

**Analysis of Industrial Land Use Compatibility: A Case Study of Gelan
Sub-city, Shagar City, Ethiopia.**



Remedan Aman

A Thesis Submitted to the Department of Architecture College of Civil
Engineering and Architecture

Presented in Partial Fulfilment of the Requirement For the Degree of Masters
in Urban Planning and Design

Office of Graduate Studies

Adama Science and Technology University

November, 2024

Adama, Ethiopia

**Analysis of Industrial Land Use Compatibility: A Case Study of Gelan
Sub city, Shagar City, Ethiopia.**

Remedan Aman

Advisor: Yared Girma (PhD)

A Thesis Submitted to the Department of Architecture College of Civil
Engineering and Architecture

Presented in Partial Fulfilment of the Requirement for the Degree of Masters
in Urban Planning and Design

Office of Graduate Studies

Adama Science and Technology University

November, 2024

Adama, Ethiopia

DECLARATION

I declare here by this research thesis entitled “Analysis of Industrial Land Use Compatibility: A Case Study of Gelan Sub city, Shagar City, Ethiopia” is my own work and has not been submitted to any university for similar purpose. The reference used in this Thesis are dully recognized by proper citations.

Name of student

Signature

Date

RECOMMENDATION OF ADVISORS

I, the major advisor of this thesis, here by certify that I have read the revised version of the thesis entitled “Analysis of Industrial Land Use Compatibility: A Case Study of Gelan Sub city, Shagar City, Ethiopia” prepared under my guidance by Remedan Aman. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedures.

Major Advisor/Supervisor

Signature

Date

APPROVAL SHEET

I/we, here by certify that the recommendation and suggestion given by the proposal review committee are appropriately incorporated into final thesis/dissertation proposal entitled “Analysis of Industrial Land Use Compatibility: A Case Study of Gelan Sub city, Shagar City, Ethiopia” by Remedan Aman.

Yared Girma (PhD)

Major Advisor/Supervisor

Signature

Date

We, the undersigned, members of the Board of Examiners of the thesis by Remedan Aman have read and evaluated the thesis entitled “Analysis of Industrial Land Use Compatibility: A Case Study of Gelan Sub city, Shagar City, Ethiopia” and examined the candidate during open defence. This is, therefore, to certify that the thesis is accepted for partial fulfilment of the requirement of the degree of Master of Science in Urban Planning.

Chairperson

Signature

Date

Internal Examiner

Signature

Date

External Examiner

Signature

Date

Finally, approval and acceptance of the thesis proposal is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head

Signature

Date

School Dean

Signature

Date

Office of postgraduate studies, Dean

Signature

Date

ACKNOWLEDGEMENTS

First and foremost, I would want to thank the Almighty God for his incredible gift, assistance, and protection throughout my work and life.

I would like to convey my heartfelt gratitude and thanks to Dr.Yared Girma (PhD), who encouraged, guided, and supported me from the beginning to the end of this thesis. He helped me construct and understand the subject matter, as well as the method of composing this research.

Furthermore, I would like to express my heartfelt gratitude to the Sheger City Administration and Gelan Sub City employees for their cooperation in providing me with useful information and allowing me to collect the data used in this research.

In addition, I am very grateful to my family, my wife, my lecturers and friends for their prayers and priceless support. Finally, thanks to Adama Science and Technology University.

TABLE OF CONTENTS

Contents	Pages
DECLARATION.....	i
RECOMMENDATION OF ADVISORS.....	ii
APPROVAL SHEET.....	iii
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF ACRONYMY	x
ABSTRACT	xi
CHAPTER ONE: INTRODUCTION	1
1.1. Background of study	1
1.2. Problem of the statement	3
1.3. Research objectives.....	5
1.3.1. General objectives	5
1.3.2. Specific objectives.....	5
1.4. Research question	5
1.5. Significance of the study.....	6
1.6. Scope of the study	7
1.7. Operational definition	8
1.8. Thesis organization	8
CHAPTER TWO: LITERATURE REVIEW	9
2.1. Theoretical review	9
2.1.1. Neighbourhood Concept	10
2.1.2. Environment Concept.....	10
2.2. Empirical literature review	11
2.2.1. Global perspectives	11
2.2.2. Local perspectives	12
2.3. Conceptual framework.....	13
2.3.1. Problems of incompatible land uses in the study area	13
2.3.2. Major impacts of industrial land use on nearby residence	14
2.4. Methodological approach to land use compatibility study	14
2.4.1. Multi criteria decision analysis (MCDA).....	15
2.4.2. Technique for order performance by similarity to ideal solution (TOPSIS).....	16

2.4.3. Ordered Weighted Averaging (OWA)	16
2.5. Research Gap	16
CHAPTER THREE: METHODOLOGY	18
3.1. Description of study area	18
3.1.1. Location Description	18
3.1.2. Topography	18
3.1.3. Population.....	19
3.2. Case Study Area Section.....	20
3.3. Research Approach	21
3.4. Types and Sources of Data	22
3.5. Software used for study	23
3.6. Sampling Techniques and Sampling Size.....	23
3.5. Data Collection Instruments	25
3.5.1. Questionnaires	25
3.5.2. Key Informant Interview	25
3.5.3. Focus Group Discussion	25
3.5.4. Field Observation	26
3.5.5. Mapping	26
3.6. Data Analysis Methods	27
3.7. Compatibility matrix Analysis.....	29
3.9. Ethical Consideration.....	30
CHAPTER FOUR: RESULTS AND DISCUSSION.....	31
4.1. Background of the respondents.....	31
4.2. Existing Situation of land use in study area.....	33
4.3. Industrial Land Use and Compatibility.....	35
4.3. Environmental Impact in relation industrial activities.....	38
4.4. Socio economy and employment opportunities in relation industrial activities	42
4.4.1. Effect of industrial activities on residential property values.....	43
4.4.2. Economic Impact of Industrial Land Use on the Rental Values of Neighbouring Residential Property Values.	43
4.5. Compatibility Analysis of Residential and industrial Land Use Activities with other land uses in study area.	47
4.5.1. Education activities/Administrative activities.....	47
4.5.2. Religious Land Use/Health institution (i.e Health Centre)	47

4.5.3. Commercial Land Use/Industrial Area	48
4.5.4. Transportation Activities/Other Industrial Activities.....	48
4.6. Potential areas of conflict and incompatibility between industrial land use and residential land uses in the study area.....	49
4.6.1. Proximity to residential and Air Pollution Assessment.	50
4.6.2. Proximity to residential and Noise Pollutions.....	51
4.6.3. Distance to residential land use	52
4.7. Determining land use compatibility and Overall Compatibility Score.....	53
4.8. Discussions	55
CHAPTER FIVE CONCLUSION AND RECOMMENDATIONS	57
5.1 Conclusions.....	57
5.2 Recommendations.....	58
REFERENCES	60
Appendix	63

LIST OF TABLES

Table number and titles	pages
Table 3.1. Data sources and types	23
Table 3.2. Material used in study	23
Table 4.1. Gender, Age and marital status of respondents	31
Table 4.2. Education level of respondents.....	32
Table 4.3: For how many years Living in this area.	32
Table 4.4. Analysis of Land Use area coverage	35
Table 4.5: Type of industries located in study area.....	36
Table 4.6. Close Distance to the nearest industrial facility in study area.....	37
Table 4.7: Compatibility of industrial land use with surrounding residential.	37
Table 4.8: The environmental problem posed on residents by industrial activities	39
Table 4.9 Employment condition and level of income of respondents	42
Table 4.10. Level of agreement on Industrial land use effect residential property values. .	43
Table 4.11. The impact of the environment problem on the rental value.....	43
Table 4.12 respondents feel safe living near industrial activities.....	45
Table 4.13. Industrial activities create jobs in the neighborhood.....	45
Table 4.14: Industrial activities contribute to the overall economic prosperity of the neighbourhood.	46
Table 4.15: Household Overall, satisfactions with the social and economic impacts of the industrial activities on their neighbourhood	47
Table 4.16: Area coverage of compatibility Level of study area.	55

LIST OF FIGURES

Figure Number and Lists	Pages
Figure 3.1: Location map of study area Gelan Sub city Ethiopia	19
Figure 3.2. Technological scheme of the research by Author,2024	28
Figure 4.1: Existing Land use map of study area.	33
Figure 4.2. Incompatibility of manufacturing industry and area close to residential area. .	36
Figure 4.2. Manufacturing Industry problem with Open dump site for disposal of solid waste.	40
Figure 4.3. problems of Environmental Impact of manufacturing industry nearby residential.	41
Figure 4.4. The Above images in figure 4. Manufacturing industry waste water unprotected open ditch (Bad Smell) Air pollution.	41
Figure 4.5: Potential conflict Area Between Residential and Industrial land use.	50
Figure 4.6. Air pollutions proximity of residentials from Industrial area.	51
Figure 4.7: proximity distance and Pollutant emission on the residential districts of the study area.	52
Figure 4.8. manufacturing industry (Mis) proximity to residential area.	53
Figure 4.9. Compatibility Level map of study area.	54

LIST OF ACRONOMY

CSA	Central statistical authority
DMs	Decision makers
DEM	Digital Elevation Model
ERA	Ethiopian road authority
FGD	Focused Group Discussion
GIS	Geographical information system
IDCs	Industrial Development Centers
LULC	Land Use Land Cover
Mis	manufacturing Industry
IZs	Industrial Zones
MCDA	Multi criteria decision analysis
NDI	Noise Depreciation Index
OWA	Ordered Weighted Averaging
SPSS	Statistical Package for Social Sciences
TOPSIS	Technique for order performance by similarity to ideal solution

ABSTRACT

The rapid urbanization of recent decades has transformed cities and intensified land use demands. Industrial land, industrial location and their effect on urban form have been the subject of considerable study over the past century. The location and character of industry have redefined many urban landscapes and labour markets, and have shaped the foundations and practice of planning. The effect of industrial location on urban form remains profound. Ethiopian urban centers have experienced significant land use pattern changes, with diverse buildings and uses located incompatibly. This has increased risks and created a disordered landscape. This research has conducted a comprehensive analysis of industrial land use compatibility with the surrounding environment and residential areas in Gelan Sub city. The research employs a mixed-methods approach. Quantitative data on environmental parameters and current land use were collected and analyzed using GIS techniques. Qualitative data on social and economic impacts were obtained through field surveys and interviews with stakeholders. Given the numerous factors influencing land use compatibility, a multi-criteria evaluation approach was applied, incorporating four key factors. The findings indicate significant environmental concerns, particularly in industrial areas near residential zones, with chemical industries causing air, water, and soil pollution. A majority of residents (75.8%) live within 1 km of these industries, experiencing high levels of pollution. Compatibility assessments highlight that 55.8% of respondents perceive a very incompatible relationship between industrial and residential areas, while 29.2% find it somewhat incompatible. Only a small fraction (8.3%) reports some compatibility, with 6.7% considering the areas very compatible. Compatibility analysis revealed that 69.8% of the industrial area is not suitable for residential use. Given the high level of perceived incompatibility between the current industrial area and surrounding residential zones, as well as the substantial proportion of the study area deemed unsuitable for industrial use, it is crucial to reassess and redesign land use planning strategies. Recommendations include identifying and developing alternative industrial zones that are better isolated from residential areas to minimize conflicts. Additionally, enhancing buffer zones and implementing stricter zoning regulations could help mitigate adverse impacts on residential areas. Engaging with stakeholders and residents in the planning process can ensure that future developments address community concerns and improve overall land use compatibility.

Key word: Land use compatibility, Environmental impact, industrial area.

CHAPTER ONE

INTRODUCTION

1.1. Background of study

The phenomenon of rapid urbanization has become a defining feature of the 21st century, transforming the fabric of cities worldwide. As cities grow, so does the demand for industrial spaces, leading to complex challenges in land use management. According to the United Nations, the global urban population is expected to reach 68% by 2050, emphasizing the urgency of developing sustainable urban planning strategies. Within this dynamic global context, understanding and managing industrial land use compatibility have become critical aspects of fostering resilient and sustainable urban environments (United Nations, 2018).

The rapid urbanization sweeping across developing countries presents a complex tapestry of challenges. One of the most pressing concerns is the intermingling of industrial and residential land uses, a phenomenon that often leads to a clash between economic progress and environmental well-being. This incompatibility can manifest in a multitude of ways, from air and noise pollution plaguing residential areas to environmental degradation threatening the health and livelihoods of communities (Taleshi & Bishehii, 2012)

Land use compatibility, in the planning context, refers to the harmonious coexistence of various land uses, ensuring healthy, liveable, and sustainable communities. Industrial facilities, with their inherent risks, must be thoughtfully positioned to minimize negative impacts on sensitive neighbouring uses, like residential areas. This requires a robust framework of statutory and policy instruments, as (Raji, 2021) emphasizes. The Planning Performance and Provincial Policy Statement, for instance, serve as cornerstones for guiding land use decisions that prioritize both economic vitality and community well-being.

Land use planning is more than just laying down the bare minimum for acceptable land use. It's about weaving a tapestry of sustainability, social harmony, and environmental responsibility, where every thread serves a purpose and contributes to a beautiful, functioning whole (Mansourihanis et al., 2023).

As (Raji, 2021) properly stated, land use planning provides the "prerequisites" for achieving a sustainable form of land use that fits within the social and environmental

contexts while maintaining an aesthetically pleasing landscape. It creates the backbone, the framework upon which a thriving community can be built.

Land use planning goes beyond mere acceptability; it strives for desirability and economic viability. As Adhikari and Li (2013) pointed out, cited in (Abedini et al., 2015a). it's a science of ordering and regulating different land uses in urban areas for optimal efficiency. It's about carefully arranging, organizing, and planning land use patterns with a clear vision in mind: creating a conducive environment that's not only functional but also aesthetically pleasing. This requires a deep dive into the existing land structure and arrangement, a critical analysis of compatibility between different uses, particularly the often-conflicting interests of industrial and residential areas. It's about understanding the complex interplay between economic demands, social needs, and environmental limitations (Kalfas et al., 2023).

Incompatible land uses can lead to a plethora of negative consequences. Industrial activities can generate noise pollution, air and water contamination, and traffic congestion, impacting the well-being of surrounding residential communities and the environment (World Health Organization, 2019). Conversely, incompatible residential development near industrial zones can expose residents to health risks and disrupt industrial operations ((Tanku & Woldetensae, 2023)

Historically, Ethiopian cities like Gelan have seen significant changes in land use patterns, often characterized by haphazard development and incompatible zoning (Benti et al., 2022) ;(Tanku & Woldetensae, 2023). This has led to a rise in environmental risks, inefficient urban landscapes, and diminished quality of life for residents in disadvantaged areas.

In Gelan Sub city, the potential for conflict between industrial activities and the surrounding environment and communities is particularly acute. Pollution, noise, and traffic congestion are just some of the potential consequences of poorly planned industrial development. This research aims to address these concerns by conducting a comprehensive analysis of industrial land use compatibility in Gelan Sub city.

By understanding the complex interplay between industrial activities, the environment, and residential communities, this research seeks to provide valuable insights for urban planners and policymakers. The ultimate goal is to promote sustainable industrial development in Shegar City Gelan Sub city that benefits both the economy and the well-being of its citizens.

Geographic Information Systems (GIS) have become indispensable tools in urban planning and land use management, offering a comprehensive approach to analyzing and mapping the compatibility of industrial land use with other land uses. This GIS-based analysis methodology involves the integration and overlaying of various spatial datasets to systematically evaluate the relationships and interactions between different land uses within a given geographical area. Through the layering of information such as zoning regulations, environmental conditions, infrastructure networks, and demographic data, planners and researchers can gain a nuanced understanding of the spatial dynamics and potential conflicts associated with industrial activities in proximity to other land uses (Mansourihanis et al., 2023b).

This GIS-based approach provides a spatially explicit representation of the landscape, allowing for the identification of areas where industrial land use may conflict or harmonize with residential, commercial, or environmental zones. By visually representing these layers of information, decision-makers can make informed choices regarding land use policies, zoning regulations, and urban development strategies to enhance compatibility and mitigate potential negative impacts. The use of GIS in land use compatibility analysis not only facilitates the identification of conflict zones but also aids in the formulation of targeted interventions and solutions to create sustainable and harmonious urban environments (Brown & Raymond, 2014).

