.1 Research Methodology	35
3.1.1 Research Design	35
3.1.2 Research method	35
3.2 Target Population of the Research	35

3.2.1	Sample Size Determination and Sampling Techniques	35
3.2.2	Sample size in qualitative studies	35
3.2.3	Sample size in quantitative studies	36
3.3	Data sources	36
3.3.1	Data collection methods	36
3.3.2	In-depth interview	36
3.3.3	Interview with key informants	37
3.3.4	Observation	37
3.3.5	Photographic registration	38
3.4	Data Analysis Techniques	38
3.4.1	Qualitative Data Analysis	38
3.4.2	Quantitative Data Analysis	38
3.5	Ethical considerations	38
3.6	To evaluate the locational suitability of Abiy Adi town condominium housing	39
3.7	To assess conformity of the site location with the land use or structure plan of the town in relation to access to services	39
3.8	To identify the major challenges of the condominium housing in relation to its location	40
3.6	Research design	41
3.6.1	Procedure design for Residential Land Suitability Analysis using GIS	42
Chapter Four		43
4	Data analysis and presentation	43
4.1	Demographic Information	43
4.1.1	Respondents' data	44
4.2	Locational suitability of Abiy Adi town condominium housing	44
4.2.1	Transportation and Mobility Constraints	44
4.2.2	Socioeconomic and Demographic Impacts	45
4.2.3	Environmental and Ecological Considerations	45
4.2.4	Environmental and Ecological Concerns	46
4.2.5	Social and Community Development Limitations	47
4.2.6	Climate Vulnerability and Resilience Deficits	47
4.2.7	Suitability analysis	48
4.3	Major challenges of the condominium housing in relation to its location	52

4.3.1	Transportation and Mobility Constraints	52
4.3.2	Infrastructure Deficiencies and Utility Challenges	53
4.3.3	Economic and Livability Impacts	54
4.3.4	Key Threats from Seasonal Floods	54
4.4	Conformity of the site location with the land use or structure plan of the town in relation to access to services	58
4.4.1	Essential Service Accessibility	58
4.4.2	Land Use Compatibility and Adjacent Zone Interactions	61
4.4.3	Public Space and Social Infrastructure	61
Chapter Five		62
5	Conclusion and recommendation	62
5.1	Conclusion	62
5.2	Recommendations	63
References		65
APPENDIX		67
Questionnaire: Locational Suitability of Urban Residential Areas – The Case of Abiy Adi Town		67

Figures:

Figure 1- 1.	location of Abiy Adi town condominium housing	4
Figure 2- 1	Suitability composite score	19
Figure 2- 2	Suitability composite score calculator	19
Figure 2- 3.	Delineation of Developable Land	20
Figure 2- 4.	The map of suitability model	33
Figure 3- 1.	location map of the research area	34
Figure 3- 2.	Research design	41
Figure 3- 3	Procedure Design	42
Figure 4- 1	demography information	43
Figure 4- 2.	Residential areas suitability analysis of Abiy Adi town	49
Figure 4- 3.	picture of the condominium housing	53
Figure 4- 4.	Tanqua River	55
Figure 4- 5.	Nearest Restricted for residential to hazardous river sides	56
Figure 4- 6.	access the condominium housing to social services	59

Tables:

Table 2- 1. Land suitability scores for a residential development	13
Table 2- 2 Weights of land suitability factors	14
Table 2- 3 Land suitability classification	15
Table 2- 4. Factors and criteria's for suitability model for residential development	29
Table 2- 5. Factors and criteria's for restriction model for residential development	30
Table 3- 1. Data identification and dictating the methods	38

Chapter One

1 Introduction

1.1 Background of the Research

Land use suitability is not uniformly distributed across the earth's surface. Each site has a unique set of physical, biological, and cultural attributes and some of these attributes limit the site's suitability for certain uses. Consequently, a comprehensive understanding of each site and its context is a necessary precursor to good site planning and design. If the site's existing contextual conditions are poorly understood, the site's development may detrimentally impact people, property, and the environment (Thomas H.Russ; 2019). Land suitability is a factor to be considered in land use allocation. The meaning of suitability is that a piece of land has the required feature to support a proposed land use, considering social, physical, spatial, and economic factors. Land suitability analysis is a systematic procedure for examining combined effects of a related set of factors that an analyst assumes to be the important determinants of locational suitability (Kaiser et al., 1995).

Residential property is defined as buildings/structures which are used for residential purposes. For example; condominiums, apartment buildings, single story and multi-story housing units etc. Analysis of location suitability when enables the urban growth boundary or the development of new residential areas or other, to becomes so scientific, fair, transparent and practical, eliminating largely subjective factors that often influence the inadequate plans.

According to Abiy Adi town structural plan report of 2009 E.C Residential areas located near to Tanqua river corridor and Gereb Shegalu River are inaccessible especially during the summer season especially due to seasonal flood. The condominium housing of Abiy Adi town is located in the southern part of the town at the periphery of kebele 02 around an area called Da'Aba Dera which is very near to the point where the Tanqua river corridor and Gereb Shegalu river merges into common corridor.it also states that there is poor or unfair distribution of social services in the town. The construction of Abiy Adi condominium housing started in 2000 E.C and transferred in 2005 E.C to the dwellers.

In Ethiopia, studies focusing on locational suitability of urban residential areas are scarce. This research aims to evaluate the locational suitability of urban residential areas and to assess the major challenges due to its location.

1.2 Statement of the Problem

Residents would prefer not to live in noisy, areas very far from social services, polluted, and hazardous area. The purpose of a land suitability analysis is to analyze the physical and locational attributes of land in relation to a particular land use considering social, physical, spatial, and economic factors (Dr. Xinhao Wang et al 2007 p316). If the site's existing contextual conditions are poorly understood, the site's development may detrimentally impact people, property, and the environment.

Each site has a unique set of physical, biological, and cultural attributes and some of these attributes limit the site's suitability for certain uses. Consequently, a comprehensive understanding of each site and its context is a necessary precursor to good site planning and design (Thomas Russ 2009, p 47).

According to Abiy Adi town structural plan report of 2009 E.C Residential areas located near to Tanqua river corridor and Gereb Shegalu River are inaccessible especially during the summer season especially due to seasonal flood. The condominium housing of Abiy Adi town is located in the southern part of the town at the periphery of kebele 02 around an area called Da'Ababa Dera which is very near to the point where the Tanqua river corridor and Gereb Shegalu river merges into common corridor. It also states that there is poor or unfair distribution of social services in the town.

Reliable, quantified, rapid and fine-grained urban residential land suitability analysis is very essential for urban planners and decision makers to improve urban residential environments. Therefore, the urban residential land suitability analysis is designed to determine and locate the best potential sites for land planning. In some cases, the problem may occur long after the development is completed.

In Ethiopia, studies focusing on locational suitability of urban residential areas are scarce. Given this knowledge gap this research aims to evaluate the locational suitability of urban residential areas and to assess the major challenges due to its location.

1.3 Objectives of the Research

1.3.1 General objective

The general objective of the research is to evaluate the locational suitability of urban residential areas and to assess the major challenges in relation to its location in Abiy Adi town.

1.3.2 The Specific Objectives of the Research

1. To evaluate the locational suitability of Abiy Adi town condominium housing
2. To identify the major challenges of the condominium housing in relation to its location
3. To assess conformity of the site location with the land use or structure plan of the town in relation to access to services

1.4 Research Questions

1. How safe is the location of Abiy Adi's condominium housing in terms of environmental hazards?
2. What are the major challenges of Abiy Adi's condominium housing in relation to its location?
3. What is the level of conformity of the condominium housing in relation to the land use of the town

1.5 Scope of the research

The research covered the condominium housing in Abiy Adi town in Tigray National Regional State of Ethiopia. Thematic area of the research focused on the evaluation and assessment of the locational suitability of urban residential areas. The research populations included in this research are the current condominium residents of the town which is 180. The inclusion criteria to this research are age and permanent residence in the research area. Besides for the evaluation and assessment of the locational suitability of Abiy Adi's town condominium housing the researcher have used semi-structured interview and GIS software considering only land use,

accessibility to services, environmental aspect and slope of the area in consideration of the town and experience of the residents.

Figure 1. Geographic location of the study area

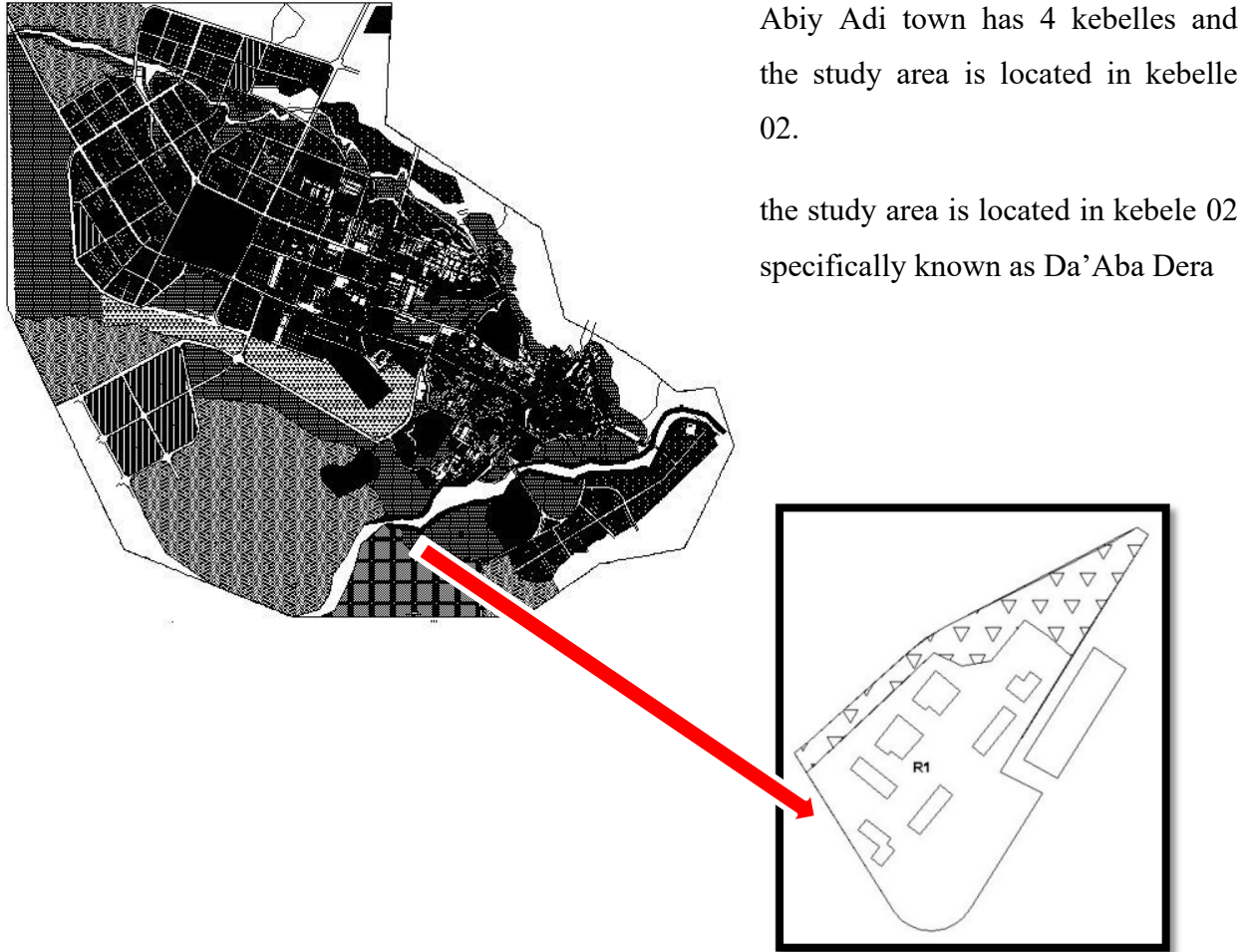


Figure 1-1. location of Abiy Adi town condominium housing

Geographical scope: Geographically this research is limited on Abiy Adi town condominium housing.

Thematic scope of the research: The research limited on the thematic area of locational suitability of urban residential areas-the case of Abiy Adi town condominium housing.

Temporal Scope: This research is limited to the temporal between 2025 to date of construction

1.6 Significance of the research

Land suitability is a factor to be considered in land use allocation. The meaning of suitability is that a piece of land has the required feature to support a proposed land use, considering social, physical, spatial, and economic factors. A land suitability analysis should be conducted for each land use proposed for the future. New developments could impact the physical environment or human society, such as an aquifer, a wildlife habitat, or historical sites so land suitability analysis examines selected land characteristics to determine the level of suitability, and ranks available land accordingly. The most suitable land will be used for development first.

This research evaluated and assessed locational suitability of urban residential areas by taking Abiy Adi's town condominium housing as a case to show what should be considered before proposing areas for residential development and how suitable it is, in terms of its locational suitability and access to social services.

Regarding this the research has its own role on showing a direction to decision makers and planners regarding locational suitability and residential areas related to scientific information. This research is also considered as a contribution to the research community by evaluating and assessing the locational suitability of Abiy Adi town condominium housing and significant for other studies in the research area.

1.7 Research Organization

The research is organized in five chapters which each contains all their detail research procedural and technical flow the overall research to have life.

Chapter one contains general introduction of the research which are the background of the research brief details about the research thematic area from wider to local research area, Statement of the problem contains the relevance and urgency of the problem identified for the research area, The general and detail objectives of the research to conduct, The research questions which are expected to answered at the end of the research for the problem statement, significant of the research contains the research end users and how they use the product of the research, scope of the research are detail described its geographic scope, Thematic and temporal scopes are well defined and the research limitation also listed and the way how they are handled by the researcher also reported. Finally, the research chapter organizations are presented.

Chapter two contains the literature review in the way that from defining key words and terminologies according to scholar's perspective and the relevance and to the thematic area perspective of this research, Conceptual literatures in details are discussed and theoretical frameworks of the research area are discussed in detail as possible.

In Chapter three also the methodological procedure to conduct the research are briefly presented from Describing the research area to research design, Site selection criteria, data Source and data collection tools, data sources and methods of data collection, data sampling frame and sampling size, sampling technique, data collection technique, data presentation and analysis techniques all of those are discussed in this chapter.

In chapter four the collected data and organized according to the methodology discussed in chapter three, data presentation in different formats like tabular data, charts and spatial data maps are presented as its necessary in appropriate way. In each data presentation there is an analytical discussion its implication what does it mean regarding the research area thematic.

Finally, chapter five have two broad categories the conclusion and recommendation parts, again the recommendation part has two sub categories, those are recommendation for action and recommendation for further research.

Chapter Two

2 Literature review

2.1 Definition of Terms

Residential: area is a land use in which housing predominates, as opposed to industrial and commercial areas. Housing may vary significantly between, and through, residential areas. These include single-family housing, multi-family residential, or mobile homes (Huiping Huang et al2019).