As highlighted by, (Clarke et al., 2015) GIS offers a powerful platform for this type of analysis, enabling the integration of diverse datasets and the visualization of spatial patterns. This approach enhances the decision-making process by providing a clear, data-driven understanding of the complex relationships between industrial land use and other land uses. The utilization of GIS technology ensures a more efficient and accurate assessment of land use compatibility, supporting evidence-based urban planning practices that contribute to the development of resilient and sustainable communities.

1.2. Statement of the Problem

Shegar City, Ethiopia, is witnessing a surge of industrial activity, promising economic prosperity and progress. Yet, within its designated industrial zone, Gelan Sub city, a troubling discordance emerges. The rapid expansion of industrial facilities has created a tapestry of conflicting land uses, where industries stand shoulder-to-shoulder with residential neighbourhoods and fragile environmental elements. This haphazard development raises a critical question: can industrial activities and their surrounding

environment and communities co-exist in harmony, or is Gelan Sub city destined for a clash of incompatible land uses?

The potential for conflict is stark. Residents in Gelan Sub city face a constant barrage of noise pollution from industrial operations, threatening their health and well-being. Air quality plummets, choked by emissions that endanger their respiratory health and the environment. The once pristine landscape is marred by industrial waste, jeopardizing the delicate ecological balance of the region (Dempwolf, C. S. 2010). This incompatibility breeds anxieties and hinders the development of a thriving community within Gelan Sub city. Due to the lack of proper land use regulations and partly unplanned city growth, the industries in the inner city pose health and other socio-economic problems to many residents. The process of operation and development of industry zones is showing signs of inadequacy related to air pollution, noise, water and waste pollution (Taleshi, M., & Bishehii, S. 2012).

The consequences extend beyond immediate environmental and social impacts. Incompatibility hampers the efficiency of industrial operations themselves. Residential encroachment restricts expansion potential and disrupts logistical flows. The lack of a coherent land use plan fosters uncertainty, hindering investment and sustainable industrial development.

This state of affairs demands immediate attention. Unchecked, the incompatible tapestry within Gelan Sub city will unravel, leading to environmental degradation, social distress, and economic stagnation. It is imperative to understand the complex interplay between industrial activities and their surroundings, to identify the fault lines of incompatibility, and to weave a new narrative where industry thrives alongside a healthy environment and a vibrant community. Therefore, this research investigates into the heart of this conflict.

There is a research gap in understanding how industrial land use can coexist with residential areas to promote healthy and sustainable communities. While studies focus on either industrial suburbanization patterns or the impacts of industrial sites near residential areas, there is limited research on the intersection of these issues (Vesely, J., & Taylor, N. (2019). Additionally, current strategies primarily emphasize spatial segregation and buffer zones to manage conflicts, but there is a lack of policy and models, particularly in Ethiopia, that address mixed-use industrial designs. This study aims to fill the gap by assessing land use compatibility between residential and industrial areas.

The study aim to systematically analyse the compatibility of industrial land use with the environment and residential areas in Gelan Sub city. By mapping land uses, measuring environmental parameters, and engaging with stakeholders, the study seek to unravel the threads of harmony and discord within the sub city. Ultimately, study aspires to guide the development of informed policy decisions and planning strategies that ensure a future where industry and its surroundings find not just co-existence, but symbiotic harmony.

1.3. Research objectives

1.3.1. General objectives

The general objective of the study is to analyse the compatibility of industrial land use with the surrounding environment and residential areas in Gelan Subcity, Shegar City, Ethiopia, and provide comprehensive insights into the challenges and opportunities for harmonious coexistence of industrial activities, the environment, and the community.

1.3.2. Specific objectives

The specific objectives that will be attained by the research are to:

1. identify analysis potential areas of conflict and incompatibility between industrial land use and other land uses in the study area.
2. assess the degree of incompatibility between industrial land use parcel with its neighbours
3. evaluate the environmental impacts resulting from industrial activities within the study area.
4. assess the social and economic implications of industrial activities on the local communities in the study area.

1.4. Research question

1. Where and how do potential conflicts and incompatibilities arise between industrial land use and other land uses in the study area?
2. To what extent are individual industrial land use parcels incompatible with their surrounding land uses in in the study area?
3. What are the environmental impacts of industrial activities within the study area?
4. How do industrial activities affect the social and economic conditions of local communities in the study area?

1.5. Significance of the study

This research will investigate the critical issue of land use compatibility in Gelan Sub city, where the rapid expansion of industrial activities raises concerns about its impact on the environment and surrounding communities. Understanding the compatibility of industrial land use is not only crucial for the practical development of Gelan Sub city but also holds significant theoretical and academic value. This research will provide a comprehensive understanding of the challenges and opportunities for harmonious coexistence between industrial activities, the environment, and the community. This knowledge can inform the development of land use plans and policies that promote sustainable industrial development, minimizing negative impacts and fostering a thriving city. By identifying potential areas of conflict and incompatibility, the research can guide decision-making towards allocating land for industrial activities in a way that minimizes disruption to residential areas and environmental resources. This can lead to improved air and water quality, reduced noise pollution, and waste generation, ultimately enhancing the quality of life for residents.

The research can provide valuable insights for investors and businesses considering industrial development in Gelan Sub city. By understanding the compatibility of different land uses, they can make informed decisions about location selection, minimizing environmental risks and maximizing operational efficiency. This research will contribute to the growing body of knowledge on land use compatibility, particularly in the context of developing countries like Ethiopia. It adds valuable empirical data and case studies that can inform theoretical frameworks and best practices for managing industrial development in similar settings.

By examining the specific challenges and outcomes in Gelan Sub city, the research can test and refine existing theories of land use compatibility and environmental impact assessment. This can lead to the development of more nuanced and context-specific approaches to managing industrial land use in diverse urban environments. Moreover, this study can act as a catalyst for further research in related fields, such as environmental engineering, public health, and urban planning. By highlighting the complex interplay between industrial activities, the environment, and communities, it can pave the way for new research questions and initiatives to address the challenges of sustainable industrial development.

In conclusion, analyzing industrial land use compatibility in Gelan Sub city holds significant practical, academic, and theoretical value. It can contribute to the development of sustainable cities, improve the lives of residents, inform investment decisions, and advance our understanding of land use management in developing countries. This research, therefore, has the potential to make a significant contribution to both the immediate needs of Gelan Sub city and the broader field of urban planning and environmental sustainability.

1.6. Scope of the study

Thematic Scope:

- **Spatial Analysis:** Identifying and analysing potential areas of conflict between industrial land use and other land uses, such as residential neighbourhoods, green spaces, and water bodies. This spatial dimension will involve mapping land use patterns, buffer zones, and pollutant dispersion patterns to understand the geographical distribution of potential incompatibilities.
- **Environmental Assessment:** Evaluating the environmental impacts of industrial activities on air and water quality, noise pollution, and waste generation. This will involve data collection and analysis of relevant environmental parameters, providing a quantitative understanding of the environmental consequences of industrial expansion.
- **Social and Economic Impact Assessment:** Assessing the social and economic impacts of industrial activities on the health, well-being, and livelihoods of residents. This will involve qualitative and quantitative research methods, including surveys, interviews, and economic data analysis, to capture the lived experiences and socioeconomic implications of industrial development.
- **Compatibility Assessment:** Assess the degree of incompatibility between individual industrial land use parcels and their surrounding land uses. This will involve developing a scoring system or matrix that considers factors like proximity, emissions, and potential health risks, providing a nuanced understanding of site-specific compatibility levels.

Spatially Scope:

Spatially, this study focuses on Gelan sub-city, specifically the Tulu Guracha industrial area, due to its substantial concentration of manufacturing industries. Gelan was chosen as a research site because the Ethiopian government designated it as a key corridor for national and regional economic development, attracting numerous factories. Factors like its

advantageous location on the Addis Ababa-Djibouti railway and highway, readily available and affordable labor, and promising underground water reserves were instrumental in this decision. Within Gelan, the specific kebeles included in the study were those experiencing the highest levels of industrialization and land use incompatibility.

1.7. Operational definition

Different literatures have different definitions for Land use compatibility. According to ((UNIDO, 2019) Land use compatibility is achieved when major facilities and sensitive land uses can co-exist and thrive for the long-term within a community through planning that recognizes the locational needs of both. These different land uses need to be planned and managed properly to avoid conflicting with or adversely impacting each other.

Compatibility Study: study that assesses potential adverse effects and recommends separation distances between land uses and mitigation measures, if needed, to prevent impacts to surrounding sensitive land uses.

Sensitive Land Uses: “Buildings, amenity areas, or outdoor spaces where routine or normal activities occurring at reasonably expected times would experience one or more adverse effects from contaminant discharges generated by a nearby major facility. Sensitive land uses may be a part of the natural or built environment.

Industrial land use: Industrial land use means the use of land primarily for the purpose of manufacturing, production, fabrication or assembly processes and ancillary services.

“Incompatible” means that the proposed land use shall not be allowed under any circumstances.

1.8. Thesis organization

This thesis document is structured by chapters. Chapter one gives an overview of the study area and outlines the key problems that forms the basis of this research. The research objectives, research questions, hypothesis, conceptual framework and the thesis outline. Chapter two gives in detail the concepts of the thesis based on existing literatures to gain insights that may be applicable to this research. Chapter three gives a brief description of Gelan and the case study area and also presents the methodology used, the fieldwork data collection and analysis. It forms the basis of all other chapters. Chapter four presents the findings and results of the analysis. Also discusses the results obtained and their relevance to the study area. Chapter five outline the conclusions and recommendations arising from this research.

CHAPTER TWO

LITERATURE REVIEW

2.1. Theoretical review

The term land is a subject of discussion among scholars and professionals. (Othieno, L., & Shinyekwa, 2011) cited in (Akande Raji, 2019) Land is required for various uses in both the urban and rural areas of all society and it is a necessity for development. As nations grow in size and rural areas become urban centres and urban centres continues to expand, there is always increased competition as well as demand for land for different uses. This requires adequate planning and control to ensure harmonious development and functional efficiency of these uses and settlements (Akande Raji, 2019)

Industrial land, industrial location and their effect on urban form have been the subject of considerable study over the past century. The oppressive density and poor conditions of worker housing near many factories in the early part of the 20th century led in part to the first zoning and building code (Dempwolf, 2010). In practical terms, the effects of industrial operations on surrounding communities formed the core of the environmental and movement of 1960 and 70s (Dempwolf, 2010).

Land-use compatibility is defined as “the degree to which two or more land use types co-exists without significant negative impact” (Taleai, et al., 2007) cited in (Cheniki et al., 2019). The co-habitation of different activities of different scales may cause positive or negative effects on urban space. Those effects may vary from one space to another, depending on the existing activities in the urban area. For example, cohabitation of residential and industrial activities in the same urban space may cause negative impact like congestion, air pollution which makes urban life more difficult.

According to Cheniki et al., (2019b), interaction between different activities could get a constrained land use usability. They explain that the existence of different activities in the same area may cause negative externalities, impeding by consequence, the functioning of land uses that exist in urban area. Land use incompatibility could lead to less valuable land uses. However, compatibility may get more performed and more valuable urban spaces. Compatibility between adjacent lands uses leads to improve safety and welfare and protect environment health by reducing different kinds of pollution, increasing well-being and value of urban space.

In the land use compatibility, the characteristics of different uses or activities or design which allow them to be located near or adjacent to each other in harmony (Nourian, F. 2021). Some elements affecting compatibility include height, scale, mass and bulk of structures. Other characteristics include pedestrian or vehicular traffic, circulation, access and parking impacts. Other important characteristics that affect compatibility are architecture, landscaping, lighting, noise and odor. Compatibility does not mean “the same as”. Rather, compatibility refers to the sensitivity of development proposals in maintaining the character of existing development.

2.1.1. Neighbourhood Concept

The neighbourhood unit plan in brief is the effort to create a residential neighbourhood to meet the needs of family life in a unit. related to the larger whole. but possessing a distinct entity characterized by A residential environment with harmonious architecture, carefully planting, centrally located community buildings, and special internal street system. A neighbourhood is assumed to be a community containing range of families who come together to share a common view and too issues of mutual concern. The concept which is equivalent to a residential land use district encircled by major thoroughfares and within a walking distance from home. It is a term primarily used to describe the component part of the urban area which is similar in physical function and crucial to the transformation of its landscape. Within the neighbourhood are major facilities such as residential, places of worship with associated elements like the organized recreational spaces all separately located and planned to meet the social need of the people in the neighbourhood. Nevertheless, the concept of the neighbourhood design can be adapted to the design for proper allocation of land uses.

2.1.2. Environment Concept

The objective of this concept is similar to that of Neighbourhood concept. The over-riding consideration is the convenience, comfort and safety of residents. Thus, the environment area is designed to have clean, peaceful environment where there is no disturbance of all sorts most especially traffic. It is guided by Neighbourhood environment capacity, restricted on its internal circulatory system. Environment can be defined as a sum total of all the living and non-living elements and their effects that influence human life. While all living or biotic elements are animals, plants, forests, fisheries, and birds, non-living or abiotic elements include water, land, sunlight, rocks, and air. Environmental planning seeks to balance

human needs with the protection of natural environments in order to improve our lives today and serve our needs in the future.

2.2. Empirical literature review

2.2.1. Global perspectives

Land use incompatibility could lead to less valuable land uses. However, compatibility may get more performed and more valuable urban spaces. Compatibility between adjacent lands uses leads to improve safety and welfare and protect environment health by reducing different kinds of pollution, increasing well-being and value of urban space. The most relevant recent findings on the evaluation of the impacts of the land use compatibility are presented by (Abedini et al., 2015b) For instance, Taleai et al. (2007) developed a model in order to evaluate land use compatibility in both horizontal and vertical directions. (Abedini et al., 2015b) proposed a model in order to verify how suitable different location for the construction an elementary school. Even, (Vaezi et al. 2015) proposed a model for assessing and mapping land use compatibility.

Khan and Malik (2014) also conducted a study on the environmental and health effects of textile effluents in India. They showed that untreated or insufficiently treated textile effluents contain chemicals that can pollute the air people breath, causing respiratory health problems. The author also discovered that effluents with high concentrations of chemical pollutants affect normal functions of human cells, especially in the case of infants, and children. According to their findings some textile pollutants in higher concentrations can alter the physiology and biochemical mechanisms of humans, resulting in the impairment of the physiological functions such as Osmoregulation, reproduction, and can sometimes cause death (Khan and Malik 2014). one of the main reasons for shorter life expectancy in many countries (WHO 2003).

(Mansouri et al., 2021) conducted study on land use compatibility Assessment using neighbourhood focal Analysis in Gis. Land use planning plays an important role in urban development Traditionally land use suitability analysis is still referred as an effective decision-helping aid that will enhance the complicate planning decision environment (Kim et al, 2016). Researchers define compatibility as the level of proportionality among land uses together in a neighbourhood. Due to multiplicity and complexity of relationships among them, the compatibility matrix is used to explain this indicator. (Mansourihanis et

al., 2023b) defines compatibility as establishment of land uses in a reference region, which they should not disturb or stop each other activities.

(Wang et al., 2014 and Wang et al., 2013) Discovering land use appropriateness and their interference is as complicated parts of land use planning. This is resulting from plurality parameters including: examining and analysing degrees of compatibilities, the appropriateness among types of land uses, their position and their equitable distribution in proportionate scales. The distance between two land uses bears a reversed proportion in comparison with the intensity of their interactions. The compatibility indicator needs spatial analysis according to interaction radiuses of land uses and their establishment. Besides becoming more comprehensive and increasing amount of studies, the volume of calculation and analysis increase progressively. Therefore, most planners are limited and satisfied alternatively to analyse the indexes case by case (especially incompatible land uses) or in partial measures such as being neighbours in one or some units.

2.2.2. Local perspectives

In Ethiopia, a rapidly growing population size, continued dependency on agriculture as well as an increased urbanization and industrialization have led to inappropriate use of land and degradation of natural resources. The increasing pressure on land in the rural and peri-urban areas has led to conflicts among different interest groups and clashes between communities and the government. Ethiopia is an overwhelmingly agrarian economy. The agricultural sector absorbs around of the labor force and adds more than 40% to the national GDP (MoFED, 2014). While the industry sector only contributed 10% to the GDP in 2008/09 and 12% of the GDP in 2013, its role remaining very small. In 2011/12, the industry sector employed less than 5% of the labor force (MoFED, 2013; GTP, 2013) and since 1990s, the Government of Ethiopia has taken a number of steps in an effort to industrialize the economy and to promote industrial development.

In the Ethiopian Constitution, Article 44 grants all citizens the right to live in a clean and healthy environment. Furthermore, Proclamation No. 300/2002, article 3 (1), stipulates that, “No person shall pollute or cause any other person to pollute the environment by violating the relevant environmental standard”. Article 3 (2) of the same proclamation further states that the relevant authority or the relevant regional environmental agency may take administrative or legal measures against a person who, in violation of law, releases any pollutant into the environment.

The City in central Ethiopia Sub city of Gelan were selected in 2004 in order to establish Industrial Development Centers (IDCs). So, doing was part of the Ethiopian government's strategy to accelerate economic growth by establishing industrial development corridors in the selected town's four regions, namely Oromia, Amhara, Tigray, and the Southern Nations, Nationalities, Peoples and Regions (SNNPR), as well as in Addis Ababa and Dire Dawa since 2004. Thus, the selected IDCs, the federal government, or private companies in collaboration with the federal government, were enabled to establish Industrial Zones (IZs) that specialize in the manufacture of specific products in factories or industries set up in a single premise (e.g., IZs for leather and leather products).

The Sub city of Gelan in shegar city is located close to Addis Ababa, near the country's single railway line and major highway that connects Addis Ababa to Djibouti port. The Sub city possess "sufficient converted agricultural land" for investment, cheap labour, and sufficient underground water reserves. The area around Gelan have relatively low slopes between 5% and 10% (OWWDSE, 2011), making land preparation and construction more cost effective than in other IZs in Ethiopia. Specifically, selected area for this research is Tulu Guracha kebele and this located at the Center of Gelan town.

According to (Gizaw, 2021) study on the "impact of industrial land use effect on agriculture land" In Tulu Guracha kebele out of a total 1,536.47 hectare of land, 235 hectare has been used for industry. Land for long time has played the fundamental role among Gelan inhabitant's life. Numerous socio- economic lives are intensely attached with their productive asset i.e., land. Hence economically inhabitants of Gelan are dependent to their land.

2.3. Conceptual framework

2.3.1. Problems of incompatible land uses in the study area

Incompatible land-use indicate the trend in territorial planning and generate instability and conflicts leading to degradation in terms of environmental quality (Alina Tudor, 2012). It has been noticed that, there are problems associated with incompatible land uses in most urban areas. These include untidy confusion, high population rate, traffic congestion as a result of a mixture of incompatible uses to which land has been subjected. To these categories of problems are very common, in most urban area where many activities such as commercial and services activities from, residential, industrialization and recreational location are been found. The above stated problems have given rise to the government to enforce zoning regulation especially at the core areas of our cities.

2.3.2. Major impacts of industrial land use on nearby residence

Environmental pollution which include land, water, air, and noise pollution from industrial activities have negative effect on both residential property values and on the health and wellbeing of the occupants of those properties and thus reduces the values of residential properties because people will not want to live close to areas where their health will be endangered and where they will be disturb by frequent noise and they will want to live in areas where their health will be secured (Sofer et al., 2012). This issue has been addressed by many researchers so as to proffer a lasting solution to these negative effects but their recommended measures is yet to bring these negative externalities on residential property values as a result of proximity to industrial properties to a satisfactory level which prompted this study.

(Bentinck and Chikara, 2001) Unhealthy conditions prevail where industry and residences are intermixed. Also, there are traces of areas in developing countries such as African countries where there is concentration of industries located close to residential areas such as Kenya, Morocco, Egypt, Sudan, etc. Many studies have also revealed the negative impacts of such pollution. Mark (2004), Kumer et al. (2012), and Manunatha (2008), for example, have shown that industrial effluents polluting the soil can affect plant growth, including agricultural crops and, apparently, affect the livelihood of farmers in the area. Furthermore, in Ethiopia particularly Gelan, dukem and city surrounding Addis ababa, there are concentration of industries located close to residential areas most of which are operating illegally and it is very common in Gelan sub city such as Tulu Guracha. There is also many clustering of localization of industries in various part of Gelan subcity.

2.4. Methodological approach to land use compatibility study

(Friso and Henri, 2009) conducted research on Impact of Industrial Site on Property Values in 2009 in the Randstad region and the province of Noord-Brabant (both in the Netherlands) by means of a hedonic pricing analysis of residential property transactions, they identify the impact ceteris paribus of the distance to industrial sites on property transaction prices. Industrial sites cause several negative externalities, such as traffic noise disturbance, congestion, and obstruction of view, etc. And the distance to an industrial site has a statistically significant negative effect on the value of residential properties. However, the effect is largely localized within a relatively short distance from the nearest industrial site. (Friso and Henry, 2009) Land-use compatibility is a component element of urban planning. So, planners do their best to avoid conflicts between functions, in order to

get a best desirable urban space. However, planners might be seen as one element of the whole system. The interactions with the other elements (socio-cultural, economic, environmental and technical) that constitute the land use compatibility lead us to say highlight that the dynamism more than impossible, such as social, security and economic constraints. While Incompatible land uses are a major source of potential degradation at the urban level. Knowledge about land uses compatibility can be a useful guide for planners and local authorities to manage the existing issues and to generate social, environmental and economic welfare without degrading the environment.

(Cox, 2005) studied impact of airport noise on residential property values in Asia. He adopted Hedonic Pricing for Noise Depreciation Index (NDI) calculation. According to him, NDI's are defined as the percentage increase in the loss of property values due to a unit increase in noise exposure and are generally determined using Hedonic Price (HP) techniques, which utilizes the trade-off between varying property prices and associated noise levels (and other factors that affect the price of properties) in the real estate market.

2.4.1. Multi criteria decision analysis (MCDA)

Multi-Criteria Decision Analysis (MCDA), also known as Multi-Criteria Decision-Making (MCDM), is about making decisions when multiple criteria (or objectives) need to be considered together in order to rank or choose between alternatives. Due to ever increasing complexity of human society, people often need to consider multiple criteria (attributes, factors, objectives) to make decisions. The research area of multiple criteria decision analysis is developed to provide decision aid for complex decision situations. MCDA aims to furnish a set of decision analysis techniques to help decision makers (DMs) logically identify, compare, and evaluate alternatives according to diverse, usually conflicting, criteria arising from societal, economic, and environmental considerations (**Chen et al., 2011**). MCDA provides a systematic framework to investigate complex decision problems containing multiple intertwining criteria. MCDA concentrates on decision analysis with a finite set of alternatives and offers a host of methods for preference elicitation and aggregation. A unique feature of MCDA is preference-based aggregation. To reach a final recommendation, it is inevitable that an aggregation procedure is required to synthesize alternatives' performances over different criteria.

2.4.2. Technique for order performance by similarity to ideal solution (TOPSIS)

The TOPSIS model quantitatively measures the distance between different data and the optimal values, accurately evaluating the safety level at different time points and determining the optimal solution among multiple alternatives. The TOPSIS (technique for order performance by similarity to ideal solution) method (Parida, 2013) constitutes a useful technique in solving ranking problems. The basic idea of the TOPSIS is simple and intuitive: measure alternatives' distances to pre-defined ideal and anti-ideal points first and, then, aggregate the separate distance information to reach overall evaluation results.

2.4.3. Ordered Weighted Averaging (OWA)

The Ordered Weighted Averaging aggregation operators, commonly known as OWA operators, are introduced by (Abedini et al., 2015b) to provide a parameterized class of mean-type aggregation operators. Many notable mean operators, such as the Max, arithmetic average, median, and Min, are members of this class. OWA operators have been widely used in computational intelligence due to their flexibility in modelling linguistically expressed aggregation instructions (Cheng, Wang, & Wu, 2009). TOPSIS and OWA methods become increasingly popular research topic in several academic fields. For this study OWA aggregation and TOPSIS is designed to incorporate the unique features from both methods to provide additional flexibility for MCDA.

2.5. Research Gap

Land use compatibility in the planning context is achieved where industrial and other major facilities can coexist with sensitive land uses to contribute to healthy, livable and sustainable communities.

Different aspects of the literature discuss either the patterns of industrial suburbanization over time or the effects of industrial land use near residential land use. A gap exists at the intersection of these two topics and in the interpretation of de-industrialization in terms of historical land use patterns.

However, more research is needed, not only case studies, but also models that help us to understand the role of available industrial land in start-ups and relocations as well. In the literature, strategies focus on spatially segregating incompatible land uses. Many city guidelines use separation distances and buffers to minimize site adjacency conflicts. Transitional zoning, or “use buffers”, protect a zone from another by interposing an in-between district. Landscape buffers can be used to address visual conflicts; however, their application should be carefully considered. In general, policy and regulations for Ethiopian

specially in Gelan municipalities outside of Gelan are broad and limited to spatial separation guidelines. Existing policy and literature have scarce resources that directly inform mixed-use industrial designs.

The first step in any planning process is to assess the current situation and define the problems that are to be addressed. In urban land use planning this step implies the need to identify and assess potential land use compatibility problems. However, methods and tools to perform such an evaluation in multi-functional and intensive urban environments are lacking. Finally, this research aimed at filling this gap in planning tools by integrating a new model to assess and define degrees of compatibility among set criteria of residential land use and industrial land use.

CHAPTER THREE

METHODS AND MATERIAL

3.1. Description of study area

Geographically Gelen Subcity is located between 7° 12'00" to 9° 14'00"N Latitudes and 38°32'00" to 39°32'00" E Longitudes in eastern part of sheger city. Shegar City, a new urban center on the outskirts of Addis Ababa, is located in the Oromia Regional State of Ethiopia. In 2022, the Ethiopian Reporter confirmed the consolidation of six previously independent towns surrounding Addis Ababa (Sebeta, Burayu, Legatafo Legedadi, Sululta, and Gelen) into a single city administration under Shegar City. This new entity comprises 12 sub-cities, 36 districts, and 40 rural kebeles (now known as county administrations).

Gelan, one of the 12 sub-cities within Shegar City, has a relatively recent history. As described by (worku, 2016) its establishment coincided with the millennium anniversary of Ethiopia. Driven by the expansion of Addis Ababa (then known as "Finfine"), the Oromia Regional State sought to control its surrounding areas and incorporated Gelen into its administration. The town's name derives from the local Tulama Oromo group called Gelen.

3.1.1. Location Description

Gelan's current location, 25 kilometers from Addis Ababa's center (Piassa), places it within the Shegar City administration, adjacent to the Special Zone of the Oromia Regional State. Astronomically, it is located between 7° 12' to 9° 14'N Latitudes and 38°32' to 39°32' E Longitudes. According to the current master plan, the total area coverage of the town is 90.6835 km² (9068.35) hectares.

Gelan sub city sits on a flat landscape covered in volcanic soil and porous rocks. A watershed running north to south divides streams flowing towards the Akaki groundwater catchment zone from those flowing towards Dukem, except for streams originating on surrounding hilltops.

3.1.2. Topography

The altitude difference between GaraBushu, the highest mountain, and Merino, the lowest area, influences soil types. Lower-lying areas have vertigos (clay) soil, while higher areas have nit soil and select materials often used by residents for construction.

The town's altitude ranges from 1500-3100 meters above sea level, with GaraBushu at 2100 meters and Merino Kebele at 1750 meters. This altitude range creates a sub-tropical (Woinadega) climate with an average maximum temperature of 17°C (62.6°F) and a mean annual temperature of 20°C, similar to tropical and subtropical regions. This temperature range makes Gelan suitable for human habitation. Figure 3.1. location map of study area.

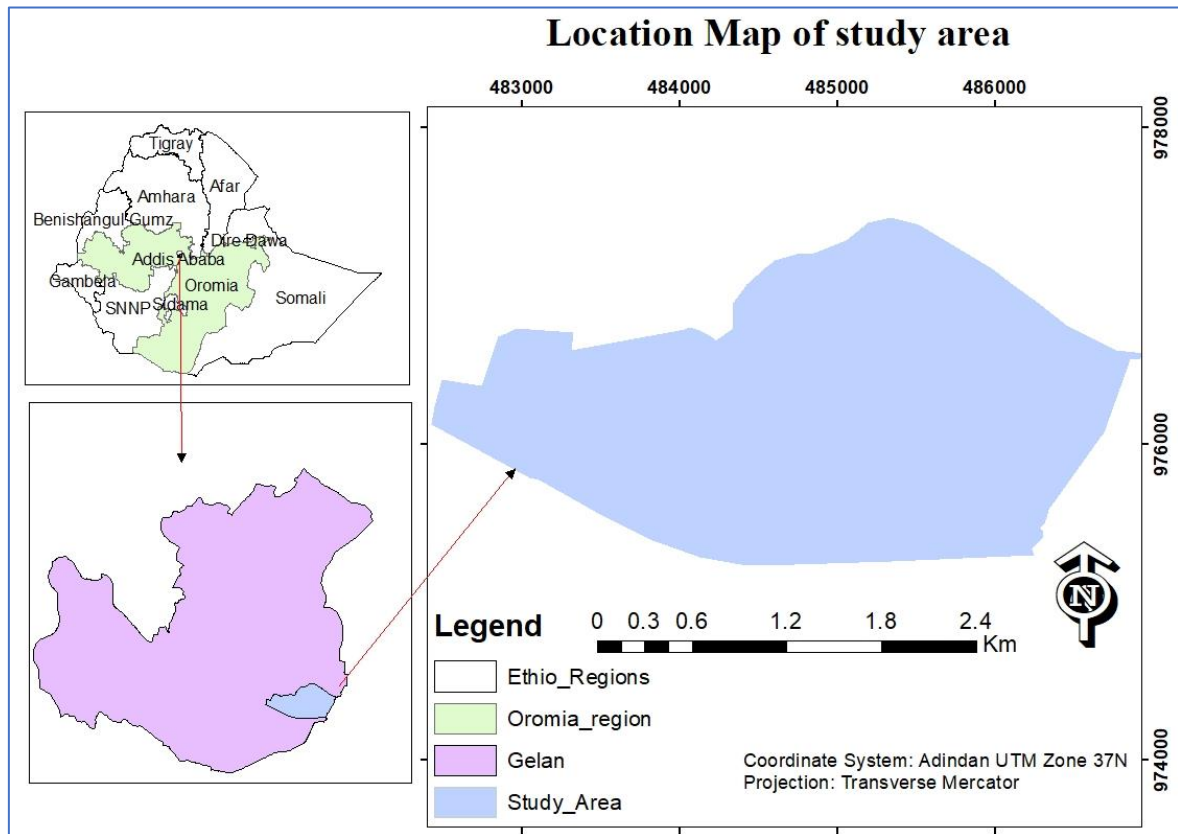


Figure 3.1: Location map of study area Gelan Sub city Ethiopia

Rainfall averages between 700 and 800mm annually, with mean monthly rainfall at 154mm. Although Gelan lacks its own weather station, data from the nearest station in Addis-Akaki suggests that southeasterly trade winds dominate, accounting for approximately 50% of annual winds.

3.1.3. Population

Population dynamics in Gelan are affected by fertility, mortality, and migration. These complex processes involve social, cultural, economic, political, and psychological factors. In urban environments, migration plays a leading role in shaping population characteristics and reflects the town's urbanization rate. According to the 1999 census, Gelan had a total population of 13,898 (7,033 male and 6,865 female). Based on a 2.5% annual growth rate,

the average household size was estimated to be 3.6 and 3.61 in 2011 and 2012, respectively. However, rapid migration and other factors likely suggest a current population exceeding these projections.