Condominium: it is a Single, individually owned housing unit in a multi-unit building. The condominium owner holds sole title to the unit, but owns land and common property (elevators, halls, roof, stairs, etc.) jointly with other unit owners, and shares the upkeep expenses on the common property with them. Unit owner pays property taxes only on his or her unit, and may mortgage, rent, or sell it just like any other personal property. And also, the word condominium divides in to the prefix “con” means sharing and “dominium” which means, owner ship. It is simply means sharing with others. A condominium is not particular kind of building rather; it is a legal arrangement. It refers to a form of owner ship (Tigray 2003 E.C, Condominium Proclamation No. 109/1998).

Condominium housing: is a name given to the form of housing tenure where each resident household owns their individual unit, but equally shares ownership and responsibility for the communal areas and facilities of the building, such as hallways, heating systems, and elevators. There is no individual ownership over plots of land. All of the land on a condominium site is owned by all homeowners (UN- Habitat, 2011).

Site suitability: is the method of understanding existing site qualities and factors that will determine the location for a particular activity. It involves the detailed investigation of the natural resources and processes that characterize a site and include mapping techniques including GIS tools that help in processing the geographical database that display the areas of the site, suitable for various planning objectives and alternatives (Santanu Kumar Misra 2015).

Geographic information system (GIS): application is a tool that allows users to create interactive queries, analyze spatial information, edit data in maps and present the results of all these operations. Geographic information science is the science underlying geographic concepts, application and systems. GIS is a broad term that can refer to a number of different technologies, process and methods.

So, by generating the qualitative and quantitative spatial data such as land use, slop and service proximity suitability analysis of the research area will be made. In terms of land suitability, GIS helps the user to define which locations are most appropriate or inappropriate for certain developments (Rizah Murseli and Florim Isufi, 2014).

Site location: The first consideration of the site analysis is to locate the site. Site location entails more than simply locating the site on a map. “Location” in this sense is referring to the site in terms of the project’s relationship to the community (James A. LaGro, Jr. 2013).

Site analysis: In many respects site analysis is the most important step in the successful site design process. The purposes of the preliminary site analysis are to gather data for preliminary planning, evaluate the site for compatibility with the proposed project or use, recognize concerns requiring additional research, and form an understanding of the administrative requirements of the project such as building permits and approvals (Ibid).

Land use: indicates the distribution and extent of land use categories and be sufficiently descriptive to distinguish between levels of intensity and allowable uses. It is the basis for the integrated development of an urban area. The land use plan must deal with relevant physical development issues of the community and the planning areas. Its objectives, policies and projects must be consistent with that of the other mandatory elements (Urban planning & implementation manual 2002 E.C).

2.2 Land Suitability Analysis

Land suitability is a factor to be considered in land use allocation. The meaning of suitability is that a piece of land has the required feature to support a proposed land use, considering social, physical, spatial, and economic factors.

In general, different factors considered in a land suitability analysis fall into one of three categories: (1) physical constraints, such as slope, soil, groundwater aquifers, and flood plains; (2)

access, such as distance to roads, surface waters, sewer lines, or water lines; and (3) costs and benefits of the development. New developments could impact the physical environment or human society, such as an aquifer, a wildlife habitat, or historical sites

Specifically, a land suitability analysis examines selected land characteristics to determine the level of suitability, and ranks available land accordingly. The most suitable land will be used for development first. The selection of land characteristics is normally a judgment of the person in charge of the research. Those characteristics are represented with a set of factors. In general, the process follows the following eight steps:

- (1) Select a land use type for analysis;
- (2) Select factors to be considered and attribute values of each factor;
- (3) Determine a score for each factor attribute;
- (4) Weigh the factors;
- (5) Calculate a composite score from the attribute values and weight it for each factor;
- (6) Rank the combined scores to establish suitability levels;
- (7) Identify available land based on existing land uses;
- (8) Compare with comprehensive plan, zoning or other land use controls that further remove unavailable land.

Land suitability analysis is a systematic procedure for examining combined effects of a related set of factors that an analyst assumes to be the important determinants of locational suitability (Kaiser et al., 1995).

A land suitability analysis should be conducted for each land use proposed for the future. As we discussed before, different land uses require different land conditions and pose different impacts to the land and surrounding areas. These differences are reflected in the land suitability analysis. In order to decide land suitability, multiple factors are combined into a composite value. Two aspects are considered during this process. The first is the suitability score for each individual factor. After a score range is decided, a score can be assigned based on the attribute of a factor to

reflect the suitability level. The more suitable, the higher the value is. The second is to weigh each factor based on its relative importance level, compared with other factors. The weighed total of scores, which is also called a composite score, is the final suitability score for the site. Everything else equal, the site with a higher composite score should be developed prior to the site with a lower composite score.

Step 1: Select a land use type for analysis

A land suitability analysis focuses on one type of land development at a time. Normally, the development can be grouped as commercial, industrial, or residential use. When there is more than one land use type in the analysis, a suitability analysis of each land use type will be conducted. In the end, a preference order needs to be developed for areas suitable for multiple uses. In the following discussion I will use residential type of land use as an example so as to make it conform to my thesis.

Step 2: Select factors to be considered and attribute values of each factor

The purpose of a land suitability analysis is to analyze the physical and locational attributes of land in relation to a particular land use. Based on such analysis, the location for future land use in a research area can be identified so as to increase economic benefits with minimum degradation of environmental quality. The factors considered here are those that can help us decide on the priorities for land development. Some factors are related to the physical conditions that may determine the impact of the proposed land use to the area or to the development itself. Other factors reflect the demands posed by the proposed development. The factors could also be related to the costs and benefits of the proposed land use. Examples of factors commonly included in land suitability analysis are floodplain, aquifer, soils, slope, wetland, habitat, distance to streams, special landmarks (for instance historical buildings), transportation (e.g., streets and railroads), and utility services (e.g., sewer and water). Land suitability analysis is a systematic procedure for examining the combined effects of a related set of factors that the analyst assumes are the important determinants of locational suitability (Kaiser et al., 1995). There is no uniformly applicable list of factors. We need to review the local situation and engage in discussions with the stakeholders in order to determine which factors should be included in the land suitability analysis. For illustration purposes, we will use five factors. They are slope, floodplain, soil

features related to construction, distance to sewer lines, and distance to highways. The slope factor is one of the main determinants for future land uses. For instance, flat land is the most desirable land for an industrial land use. It may become unsuitable for industrial uses if the slope is greater than 5%. The slope also affects road construction. The higher the road class, the lower the allowable maximum grades (Marsh, 2005). A slope greater than 25% will be the least desirable place for any kind of construction, based upon three considerations. The first is related to construction cost. The steeper the slope, the higher the construction cost is. When the cost exceeds a certain amount, it makes the development economically unfeasible. The second is related to the safety of land use. A structure built on steep slope may not be stable because of erosion or land sliding, which may cause property damage or become unsafe for humans. The third is related to the impact of surrounding areas. For example, a steep slope may increase runoff and soil loss, which could affect the environmental quality in downstream areas. Protection of property and people from natural environmental hazards such as flooding is a major consideration in development decisions. A floodplain defines areas that may be affected by a storm statistically reoccurring on at a given frequency.

Any structures built on a floodplain may alter the water flow during a storm event. The structures themselves may also be damaged. Therefore, land development within a floodplain should be avoided.

Soil is a factor that has multiple effects on the suitability of a proposed land use. In less populated areas, septic systems are often used for individual homes to dispose of human waste. If soil does not drain well, it is not suitable for septic systems. In a septic system, the septic tank collects the solid portion of the waste and the liquid flows to a drainage field where water seeps through the soil. During the process, the soil absorbs and filters wastewater. Therefore, the water will be purified before it eventually reaches the groundwater aquifer. If the soil does not have good permeability, such as clay soils, the wastewater will not be able to drain through the soil easily. Consequently, the septic system will not be able to handle the human waste without an outflow. Soil with good drainage is preferred for development. Another aspect of the soil features related to development is the suitability for construction. Certain types of soil restrict building construction because of their slope or wetness.

Accessibility refers to considering whether the proposed land use is compatible with adjacent land uses and whether it has adequate access to services, such as transportation (streets, railroads and ferries), utilities (water or sewer lines), recreation (parks and recreational facilities), and education (schools).

Consequently, the area within the service area will have higher preference. Quality residential land developments must have access to the network of supporting infrastructure and community facilities (Kaiser et al., 1995). Areas closer to the facilities are more likely to be developed before the more remote areas.

Step 3: Determine the score for each attribute of each factor

Once the factors are determined, their attributes need to be determined. Attributes of a factor reflect its variation, which may be measured at any of the four levels of measurement—nominal, ordinal, interval, or ratio. For example, the floodplain data are at the nominal level, with two values—inside or outside the 100-year floodplain. The soil data regarding construction suitability has three values at ordinal level—severe, moderate, and slight, referring to the level of limitations a type of soil posted on construction. The slope measured in degrees is an example of ratio level of measurement. The slope can be any numerical value between 0 and 90 degrees. The sewer service factor is measured as inside or outside a sewer service district. The distance to major roads is measured as kilometers.

The idea of a suitability analysis is to review relevant factors together, which requires a unified measurement of different factors. In order to link suitability to a factor, the relationship between the suitability measurement and the original factor attributes must be established. Scores, which are the suitability measurement, should always be at the interval level using a few manageable values. A higher score corresponds to a higher level of suitability and a lower score represents a lower level of suitability. The first step of measuring individual suitability is to decide the lowest and highest possible scores. For example, the scores can be any values between 1 and 5. A score of 0 reflects the least suitable use and a score of 5 indicates the most preferable use. A land with a score of 4 can be interpreted as twice as suitable as the land with a score of 2.

Assigning scores is one of the most challenging tasks in land suitability analysis due to the subjective nature of the process. First, the original attributes need to be reclassified or ordered.

As shown in the following table, the slopes are measured as continuous values, which need to be reclassified into four categories.

Table 2- 1. Land suitability scores for a residential development

Factor	Attribute	Score
Slope	„ 5%	5
	5%~ „ 15%	4
	15%~ „ 25%	2
	> 25%	1
Floodplain	Inside 100-year floodplain	1
	Outside 100-year floodplain	5
Soil classified based on restrictions to construction	Slight	5
	Moderate	3
	Severe	1
Sewer service district	Inside the district	5
	Outside the district	2
Distance to major roads	„ 1 kilometers	5
	1~ „ 2 kilometers	4
	2~ „ 5 kilometers	3
	> 5 kilometers	2

The two values of the floodplain factor must be arranged in an order to reflect the level of suitability. Second, scores are assigned to the reclassified factor values. Although the process is subjective, some approaches may be more reliable than others. A simple way is for the analysts, who conduct the research, to and assign scores based on the best knowledge available about the factors. This approach is subject to the challenge of validity. Another approach is to involve professionals, citizens, decision makers and other stakeholders in the score assignment process. The literature has shown that the method can help to translate scientific knowledge into an informed judgment on evaluating and analyzing decision options (Linstone and Turoff, 1975). Experts (or stakeholders) work corroboratively towards a common problem. During the process, participants can clarify the issue and the reasoning process, as well as increase the understanding of other participants' positions.

Step 4: Weigh the factors

In this step, the relative importance of each factor is reflected in the weights assigned to each factor. The simplest weighing system assumes all factors are equally important; therefore, an equal weight will be assigned to each factor. When some factors are more important than others, those factors will be assigned a higher weight. Consequently, other factors will have a lower weight. When weights are expressed as percentages, the total of all weights must be 100%. This requirement ensures that the final composite score derived from the factors will have the same data range as each factor.

Using the following table as an example, the most important factor in determining residential land suitability is slope and the least important factor is distance to roads. The weight for slope is 30% and the weight for soil is 15%. Therefore, the slope factor is treated twice as important as the soil factor.

Table 2-2 Weights of land suitability factors

Factor	Weight
Slope	30%
Floodplain	20%
Soil classified based on restrictions to on-site septic systems	15%
Sewer district	25%
Distance to major roads	10%

Step 5: Calculate a composite score from attribute value and weight for each factor

After assigning factor scores and weights, we can calculate the composite suitability score using the following formula.

$$S = \sum si . wi$$

Where, the composite score, S, is the sum of the product of the individual weight, and the score, w_i is for each factor, i. For example, consider a piece of land with a slope of 20% outside the (s1=2, w1=0.3) outside the 100-year flood plain (S2= 5, w2 = 0.2) and within the sewer service district (S3= 5, W =0.25) .The soil has moderate restrictions (S4= 3, W4= 0.15) to building site development and the major roads are two kilometers away (s5 = 4, w5=0.1).The composite suitability score for this land would be calculated as:

(slope score x slope weight) + (floodplain score x floodplain weight) + (sewer score x sewer weight) + (soil score x soil weight) + (highway score x highway weight), that is,

$$S = (2 \times 0.3) + (5 \times 0.2) + (5 \times 0.25) + (3 \times 0.15) + (4 \times 0.1)$$

$$S = 0.6 + 1 + 1.25 + 0.45 + 0.4 = 3.7$$

Step 6: Rank the combined scores to establish suitability levels

Once composite scores are calculated for each piece of land, the land can be compared and ranked based on scores. The highest scores will be the most suitable land for the proposed use and the lowest scores will be the least suitable land. The suitability scores can be used as a guide for land use decision-making. A possible classification is shown in Table 2-3. The most suitable land has a value above 4 and the least suitable land has a value of 0.

Table 2-3 Land suitability classification

Composite score	Land suitability class
0~1	Least suitable
1.1~2	Less suitable
2.1~3	Moderate suitable
3.1~4	More suitable
4.1~5	Most suitable

With the scores and values we used in the example, the lowest possible scores for the five factors are: 1 for slope, 1 for floodplain, 1 for soil, 2 for sewer service district and 2 for distance to major roads. Therefore, the minimum possible composite score is:

$$S = 1 \times 0.3 (\text{slope}) + 1 \times 0.2 (\text{floodplain}) + 1 \times 0.25 (\text{soil}) + 2 \times 0.15 (\text{sewer}) + 2 \times 0.1 (\text{roads}) = 0.3 + 0.2 + 0.25 + 0.3 + 0.2 = 1.25$$

This means that no land in this research will be classified as least suitable. The worst possible case will be in the less suitable category, a composite score between 1.1 and 2. This result is because none of the factors has a minimum score of 0. The minimum score for “the distance to major roads” is 2 and other minimum scores are 1.

Step 7: Identify the available land based on existing land use

Unless development occurs in an area never touched by humans, it will require a conversion from an existing use, which has to meet certain people's needs, to the proposed use. As discussed before, land uses vary in intensity. It is rare that a land use with higher intensity is changed to another use with less intensity. In general, different land uses can be ranked based on human impact. Undeveloped land, such as forest area or barren land, is the area where human impact is the least. Consequently, the new development would most likely occur on undeveloped land.

Step 8: Constraints with comprehensive plans, zonings or other land use controls to further remove unavailable land

Comprehensive plans, zonings, and/or other regulations specify the permitted uses in an area. Unless there is a zoning change of zoning, future residential development can only be considered in permitted areas. Additional constraints may exist based on existing land uses or other physical conditions. For example, if certain areas are designated for conservation purposes, no residential development will be allowed there.