3.2. Case Study Area Section

The study selected one woreda, Tullu Guracha as a case study site, out of the four woredas found in Gelan sub city for the following reasons:

- **High Concentration of Manufacturing Industries:** Tulu Guracha wereda boasts a significantly higher concentration of manufacturing industries compared to other weredas in Gelan Sub city. This concentration amplifies the potential impact of industrial activities on the surrounding environment and community, making it an ideal site for in-depth analysis.
- **Liquid Effluent Discharge and Pollution Concerns:** A key issue within Tulu Guracha wereda is the high prevalence of industries discharging liquid effluents. These effluents often contain pollutants that can contaminate water sources, air, and soil, posing significant environmental and health risks. Studying this specific challenge within Tulu Guracha wereda allows for a focused analysis of its impact on the community and surrounding environment.
- **Socio-economic and Environmental Impacts:** Residents within Tulu Guracha wereda have consistently voiced concerns about the negative socio-economic and environmental impacts of industrial activity in their community. These concerns include air and water pollution, noise disturbances, health problems, and potential land degradation. Choosing Tulu Guracha wereda as the case study allows for a thorough investigation of these concerns and their impact on the well-being of the residents.
- **Compatibility Conflict:** The juxtaposition of densely populated residential areas with concentrated industrial activity in Tulu Guracha wereda creates a stark case of land use incompatibility. This clash provides a fertile ground for examining the challenges of coexistence between industrial activities and residential areas, offering valuable insights for future planning and development.
- **Representativeness and Generalizability:** Although Tulu Guracha wereda presents a particularly prominent case of industrial land use incompatibility, it shares similar challenges with other rapidly industrializing regions in Ethiopia and beyond. Studying this specific case can yield valuable findings with broader applicability, informing

strategies for managing industrial development and fostering harmonious coexistence in similar contexts.

In conclusion, selecting Tulu Gurach wereda as the case study site was a strategic decision driven by its unique combination of factors, including the high concentration of polluting industries, the concerns of residents, and the clear conflict between industrial and residential land uses. This site offers a rich tapestry of challenges and opportunities for analyzing industrial land use compatibility, providing valuable insights that can be applied both locally and globally.

3.3. Research Approach

In conducting this research, a mixed-methods approach has been employed, strategically combining both quantitative and qualitative methodologies to comprehensively assess the compatibility of industrial land use within Gelan Sub city, Shegar City, Ethiopia. This approach is chosen to ensure a nuanced and holistic understanding of the complex interplay between industrial activities, the environment, and residential areas.

Quantitative data collection methods involved the administration of surveys to residents, industrial stakeholders, and environmental experts. These surveys will be designed to quantitatively measure perceptions and experiences related to industrial land use compatibility. Additionally, Geographic Information System (GIS) mapping will be utilized to spatially visualize and analyze the distribution of industrial zones, residential areas, and key environmental features within Gelan Sub city. This quantitative phase aims to provide numerical insights into trends, correlations, and statistical significance regarding the compatibility of industrial land use.

Concurrently, qualitative data collection methods were implemented to capture the richness of contextual information. In-depth interviews with key informants, including local authorities, industrial managers, and community leaders, will be conducted to obtain detailed and nuanced perspectives on compatibility issues. Focus group discussions with residents will further contribute to the qualitative data by exploring community perceptions and concerns related to industrial activities. This qualitative phase is essential for uncovering underlying complexities and nuances that may not be fully captured through quantitative measures alone.

3.4. Types and Sources of Data

To assess industrial land use compatibility in Gelan Sub city, this research will draw upon a diverse range of data sources, both primary and secondary.

a) Primary Data:

- **Mapping and Spatial Analysis:** High-resolution satellite imagery and Geographic Information Systems (GIS) will be employed to map land use patterns, including the precise location of industrial facilities, residential areas, green spaces, and environmental features. This will provide a spatial foundation for understanding the physical relationships between different land uses and potential conflicts.
- **Household Surveys and Interviews:** In-depth interviews and surveys will be conducted with residents living near industrial areas. This qualitative data will capture their lived experiences, concerns about health and safety, perceptions of environmental impacts, and hopes for the future. Focus group discussions with stakeholders, including industry representatives, government officials, and NGOs, will provide diverse perspectives on the challenges and opportunities for compatibility.

b) Secondary Data:

- **Government Documents and Reports:** Official documents and reports from relevant government agencies, such as the Gelan sub city and the Shegar City Planning Commission, will provide valuable insights into existing policies, regulations, and land use plans related to industrial development.
- **Academic Research and Publications:** Published research on industrial land use compatibility, environmental impact assessments, and social studies of communities living near industrial areas will offer valuable theoretical frameworks and empirical evidence to inform the analysis.

Table 3.1. Data sources and types

S/N	Data	sources	Data types	Cell size/scale	remark
1	Aerial Image	Geospatial Institute	Raster (tiff)	0.15m	
2	Digital Elevation model (DEM)	USGS/Alos plasar	grid	12.5m	
3	Structure plan of the sub-city	City administration	cad		
4	Road infrastructure	ERA	Shape files		
5	Stream	ERA	Shape files		
6	Population data	Central Statistical Agency	csv		

3.5. Software used for study

Software like, ERDAS IMAGINE, ArcGIS, and other geospatial software will be used for data extraction and preparation of data analysis. SPSS and micro soft excel 2019 will be used for socioeconomic data analysis and interpretative. Table 3.2 below show summary of software proposed.

Table 3.2. Material used in study

S/N	Material name	Versions/ sources	purpose	Remark
1	ArcGIS 10.8	ESRI	Data Processing and Thematic map preparation	
2	ERDAS Imagine 2015	-	Image pre-processing	
3	Google Earth pro	-	Use as a base map in visual image interpretations, and generate coordinate points for the images.	
4	Microsoft office (Word, Excel, Power point)	Microsoft 2019	Integrating attribute and compositing proposal (report writing)	
5	SPSS 26	-	Analysis of statistical data	
6	Hand held GPS	-	Filed data collection while site visitation for accurate location	

3.6. Sampling Techniques and Sampling Size

To achieve the intended objective of the study both of random sampling and purposive sampling methods was employed. Purposive sampling method was used to select the Weredas. The usage of the purposive sampling technique in the study is not arbitrary, but

based on its strength in helping select key Wereda from which detailed information has obtained to have a better understanding of specific events and activities. Accordingly, Tullu Guracha weredas has selected from four Wereda found in Gelan sub-city. The main criteria for selection of the wereda is that there is high concentration of polluting industries, the concerns of residents, and the clear conflict between industrial and residential land uses. The selection of the wereda is done in consultation with experts from the Sub city and Wereda Administration.

The sampling frame to identify respondents is the list of 1270 households who found in the Wereda. Accordingly, the sample size of the respondents was determined using a formula (Eq.1) developed by Yamane (1967).

$$n = \frac{N}{1 + N(\alpha)^2} \text{-----Eq.1}$$

Where: n= sample size of the study population

N=Number of households

α =the margin of error, and

1=constant

Thus, actual sample size was calculated as follows:

$$n = 1270 / (1 + 1270 * 0.05^2)$$

$$n = 1270 / (1 + 3.175)$$

$$n = 1270 / 4.175$$

$$n \approx 303.45$$

Accordingly, out of 1270 households, 304 sample informants were selected for household surveys. In order to increase the accuracy of the research results, the research operated at a 95 % level of confidence with a margin of error of 5%.

To select the sample households, a simple random sampling method was used. This meant that every household on the registered list of the wereda had an equal chance of being selected in the sample. A table of random numbers was used for this purpose. Each household on the list was assigned a number, and random numbers were drawn from the

table. The households that corresponded to the random numbers were then selected for the sample. Once the requisite sample size (n) was reached, the household head or one mature member of the household (age > 18) was invited to respond to the survey questions.

The study also included interviews with 30 key informants from different offices in the Wereda and Sub-city Administration, industry owners, and community elders, as well as one focus group discussion (FGD) with a minimum of six participants.

3.5. Data Collection Instruments

3.5.1. Questionnaires

The researcher used 304 questionnaires to collect data from all respondents in the selected sample. The questionnaires were designed to address the socio-economic impacts of manufacturing in their residence and its compatibility with the surrounding environment. The items on the questionnaires were originally prepared in English and then translated into Afan Oromo. The Afan Oromo questionnaires were then back-translated into English to ensure the accuracy of the translation. The questionnaires contained both closed-ended and open-ended questions.

3.5.2. Key Informant Interview

An interview is fundamentally a conversation involving a face-to-face verbal exchange between two or more people, where the interviewer seeks to gather information, opinions, or beliefs from the interviewee(s). This method is valuable for obtaining additional information with greater flexibility. The researcher conducted face-to-face structured personal interviews with 30 key informants, including officials, manufacturing owners, and community elders. A purposive sampling technique was used to select key informants, focusing on professionals and office managers directly working on the issue, as they were believed to have more detailed data. Additionally, local elders provided crucial insights into land use compatibility issues and historical changes in the area.

3.5.3. Focus Group Discussion

Focus groups discussions are a type of collective interview where the researcher encourages discussion among participants to generate rich data. Focus groups are one of the most important techniques for gathering participants' opinions, attitudes, values, and expectations on a particular topic.

Focus groups were used in this study to collect data on the industrial land use compatibility with the surrounding residential area and the environment. Two focus groups were held, with 5-10 participants each. Participants included representatives of industries, local communities, officials from various administrative tiers and experts with experience in the field of the study. The participants for the Focus Group Discussions (FGDs) were selected using a purposive sampling technique. This approach was chosen to ensure that individuals with specific knowledge and experience related to the topic were included. Participants were carefully chosen based on their direct involvement with, or expertise in, the subject matter, such as local community members, manufacturing owners, government officials, and experts familiar with land use and industrial development issues. The selection process aimed to include individuals who could provide diverse perspectives, particularly those who had first-hand experience with land use compatibility and its impact on the local area. This method ensured that the discussions were enriched with relevant, informed contributions from participants who were best positioned to offer valuable insights.

3.5.4. Field Observation

Field observation was conducted to collect data and verify the findings of the interviews. This was done through physical inspection, reconnaissance, sketches of problem areas, and photographs. Observation is the main data collection method for this study, as it allowed the researcher to gather information about the compatibility of the industrial land use with other land uses and its impact on the surrounding environment and also interactions between industrial and residential spaces.

3.5.5. Mapping

In this study, Geographic Information Systems (GIS) software was utilized for a detailed spatial analysis to map and assess various land use types, such as industrial, residential, green spaces, and key environmental elements like air quality monitoring stations and water bodies. The primary purpose of using GIS was to create visual representations and spatial overlays that would help in understanding the spatial relationships and interactions between different land uses and environmental factors. By mapping these elements, GIS enabled a more comprehensive assessment of land use compatibility, particularly in identifying areas where industrial activities overlap with sensitive residential zones or natural resources.

The process involved gathering spatial data from different sources, including satellite imagery, government records, and on-site surveys. These data sets were then digitized and integrated into the GIS platform to generate detailed land use maps. These maps provided a visual framework for analyzing critical aspects like proximity between industrial and residential areas, environmental risks such as air and water pollution, and the extent of green spaces acting as buffers.

Furthermore, GIS was used to conduct spatial analyses, such as calculating buffer zones around industrial facilities to assess their impact on nearby residential areas and environmental features. By doing so, it allowed the researcher to evaluate potential land use conflicts, quantify the extent of overlap between incompatible land uses, and suggest zoning adjustments or mitigation measures. This tool was essential in not only visualizing the current land use patterns but also in supporting decision-making by providing precise data to inform land use planning and environmental management..

3.6. Data Analysis Methods

This research will utilize a robust combination of tools and techniques for analyzing both quantitative and qualitative data. For quantitative data, Likert scales will remain a core methodology, as (Gallaso et al., 2019) aptly stated, for measuring attitudes through survey research. However, the research was gone beyond Likert scales by employing advanced software packages to delve deeper into the data. The quantitative data, derived from both secondary sources and field surveys, was analysed using advanced spatial and geoprocessing tools, including buffering and Euclidean distance calculations. This was allowed for a precise spatial analysis of the compatibility of each land parcel for industrial use based on various factors, including noise pollution, air pollution, and safety. The whole methodology followed in research illustrated below figure 3.2.

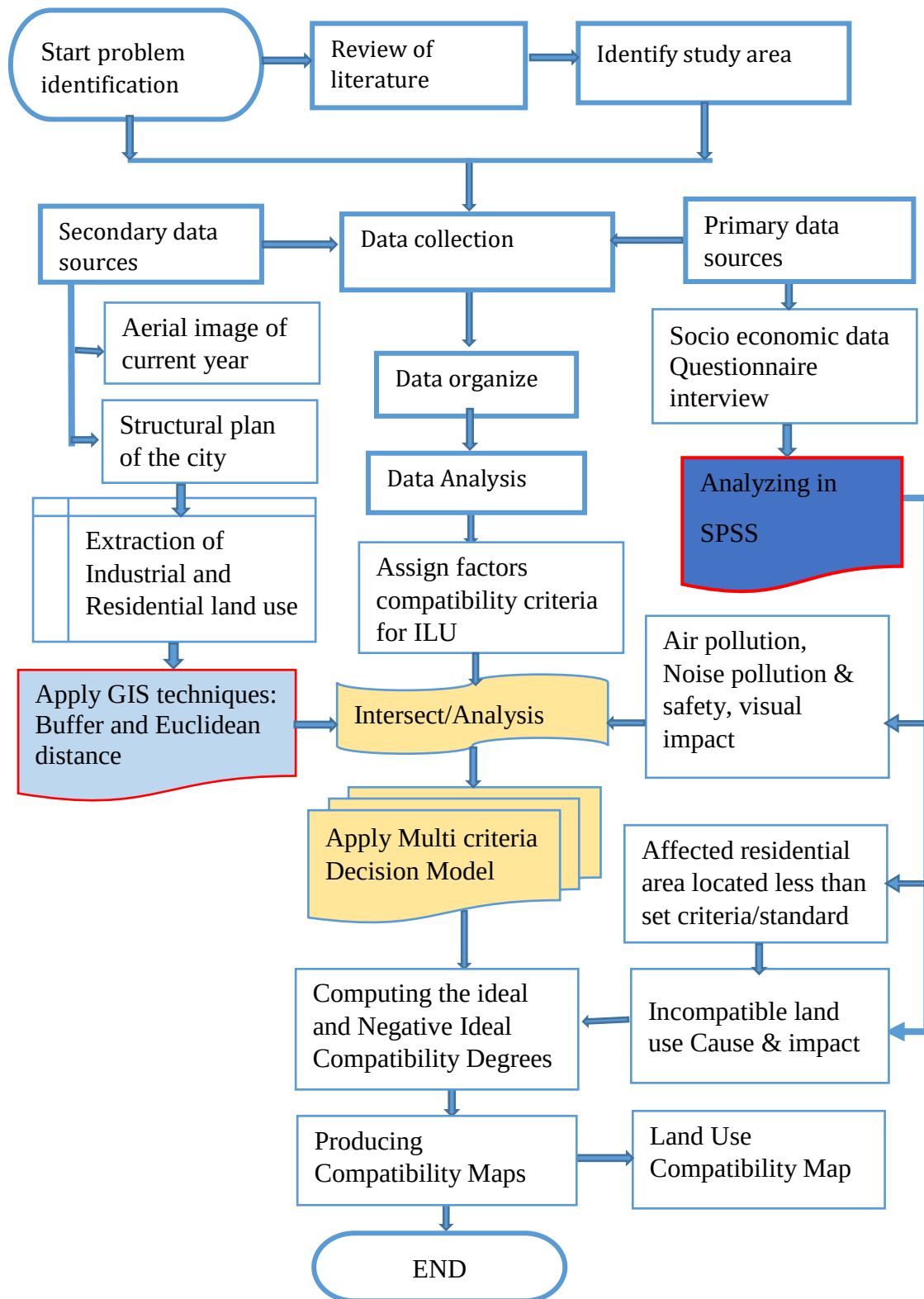


Figure 3.2. Technological scheme of the research by Author, 2024

To ensure a robust framework for compatibility analysis, this research proposes an MCDM model utilizing the TOPSIS method. TOPSIS is a multi-criteria evaluation technique that identifies the alternatives closest and furthest from ideal and negative ideal solutions (Chen, 2000). By calculating the overall score based on these distances, TOPSIS can determine the relative compatibility of different land use configurations.