2.3 GIS-Based Land Suitability Analysis

The legendary landscape architect and city planner Ian McHarg (1920-2001) recognized interaction between humans and the environment and advocated for the consideration of the environment in land use decisions. In his landmark book, *Design with Nature* (McHarg, 1969), McHarg illustrated a new method to support such consideration—overlay analysis. In the example of a road construction project in Staten Island, New York, McHarg considered social benefits and cost factors such as historic, water, forest, wildlife, scenic, recreation, residential, institutional, and land values. A series of maps were prepared, one for each factor, with transparencies and magic markers. The colors and gray tones reflected an ordinal scale. The darkest areas were the areas of greatest social benefits and the lightest areas were the areas of greatest social costs. These maps were drawn on transparencies as individual layers. The layers were put on top of other layers on a light projector. The final product is a composite layer of different tones reflecting different social benefits and costs at different locations. This composite layer provides the basis for identifying areas where a future road can provide the most social benefits.

Two types of GIS analysis, raster based and vector based, can be used to implement this overlay process. In raster-based analysis, the overlay is accomplished through a cell-based calculation. With vector-based overlay analysis, all factors are saved as polygon layers. Those polygons are then intersected together, two at a time, until all the factors are included in the final layer. The vector-based overlay procedure will create many intermediate layers. As the number of factors increase, the intersected data layers will have many small polygons, which may take a long time to process. Therefore, a raster-based analysis is generally preferred.

In a GIS based land suitability analysis, the factors are treated as individual layers. The scores for the classes of each layer are the layer values. The land suitability at a location is determined by accumulating the scores from all of the layers, and then multiplying the weight for each layer (Dr. Xinhao Wan et al 2007).

Data Preparation

In order to perform the overlay analysis, the layers must be developed. Conversion and other management functions are necessary to make the layers in raster format. A raster format data layer represents a research area with uniformly distributed grids. The grids, also called cells, have a fixed size.

Slope Layer

A slope is defined as the difference in land surface elevation divided by the horizontal distance between two points on the land. In a raster-based data file, the slope of a cell is the steepest downhill slope of a cell. It is calculated by determining the largest elevation difference between a cell and an adjacent cell of lower elevation and dividing it by the distance between the centers of the two cells. The result is expressed as a percentage.

Soil Layer

The second layer, soil data are normally in vector format using polygons to represent different soil types.

Floodplain and Sewer Service District Layers

Sometimes flood plain maps are in hardcopy, though digital maps have recently become more common. Once vector polygon flood plain data are obtained or digitized, a new field can be added to store the suitability scores for the floodplain layer.

Distance to Roads Layer

To create the distance to roads suitability score, a data layer of major roads is required. Most communities have developed roads as part of the baseline database. With such a file, we can use the GIS Buffering function to create distance buffers to roads and reclassify the buffers to reflect the distance classes for different suitability scores.

Calculate Composite Scores

If we have prepared all five suitability factor layers, in the next step, those layers are used to create a composite suitability layer. This process is implemented with raster map algebra calculation.

Map algebra calculates a cell value based on the values of other layers for the cells representing the same location.

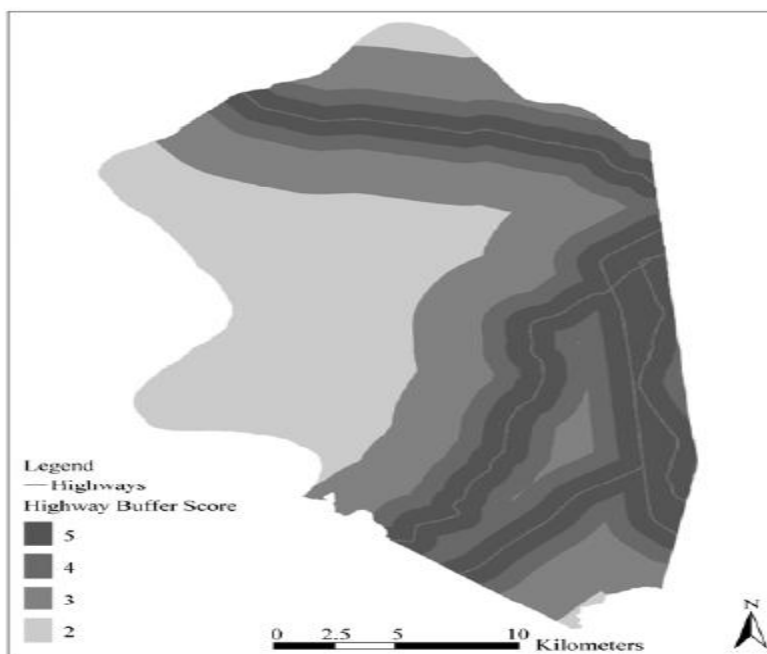


Figure 2-1 Suitability composite score

Factor	Score	×	Weight	
Slope	5		0.3	1.5
Floodplain	1		0.2	0.2
Sewer	5		0.25	1.25
Soil	1		0.15	0.15
Roads	3		0.1	0.3
Composite	3.4			3.4

Figure 2-2 Suitability composite score calculator

To implement this calculation with Arc Map, select the Raster Calculator from the Spatial Analyst Toolbar, and enter the following formula: (slope) x 0.3 + [floodplain]x 0.2 + [sewer]x 0.25 + [soil]x0.15 + [roads]x 0.1

Click the Evaluate button, a composite suitability layer is created and added to Arc Map. The composite score for the cell in the above formula is 3.4. The final task is to reclassify the composite scores into groups, as shown in the above table.

The following map clearly shows where land is suitable for residential development and where land is not suitable based on the scores and weights assigned.

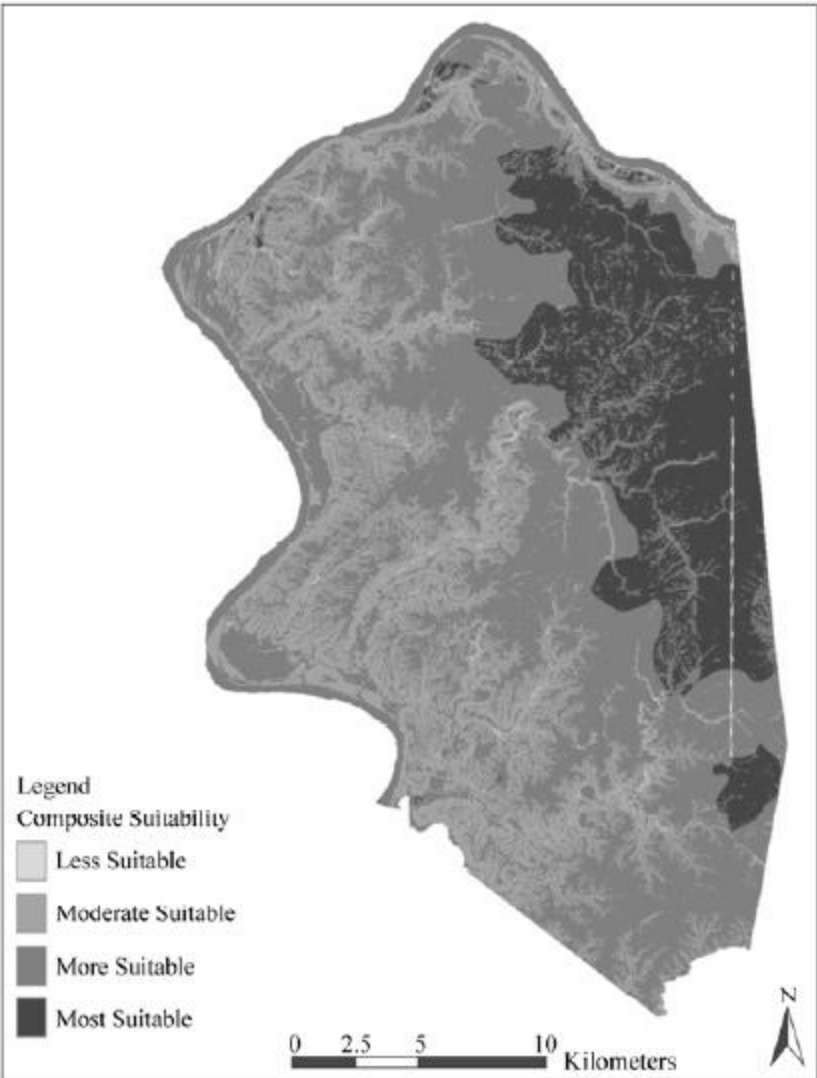


Figure 2-3. Delineation of Developable Land

However, not all of the land is available for residential development. Some of the land has already been developed which should not be converted to future residential land. Some of the areas are not permitted for residential land development. The constraints for land availability are derived from existing land uses to indicate currently undeveloped (open space or woodland) land or farmland. Other constraints may be imposed by government rules or regulations as a way to guide where development may go.

2.4 Challenges of condominium housing

According to (Buckley, R. (2014).) infrastructure is a cornerstone of a sound and creative society. The right approach to delivering and maintaining transport, housing, energy, water, and communication infrastructure is essential to create a strong and competitive economy and provide social services. Therefore, infrastructure presents unique challenges and opportunities for condominium housing. For instance, (Guesh Dejen,2017) reported that Addis Ababa has faced different challenges in affording Condominium Housing which includes insufficient and sub-standard infrastructure provisions of electric grading, health institution, portable water and road infrastructure; insufficient public facilities and acute shortage of water, electricity, health and transport. All these shown in deprived poverty status of the metropolis.

Each site has a unique set of physical, biological, and cultural attributes and some of these attributes limit the site's suitability for certain uses. Consequently, a comprehensive understanding of each site and its context is a necessary precursor to good site planning and design. If the site's existing contextual conditions are poorly understood, the site's development may detrimentally impact people, property, and the environment. Or, more commonly, opportunities to maximize the site's social, economic, and environmental value will be missed.

Hurricanes, floods, and other natural hazards continually threaten human health, safety, and welfare. Yet, many disasters causing the loss of life and property can be prevented, or at least mitigated, by better land use decisions that reduce these risks (H. John Heinz Center for Science, Economics, and the Environment, 2000; Mileti, 1999). Dennis Mileti, who led the Heinz Center's natural hazards risk analysis, concludes in a press release from the National Science Foundation (1999, p.1).

2.4.1 Suitability analysis, site location Land use and site analysis

Site suitability: is the method of understanding existing site qualities and factors that will determine the location for a particular activity. It involves the detailed investigation of the natural resources and processes that characterize a site and include mapping techniques including GIS tools that help in processing the geographical database that display the areas of the site, suitable for various planning objectives and alternatives. It is the usual practice of individuals,

institutions and organizations to undertake the task of searching for the optimal site for their intended project such as new school, a new residential settlement or a new airport. Intensive research of a large number of maps containing data about land use, geology, geomorphology, slope, soil type, land ownership and other relevant factors which is important to find an optimum solution to any given problem. GIS techniques offer an alternative approach which facilitates quick and easy remodeling for slight changes in sitting criteria, and produces results as maps suitable for analysis and presentation. Geographical Information System is a system designed to capture, store, manipulate, analyze, manage and present all types of spatial or geographical data. GIS applications are tools that allow users to create interactive queries, analyze spatial information, edit data in maps and present the results of all these operations. Geographic information science is the science underlying geographic concepts, application and systems. GIS is a broad term that can refer to a number of different technologies, process and methods. It is attached to many operations and has much application related to engineering, planning, management, transport, insurance, telecommunication and business (Santanu Kumar Misra 2015).

The results of suitability these analyses can greatly reduce the time and effort, which might otherwise be spent manually searching records, processing data or field surveying. Site location is a key factor and initial step in the design of many projects. The results of the site suitability analysis produce a detailed display of the most suitable to least suitable areas for consideration of placement of a certain facility, while filtering out unusable or less desirable sites. Certain aspects are more important than others in determining the best location for each site, and might include an areas proximity to existing infrastructure, soil types, and slope. These site suitability analyses require unlike measurements to be converted to common values that can be summed and compared to ease the final site selection process (Rizah Murseli and Florim Isufi, 2014).

Land use: Land use planning and development and regulation are generally an issue and a concern for local government. Local governments very often have substantial information about a site. As discussed in preceding sections, aerial photography, mapping, and other physiographic information is often available from local governments. **Zoning** of all of the local sources of information, zoning regulations are probably the most important. Zoning regulations provide a prescription for how development is to be done in a community. The general conditions of development are described in terms of what development is encouraged and where in the community it will be. Zoning maps provide an overview of the community's vision for itself,

showing not only how a site may be developed or used but also how surrounding sites might be. Having a clear evaluation of the zoning particulars of a site is a critical requirement of a complete site analysis. Occasionally zoning may include overlay zones that have important implications for land use. Overlay zones such as steep slope restrictions, watershed protection, historic preservation, or aquifer protection zones may severely limit land development activities or require a higher order of performance from the design, construction, and operation of a site (Ibid).

Site analysis: In many respects site analysis is the most important step in the successful site design process. The purposes of the preliminary site analysis are to gather data for preliminary planning, evaluate the site for compatibility with the proposed project or use, recognize concerns requiring additional research, and form an understanding of the administrative requirements of the project such as building permits and approvals. The value of an analysis is in its clear and complete identification of issues and the character of the site as they relate to a proposed use. Although it is usually subject to fairly limited resources, it should be as far-reaching and broad in scope as feasible. The nature of the design business is that very often the initial site assessment is part of the proposal effort and is completed “out-of-pocket.” Even more troublesome is that the effectiveness of a particular analysis may be difficult to measure until well into the design process or even after site work has actually begun. Corners cut or inaccurate assumptions made in the site analysis for expediency or economy may result in expensive rework and change orders during the design process or worse yet, during construction ((Ibid).

Site location: The first consideration of the site analysis is to locate the site. Site location entails more than simply locating the site on a map. “Location” in this sense is referring to the site in terms of the project’s relationship to the community. Commercial projects will be concerned with visibility, site access, and traffic. Is the traffic past the site adequate or too congested? Is the street infrastructure adequate for the anticipated increase? What sort of improvements might be anticipated? Is the site accessible from the street? What sort of on-site improvements might be expected to facilitate access? Is the interior of the site visible from the street? From how far away will drivers be able to see the site? Can traffic access the site from both directions? Is a left-hand turn possible? Are the neighboring sites commercial or residential? Are off-site improvements required? Are the necessary utilities nearby? Residential projects raise different concerns. How far away are schools, government services, and shopping? Are local roads and streets adequate to

handle increased traffic? Is the character of the area conducive to the proposed project? Will future residents be able to enter and leave the site without traffic congestion? Are adjacent properties developed? If not, what will zoning allow? (Ibid).

Site analysis is an interpretive process. The site assessment process involves collecting a broad array of information from what are individually fairly limited sets of information and combining the data collected for the purpose of projecting a future use of the land. In general, preliminary site assessments are based on precious little new information—that is, much of the analysis is based on the existing sources of information or first-hand observation. It is how the site information is understood and used that makes the difference. Site analysis of course is not conducted in a vacuum; it is the context of the proposed use that frames the scope and character of the effort. For example, among the most important considerations is the topography of the site. Sites with significant change in elevations are typically difficult and more expensive to development.

Topography: The most basic element of site analysis is the lay of the land. The topography of a site may dictate the purposes for which the site may be practically used and eventually the layout of the proposed project. The location of buildings and roads, pedestrian circulation, and the arrangement of storm water features are all commonly affected by topography. The analyst must consider how the existing topography affects the proposed use and vice versa. Although the contour intervals are fairly large, the relative accuracy of the quad maps allows for interpolation for general planning purposes although they are not adequate for design. The analysis of the site in the context of the proposed development program provides an early look into how the proposed development will fit into the site. Will significant earthwork be necessary? Will retaining walls or other appurtenances be required? Can the site be accessed from adjacent roads? Is there visibility into the site from adjacent roads?

Many lands development and zoning regulations include restrictions on the development of steep slopes. A slope analysis is done to identify the areas of steep slopes and the possible location for building sites and access. The slope analysis is usually a graphic representation of slope shown in classes or ranges. The ranges are sometimes established by local ordinances that describe the parameters to be observed when conducting a slope analysis and steep slope development restrictions. The slope analysis may identify possible routes for on-site traffic circulation as well

as drainage patterns. By viewing the finished drawing, the restrictions imposed by slopes and the development patterns that are in tune with the site generally become more apparent.

Other elements of the site analysis should include the identification of canyons, wetlands, rock outcroppings, existing structures, unique habitats, or natural features, as well as neighboring land uses and utility locations. The location of rights-of-way, easements, and other encroachments is also important. Based on the site analysis, it may be found that further research or research is required to determine the stability of slopes, hydrologic conditions, or the extent of wetlands. The site analysis is the foundation of the plan. It will provide the framework from which the planning and design are developed. Flat and low areas may present their own concerns. Boggy or wet areas may be wetlands and restrict development (Ibid).

Hazardous soil conditions: Liquefaction is associated with earthquakes. It refers to the condition in which solid ground can turn mushy when soils are vibrated. Under certain conditions soils lose all bearing capacity, and buildings and bridges can slip or sink (as in quicksand) or buried structures (such as tanks) can float to the surface. These conditions have been associated with fine- to medium-grained sands and silts found in loosely packed layers. In general, the greater the soil density, the lower the liquefaction risk. A clay content of 15 percent or more is believed to be adequate protection from liquefaction (Borcherdt and Kennedy 1979). Another form of liquefaction is found in quick clays. These are clays that can become “quick”—that is, they can liquefy (Thomas H.Russ, 2004).

Hydrology: The presence of water on the site and the general pattern of drainage are important concerns of the site analysis. Water is often the key feature of a site.

Waterfront on a lake or the ocean or the presence of a stream or pond is considered to bring added value to a development, but it also brings concerns. The presence of a surface water feature may be coincidental with a fairly high-water table or shallow geological features. Drainage patterns should be carefully observed in the field as well as from the published sources of information. The presence of associated wetlands and floodplains must also be considered and preliminarily located.

The analyst should consider storm water drainage including drainage from other sites onto the subject site. Of particular concern are the volume, concentration, and quality of the run on storm

water. Sites located along streams in the lower reaches of a watershed may be concerned with conditions higher in the watershed. The site analysis will also begin to identify storm water management strategies. The drainage pattern of the site and the presence of water features will indicate the likely location of storm water collection facilities. The site analyst should consider the sensitivity of hydrologic features to development (Ibid).

Infrastructure: The location of surface and subsurface utilities is also completed in the site analysis. The analyst should identify the locations, capacity, and access to all necessary utilities, as well as the requirements for connections. Of particular importance might be moratoriums on sanitary sewer or water connections or exorbitant connection fees. Equally important is the consideration of interferences between utilities either on the site or in bringing the utilities to the site. Access to public water and sewers should be evaluated. The capacity of existing water and sewers may be of a concern in some communities and should be evaluated at these early stages. The capacity of road networks to accommodate proposed traffic is also a concern. Are local roads of a type and design sufficient for the proposed project? Are turning radii adequate? Will traffic signals and other improvements be necessary? Requirements to upgrade public highways may be prohibitive for some projects (Ibid).

Environmental Conditions: Analysis has necessarily expanded to include at least a cursory assessment of the environmental conditions evidenced on a site. “Environmental” in this sense refers to the narrow considerations of impacts caused by past industrial or commercial activities. An analyst should be aware of conditions that may indicate environmental contamination. Another environmental aspect of growing concern to site designers is the impact of environmental trends such as global climate changes and its anticipated impacts and the growing demand to incorporate sustainability into site development. In particular, site designers working in coastal areas, areas subject to tidal influence, and areas with important hydrologic characteristics such as wetlands or cold-water fisheries may wish to consider the anticipated impacts (Thomas H.Russ, 2009).

2.5 Case Study

2.5.1 Land suitability location analysis for housing development using GIS in KOSOVO

Prishtina city, (By Rizah Murseli, Florim Isufi 2014)

Application and implementation of location suitability analyses are powered through the use of GIS along with spatial analysis component, which enables the creation of buffers, overlay, termination, proximity analysis, spatial unity, map algebra, reclassification of raster and other operations. In terms of land suitability, GIS helps the user to define which locations are most appropriate or inappropriate for certain developments. Consequently, GIS as a tool becomes more important to provide support for decision makers. This analysis takes into account environmental and socioeconomic factors as determinant of urban land development. This analysis requires first finding spatial, environmental and socio-economic constraints and then finding the land suitable for development of residential areas according to specified criteria. Hence, two preliminary results derive mainly from this analysis, such as composite (raster) map of restrictions for housing developments, and composite (raster) map of suitability housing development. Once these two composite maps are completed using specified GIS operations and functions, it is created the final map of site suitability for housing development. In creating the final map several factors had been used in total to establish the restriction model and also many criteria divided into five classes for establishing a map of land suitability for residential development in Prishtina city, namely in the research area.

The research aims to find out which are the most suitable locations for the allocation of land for future urban - residential developments based on given and required factors and criteria. Conducting this analysis initially requires finding spatial, environmental and socioeconomic constraints and then finding the land suitability for specific developments based on defined parameters. So, mainly two preliminary results come through this analysis, as follows:

1. A composite (raster) map of residential development restrictions, and
2. A composite (raster) map of the suitability of residential developments.

Once these two composite maps are completed using GIS certain operations and functions, the final map of land suitability for development is created.

Based on data provided and for the purposes of this research was developed the Final Model of Land suitability for Residential Development, with two main supporting models of restrictions and suitability as follows:

1. The final suitability model for residential development (FSMRD),
 - a. Restriction model for residential development (RMRD);
 - b. Suitability model for residential development (SMRD);

Application and conducting of these analyze is enabled through the use of GIS together with spatial analysis tools, which allows the creation of buffers, overlay, termination, proximity analysis, spatial unifications, map algebra, raster reclassification and other operations. In terms of land suitability, GIS helps the user to define which sites are suitable or unsuitable for development. In this way, GIS as a tool becomes very important, providing support for decision makers. In building a model are required eight steps, which are achieved through spatial analysis, which include: defining the criteria for analysis, defining the necessary data, defining what GIS analysis operations should be performed, preparation of data, design a model, activation of the model, analysis of model results, and refining the model as it needed.

Defining the criteria for analysis

During the planning process two steps are very important, the first step is to know and locate which area important resources to preserve or restrict for future development in an area and second step is what is left from preserve or restrict resources to plane then to develop for future development. Defining the criteria is made based on the restrictions of spatial developments arising as part of the national legislation, planning documents (Estimated investment in infrastructure), analyzing the most appropriate distance for land functions dedicated for housing, as well as documents and different practices. Here is very important to know the methodology and the benefits of this analysis than the results itself. Criteria's have been taken from various local urban plans and some set up criteria's which exercise here are in this research.

The formula for calculating the land suitability is:

$$S = \sum_{i=1}^n w_i C_i \prod_{j=1}^m r_j$$

Equation 1. land suitability

Where:

S = Suitability model for residential development;

w_i = Weight for criteria i (C_i);

C_i = Criterion for suitability;

r_j = Restrictions (stops).

Weight and criteria for suitability model:

- w₁ & C₁ = Weight and criteria for economic zones;
- w₂ & C₂ = Weight and criteria for healthcare services;
- w₃ & C₃ = Weight and criteria for recreation (parks, sport) areas;
- w₄ & C₄ = Weight and criteria for education (schools and preschools) services;
- w₅ & C₅ = Weight and criteria for existing residential areas;
- w₆ & C₆ = Weight and criteria for water supply accessibility;
- w₇ & C₇ = Weight and criteria for canalization network accessibility;
- w₈ & C₈ = Weight and criteria electric network accessibility;
- w₉ & C₉ = Weight and criteria for roads accessibility;
- w₁₀ & C₁₀ = Weight and criteria for slope conditions;
- w₁₁ & C₁₁ = Weight and criteria for aspect conditions;

Table 2- 4. Factors and criteria's for suitability model for residential development

Factor/ Criteria	S1 (5)	S2 (4)	S3 (3)	S4 (2)	S5 (1)	W	%
C ₁	<1.5km	1.5-3.0km	3.0-5.0km	5.0-10km	>=10.0km	0.04	20 .00
C ₂	0.5km	0.5-1.5km	1.5-3.0km	3.0-5.0km	>=5.0km	0.04	
C ₃	<0.5km	0.5-1.5km	1.5-3.0km	3.0-5.0km	>=5.0km	0.04	
C ₄	0.5km	0.5-1.5km	1.5-3.0km	3.0-5.0km	>=5.0km	0.04	
C ₅	0.2km	0.2-0.5km	0.5-1.0km	1.0-2.0km	>=2.0km	0.04	
C ₆	<0.1km	0.1-0.25km	0.25-0.5km	0.5-2.0km	>=2.0km	0.10	40 .00
C ₇	<0.2km	0.2-0.5km	0.5-1.0km	1.0-2.5km	>=2.5km	0.10	
C ₈	<0.2km	0.2-0.5km	0.5-1.0km	1.0-2.5km	>=2.5km	0.10	
C ₉	0.25km	0.25-0.5km	0.5-1.0km	1.0-2.5km	>=2.5km	0.10	40 .00
C ₁₀	0-2°	2-5°	5-8°	8-15°	>=15°	0.25	
C ₁₁	South	South-East	South-West	North-West & North-East	Null	0.15	10 0.00
11	Sum					1.00	

Restriction factors and criteria:

- r₁ = Restriction related to road (street);

- r2 = Restriction related to railway;
- r3 = Restriction related to water deposits;
- r4 = Restriction related to high electric power line;
- r5 = Restriction related to high voltage electric stations (TS);
- r6 = Restriction related to public institutions;
- r7 = Restriction related to cemetery;
- r8 = Restriction related to river bad;
- r9 = Restriction related to existing forest areas;
- r10 = Restriction related to riparian woods;
- r11 = Restriction related to parks;

Table 2-5. Factors and criteria's for restriction model for residential development

Factor	Described factor	Criteria
<i>r1</i>	National road (within urban areas)	6m
	Primary urban road	6m
	Collective urban road	6m
	Local urban road	3m
	Special urban road	3m
	Rural road	3m
<i>r2</i>	Railway	3m
<i>r3</i>	Water deposit	10m
<i>r4</i>	High voltage electric power line	100m
<i>r5</i>	High voltage electric stations (TS)	100m
<i>r6</i>	Public institution	10m
<i>r7</i>	Cemetery	10m
<i>r8</i>	River	30m
	Stream	10m
<i>r9</i>	Forest area	5m
<i>r10</i>	Riparian wood	5m
<i>r11</i>	Parks	10m

Specification of the Necessary Data

The model operates through geographic data, and as much precise the geographic data are and as better the weight and scale of these data defined, so the most acceptable are the model results. In

the analysis of land suitability model for residential developments, as well as models of development constraints have been used the following data:

1. Land Use - Geo-database of land use for Prishtina city in 2013, developed by R. Murseli Master thesis;
2. Water supply network- the data is provided by RWC Prishtina and has accuracy equivalent to land use map;
3. Sewerage network - the data is provided by RWC Prishtina and has accuracy equivalent to land use map;
4. Local electricity network - the data source is KEDS and has accuracy equivalent to land use map;
5. Road network - the data is developed by R. Murseli Master thesis;
6. Digital relief model (10x10m pix.) - The data is developed from topographic maps 1:25000 as isoclines;
7. The slope of the terrain and aspects (10x10m pix.).

Setting Operations – Function in GIS

Based on the criteria and data set for the establishment of relevant models, the next necessary step is to set operations-functions in GIS, which are necessary for specifying the land suitability. Almost all files must be converted from vector to raster. Then, the raster should be reclassified in the classification system from 0 and 1 for restrictions model and from 1 to 5 classes for the land suitability model, where the value 0 indicates preservations or restrictions, and value 1 (S5) shows the worst suitability and value 5 (S1) shows the best suitability. Then, it becomes the integration of the model of restrictions and suitability to produce the final model of suitability.

All values of the model of suitability should be extended within cells of value 1 of the restrictions model. The buffer operation should be applied to all files in the model of restrictions, with the aim of including restrictions distance for certain developments. For example, the protective area of river has 30m buffer, while the urban local roads 3m buffer from the edge of the road or sidewalk.

In the model of limitations each pixels that falls in the value of 0 indicates restrictions of that space, and the value 1 indicates that there are no restrictions. But at the model of suitability, each cell with value 1 indicates the lowest or poor suitability, while the cell with the value 5 indicates

the highest suitability. Because the research area is small and S5 and S4 sometimes extend it, the classes might not be shown in the suitability maps.

Data preparation

After setting GIS operations, data should be prepared for the model. This includes cut-off data within the research area; classification of data and some conversions of vectors into raster.

Setting the Model

Setting the model is done in Model Builder application in ArcView program. In this application we can activate the above GIS operations and execute at the defined data using classification by weight and scale. So, the model builder is an application for building, editing and management of the model or models.

Model Activation

Model activation is made in the application where the model is built through the command "Run Model". In this phase, which is followed by the building phase is designed the map for what the model is built, in this case becomes the mapping of land suitability for residential development.

Analysis of Model Result

At this stage the model results are analyzed, if they have given the desired result based on data of defined criteria and operations performed in GIS. If the model is acceptable, then the final map of land suitability is prepared, if not then we substitute the GIS operations or change the criteria or factors as it has been describe above as refining the model.

Conclusion

In many municipalities in Kosovo not to say It has become a habit, that during the planning process and especially when the need of the urban growth boundary and designation of areas for future development are made under the influence of subjective factors, and as a result the urban boundaries expanded in an inappropriate locations, also intended surface settlements in unsuitable locations and often with a high degree of risk or even in areas with restriction development. Also, natural resources and values are not observed due to the interference of political interests and other interest groups. Analysis of location suitability when It needed enables the urban growth boundary or the development of new residential areas or other, to becomes so scientific, fair, transparent and practical, eliminating largely subjective factors that often influence the inadequate plans and therefore not sustainable investments, which do not serve well to community and neither local government nor the investors. This analysis is not

saying that will solve the problems of urban planning, but enable the development of new areas of development in order to become fairer and more appropriate in locations term.