3.7. Compatibility matrix Analysis

Land use planning is a complex process (Guyadeen, 2018) and it has been described as a process aimed at achieving orderly physical development with the overall aim of evolving a functional and livable environment where individual and common goals can be achieved (Owei et al., 2010). One aim in planning urban land use is site selecting for land uses and separating incompatible ones, and this comes true after collecting data on current situation and evaluating it. Evaluation of various urban land uses has done to make certain about their logical position and regard necessary proportions in both quantitative and qualitative ways.

A. Quantitative evaluation: this evaluation has done according to a comparison of available land use per capita with related standards by analysing present and future needs of the region under study to space.

B. Qualitative evaluation: in this stage qualitative features have determined and their proportion has examined according to four matrices which are as follows:

1) Compatibility 2) desirability 3) capacity 4) dependency (Maleki et al., 2017).

Each land use types in an area should not bring down the usability of other groups of land use types (Taleai et al., 2005). The land uses which are situated in a region must not disturb doing other activities. Therefore, according to the degrees of compatibility, land uses may be in different types like fully compatible, relatively compatible, relatively incompatible, fully incompatible or neutral:

A. Fully compatible: that both have common characteristics and their usability are consistent with each other, such as a pair of low-density residential land uses.

B. Relatively compatible: In the case both of the land uses are almost similar, but are different in details such as low-density residential next to a medium density residential.

C. Relatively incompatible: means the incompatibility between these two land uses are more compatible.

D. Fully incompatible: features of a land use do not match each other and interact with each other in ways such as residential and industrial land uses.

E. Neutral: the use of two types of compatibility to be indifferent. (mohammadi, 2008).

3.9. Ethical Consideration

This research will strictly adhere to a robust framework of ethical principles governing research design and practices. Recognizing the significance of participant well-being and scientific integrity, researchers will uphold a rigorous code of conduct throughout the data collection process. The research questions and methodology will be meticulously designed with ethical considerations at the forefront, ensuring the protection of participants' rights, the enhancement of research validity, and the maintenance of scientific rigor.

To ensure ethical research conduct, the necessary licenses and permissions will be obtained in advance from relevant authorities. These include Adama Science and Technology University, Gelan sub-city Administration office, Oromia Investment bureau (Industry office), and wereda offices. Formal letters outlining the research purpose and requesting support will be submitted by the Department of Architecture, Urban Planning & Design of Adama Science and Technology University to facilitate the smooth acquisition of permissions. This proactive approach to ethical considerations and licensing demonstrates the research team's commitment to conducting the study with transparency, accountability, and respect for all stakeholders involved.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter dealt with presentation, analysis and interpretation of the data gathered via the structured questionnaire from households, spatial data, Key Informants interviews from the residents and heads and experts of Gelan City Administration and field observation employing descriptive and inferential statistics.

4.1. Background of the respondents

The field survey was conducted to elicit relevant information for analysis in the study area. From selected respondents those 120 respondents are reply their questioner. The questionnaires were administered on both Residential Household heads and occupiers of Industrial area. The summary of data collected in respect of the stated variables of the research is presented as follows:

As the data revealed in table 4.1 with regards to distribution of sex of the respondent's Household head shows that male household headed are 65.08% and female household headed are 34.2%. Large numbers of the respondents were from the age group 31-40 years old and elderlies contribute to 39.2% of the sample. Nearly a quarter of the sample (27.5%) constitutes young individuals of age less than 30 years. another variable marital status of respondent's marrieds is 7%, single account for 20% while separated only 5% from total.

Table 4.1. Gender, Age and marital status of respondents

Variable	Category	Frequency	Percentage %
Age	less than 18	4	3.3
	19-30	33	27.5
	31-40	47	39.2
	41-60	17	14.2
	Above 60	19	15.8
	Total	120	100.0
Gender	Male	79	65.8
	Female	41	34.2
	Total	120	100.0
Marital Status	Single	25	20.8
	Married	89	74.2
	Separated	6	5.0
	Total	120	100.0

Sources Authors filed survey and computation, 2024

As per the educational background of the respondents shown in Table 4.2, Out of the total sampled households. Most of the respondents are below enrolment 30.8% primary school followed by 21.7% cannot have basic reading and writing. Diploma/TVET 20.8%, secondary high school 14.20%, and university or college 12.5 %. Even though the total sum of the literate sampled household is greater than the below enrolment ones. This shows that the number of respondents with basic reading and writing and a higher level of educational qualification is significant for the specific study.

Table 4.2. Education level of respondents

Category	Frequency	Percentage
Cannot read and write	26	21.7
Primary School	37	30.8
Secondary School	17	14.2
Diploma	25	20.8
1st Degree and Above	15	12.5
Total	120	100.0

Sources Authors filed survey and computation, 2024

According to the results show health problems have to face when live near industrial area for long time. Both short- and long-term exposure to air pollution can lead to a wide range of diseases, including stroke, chronic obstructive pulmonary disease, trachea, bronchus and lung cancers, aggravated asthma and lower respiratory infections. The results indicate 44.2% of them live 15 years and above. While the least 15% less than five years (Table 4.3).

Table 4.3: For how many years Living in this area.

Category	Frequency	Percentage
Less than 5 years	18	15.0
5-10 years	21	17.5
10-15 years	28	23.3
Above 15 years	53	44.2
Total	120	100.0

Sources Authors filed survey and computation, 2024

4.2. Existing Situation of land use in study area

The existing structures are located haphazardly without any distinct land use plan. The institution has no definite form and most of the activities are sighted at the detriment of the other. Effect of land uses from one another are not considered before sighting development. Most of the development are sighted without no enough space among them. The existing land uses of the study area were identified. These are: Residential land use, Educational land use; Commercial land use; Recreational land use; Industrial land use; Religious land use; Agricultural land use; Health institutions; Circulations; Conservation; and others.

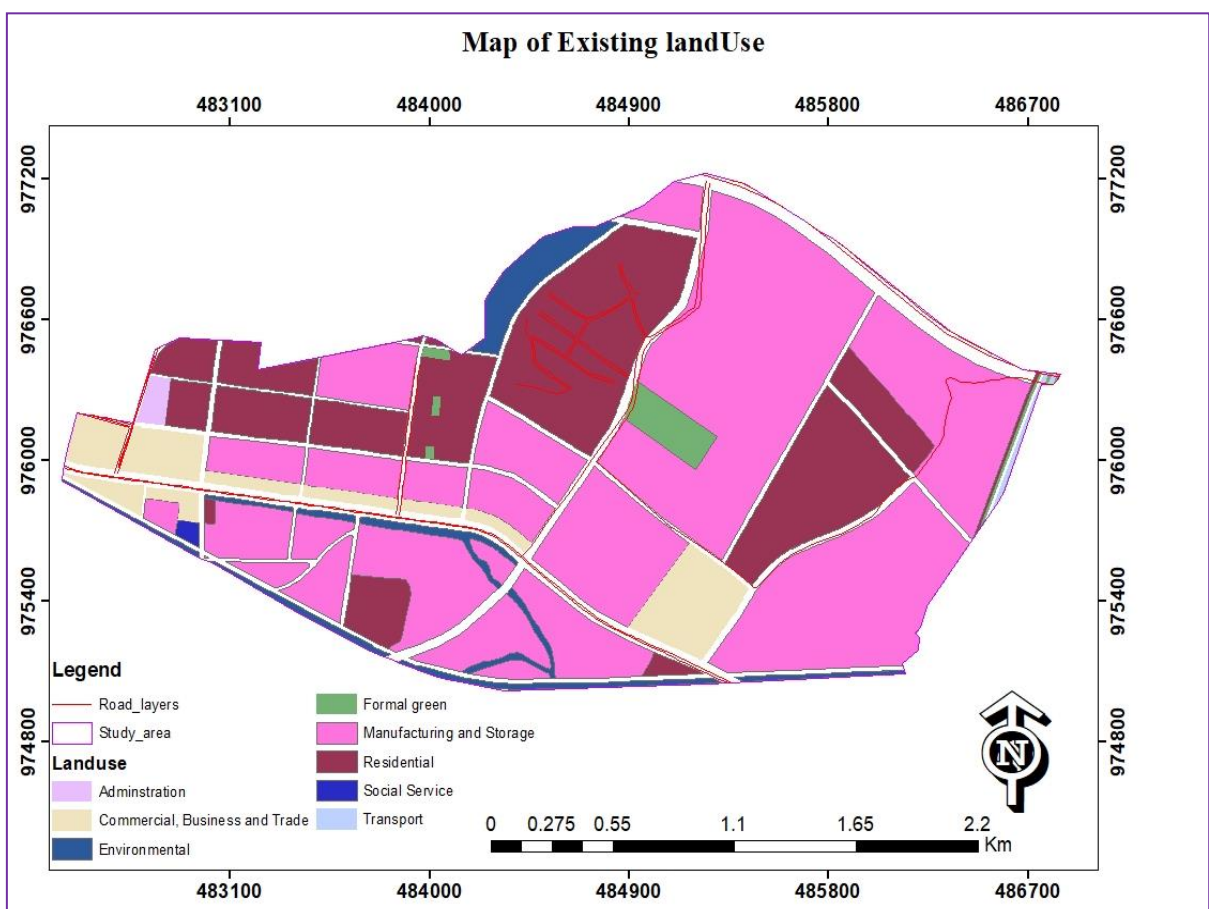


Figure 4.1: Existing Land use map of study area.

Educational land use: This type of land use is under social service which area coverage of 0.857 hectares in study area but not in Sub city. these are the land uses where educational activities takes. Examples of these are: classrooms; lecture theatres; tutorial sheds; designs studio; laboratories; school library; alumni library; workshops and so on. This land use covers a large expanse of land of the total land use of the study area. This is so because the study site is an educational land use in itself. In this category is the “other educational land

use”. This land use is an educational land but not fully utilized for the purpose of teaching and learning. They are used for the ceremonial functions of the educational activities. These includes places such as the convocation ground.

Administrative land use: this is where administrative activities of the institution takes. This type of land use area coverage of 2.280 hectares in study area but not in Sub city. This is also categorized as public land use at the macro scale. However, at micro scale, differences need to be made for easy analysis of the various land uses. The identified administrative centres within the institution are: senate building; student affairs building; student union building; faculties building; departmental buildings; departmental association buildings; PDS complex; post-graduate building; post office; faculty, govnt office. And so on.

Commercial land use: this is where commercial activities takes place within the school campus. The identified commercial land use includes: restaurants, banks, shops and kiosk.

- **Recreational land use:** this is where recreational activities takes. The major recreational land use is the greenery park, institution sport complex; Lautech staff school field; basketball court; and Lautech chapel volley ball field.

- **Industrial land use:** this is where industrial activities takes place. Types identified are: light industries which includes the school bakery and garri processing industry of the faculty of agricultural sciences. Service industries available on site are; barbers’ shop and so on.

- **Agricultural land use:** these are land uses where agricultural activities such as rearing of animals and planting of crops takes place. The major agricultural land use in the study area is located at faculty of agricultural sciences of the institution. Some of these are: agricultural research poultry, agricultural farm, piggery and goattery and so on. Others are vacant site used for farming activities such as places behind department of architecture and faculty of environmental sciences building among others.

- **Religious land use:** this is where religious activities of the institution takes place. The available religious land uses are: the school chapel and mosque and faculty mosques which is located within the close proximity of each faculty.

Health institutions: this type of land use is also categorized as an institutional or semi-public land use. However, since the study area is also either an institutional or semi-public land use at the macro level. Therefore, need be made to make differences between the two at the micro level for a proper land use analysis. The identified land use in this category are: health centre, x-ray laboratory and anatomy mortuary. Land uses such as laboratories falls in these categories. However, since these buildings are meant for educational activities, they are all been categorized under educational land use.

- **Circulations or road network:** these are roads, streets, walkways, footpath and car parks.

- **Conservation:** these are land uses such as the school botanical garden and horticultural garden.

Others: land uses in this category includes; store, construction site, toilet, gate house, security post, mast, shanties, open space, and vacant land.

Table 4.4. Analysis of Land Use area coverage

Detail_Landuse	General_LU	area ha	Percentage
Administration	AD	2.280	0.425
Commercial, Business and Trade	CO	37.324	6.958
Environmental	RE	23.365	4.356
Formal green	RE	8.858	1.651
Manufacturing and Storage	M	320.375	59.722
Residential	R	142.209	26.510
Social Service	S	0.857	0.160
Transport	T	1.172	0.218

4.3. Industrial Land Use and Compatibility

Industry awareness is an understanding of how industries and businesses operate. Quarter half of respondents that they aware of industrial facilities located near their residence. In general, Industrial facilities includes any property, real or personal, which is used for manufacturing, warehousing, transportation of goods for manufacturing or sale, offices, research and development and other facilities of trades or services which perform activities ancillary to industrial activity.

Table 4.5 show that industrial located in study area near residents most of them are oil refineries, Chemical products industry, and warehousing [32.5%, 29.2% and 18.3%]

respectively. This show Chemical manufacturing has a significant impact on the environment, including air and water pollution, soil contamination, greenhouse gas emissions, and the depletion of natural resources. The production and use of chemicals contribute to climate change and can harm human health, wildlife, and ecosystems.

Table 4.5: Type of industries located in study area

	Types of industry	Frequency	Percent
Valid	Manufacturing	16	13.3
	Warehousing/Distribution	22	18.3
	Power plants	8	6.7
	Oil refineries	39	32.5
	Chemical plants	35	29.2
	Total	120	100.0

Figure below show incompatibility of manufacturing industry and close to residential area.



Figure 4.2. Incompatibility of manufacturing industry and area close to residential area.
Sources: Photo captured by Author, 2024

In the above Red circled number 1: show residential area near manufacturing and 2: show manufacturing industrial area while 3: Manufacturing and residential mixed area.

The image above shows the fact area while discussion with respondent's results. Distance of residence close to industrial facility; From investigations conducted 36 (30%) of the respondents lived 500m to 1km away from the factory. 31 of the respondents representing 25% of the total respondents lived 100m to 500m away from the Manufacturing industry, 29 of the respondents representing 24.2% of the total respondents lived more than 1km away from the Manufacturing industry, while 24 of the respondents representing 20% of the total respondents lived less than 100m away from the Manufacturing industry (Table 4.6). From the analysis, the majority of the respondents (91) representing 75.8% of the respondents lived within 1km away from the Manufacturing industry; this means they are all under the influence of pollution resulting from the operation of the industry.

Table 4.6. Close Distance to the nearest industrial facility in study area

	Distance	Frequency	Percentage %
Valid	Less than 100 m	24	20.0
	100-500 meters	31	25.8
	500 meters - 1 kilometre	36	30.0
	More than 1 kilometre	29	24.2
	Total	120	100.0

Compatibility of current industrial area with the surrounding residential areas From Table 4.7, 67 of the respondents representing 55.8% of the total respondents experience Very Incompatible. 35 of the respondents representing 29.2 % of the total respondents agreed that Somewhat Incompatible current industrial with the surrounding residential areas while 10 of the respondents representing 8.3% of the total respondents experienced Somewhat Compatible; and lastly 8 of the respondents representing 6.7% of the total respondents have very Compatible. From the analysis it is quite obvious that compatibility of industrial and surrounding residential is the major environmental problem experienced in Tulu Guracha and surrounding community.

Table 4.7: Compatibility of industrial land use with surrounding residential.

	Compatibility Index	Frequency	Percentage
Valid	Very Compatible	8	6.7

Somewhat Compatible	10	8.3
Somewhat Incompatible	35	29.2
Very Incompatible	67	55.8
Total	120	100.0

4.3. Environmental Impact in relation industrial activities

Regarding noticed of concerned body they noticed changes in air quality since the industrial area was established in their village. This included increasing dust and water pollution is highly changed.

Table 4.8, which presents the environmental problem that industrial activities pose to the residents, shows that the majority of respondents 42.2% claimed there are high environmental problems 11.5% believed there are no environmental problems, and only (38.3%) believed there are little to no environmental problems, With respect to water pollution, the largest proportion (42.2%) stated that there are significant environmental problems; just 10.8% classified it as minimal, and 11.7% said there are no environmental concerns.