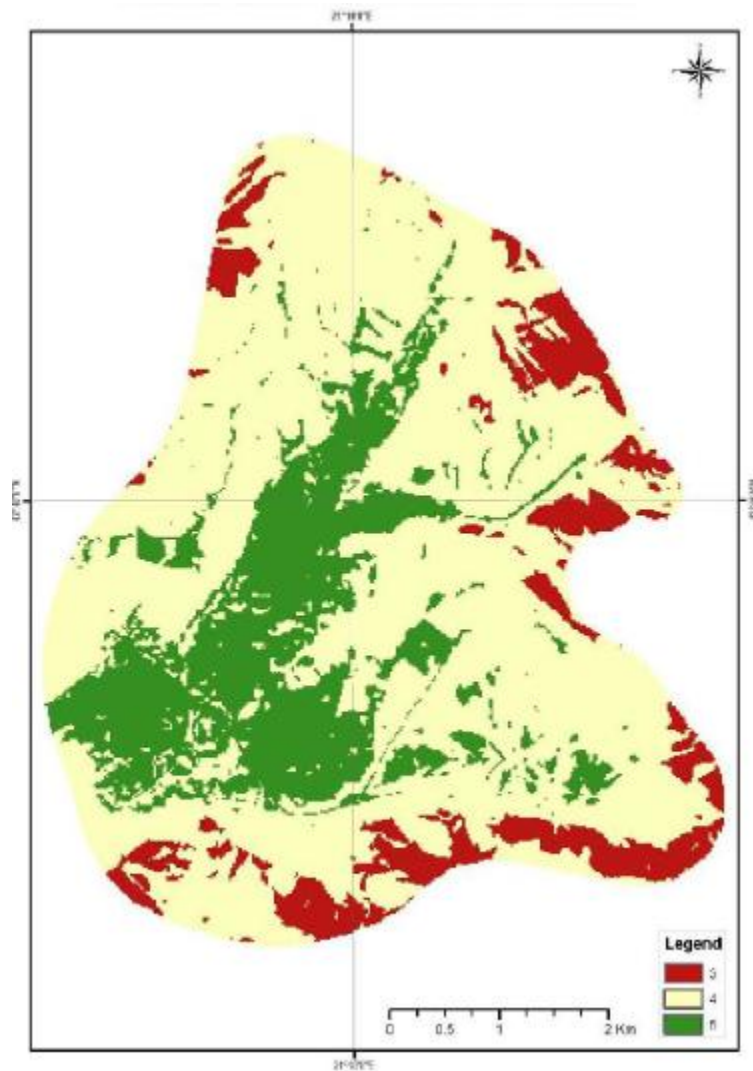


Figure 2- 4. The map of suitability model

Chapter Three

3 Description of the Research Area

Abiy Adi town is located in the central part of Tigray, Ethiopia. It has a latitude and longitude of 13°37'23"N 39°00'06"E with an elevation ranging from 1917 to 2275 meters above sea level. Abiy Adi is at the southeastern edge of the Kola Tembien woreda, of which it is the capital. The town is divided into two parts by the Tanqwa River, the lower part being the more respectable part while the upper part "is where you'll find the marketplace and the seedier bars in which you're most likely to see Awris dancing as the myes hits the mark. Abiy Adi is known in Tigray for the frenetic style of dancing called "Awris", as well as the quality of its honey. The town includes four kebele. The total population of the town currently is accounted around 50,000 and most of the people are engaged in agriculture and trade.

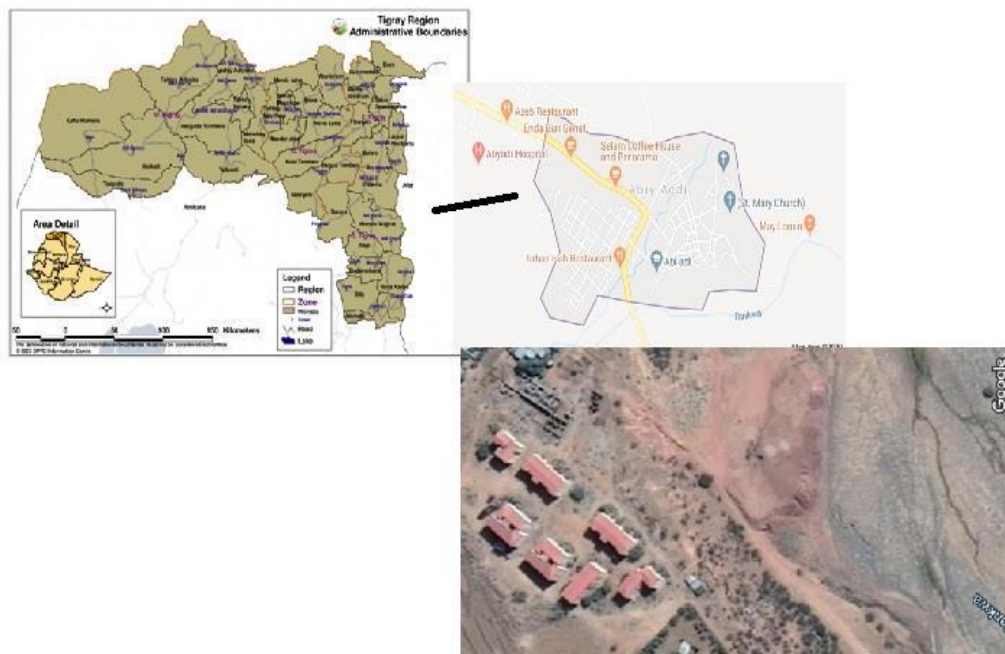


Figure 3-1. location map of the research area

3.1 Research Methodology

In this chapter an illustration of the methods and strategies used in the research will be presented in detail. This part will describe briefly the research area, research population, sample size determination and sampling techniques, data sources and types as well as data collection instruments, type of research design and methods of data analysis to be employed to attain the research objectives.

3.1.1 Research Design

The research will be both descriptive (describes & interprets i.e. what is..?) And explanatory for it establishes variables such as site selection and suitability (cause & effect).The research will employ mixed approach: both qualitative and quantitative in order to collect reliable and valid information

3.1.2 Research method

The research will be both descriptive (describes & interprets i.e. what is..?) And explanatory for it establishes variables such as site selection and suitability (cause & effect).The research employees mixed approach: both qualitative and quantitative in order to collect reliable and valid information.

3.2 Target Population of the Research

The target populations of the research will be all the condominium housing residents of Abiy Adi town. There are a total number of 180 households.

3.2.1 Sample Size Determination and Sampling Techniques

3.2.2 Sample size in qualitative studies

There are no fixed rules for sample size in qualitative research. The size of the sample depends on what you try to find out, and from what different informants or perspectives you try to find that out. Accordingly the conducted 120 house premises to find out the relation between residential area and locational suitability .

3.2.3 Sample size in quantitative studies

There was a certainty that the research area's sampling in quantitative type of data has exceptions of a compound with very large number of households, dwellers and the size of premise that are not repeated on the rest part of the research area. Therefore, the research covers all the delineated area of Abiy Adi condominium housing to evaluate the residential area and locational suitability, so as to examine its suitability and assess the challenges.

3.3 Data sources

Case research type of research can use all kind of data source and type. Nevertheless, for this research primary and secondary data sources were employed.

1. Primary data: Primary data includes data which collects primarily through interviews and conversation with the target group, local authorities. This stage covers a lot of data sources. In addition, semi structured interview, observation; recording and documenting all the activities were employed.

2. Secondary data source: Secondary data source includes collects data from written documents and softcopies data from municipal office of the research area. This creates a good advantage to know more about the research area and lead to focus on interesting and uncovered topic. Gathering data from local municipality makes the research reliable and based on acceptable data.

3.3.1 Data collection methods

Yin (1994:78) states that “data collection for case studies rely on many sources of evidence like documentation, archival records, interview, direct observation, participant observation and physical artifacts”. He further notes that there is other source of evidence like films, photographs and videotapes. Data collection methods that have been employed are mentioned below:

3.3.2 In-depth interview

According to Yin (1994) one of the most important sources of case research information is the interview. He identifies three forms of interview, namely an open-ended interview, whereby one can ask the residents for the facts concerning their opinion about ongoing events. A focused interview is where a resident is interviewed for a short period of time during which interviews

may remain open-ended and assume a conversation manner. A third type of interview demands more structured questions.

The criteria for selecting the houses for in-depth interview based on a number of factors. The main factor is the experience or year of residency, which are considered to be well experienced in sensing the locational setting and its suitability considering different factors.

The interview was designed and prepared with the steps listed below. First step is getting in and accessing the setting, understanding the language and culture of the interviewers, deciding how to present one self, locating an informant, gaining trust and establishing bond and finally capturing the data.

3.3.3 Interview with key informants

Interviews with key informants helped in finding out the locational suitability of residential area in the case of Abiy Adi town condominium housing which includes Abiy Adi housing bureau, urban planning office and the municipality of the town. They spoke of changes in land use in the settlement and housing development. Patton (1987:95) states that key informants are respondents who are knowledgeable and articulate, with deep insights that assist the researcher in understanding what is happening.

3.3.4 Observation

In a way we all observe things around us, but this sort of observation is not scientific observation. Observation becomes a scientific tool and the method of data collection of the researcher, when it serves a formulated research purpose, is systematically planned and recorded and is subject to checks and controls on validity and reliability. In the field observation the researcher used field observation supported by note taking, photographing, checklist and narrating. The researcher also observed if the location of the condominium housing is exposed to some natural hazards and availability of infrastructures and utilities such as street light.

The idea was to carry out observation anonymously without any previous explanation to the people who were being observed in order to avoid influencing people's behavior. The researcher carried out the observation by himself.

3.3.5 Photographic registration

Photographs were also taken to document real life situations such as if the condominium housing is exposed to some natural hazards, degradation and availability of infrastructures and utilities such as street light.

3.4 Data Analysis Techniques

3.4.1 Qualitative Data Analysis

The qualitative data will be collected from site observation and key informant interview and then, it will be analyzed with qualitative techniques mainly through narrative analysis and thematic analysis and it will be interpreted with the existing relevant literatures.

3.4.2 Quantitative Data Analysis

After the data collection is completed and well organized then the data will be edited and checked before it is analyzed. This could help the researcher to correct problems such as respondent errors. Then the researcher will organize and categorize the data. After all the quantitative data collected, coded and entered to Microsoft excel it; will be analyzed using frequency, Percentage, graphs) and spatial data will be analyzed using GIS. The method that will use to analyze the data will be a descriptive and explanatory analysis.

3.5 Ethical considerations

Research involves human participant's raises unique and complex ethical, legal, social and political issues. Research ethics is specifically interested in the analysis of ethical issues that are raised when people are involved as participants in research. The first objective is to protect human participants. The second purpose is to ensure that research is conducted in a way that serves interests of individuals, groups and society as a whole. Finally, the third objective is to examine specific research activities and projects for their ethical soundness, looking at issues such as the risk, protection of confidentiality and the process of informed consent (Saunders and Lewis, 2007). Therefore, participants' privacy, confidentiality awareness and anonymity will be guaranteed.

Table 3-1. Data identification and dictating the methods

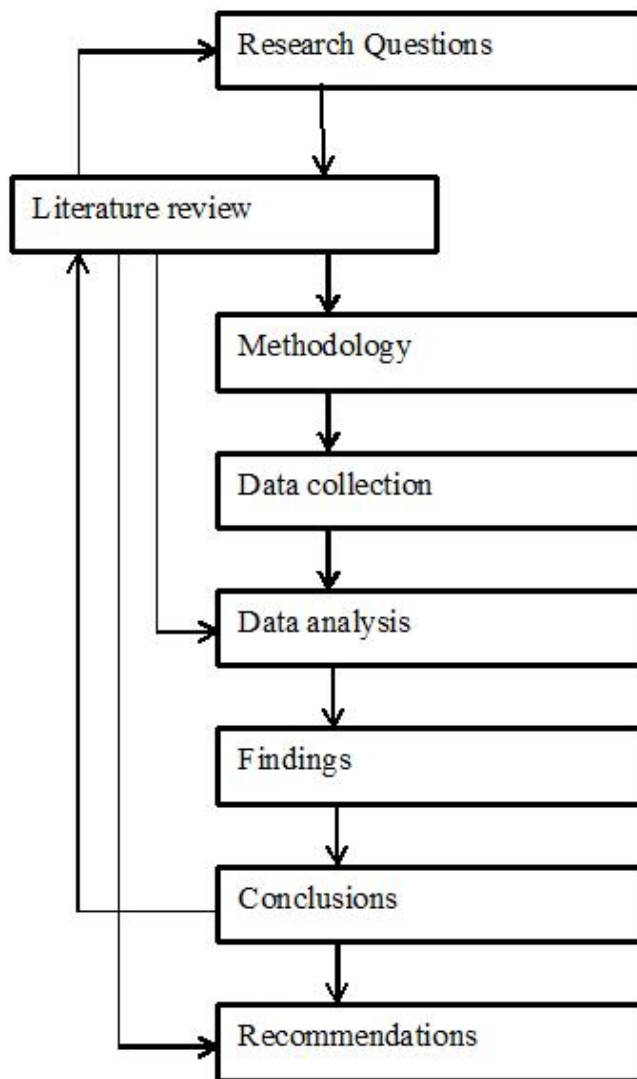
Research question	Research objective	Type of data	Source of data	Method of data collection	Method of data analysis
1. How safe is the location of Abiy Adi's condominium housing in terms of environmental hazards?	3.6 To evaluate the locational suitability of Abiy Adi town condominium housing	Qualitative	Primary & secondary	Semi-structured Interview with selected group, Collecting credible Aerial photo, CAD & GIS data from municipal office	GIS comparison between the structure plan and findings of the research
2. How compatible is it with the adjacent land uses?	3.7 To assess conformity of the site location with the land use or structure plan of the town in	Quantitative	Primary & secondary	Questionnaires Collecting CAD & GIS data from municipal office	

	relation to access to service s				
3. What are the major challenges of Abiy Adi's condominium housing in relation to its location?	3.8 To identify the major challenges of the condominium housing in relation to its location	Qualitative	Primary & secondary	Structured observation (recording and documenting) in-depth Interviews with the focus groups Collecting credible Arial photo, CAD & GIS data from municipal office	

3.6 Research design

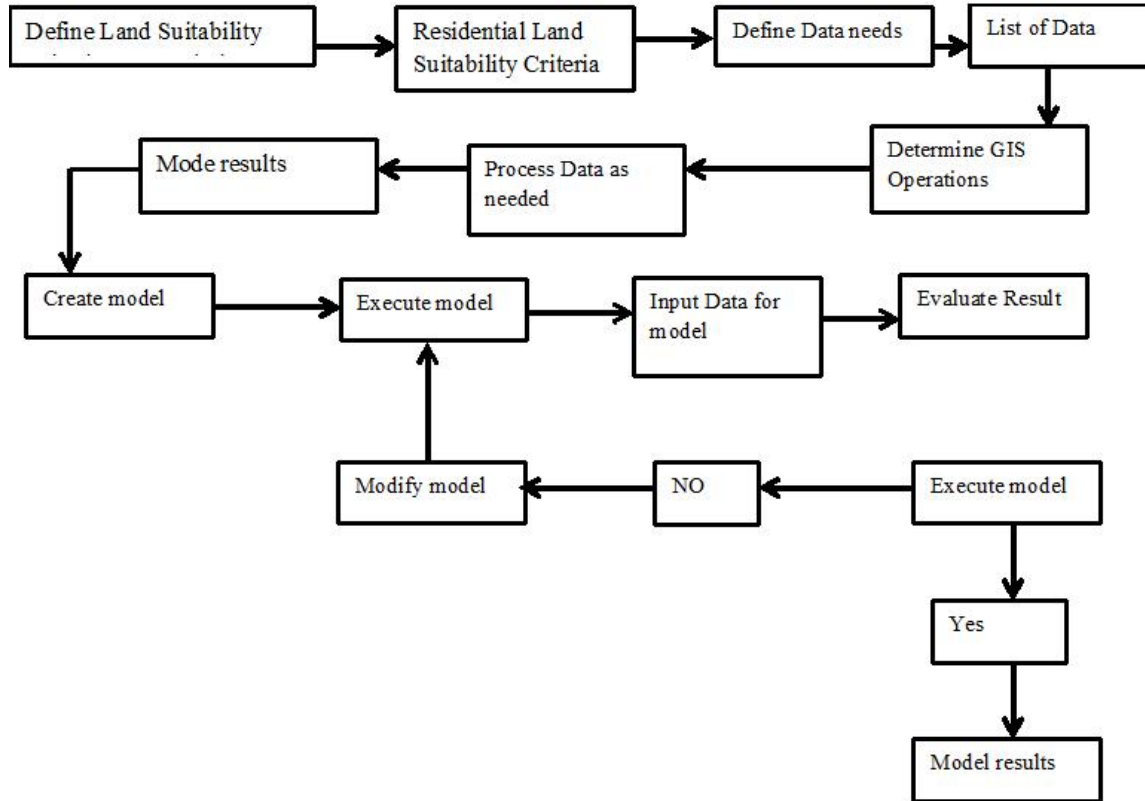
The entire research was planned to perform through deductive approach by evaluating the locational Suitability of the condominium housing and investigate its conformity with the structure plan of the town and considering the literature (hypothesis).