Regarding dust particles, 35.0% of respondents reported having a very high environmental problem, practically 29.2% reported having a high environmental problem, and just 4.2% reported having no environmental problem. On Noise pollution from factory plants and machinery and generators, the percentage (28.3%) indicated Moderate environmental problems finds uniformity with the percentage that claimed very high environmental problems while just 10.8% embraced no environmental problems.

1[LEp]=for Little Environmental problem, 2[LEp]=Low Environmental problems
3[MEp]=Moderate Environmental problems, 4[HEp]=High Environmental Problems,
5[VHEp]= very High Environmental Problems

Table 4.8: The environmental problem posed on residents by industrial activities

Environmental problem	1 [LEp]		2 [LEp]		3 [MEp]		4 [HEp]		5 [VHEp]	
	N	%	N	%	N	%	N	%	N	%
Noise pollution from factory plants and machinery and generators.	13	10.8	26	22	34	28.3	15	12.5	32	26.7
Dust practice	5	4.2	14	12	24	20	35	29.2	42	35
water pollution	14	11.7	13	11	12	10	29	42.2	45	37.5
Offensive odour (i.e. from chemicals and industrial waste)	8	6.7	11	9.2	37	30.8	24	20	40	33.3
Open dump site for disposal of industrial solid waste	10	8.3	14	12	31	25.8	24	20	41	34.2
Overstressed of infrastructural facilities	6	5	10	8.3	41	34.2	26	21.7	37	30.8
Obstruction of view as a result of smoke	11	9.2	9	7.5	32	26.7	22	18.3	46	38.3
Industrial emission as a result of burning fossil fuels from factory plants and machineries and generators	13	10.8	15	13	36	30	14	11.7	42	35
Indiscriminate sewage disposal	5	4.2	10	8.3	35	29.2	24	20	46	38.3

Sources Authors filed survey and computation, 2024

The impact of using an open dump site for the disposal of industrial solid waste is minimal because, according to the largest proportion (8.3%), there are no environmental concerns, little environmental problems are indicated by 11.7%, and very high environmental problems are evaluated by just 34.2%. From the result, the highest percentage (5%) opined that infrastructural facilities were not overstressed, 34.2% indicated that infrastructural facilities were overstressed minimally while only 30.8% indicated high overstressing of infrastructural facilities.

Regarding obstruction of view as a result of smoke, the highest percentage (7.5 %) indicated little environmental problems, 38.3% was of the opinion that environmental

problems is high while just 9.2% embraced no environmental problems. 35% of the respondents opined that environmental problems as a result of industrial emission is very high environmental problem, 12.5 % held that environmental problems are little while only 10 % claimed that they were not affected. The highest percentage (40.0 %) of the respondents claimed that no environmental problems exist, 21.7% indicated little environmental problems while only 38.3% indicated high environmental problems.

In summary, the largest proportion (38.3%) essentially indicated high environmental difficulties, followed by minor environmental problems (21.7%) and no environmental problems (11.7%). From the occupiers' perspective, it is implied that there are generally little environmental problems. But there were also a lot of environmental issues, like noise pollution, dust particles, and visibility blockage from industrial smoke emissions. Furthermore, there were no open landfill sites, overstressed infrastructure, or water pollution.



Figure 4.2. Manufacturing Industry problem with Open dump site for disposal of solid waste.



Figure 4.3. problems of Environmental Impact of manufacturing industry nearby residential.



Figure 4.4. The Above images in figure 4. Manufacturing industry waste water unprotected open ditch (Bad Smell) Air pollution.

4.4. Socio economy and employment opportunities in relation industrial activities

Socioeconomic factors such as income, education, and occupation define quality of life and influence behaviours in a society. Good Industrial Relations increase employee harmony. The inability of fundamental human notions or motivations to get enough satisfaction or expression generally results in disputes and good industrial relations can prevent such conditions.

Regarding the respondents' employment situation, 46.7% were unemployed. Out of all of them, half were employed, while the remaining half were either trading, farming, owning their own business, or working as daily labourers. While professional work accounted for 21.8%.

According to table 4.9, the results of the interviews reveal that, on average, each household spends 1000 Birr or more per month on daily expenses. The average monthly expense for 36.7% of the household heads surveyed is between 1,000 and 2,000 Birr. The majority of the homes who were interviewed spent, on average, between 2001 and 4,000 Birr per month on their ordinary living expenses. This represents 12.5% of all the sample households. 22.5% of the households surveyed spend an average of 4,001 to 5,000 Birr per month. In contrast, just 28.3% of all households have more than 5,000 Birr.

Table 4.9 Employment condition and level of income of respondents

Variables		Frequency	Percentage
Employment Status	Employed	64	53.3
	Unemployed	56	46.7
	Total	120	100.0
Employment type	Daily labourer	22	34.38
	Compound Keeper	21	32.81
	Professional work	14	21.88
	Others	7	10.94
Total		64	100.0
Average Monthly Income	1001-2000	44	36.7
	2001-4000	15	12.5
	4001 - 5000	27	22.5
	5001 and Above	34	28.3

Total	120	100.0
-------	-----	-------

Sources Authors filed survey and computation, 2024

4.4.1. Effect of industrial activities on residential property values

The distance to an industrial site exhibits a statistically significant negative effect on the value of residential properties. However, the effect is largely localized within a relatively short distance from the nearest industrial site. According to the results show in table 4.10 majority of respondents 56% (strongly agree and agree) are agreed that Industrial land use of study area affect residential property values.

Table 4.10. Level of agreement on Industrial land use effect residential property values.

Level of Agreement		Frequency	Percentage
Valid	Strongly Agree	32	26.7
	Agree	24	20.0
	Undecided	29	24.2
	Disagree	15	12.5
	Strongly Disagree	20	16.7
	Total	120	100.0

Sources Authors filed survey and computation, 2024

4.4.2. Economic Impact of Industrial Land Use on the Rental Values of Neighbouring Residential Property Values.

Nearly 80.02% of respondents agreed in general that the industrial land use of a particular location in Tulu Guracha has a moderate impact on the values of residential properties. Table 4.11 presents the analytical conclusion that illustrates how the environmental issues affect rental value. A third of the respondents from the firm stated that a decrease in a property's rental value had a relatively unfavourable effect on the rental value.

While minor negative impact was only 21%. from the table is observed that prolong period to let or to sell has fairly negative impact on the rental value as review by the about 25% of the estate firm respondents. While the Fairly Negative impact was 24% from the total.

Table 4.11. The impact of the environment problem on the rental value

Economic Impact on Residential Values	Strongly Negative Impact		Fairly Negative Impact		Minor Negative Impact		No Negative Impact		Positive Impact	
	N	%	N	%	N	%	N	%	N	%
Reduction in rental values of properties	31	26	37	31	25	21	10	8.3	17	14
Prolong the period to let or to sell.	25	21	30	25	33	28	14	12	18	15
Unable to sell or let	24	20	29	24	30	25	20	17	17	14
Decrease in demand for residential properties in the neighbourhood	28	23	35	29	29	24	11	9.2	17	14

Sources Authors filed survey and computation ,2024

The implication is that even though there is the presence of industrial activities operating relatively close to residential properties located close to them in Tulu Guracha area in Gelan sub city, the effect on rental values of such residential properties is not pronounced or minimal and doesn't really affect residential property values in the neighbourhood. Additionally, as can be seen from 4.11, some of the expert (respondent) results showed that the industrial land use has a favourable impact on nearby residential properties; these positive impact results were recorded at 14%. It is possible to interpret this to suggest that residential properties near industrial properties which are sources of employment will have higher rental values because people will choose to live or work close to places where they can easily find work.

Regarding questions asked related to experienced any health problems you believe are related to living near industrial activities; we conclude that It is one of the leading sources of pollution across the world, and can cause significant impacts on the air, water, and land. Environmental impacts from industrial pollution create substantial hazards to the environment, which in turn affects human health through: Decreases air quality. Unsafe drinking water. This cause disease an injures human life.

If we talk about disadvantage of building a large factory near our community then there are many things to talk about. For instance, we will have to face air pollution, water pollution and noise pollution as well. Air pollution can be due to toxic fumes released from factories. From Table 4.12, total 55 of the respondents representing 45.8% of the total respondent's Disagree for not safe living near industrial activities. 33 of the respondents representing

27.5% of the total respondents strongly disagree while 13 of the respondents representing 10.8% of the total respondents Neutrally which is not engaged on either side; and lastly 11 (9.2% and 8 (6.7%) of the respondents strongly agree and agree respectively. From the analysis it is quite obvious that not feeling safe near industry area.

Table 4.12 respondents feel safe living near industrial activities

	Category	Frequency	Percentage
Valid	Strongly Agree	11	9.2
	Agree	8	6.7
	Neutral	13	10.8
	Disagree	55	45.8
	Strongly Disagree	33	27.5
	Total	120	100.0

Regarding industrial activities create jobs in the neighbourhood From Table 4.13, from total 45 of the respondents representing 37.5% of the total respondent's Disagree industrial activity doesn't create job. 27 of the respondents representing 22.5% of the total respondents Strongly Agree while 22 of the respondents representing 18.3% of the total respondents strongly disagree.

Table 4.13. Industrial activities create jobs in the neighborhood

	Category	Frequency	Percentage
Valid	Strongly Agree	27	22.5
	Agree	14	11.7
	Neutral	12	10.0
	Disagree	45	37.5
	Strongly Disagree	22	18.3
	Total	120	100.0

Industrial activities contribute to the overall economic prosperity of the neighbourhood results shown in Table 4.14, from total 35 of the respondents representing 29.2% of the total respondent's Disagree industrial activity doesn't contribute to neighbourhood. But 24 of the respondents representing 20% of the total respondents Agree with it, while 22 of the respondents representing 18.3% of the total respondents strongly Agree. This show partially the industrial activity contributes to neighbourhood.

Table 4.14: Industrial activities contribute to the overall economic prosperity of the neighbourhood.

	Category	Frequency	Percent
Valid	Strongly Agree	22	18.3
	Agree	24	20.0
	Neutral	20	16.7
	Disagree	35	29.2
	Strongly Disagree	19	15.8
	Total	120	100.0

More of the respondents agree that they consider moving away from industrial area neighborhood due to the presence of industrial activities. Because It has changed the family system as most people moved into cities, with extended family living apart becoming more common. The movement into more dense urban areas from less dense agricultural areas has consequently increased the transmission of diseases.

In general, socio-economic impacts focus on how the activity affects human or societal well-being, as well as the use and benefit of any site. For example, the construction of a road may upset people living nearby due to noise and dust pollution, causing health impacts in some cases. Based on this the respondents respond their satisfactions illustrated in Table 4.15. From total 44 of the respondents representing 36.7% of the total respondent's Dissatisfied that with the social and economic impacts of the industrial activities on their neighborhood. 32 of the respondents representing 26.7% of the total respondents Very dissatisfied while 25 of the respondents representing 20.8% of the total

respondents satisfied. lastly 16(13.3% and 3 (2.5%) of the respondents are Very satisfied and Neutral respectively. From the analysis it shows that there's economic and social impacts of the industrial activities on neighborhood.

Table 4.15: Household Overall, satisfactions with the social and economic impacts of the industrial activities on their neighbourhood

Categories		Frequency	Percent
Valid	Very satisfied	16	13.3
	Satisfied	25	20.8
	Neutral	3	2.5
	Dissatisfied	44	36.7
	Very dissatisfied	32	26.7
	Total	120	100.0

4.5. Compatibility Analysis of Residential and industrial Land Use Activities with other land uses in study area.

The dominant land use in the study area is the Manufacturing industry land use which can be grouped as Industrial land uses; however, various other land uses dominate the landscape. Some of these land uses are compatible while some are most are incompatible. Compatibility analysis of the following land uses are discussed in the ensuing paragraphs.

4.5.1. Education activities/Administrative activities

Administrative and Educational land use are the lower in area coverage in study area. It is a tertiary establishment which needs a well formalized administrative function. Therefore, for smooth running of the institution, there need a well-planned administrative section which will be of close proximity to the academic activities. The Educational and administrative is the heart of the area, therefore, locating it close to the commercial hub of the institution depicts an incompatible land use. Also, its location is wrong as it was not centralized on the university campus.

Also, it must be noted that the location of educational facilities such as the school is located in a compatible manner. This would help in reducing unwanted noises at the educational institutions. However, care must be taken so as not to make the situation worse as it can be seen at recent times that the management is undergoing deforestation process.

4.5.2. Religious Land Use/Health institution (i.e Health Centre)

As observed from the existing situation of the study area, the religious land use of the institution is located few meters away from the health center. This is an incompatible use

of land. The characteristics of both land use are detrimental to one another. Place of worships are characterized with generation of noise either through large congregation or by the use of public address system. However, health center is a type of land use which requires a serene environment devoid of noise and more traffic. Patients that support the center needs seclusion from public activities so as to make their health recovery faster. Furthermore, instead of finding a lasting solution to the conflict of these two land uses, the little space which supposed to be uses as buffer between them are being used for the construction of ultra-modern health center and new places of worships. Therefore, there is need for urgent solution as to reduce the negative effect of these two lands uses on one another.

4.5.3. Commercial Land Use/Industrial Area

The study area Commercial land use include Business and Trade. result of critical analysis of the commercial land use activities in Galan sub city as made it to be concluded that there is only commercial land use distributed on the main road of the city. Commercial activities are located haphazardly. The location of banks within the institution supposed to be within a specific or designated location for banks and other commercial activities. However, the banks are located without plan but as the need for it. The location of banks within the institution campus constitute nuisance to the environmental landscape.

Also, commercial activities such as cafeteria, restaurant, retail shops are located dispersal without no definite boundary. Some are located at recreation areas while some are located within academic activities. Some have no location; this has created a chaos landscape within the community centre as it portrays a landscape of commercial land use such as market rather than an educational land use. Some commercial activities take place along the major road of the city. Therefore, without no definite commercial land use and the disperse location in the commercial activities with no specific land use, this land use has constituted nuisance to the academic environment and has hence makes it incompatible within the dominant use.

4.5.4. Transportation Activities/Other Industrial Activities

Road network is an important nerve in any land use activities. It is the maker and breaker of land use activities. Without it, no activities on land can be done. Therefore, for effective planning and coordination of land use activities, there is need for a proper transportation network. These activities generate large volume of both vehicular and pedestrian traffic. However, due to the location of the land use uses for these activities; they usually

constitute nuisance to the environmental landscape. Also, there is not enough parking space in the area and structures are compact around the area, therefore, the volume of traffic generated constitute an environmental nuisance to the area due to small available space. Furthermore, these activities have negative impact on the transportation activities of the Industrial land use. Thus, this makes the land use incompatible with the surrounding land use activities.

Most of the transportation activities in the study area are incompatible. Pedestrian crossing is located without taking into effect sighting distance of vehicle. There is conflict in pedestrian crossing, many cut through parking lot and there is excessive thorough traffic. Road junctions and turning distance are located indiscriminately.

In summary, generally, from the land use analysis, Gelan City is being faced with series of problems of incompatible land uses. This ranges from haphazard and clustered development, lack of pedestrian walkways, lack of parking lots, to non-utilization of the land resources among others. These problems have led to the numerous planning problems of the city. From the existing situation on ground, the only way in which these problems can be partially solved is that other proposed buildings, facilities and infrastructures should be integrated with the existing situation and all other corrections on the existing situation should be carried out.

4.6. Potential areas of conflict and incompatibility between industrial land use and residential land uses in the study area.

land use conflict identification strategy,” a process that explores future land use patterns through the sequence of conducting a suitability analysis, identifying land use preferences, and mapping potential land use conflicts. A land-use conflict occurs when there are conflicting views on land-use policies, such as when an increasing population creates competitive demands for the use of the land, causing a negative impact on other land uses nearby. The below map was prepared by following these steps in ARCGIS. Create buffers around industrial land uses to represent potential impact zones. The buffer distance was based on industry-specific regulations and guidelines. the 1st steps were Created buffers around residential land uses to represent areas that should be protected from industrial impacts.

Finally Overlay Buffers was applied using Overlay tools in ArcGIS. results show Identified areas where the buffers overlap, indicating potential conflicts figure 4.5. The output feature class will contain a new set of polygons representing the areas where the

industrial and residential buffers overlap. Area coverage of potential conflict was approximately 245 hectares. These areas indicate potential conflicts or areas where compatibility should be assessed more closely.

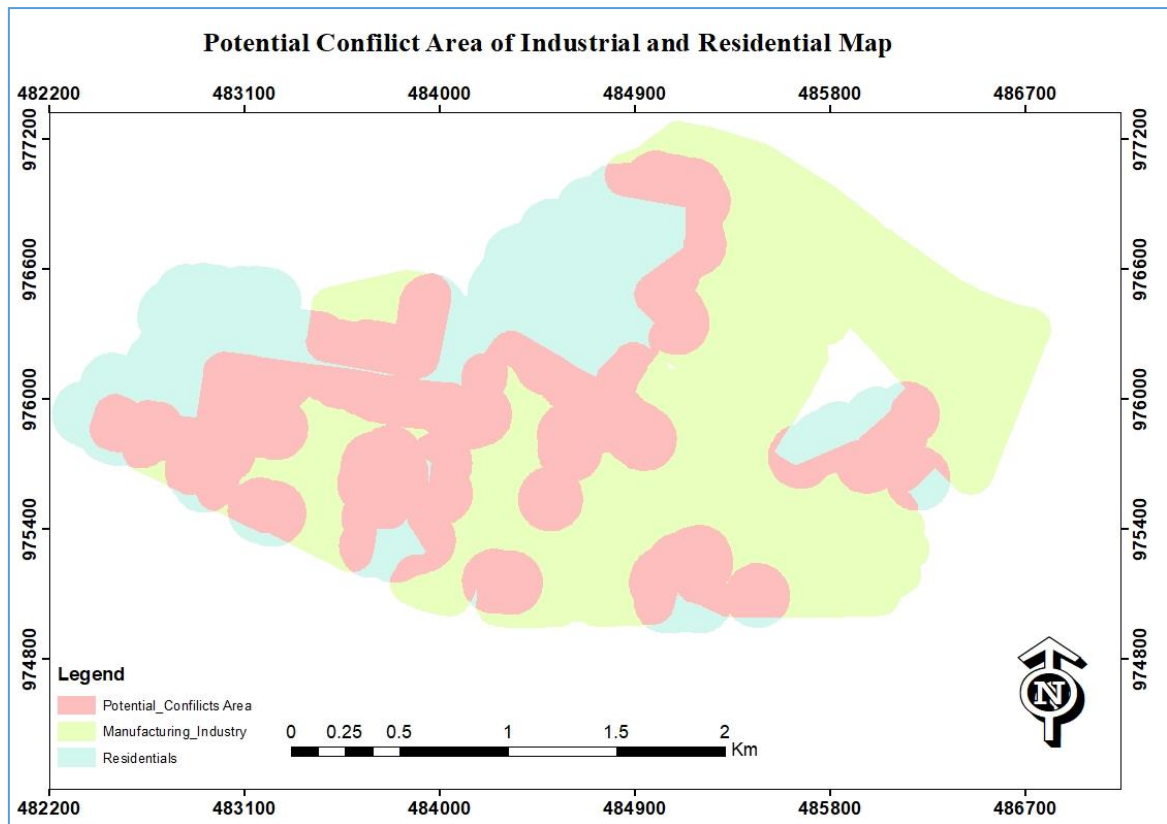


Figure 4.5: Potential conflict Area Between Residential and Industrial land use.

4.6.1. Proximity to residential and Air Pollution Assessment.

Air pollution can be described as the presence of undesirable materials in the air in quantities large enough to produce harmful effects to man and his environment. Rapid urbanisation and concentration of economic activities in urban centres can cause air pollution unless air pollution control measures are put in place. Such pollution can arise from vehicle emissions and industrial activities. Combustion of traditional fuels such as wood and charcoal for domestic energy needs is another source of air pollution in both urban and rural areas. Industrial emissions can impact air quality in nearby residential areas.

The results from spatial analysis buffer based for existing residential nearby industrial are analysed. According to the transition of industrial estate pollutants, residential places located in the radius of 100 meters of the area would be affected classified as Significant air pollution impact, making residential use unhealthy or unsafe (score = 0.25). distance of

200m moderately compatible area Moderate air pollution impact, requiring mitigation measures or restrictions on industrial activities (score = 0.5), 500m classified as Compatible Minor air pollution impact, within acceptable limits (score = 0.75) low and 800m were very low impact classified as Fully Compatible which mean Negligible air pollution impact on residential areas (score = 1). (Figure 4.6). based on air pollutions standard of industrial area using multiple ring buffer, pollutants concentration in various distances from the area is indicated in maps.

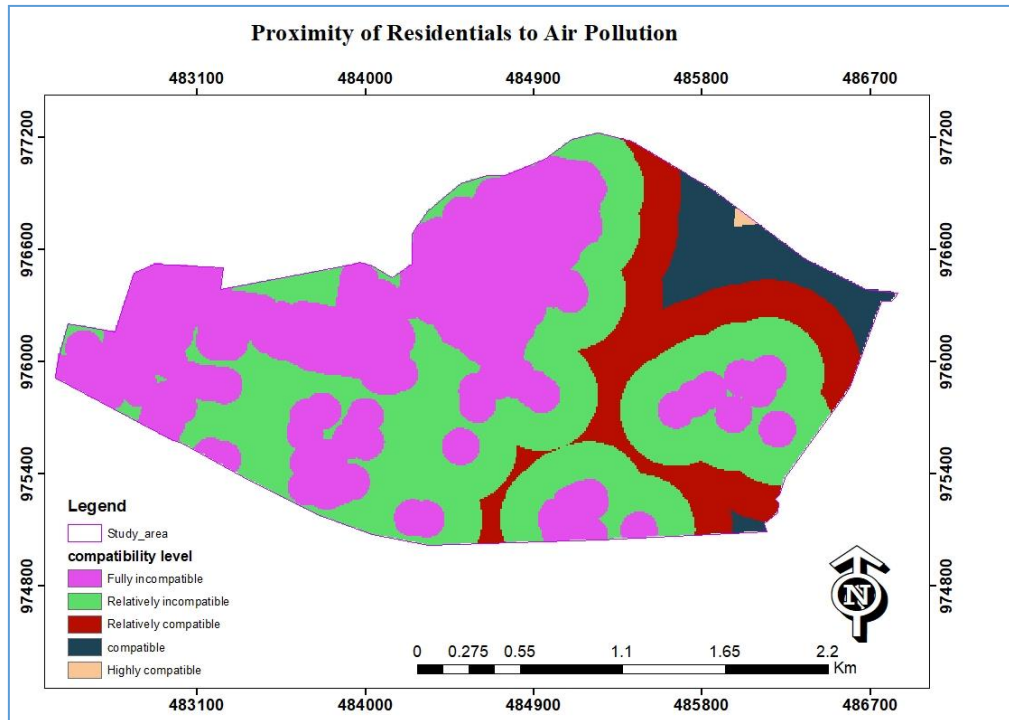


Figure 4.6. Air pollutions proximity of residentials from Industrial area.

4.6.2. Proximity to residential and Noise Pollutions

Excessive industrial noise can have negative effects on the health and well-being of workers and nearby residents. Prolonged exposure to high levels of industrial noise can lead to hearing loss, stress, sleep disturbances, and other health issues. Industrial activities can generate noise that may disturb residential areas.

The results from spatial analysis for existing residential nearby industrial are analysed. According to the map residence near by distance 50m from industrial land use categorized as fully incompatible which Significant noise impact, making residential use impractical score = 0.25 (highly affected), residential places located in the radius of 100 meters of the area categorized as Relatively incompatible and would be affected. distance of 200m moderately compatible (Moderate noise impact, requiring mitigation measures score = 0.5)

(300m low and 500m) were very low and categorized as Compatible (Minor noise impact, within acceptable limits (score = 0.75) and Highly compatible (where No noticeable noise impact score = 1). (Figure 4.7).

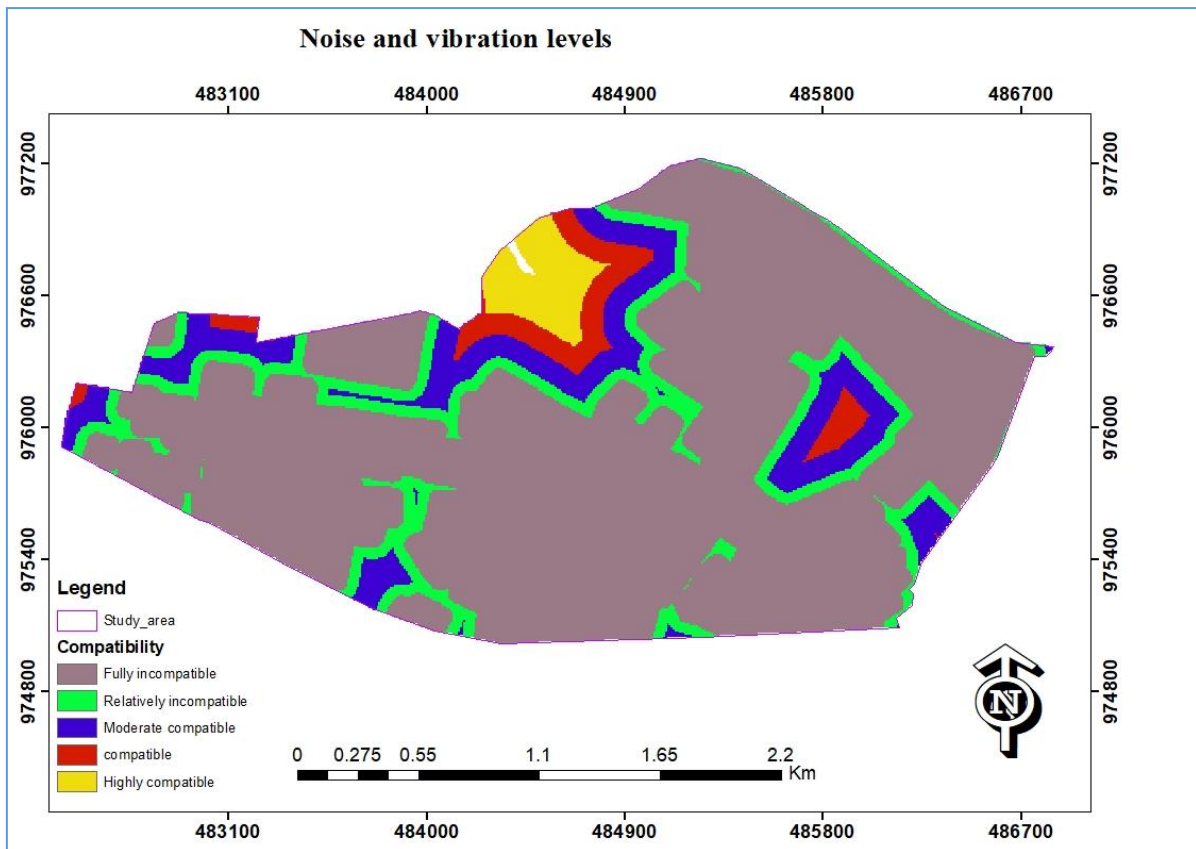


Figure 4.7: proximity distance and Pollutant emission on the residential districts of the study area.

4.6.3. Distance to residential land use

(Figure 4.8) show Industrial land use away from residential area in meter based on standards. The results indicate distance less Than 300m categorised as Fully incompatible and Industrial land use is located immediately adjacent to or within residential areas, making residential use impractical or unsafe (score = 0.25). Distance 300 – 450m classed to relatively incompatible. According to the map residence near by distance 650m moderately compatible (Industrial land use is located relatively close to residential areas, requiring significant mitigation measures or restrictions on industrial activities score = 0.5), residential places located in the radius of 1000 meters of the area categorized as Relatively compatible (Industrial land use is located at a moderate distance from residential areas, with appropriate mitigation measures in place (score = 0.75) and distance of 1300m

categorized as Compatible area (Industrial land use is located at a sufficient distance from residential areas to minimize potential impacts score = 1) (Figure 4.8).

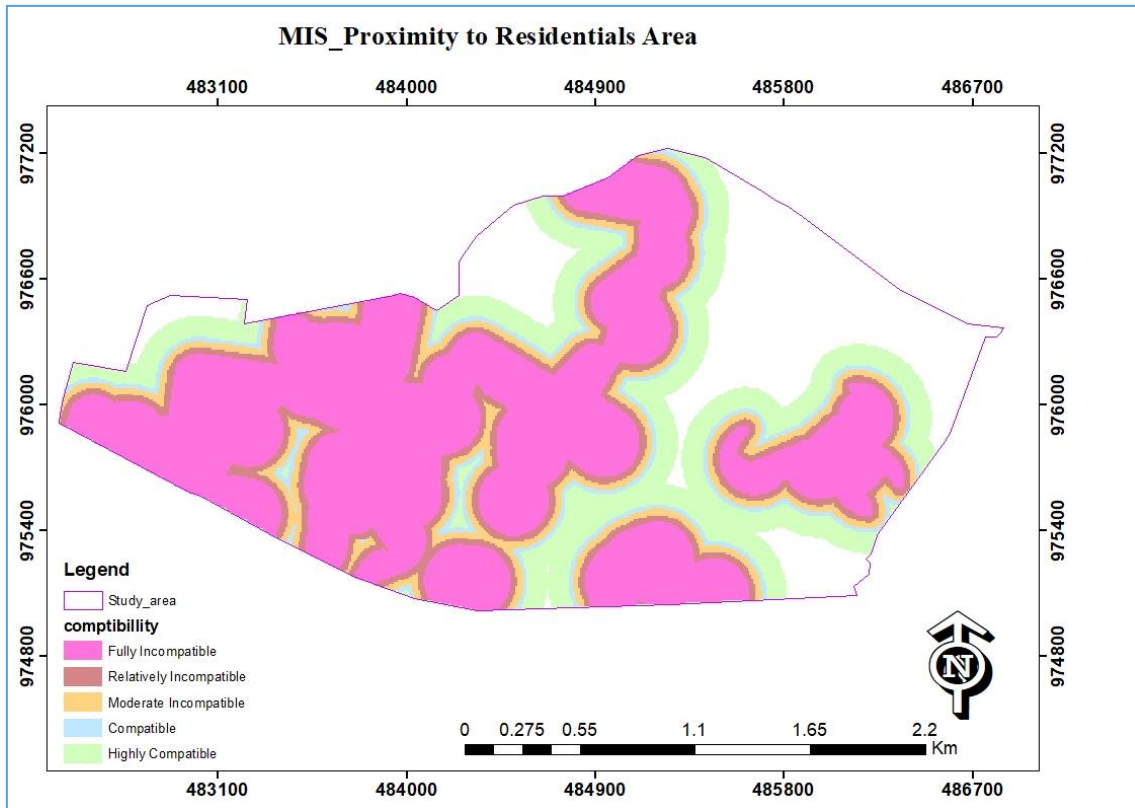


Figure 4.8. manufacturing industry (Mis) proximity to residential area.

4.7. Determining land use compatibility and Overall Compatibility Score

Land use compatibility matrix values are usually determined by experts and are representation of different levels of consistency among different land uses (omid Mansouri, 2021). This method is formed on two bases. The first one is the logic of land use compatibility. So present qualitative values presented before in compatibility table in order to be used in GIS analysis function can become quantitative as follow:

Fully compatible- value 5, compatible- value 4, Moderate incompatible- value 3, relatively incompatible- value 2, completely incompatible- value 1. It is good to mention that considering expertise comments and complete recognition of the case under study and its measures, the process of evaluating and making it quantitative can be different.

The below map shown in figure 4.9 was Developed a compatibility index based on factors such as noise, traffic, visual impact, and air pollution earlier discussed. Assign scores to each factor based on the potential impact on residential land use. Then the Combine the individual scores to calculate an overall compatibility index for each area of overlap between industrial and residential buffers. Doing this, reclassify function which is

available in GIS spatial functions (Spatial Analysts) was used; so, a restructured function is made for each kind of land use in which the way of evaluation corresponds with the compatibility extent of that land use with other land uses.