Figure 3- 2. Research design



3.6.1 Procedure design for Residential Land Suitability Analysis using GIS

Figure 3- 3 Procedure Design

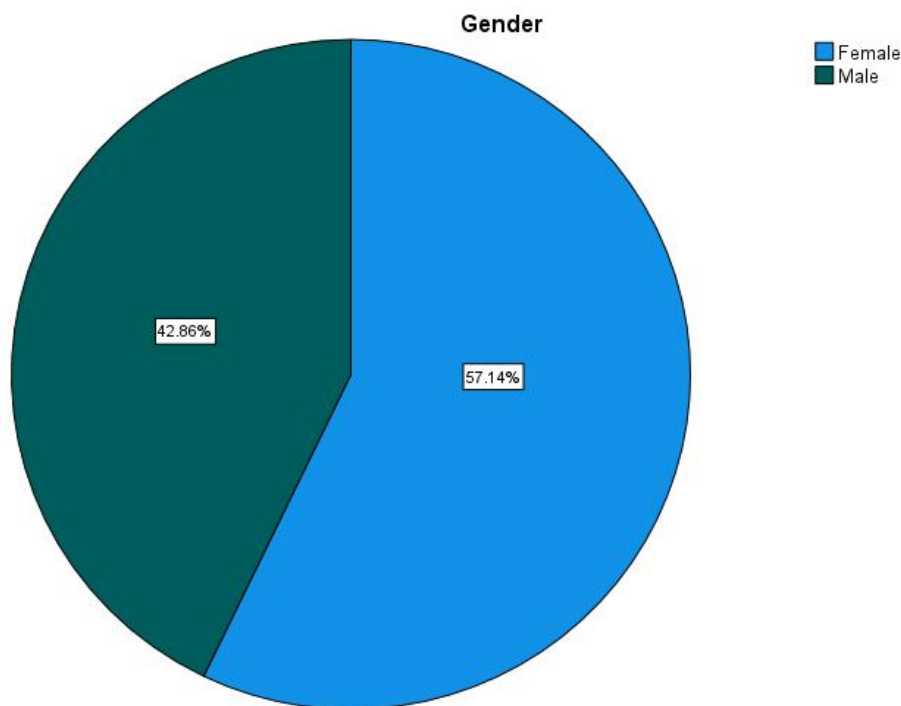


Chapter Four

4 Data analysis and presentation

4.1 Demographic Information

The survey captured responses from 160 residents across Abiy Adi Town's condominium housing blocks, providing a representative sample of the population. The total number of respondents are 180, out of it the real response rate number is 160. As shown in Table 1, the gender distribution was nearly balanced, with female respondents comprising 75% (120) and male respondents 25% (n=40). This gender distribution reflects typical household representation in housing surveys, where women often serve as primary respondents for household-related



matters.

Figure 4- 1 demography information

4.1.1 Respondents' data

This survey data collected from residents of the Abiy Adi town condominium housing. The primary aim is to evaluate the location suitability of the condominium site, identify challenges faced by residents in relation to its location, and assess the site's conformity with the town's land use or structure plan. The data are based on responses from 180 residents selected proportionally from the condominium's seven residential blocks.

4.2 Locational suitability of Abiy Adi town condominium housing

The condominium development's location on the urban periphery creates significant barriers to accessing essential services that support daily living. Residents face considerable difficulties reaching healthcare facilities, with medical services located at impractical distances that require substantial travel time. These mobility constraints create a form of spatial imprisonment, particularly for residents without private vehicles, limiting their access to employment opportunities, social connections, and urban amenities.

This isolation becomes particularly problematic in emergency situations where timely access to medical care could prove critical. Educational institutions are similarly distant, forcing families with school-age children to undertake lengthy commutes that disrupt household routines and reduce quality time together. The absence of nearby retail establishments compounds these challenges, as residents cannot easily obtain daily necessities without planning dedicated shopping trips. This lack of neighborhood-scale commercial services transforms simple errands into time-consuming endeavors. The service desert extends to cultural and recreational facilities, leaving residents without convenient access to libraries, community centers, or entertainment venues that typically enhance urban living experiences.

4.2.1 Transportation and Mobility Constraints

The development suffers from severe transportation deficiencies that amplify its peripheral disadvantages. Public transit options remain woefully inadequate, with limited routes and infrequent service that fails to meet resident needs.

These mobility constraints create a form of spatial imprisonment, particularly for residents without private vehicles, limiting their access to employment opportunities, social connections, and urban amenities.

4.2.2 Socioeconomic and Demographic Impacts

The development's location creates specific challenges for different resident groups:

- Family Dynamics
 - Parents face increased time burdens for school transportation and children's activities
 - Limited local play spaces constrain children's independent mobility and social development
 - Teenagers experience isolation from peer networks and youth-oriented facilities
- Aging Population Considerations
 - Older adults encounter mobility challenges due to inadequate local services
 - Healthcare access difficulties are particularly acute for those with chronic conditions
 - Social isolation risks increase due to limited community gathering opportunities
- Economic Impacts
 - Transportation costs consume a disproportionate share of household budgets
 - Property values are affected by both the peripheral location and service deficiencies
 - Local employment opportunities are scarce, necessitating lengthy commutes

4.2.3 Environmental and Ecological Considerations

The edge location creates unique environmental interactions:

- Wildlife Interface
 - The urban-rural boundary attracts species adapted to edge environments
 - Human-wildlife conflicts emerge around food sources and habitat encroachment
 - Domestic pets face increased risks from predator species
- Microclimate Effects
 - The condominium's massing alters local wind patterns and temperature regulation
 - Heat island effects are exacerbated by large paved surfaces

-
- Nighttime lighting affects both human circadian rhythms and wildlife behavior
 - Hydrological Impacts
 - Storm water runoff patterns are disrupted by the dense development
 - Groundwater recharge is affected by impervious surface coverage
 - Downstream water quality is impacted by urban pollutants

Policy and Planning Context:

The development exists within a complex regulatory framework:

- Zoning History
 - Original approvals were granted under different land use assumptions
 - Subsequent area changes have left the development non-conforming
 - Variance processes have created exceptions without holistic planning
- Infrastructure Planning
 - Utilities were extended at minimum capacity standards
 - Transportation investments failed to keep pace with population growth
 - Service provision models were not adapted to peripheral conditions
- Governance Challenges
 - Multiple jurisdictions claim oversight of different aspects
 - Maintenance responsibilities are ambiguously allocated
 - Funding mechanisms disadvantage edge developments

4.2.4 Environmental and Ecological Concerns

The urban-rural interface location generates unique environmental challenges. The condominium's placement disrupts natural wildlife corridors, forcing animal species to adapt in ways that sometimes create human-wildlife conflicts. Predator species are attracted to the edge environment, posing risks to pets and creating unease among residents. Native vegetation loss and habitat fragmentation alter local ecosystems, reducing biodiversity. Microclimate impacts include pronounced heat island effects from extensive paved surfaces and building materials that retain solar radiation. Wind patterns are artificially altered by the building massing, creating

uncomfortable drafts in some areas while leaving others poorly ventilated. Nighttime lighting pollution affects both resident sleep patterns and the behavior of nocturnal wildlife species. Storm water runoff from the dense development carries urban pollutants into surrounding natural areas, degrading water quality in nearby streams and wetlands. The loss of permeable surfaces reduces groundwater recharge rates, potentially affecting long-term water availability for both human and ecological needs.

4.2.5 Social and Community Development Limitations

The peripheral location creates barriers to social cohesion and community development. The absence of proximate public gathering spaces inhibits organic community interaction and the formation of neighborhood networks. Residents lack casual meeting places where spontaneous social connections might naturally occur, leading to more insular living patterns. This social infrastructure void particularly affects vulnerable populations. Older adults face isolation due to mobility challenges and lack of age-appropriate programming. Children and teenagers have limited safe spaces for unstructured play and socializing. Families struggle with the time burdens created by the need to transport children to distant activities and social engagements. The development fails to foster any distinctive sense of place or community identity. Without shared spaces for cultural expression or collective activities, residents maintain largely parallel lives rather than forming an interconnected neighborhood. This social fragmentation reduces the potential for collective action to address shared concerns or improve living conditions.

4.2.6 Climate Vulnerability and Resilience Deficits

The development demonstrates particular vulnerability to climate-related challenges. Its peripheral location leaves it exposed to extreme weather events that may increasingly affect edge areas. Storm water systems lack capacity for intense rainfall events, leading to periodic flooding. Heat waves are exacerbated by the urban heat island effect and lack of mature shade trees. The area's isolation becomes particularly problematic during climate emergencies, when residents may be cut off from emergency services and supply chains. Power outages last longer than in central areas due to the lower priority for infrastructure repairs. The lack of neighborhood gathering spaces becomes acutely problematic during extended service disruptions when mutual aid might be necessary.

4.2.7 Suitability analysis

The suitability analysis appears to have been conducted using GIS software (e.g., ArcGIS or similar), employing a weighted overlay technique. This method combines multiple raster layers by assigning weights to each factor and reclassifying values into suitability classes. Key inputs include:

Proximity to Services: Measured as Euclidean distance in meters, with closer distances indicating higher suitability.

Proximity to Hazards (Riversides): Measured as distance from river features, where greater distances reduce hazard risk and increase suitability.

Weighted Overlay: Combines the above layers, likely with weights favouring hazard avoidance (e.g., higher weight on river proximity to penalize flood-prone areas) and service access. The final output is classified into five suitability levels: Restricted, Level One Suitable, Level Two Suitable, Level Three Suitable, and Least Suitable.

Coordinate system appears to be UTM (based on easting/northing values like 494000 to 520200), with a scale bar in kilometres. Legends indicate colour gradients from green (high suitability/low distance for services; low hazard/high distance for rivers) to red (low suitability/high distance for services; high hazard/low distance for rivers).

Weighted Overlay Suitability Analysis for Residential Areas At Abi-Adi

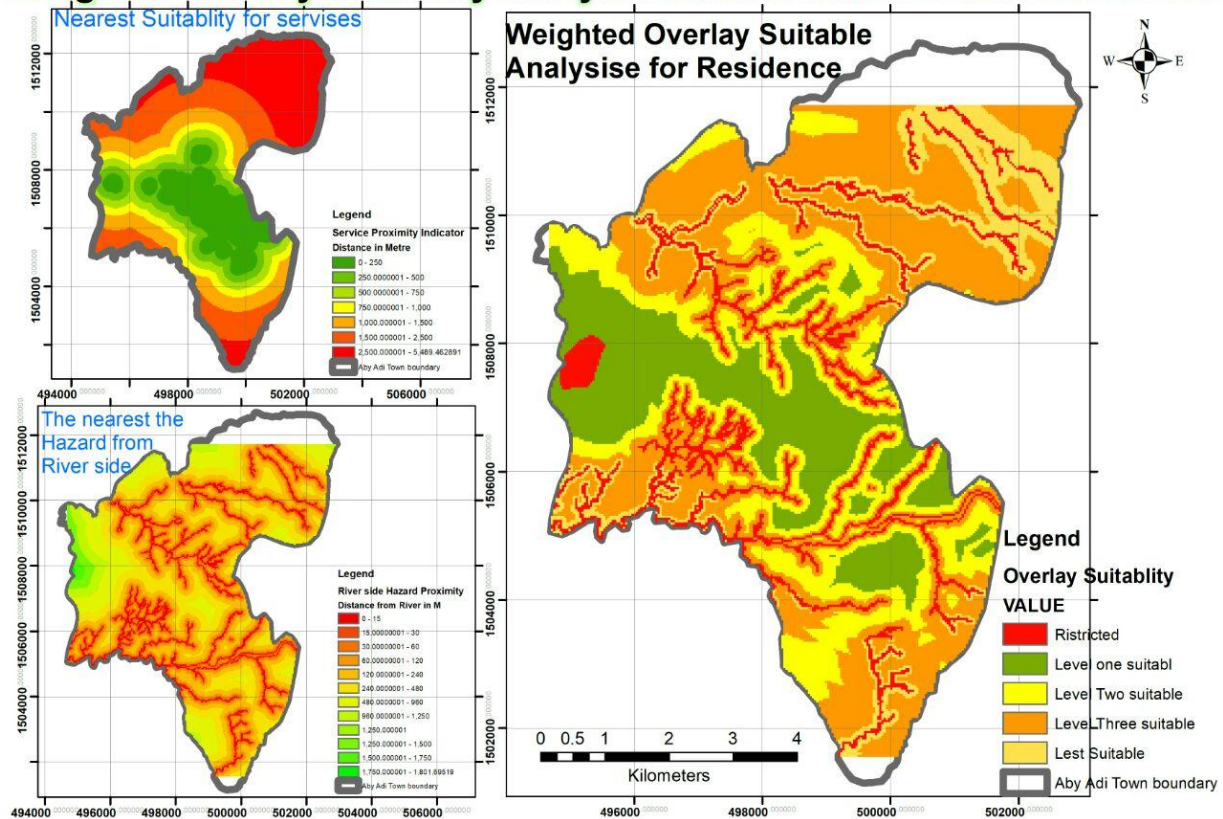


Figure 4-2. Residential areas suitability analysis of Abiy Adi town

Description of Individual Layers

1. Nearest Suitability for Services

This map (top-left) assesses residential suitability based on distance to essential services (e.g., roads, schools, healthcare, utilities—though not explicitly labelled, inferred from context). The legend uses a proximity indicator in meters:

Green (0-250 m): Highly accessible areas, likely central urban zones with dense infrastructure.

Yellow-Green (250-500 m): Moderately accessible.

Yellow (500-750 m): Fair access.

Orange (750-1,000 m): Limited access.

Red-Orange (1,000-1,500 m): Poor access.

Red (1,500-2,589,261 m): Very remote, unsuitable for residential without infrastructure upgrades.

Spatial patterns: The map shows a concentric gradient, with green clusters in the town's core (around coordinates 500000 E, 1508000 N), transitioning to red in peripheral and northern/southern extensions. River-like features (orange/red lines) suggest drainage networks influencing accessibility. The town boundary encloses an irregular shape, approximately 20-30 km across, with services concentrated centrally.

2. Nearest the Hazard from Riverside

This map (bottom-left) evaluates hazard risk based on proximity to rivers, where close distances indicate higher vulnerability (e.g., to flooding, erosion, or waterborne issues). The legend for riverside hazard proximity (distance from river in meters) is inverted compared to services:

Red (0.15-30 m): High hazard zones immediately adjacent to rivers—restricted for development.

Orange-Red (30-60 m): Elevated risk.

Orange (60-120 m): Moderate risk.

Yellow (120-240 m): Lower risk.

Yellow-Green (240-480 m): Minimal risk.

Green (480-1,501,010 m): Safest areas, far from rivers.

Spatial patterns: Rivers are depicted as dense red/orange networks traversing the town, particularly in the central and eastern sectors. Hazard zones form buffers along these features, with red dominating narrow valleys and floodplains. Greener areas are evident in upland or plateau regions (e.g., western and southern parts), indicating safer elevations. The map highlights topographic constraints, with rivers fragmenting the landscape and creating elongated high-risk corridors.

Weighted Overlay Suitability Analysis for Residence

The rightmost map integrates the service and hazard layers through weighted overlay, producing a composite suitability raster. The legend classifies overlay suitability values (likely normalized scores from 0-1 or similar, though not specified):

Restricted (Red): Unsuitable due to high hazard and/or poor service access—primarily river buffers and isolated peripheries.

Level One Suitable (Green): Optimal for residential—close to services and far from hazards.

Level Two Suitable (Yellow): Good suitability, with minor trade-offs.

Level Three Suitable (Orange): Moderate, requiring some improvements.

Least Suitable (Light Yellow/Pale Orange): Marginal, with significant limitations.

Spatial patterns: The overlay reveals a patchy distribution:

Green zones: Concentrated in central uplands (e.g., around 500000-510000 E, 1500000-1510000 N), where service proximity is high and river hazards are minimal. These cover approximately 20-30% of the town area, ideal for immediate residential development.

Yellow and Orange zones: Surround greens, forming transition areas in mid-slopes or secondary service hubs—about 40-50% of the area, suitable with planning (e.g., flood defenses).

Red and Pale zones: Dominate River valleys and outer edges, comprising 20-30%, where development should be avoided or heavily regulated.

Rivers appear as red lines slicing through the map, creating barriers and reducing suitability in eastern and northern sectors. The overall shape aligns with the town boundary, emphasizing how natural features constrain urban growth.

Key Findings and Interpretations

High Suitability Areas: Central and western plateaus emerge as prime residential zones, benefiting from service clusters and elevation-based hazard avoidance. These could support dense housing with minimal environmental impact.

Risk Hotspots: Eastern revering areas show persistent red/restricted classifications, indicating flood-prone vulnerabilities. Development here risks exacerbating disasters, especially in a region like Tigray prone to seasonal rains.

Trade-offs: Peripheral zones trade service access for lower hazards (or vice versa), resulting in orange/least suitable ratings. Urban expansion should focus on infrastructure extension to upgrade these.

Thus, the condominium housing is located in Red and Pale zones: Dominate River valleys and outer edges, comprising 20-30%, where development should be avoided or heavily regulated.

4.3 Major challenges of the condominium housing in relation to its location

Residents identified several critical issues affecting their quality of life. Access to basic services proved particularly problematic, with 78.6% of rating both health facilities and recreational areas as "Poor" or "Very Poor." Similarly, 64.3% reported inadequate public transportation and school access. While markets and shops received somewhat better ratings, 28.6%) still expressed dissatisfaction. Physical infrastructure also emerged as a major concern, with 57.1% reporting insufficient road networks connecting their neighborhoods to other town areas. Environmental hazards compounded these problems, as 42.9% (6 respondents) - primarily in Blocks 2, 4, 6, and 7 - cited flooding and erosion risks near the Tanqua River gorge. These findings support Litman's (2022) research on how service deficiencies and environmental risks degrade residential quality, suggesting the original site selection process inadequately considered these factors.

The condominium development's location on the urban periphery creates significant barriers to accessing essential services that support daily living. Residents face considerable difficulties reaching healthcare facilities, with medical services located at impractical distances that require substantial travel time.

This isolation becomes particularly problematic in emergency situations where timely access to medical care could prove critical. Educational institutions are similarly distant, forcing families with school-age children to undertake lengthy commutes that disrupt household routines and reduce quality time together. The absence of nearby retail establishments compounds these challenges, as residents cannot easily obtain daily necessities without planning dedicated shopping trips. This lack of neighborhood-scale commercial services transforms simple errands into time-consuming endeavors. The service desert extends to cultural and recreational facilities, leaving residents without convenient access to libraries, community centers, or entertainment venues that typically enhance urban living experiences.

4.3.1 Transportation and Mobility Constraints

The development suffers from severe transportation deficiencies that amplify its peripheral disadvantages. Public transit options remain woefully inadequate, with limited routes and infrequent service that fails to meet resident needs. The area's road network lacks proper

hierarchy, funneling all traffic through a few congested access points that become bottlenecks during peak periods. Pedestrian infrastructure is either missing or poorly maintained, with discontinuous sidewalks and unsafe crossing points that discourage walking as a viable transportation option. Bicycle networks are similarly underdeveloped, lacking proper connections to broader cycling routes. These mobility constraints create a form of spatial imprisonment, particularly for residents without private vehicles, limiting their access to employment opportunities, social connections, and urban amenities.

4.3.2 Infrastructure Deficiencies and Utility Challenges

The condominium's edge location results in substandard infrastructure that fails to match urban core standards. Water supply systems operate intermittently, with pressure fluctuations and service interruptions that disrupt daily life. Electrical infrastructure appears outdated and vulnerable to outages, particularly during extreme weather events. Digital connectivity lags behind city-center benchmarks, affecting work-from-home capabilities and access to online services. Waste management systems struggle with inconsistent collection schedules, leading to occasional accumulation of refuse. Stormwater drainage proves inadequate during heavy rainfall, with localized flooding occurring in low-lying areas. Emergency services face extended response times due to the distant location of fire stations and police precincts, creating potential safety gaps during crises.



Figure 4-3. picture of the condominium housing

As the picture indicates, the condominium has poor infrastructure and it is also located at the periphery of the town.

4.3.3 Economic and Livability Impacts

The location creates numerous economic disadvantages for residents. Household budgets are strained by excessive transportation costs, with residents spending significant portions of their income on vehicle ownership and fuel. Property values are depressed by the service deficiencies and accessibility challenges, potentially creating equity traps for owners. Local employment opportunities are scarce, forcing most working residents into lengthy commutes that reduce family time and increase stress levels. The lack of neighborhood commercial activity means that even basic purchases require vehicle trips, adding to weekly time commitments and expenses. The absence of a local economic ecosystem prevents the development of neighborhood-serving businesses that could improve convenience and quality of life. The cumulative effect of these challenges creates a livability deficit. Residents must expend disproportionate time and energy overcoming geographic disadvantages just to access basic services and opportunities that urban dwellers typically take for granted. This constant friction in daily life reduces overall satisfaction and makes the development less competitive compared to better-located housing options.

4.3.4 Key Threats from Seasonal Floods

Seasonal floods present immediate and severe threats to the condominium housing, primarily due to the site's proximity to the Tanqua River, as evidenced by images depicting muddy overflows onto roads and eroded banks.

1. Structural Damage and Inundation

Floodwaters can infiltrate buildings, weakening foundations and causing partial or total collapse.

2. Soil Erosion and Land Instability

The Tanqua River's seasonal surges erode riverbanks and adjacent slopes, undermining housing stability. Images show exposed soil layers and undercut banks, indicative of ongoing degradation. This poses a landslide risk for hillside condominiums, especially in deforested or graded areas, leading to cracks in walls or foundational shifts.

3. Infrastructure Disruption

Floods damage supporting utilities and access routes, isolating residents. The images illustrate road flooding, which can block emergency services and daily commutes. For condominiums, this includes compromised water towers (visible in images) and sewage overflows, heightening contamination risks.



Figure 4- 4. Tanqua River

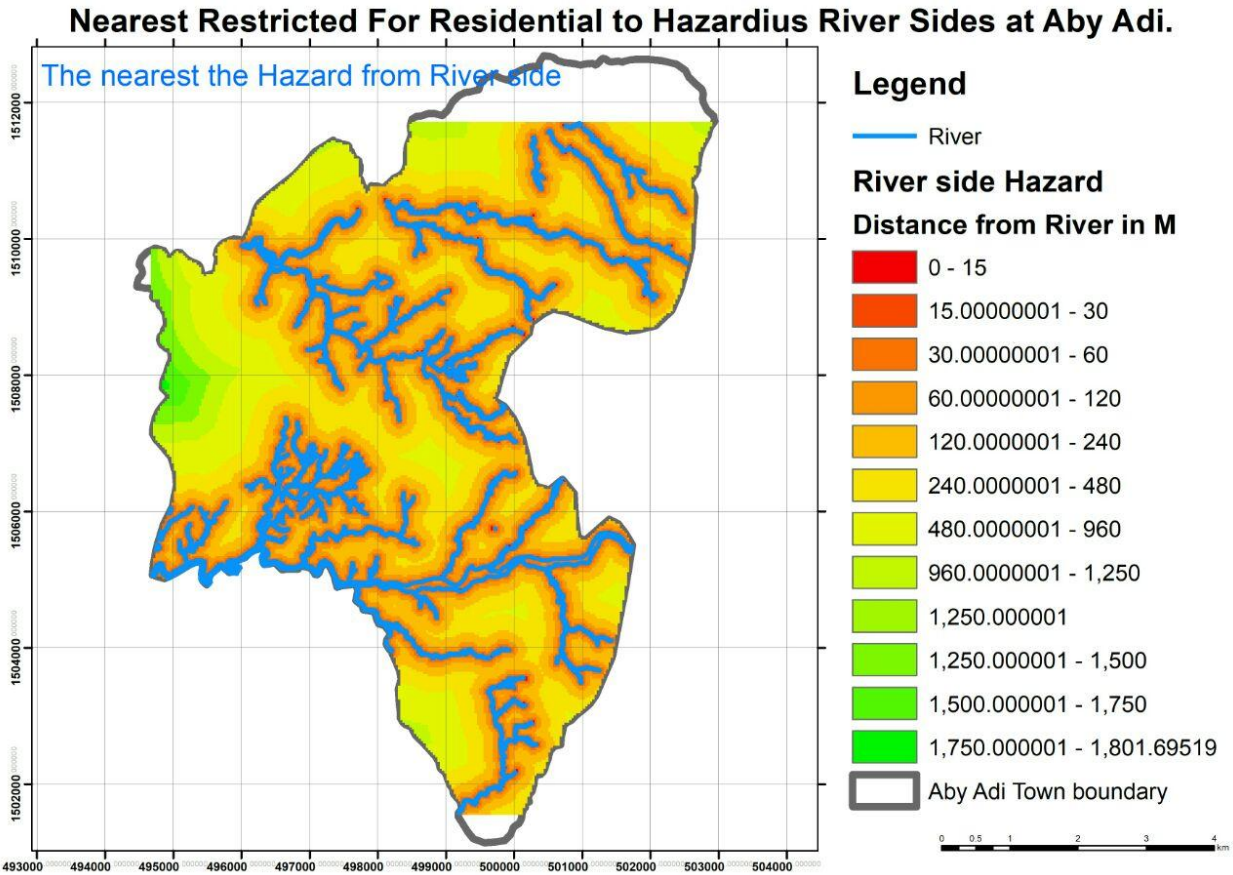


Figure 4- 5. Nearest Restricted for residential to hazardous river sides

The above map illustrates hazard zones based on proximity to river sides in and around Abiy Adi town potential flood risks. It indicates areas restricted for residential development due to hazards such as flooding, erosion, or riverbank instability. Key Map Components:

Rivers: Depicted in blue lines, forming a dendritic (branching) network that traverses the map from north to south and east to west. The rivers are densest in the central and southern sections, creating multiple narrow corridors of high hazard.

Town Boundary: Outlined in gray, enclosing an irregularly shaped area approximately 10-15 km² based on the scale (0-3 km at the bottom). The boundary hugs the river network, indicating the town is built around or intersected by waterways.

Coordinate System: Uses a grid likely in UTM (Universal Transverse Mercator) projection (e.g., Zone 37N for Ethiopia), with easting from ~493,000 to 504,000 m and northing from ~1,504,000 to 1,520,000 m. This covers a roughly 11 km (east-west) by 16 km (north-south) extent.

Color-Coded Hazard Distances: The legend shows Euclidean distance from the nearest river side in meters, with a gradient from red (close, high hazard) to green (far, low hazard). The bins are unusually precise (e.g., "15.000000001 - 30"), possibly due to GIS floating-point artifacts, but effectively:

Red: 0-15 m (immediate riverbank, highest risk; likely fully restricted for residential).

Dark orange: 15-30 m.

Orange: 30-60 m.

Light orange: 60-120 m.

Yellow-orange: 120-240 m.

Yellow: 240-480 m.

Light yellow: 480-960 m.

Light green: 960-1,250 m.

Medium green: 1,250-1,500 m.

Green: 1,500-1,750 m.

Dark green: 1,750-1,801.7 m (maximum mapped distance; areas beyond may be considered non-hazardous or outside scope).

Visual Summary and Distribution:

High-Hazard Zones (Red to Orange, 0-60 m): These form thin buffers along all river edges, widest where rivers meander or converge. They occupy an estimated 10-20% of the total mapped area, concentrated in the central river valleys. These zones fragment the landscape, creating "hazard islands" that could limit connectivity for development.

Medium-Hazard Zones (Yellow shades, 60-960 m): Broader bands surrounding the rivers, covering about 40-50% of the area. They dominate the mid-sections of the map, transitioning gradually outward.

Low-Hazard Zones (Green shades, 960-1,801 m): Expansive in the western and northern peripheries, away from major rivers, comprising 30-40% of the area. These appear safest for residential or other uses, with larger contiguous patches.

Overall Pattern: The hazard decreases radially from rivers, but the irregular river paths create a patchy, non-uniform distribution. The southern and eastern edges show greener (safer) land,

while the area around the condominium housing location has tighter hazard gradients due to closer river proximity.

4.4 Conformity of the site location with the land use or structure plan of the town in relation to access to services

The condominium development's peripheral location creates significant challenges in terms of urban service integration and daily functionality:

4.4.1 Essential Service Accessibility

Healthcare facilities are situated at distances that exceed reasonable walking thresholds, requiring residents to rely on inadequate public transportation options educational institutions serving different age groups are dispersed across wide areas, creating logistical challenges for families with school-age children. Basic retail and commercial services that support daily living are not available within convenient proximity, necessitating planned shopping trips rather than spontaneous purchases.

Euclidean distance From services of Existance priferable when Nearly

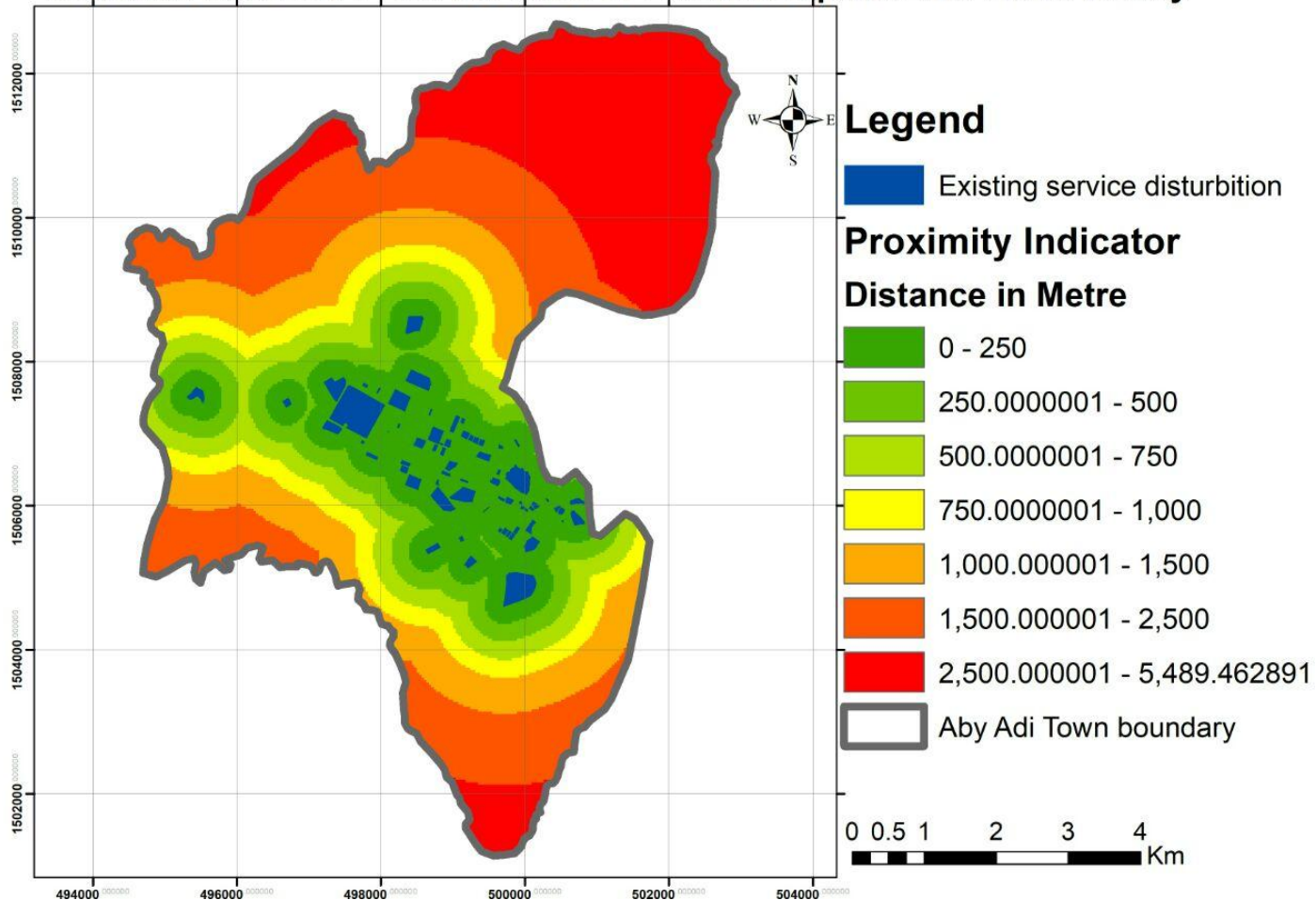


Figure 4-6. access the condominium housing to social services

This analysis show, service accessibility, identifies patterns of uneven distribution, and discusses implications, particularly for condominium housing location.

1. Overview of Service Distribution and Proximity Zones

Existing Services (Blue Clusters): The blue areas mark the locations of current social services. There appear to be 10-15 distinct clusters, primarily concentrated in the central and south eastern portions of the town. These form irregular, scattered points rather than a uniform grid, suggesting services are historically clustered around denser population or administrative hubs. No services are visible in the northern or far southern peripheries.

Proximity Indicator (Colour Gradient): The map uses a rainbow spectrum to show distance bands from services, with "preferable when nearby" implying that shorter distances (cooler colours like green) are ideal for accessibility. The legend breaks down as follows:

Green (0-250 m): Very close; immediate access, suitable for daily needs like kindergartens.

Light green (250.000001-500 m): Reasonably accessible; within a short walk (5-10 minutes at average pace).

Lime green (500.000001-750 m): Moderate access; 10–15minute walk.

Yellow (750.000001-1,000 m): Borderline convenient; 15–20minute walk, potentially challenging for vulnerable groups (e.g., children, elderly).

Orange (1,000.000001-1,500 m): Poor access; 20-30minute walk, may require transport.

Dark orange (1,500.000001-2,500 m): Very poor; over 30 minutes walking, significant barrier.

Red (2,500.000001-5,489.462891 m): Extremely distant; up to 1+ hour walk, effectively inaccessible without vehicles.

Town-Wide Coverage: The central area is dominated by green and blue, indicating good coverage within ~500 m of services. However, the gradient radiates outward, with orange and red dominating the northern half, south western edges, and isolated pockets in the south. The maximum distance in the legend (~5.5 km) likely represents the farthest point in the mapped area, though the town's compact size means most red zones are 2.5-3.5 km from services.

Spatial Patterns and Accessibility Gaps

Central vs. Peripheral Disparities: Services are unevenly distributed, creating "accessibility islands" around blue clusters.

In conclusion, communities of the condominium housing have poor access to social services like kinder garden and health center.

4.4.2 Land Use Compatibility and Adjacent Zone Interactions

The condominium's relationship with surrounding land uses reveals several critical incompatibilities. The abrupt shift from high-density vertical development to low-density suburban housing creates visual and functional discontinuities in the urban fabric.

Privacy concerns emerge due to the height differential between the condominium and neighboring single-family homes.

4.4.3 Public Space and Social Infrastructure

A complete absence of public gathering spaces within the immediate vicinity limits community interaction opportunities. Recreational facilities are located at distances that discourage regular use by residents. Cultural amenities are entirely absent from the local area, requiring significant travel for access. Utility infrastructure operates at reduced efficiency compared to central urban areas and Digital connectivity often lags behind city-center standards.

Chapter Five

5 Conclusion and recommendation

5.1 Conclusion

The research on the locational suitability of urban residential areas in Abiy Adi town, with a specific focus on condominium housing, reveals significant shortcomings in the site's selection and planning. The analysis demonstrates that the condominium site exhibits poor accessibility to essential social services, such as healthcare facilities, educational institutions, and recreational spaces, which undermines the quality of life for residents and exacerbates urban inequality.

Furthermore, its proximity to a river poses substantial environmental risks, including potential flooding, erosion, and waterborne health hazards, particularly in the context of climate change and increasing rainfall variability in the region. Additionally, the lack of conformity with adjacent land uses—such as potential conflicts with cattle market, social services, or transportation corridors—leads to inefficiencies in urban integration, increased reduced aesthetic and functional harmony within the broader urban fabric.

Overall, these findings indicate that the current condominium housing site in Abiy Adi town falls short of established urban planning standards for locational suitability, as outlined in frameworks like those from the United Nations Habitat or Ethiopia's urban development policies. This not only hampers sustainable urban growth but also perpetuates socio-economic challenges.

The research underscores the need for a more holistic, evidence-based approach to site selection that prioritizes resident well-being, environmental resilience, and long-term urban coherence. By addressing these gaps, Abiy Adi town can move toward more equitable and sustainable residential development, contributing to the broader goals of Ethiopia's urban agenda.

5.2 Recommendations

Based on the above findings and conclusions the study has forwarded the following recommendations to solve the existing problems identified by the study under considerations.

Conduct Comprehensive Site Assessments Prior to Development: Urban planners and local authorities should mandate multi-criteria evaluations for all proposed residential sites, incorporating factors such as proximity to social services, flood risk mapping, and land use compatibility. Tools like Geographic Information Systems (GIS) could be employed to model and predict potential issues, ensuring sites are selected based on data-driven insights rather than ad-hoc decisions.

Improve Accessibility to Social Services: For the current condominium site, invest in infrastructure upgrades, such as extending public transportation networks, constructing pedestrian pathways, and establishing satellite service hubs (e.g., community clinics or schools) within a 1-2 km radius. In future projects, adopt a "15-minute city" model where essential services are accessible within a short walk or commute, aligning with global best practices for inclusive urbanism.

Mitigate Environmental Risks from River Proximity: Implement riverbank stabilization measures, including green buffers, flood barriers, and early warning systems, to protect residents from hydrological hazards. Relocation of vulnerable housing units should be considered if risks are deemed too high. For new developments, enforce setback regulations (e.g., a minimum 50-100meter buffer from rivers) and integrate eco-friendly designs, such as permeable surfaces and rainwater harvesting, to promote environmental sustainability.

Enhance Land Use Conformity and Zoning Enforcement: Revise the town's master plan to ensure residential areas are zoned in harmony with surrounding uses, avoiding juxtapositions with incompatible activities like heavy industry. Encourage mixed-use developments that foster community integration, and involve stakeholder consultations (including residents and local businesses) during planning phases to address conformity issues proactively.

Strengthen Policy and Institutional Frameworks: The Abiy Adi municipal government, in collaboration with Ethiopia's Ministry of Urban Development and Housing, should develop and enforce stricter guidelines for condominium site selection. This could include capacity-building programs for planners, public participation in decision-making and periodic audits of existing sites. Additionally, exploring public-private partnerships could provide funding for retrofitting unsuitable sites.

Monitor and Evaluate Ongoing Developments: Establish a monitoring system to track the performance of residential areas post-construction, using indicators like resident satisfaction surveys, service access metrics, and environmental impact assessments. This iterative approach will allow for adaptive management and inform future urban policies.

Implementing these recommendations will require coordinated efforts from government bodies, community organizations, and development partners. By prioritizing locational suitability, Abiy Adi town can foster resilient, liveable urban environments that support sustainable growth and improve the overall welfare of its residents. Future research could expand this analysis to comparative studies with other Ethiopian towns to identify scalable solutions.

References

- AHADU CONSULTING ENGINEERS AND ARCHITECTS, ABIY-ADI *integrated development plan, September 2009 E.C.*
- Buckley, R. (2014). Affordable housing in Rwanda: opportunities, options and challenges: some Perspective from the international Experience.
- Burley, Terence M. 1961, *Land use or land utilization? Professional Geographer*, 13: 18 - 20.
- Dr. Xinhao Wang and Dr. Rainer vom Hofe 2007, *Research methods in urban and regional planning*
- Guesh Dejen, 2017; *The Assessment of 20/80 Condominium Housing Projects in Addis Ababa: The case of Bole and AkakyKaliti Sub cities.*
- Huiping Huang, Qiangzi Li and Yuan Zhang *Urban Residential Land Suitability Analysis Combining Remote Sensing and Social Sensing Data: A Case Research in Beijing, China 2019.*
- James A. LaGro, Jr 2013 *Site Analysis Informing Context-Sensitive and Sustainable Site Planning and Design* Third Edition.
- Kaiser, Edward J., David R. Godschalk and F. Stuart Chapin, Jr. 1995, *Urban Land Use Planning. Urbana, IL: University of Illinois Press.*
- Marsh, William M. 2005. *Landscape Planning: Environmental Applications*, 4th Ed. New York, NY: John Wiley & Sons, Inc.
- McHarg, Ian L. 1969. *Design with Nature*. Garden City, NY: Natural History Press.
- Mileti, 1999 E.C; H. John Heinz Center for Science, Economics, and the Environment, 2000
- MUDHC. (2005). Ministry of urban development and housing construction: Urban Housing Strategy Framework: Addis Ababa
- Proclamation (2003). *condominium proclamation, 2003E.C Regional Negarit Gazeta: Tigray Regional state, (November), 109/1998.*

Rizah Murseli and Florim Isufi, 2014, *Land suitability location analysis for housing development using GIS*

Santanu Kumar Misra 2015; *Site Suitability Analysis for Urban Development*

Thomas H.Russ *Site planning and design* hand book 2009.

UN-habitat 2011, *Condominium Housing in Ethiopia: The Integrated Housing Development Program. Situation analysis of informal settlements in Addis Ababa: Nairobi.*

Urban planning & implementation manual 2002 E.C

APPENDIX

Questionnaire: Locational Suitability of Urban Residential Areas – The Case of Abiy Adi Town

Dear Participant,

This questionnaire is designed to understand how suitable the location of the Abiy Adi Town condominium housing is for residents. Your honest responses will help improve urban planning and housing decisions. All information will be kept confidential and used for academic purposes only.

Section A: Demographic Information (Close-ended)

1. Gender

- Male
- Female
- Prefer not to say

2. Age Group

- Under 25
- 25–34
- 35–44
- 45–54
- 55 and above

3. Type of Housing Unit

- Privately owned
- Rented

4. Block Number (Select your block)

- Block 1 Block 2 Block 3 Block 4 Block 5 Block 6 Block 7

Section B: Locational Suitability Perception (Mix of close & open-ended)

5. How satisfied are you with the location of your condominium?

- Very satisfied
- Satisfied
- Neutral
- Dissatisfied
- Very dissatisfied

6. What are the main advantages of your condominium's location? (Open-ended)

7. What are the main disadvantages of your condominium's location? (Open-ended)

8. The proximity to Tanqua River gorge influences your living conditions:

- Positively
- Negatively
- No significant influence

9. If the river affects your living conditions, please explain how. (Open-ended)

Section C: Accessibility and Services

10. How would you rate access to the following from your condominium? (Close-ended, 5-point scale: Very good / Good / Fair / Poor / Very poor)

Public transportation

Schools

Health facilities

Markets/shops

Recreational areas

11. Are there adequate roads and pathways connecting your block to other parts of the town?

- Yes
- No
- Partially

Please describe any challenges related to accessibility in your area. (Open-ended)

Section D: Safety and Environmental Concerns

12. Have you experienced or are you concerned about flooding or erosion from Tanqua River gorge?

Yes

No

If yes, please describe the extent or frequency of the problem. (Open-ended)

13. How safe do you feel living in this location in terms of crime and environmental hazards?

Very safe

Safe

Neutral

Unsafe

Very unsafe