The overall compatibility score can be determined by combining the individual scores for noise, visual impact, and air pollution. The scores can be weighted differently based on the relative importance of each factor in the specific context. Hence the most important factor, is Distance to residence it could be assigned a weight of 30%, while the other factors are Noise 20%, Visual impact 25 % and Air pollution assigned a weight of 25%. The overall compatibility score would then be calculated as follows:

Overall Score = (Noise Score * 0.2) + (distance to residential * 0.30) + (Visual Impact Score * 0.25) + (Air Pollution Score * 0.25). The overall compatibility score was classified into the following categories: Completely Compatible(fully): Overall score $\geq 75\%$, Compatible: Overall score $\geq 60\%$ and $< 75\%$, Moderately incompatible: Overall score $\geq 40\%$ and $< 60\%$, Relatively Incompatible: 25% and $< 40\%$, Highly Incompatible: Overall score $< 25\%$. This ranking system can be used to identify areas where industrial and residential land uses are compatible or incompatible, and to develop appropriate mitigation measures or zoning regulations to ensure compatibility.

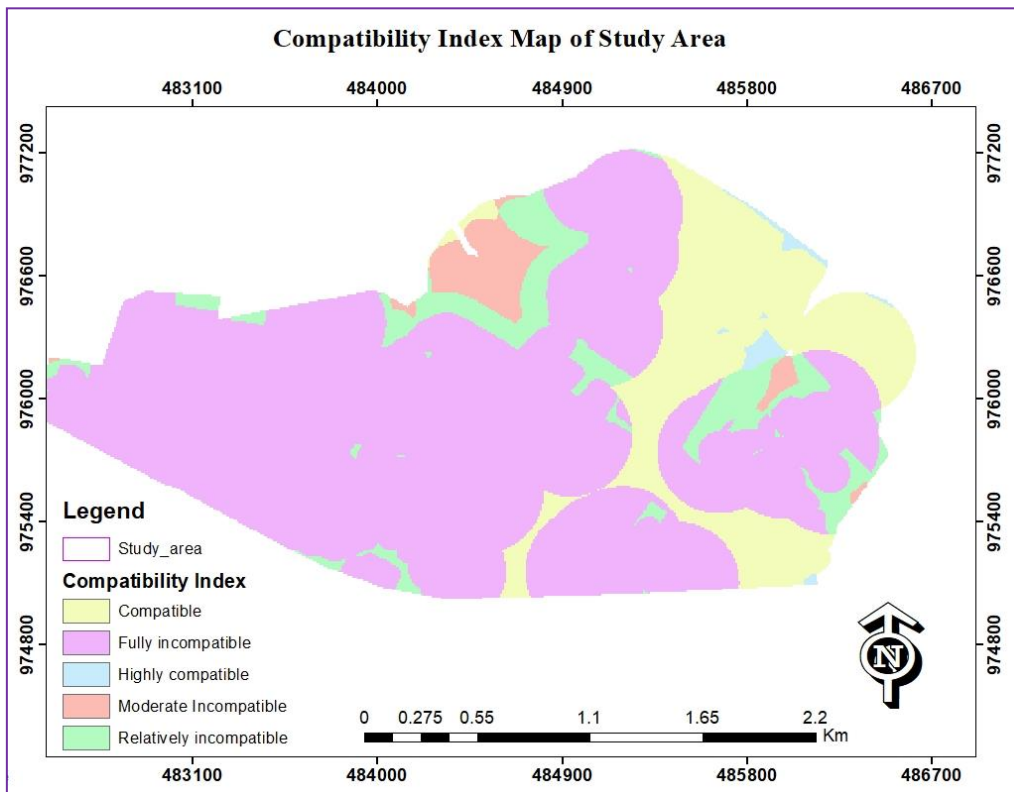


Figure 4.9. Compatibility Level map of study area.

The final step we used is Calculate Compatibility Index For each area of overlap between industrial and residential buffers, calculate the compatibility index using the following formula: Compatibility Level = (Noise Score * Noise Weight) + (Visual Impact Score * Visual Impact Weight) + (Air Pollution Score * Air Pollution Weight) + (Distance to Residential Score * Distance to Residential Weight). Results shown in Above figure 4.9.

Table 4.16 show summary of compatible area coverage in study area. Form the total the Area coverage 69.8% was not compatible land use area for residential area. While the least 4.26-hectare account for only 0.71% compatible in study area.

Table 4.16: Area coverage of compatibility Level of study area.

Compatible level	Area in Meter (m)	percentage %
Fully incompatible	4185897	69.80
Relatively incompatible	487866.1	8.13
Moderate in compatible	201778.3	3.36
Compatible	1078306	17.9
Highly compatible	42667.1	0.71
Total	5996514.5	100

4.8. Discussions

This paper assessed three methods for identifying potential land use conflict using participatory mapping data from a Gelan City Administration. The first method used landscape values as a proxy for potential land use conflict by capturing the relative importance of different values in specific locations. Conflict potential is determined by the perceived compatibility between proposed land uses and the landscape values. The second method identified potential land use conflict as differences in land use preferences in specific locations. Conflict potential is greatest when land use preferences in the region are divided. The third method combined both value and preference data. Preference differences are amplified by the values in the same location to determine the potential land use conflict.

From Compatibility analysis results industrial located in study area near residents most of them are oil refineries, Chemical products industry, and warehousing and the huge industrial are covered 32.5% of another. This show Chemical manufacturing has a

significant impact on the environment, including air and water pollution, soil contamination, greenhouse gas emissions, and the depletion of natural resources.

From the analysis, the majority of the respondents (91) representing 75.8% of the respondents lived within 1km away from the Manufacturing industry; this means they are all under the influence of pollution resulting from the operation of the industry.

Compatibility of current industrial area with the surrounding residential areas as stated in Table 4.6, 67 of the respondents representing 55.8% of the total respondents experience Very Incompatible current industrial with the surrounding residential areas while 10 of the respondents representing 8.3% of the total respondents experienced Somewhat Compatible. From the analysis it is quite obvious that compatibility of industrial and surrounding residential is the major environmental problem experienced in Gelan sub city specific location Tulu guracha and surrounding community.

Environmental impacts of Industrial and use which presents the environmental problem that industrial activities pose to the residents, shows that the majority of respondents (38.3%) believed there are little to no environmental problems, while 42.2% claimed there are high environmental problems. With respect to water pollution, the largest proportion (42.2%) stated that there are significant environmental problems; just 10.8% classified it as minimal, and 11.7% said there are no environmental concerns.

In compatibility level of study possess different factors including expert and local area knowledge of compatible area. From the total the Area coverage 69.8% was not compatible land use area for residential area. While the least 4.26-hectare account for only 0.71% compatible in study area. This show in study area most of Residential are not compatible with industrial and it may be the only industrial site.

In conducting these assessments, it's essential to work closely with experts in environmental science, engineering, and regulatory compliance. Additionally, utilizing Geographic Information Systems (GIS) can aid in visualizing the spatial distribution of environmental impacts and their potential effects on surrounding communities and ecosystems. From this point view the aim is to not only identify the environmental impacts, but also to develop strategies for minimizing adverse effects and promoting sustainable industrial practices in study area. By incorporating these methods and leveraging GIS tools and techniques, decision-makers, environmental professionals, and community

stakeholders can work towards implementing effective measures to mitigate risks and protect nearby residential areas from potential industrial impacts.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The Analysis of Industrial Land Use Compatibility and Evaluation of land use planning and implementation with respect to environmental issues were evaluated in the study area. Development of land use without a master plan is development for failure and catastrophe. Incompatible land uses develop a chaotic environment with an unpleasant scene while compatible land uses exhibit a great zeal of serene environment with a beauty landscape. The extent to which development are structured and planned largely determines their levels of functionality, aesthetic, efficiency and productivity. Better planned land uses function more efficiently and are therefore more economically productive than the less planned cities or the unplanned ones.

In addition, the effectiveness of the plan implementation was also affected by factors like lack of policy and commitment of officials, shortage of implementation tools, skilled man power, and community awareness. In general, the ineffective land use planning and implementation resulted by the factors that in turn results unhealthy natural environment in the town via various development activities such, industries, housing, quarrying activities, etc. Moreover, insufficient urban greenery, land and soil degradation, poor solid and liquid waste management, noise and poor air quality, poor sanitation infrastructures and poor environmental management has led to several social and health problems, environmental pollution, and poor urban image.

This paper has shown that land use activities in the study area are largely detrimental to one another, while few are compatible and some are located haphazardly. Therefore, for effective and compatible land use to be achieved, there is need for an integrated land use planning approach. The present approach is uncoordinated and cannot be expected to provide an aesthetic landscape. Hence, to achieve a compatible land use that is functional, economic and aesthetic, there is need for compatibility analysis of different land use activities before designing and implementation stages during the plan preparation process. At the end, this paper has suggested possible solutions to the problems of incompatible land uses in the study area with the aim of ameliorating the problem causes by these uses.

5.2 Recommendations

In line with the findings of the Industrial Land Use Compatibility and evaluation of land use planning and implementation with respect to selective environmental issues the following recommendations are presented:

1. **Integrated Land Use Planning:** It is essential to adopt a comprehensive and integrated land use planning approach in Gelan City Administration, specifically in Tulu Guracha, to ensure compatibility between industrial and residential areas. Authorities should develop a master plan that prioritizes spatial planning and zoning to minimize conflicts between industrial activities and sensitive land uses like residential areas. This should include clearly defined industrial zones, separated from residential zones by appropriate buffers or transitional spaces.
2. **Strengthening Policy and Regulatory Frameworks:** The study highlighted gaps in policy and lack of enforcement as major obstacles to achieving compatible land use. Local governments should revise existing policies to ensure strict compliance with zoning regulations, land use planning guidelines, and environmental protection standards. There should be consistent enforcement of these regulations to prevent industries from encroaching into residential zones.
3. **Environmental Impact Mitigation:** Given the significant environmental impact from industrial activities, particularly chemical manufacturing and oil refineries, there is a need to develop and enforce stricter environmental regulations. These regulations should target air, water, and soil pollution, ensuring that industries adopt sustainable practices. Implementation of pollution control technologies and regular monitoring of air and water quality should be mandated.
4. **Use of GIS for Planning and Monitoring:** Geographic Information Systems (GIS) should be utilized to continuously map land use changes and assess the compatibility of different land use types. GIS can be a valuable tool for monitoring environmental impacts and identifying areas where land use conflicts are likely to occur. This would allow decision-makers to visualize incompatible land use patterns and make data-driven decisions to avoid further land use conflicts.

5. **Public Awareness and Community Involvement:** The local community should be actively involved in land use planning processes. Public awareness campaigns can help residents understand the importance of land use compatibility and the potential health risks of living near industrial areas. Community engagement in the planning process ensures that local knowledge and concerns are integrated into land use decisions.
6. **Industrial Relocation and Redevelopment:** For areas where industrial activities are already encroaching on residential zones, a phased relocation of industries to dedicated industrial parks or zones should be considered. Additionally, policies encouraging industries to adopt greener technologies and practices should be introduced to reduce the environmental impact on nearby residents.
7. **Buffer Zones and Green Spaces:** The establishment of buffer zones, including green spaces and landscape buffers, between industrial and residential areas can help mitigate the negative impacts of industrial pollution. These buffers can serve as barriers to pollution, reducing exposure and improving the quality of life for nearby residents.

By implementing these recommendations, Gelan City can achieve better land use compatibility, reduce environmental impacts, and promote sustainable urban development that supports both industrial growth and residential well-being.

REFERENCES

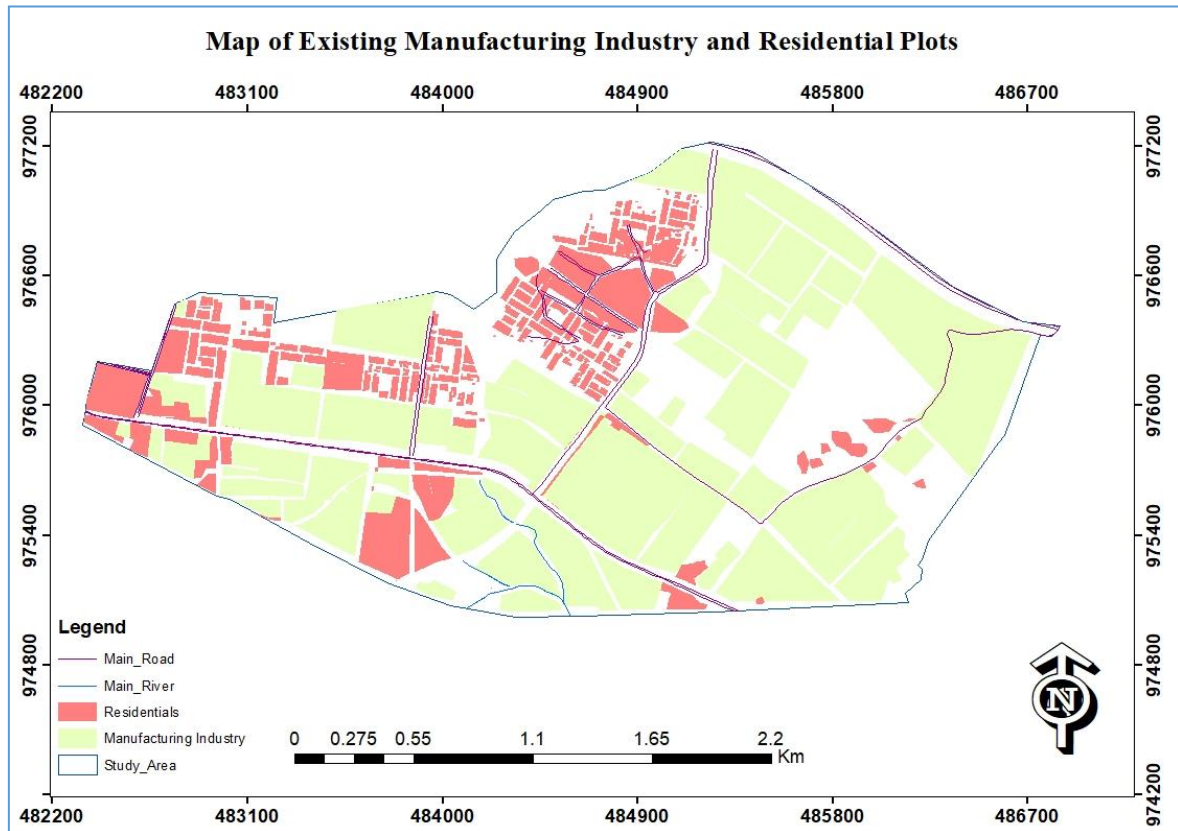
- Abedini, A., Lotfian, M., & Moradi, M. (2015a). Land use compatibility assessment using a modified TOPSIS model: A case study of elementary schools in Tehran. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 40(1W5), <https://doi.org/10.5194/isprsarchives-XL-1-W5-5-10pp>
- Abedini, A., Lotfian, M., & Moradi, M. (2015b). Land use compatibility assessment using a modified TOPSIS model: A case study of elementary schools in Tehran. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 40(1W5), <https://doi.org/10.5194/isprsarchives-XL-1-W5-5-10pp>
- Abedini, A., Lotfian, M., & Moradi, M. (2015c). Land use compatibility assessment using a modified TOPSIS model: A case study of elementary schools in Tehran. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 40(1W5), <https://doi.org/10.5194/isprsarchives-XL-1-W5-5-10PP>
- Akande Raji, A. (2019). *Compatibility Analysis of Land Use Activities in LAUTECH*. <https://doi.org/10.13140/RG.2.2.26082.04806>
- Benti, S., Terefe, H., & Callo-Concha, D. (2022). Implications of overlooked drivers in Ethiopia's urbanization: curbing the curse of spontaneous urban development for future emerging towns. <https://doi.org/10.1016/j.heliyon.2022.e10997>
- Brown, G., & Raymond, C. M. (2014). Methods for identifying land use conflict potential using participatory mapping. *Landscape and Urban Planning*, 122, 196–208pp. <https://doi.org/10.1016/j.landurbplan.2013.11.007>
- Cheniki, K., Baziz, A., & Boudiaf, B. (2019a). Evaluating Relationship between Mixed-land Use and Land-use Compatibility in Algiers Bay. In *International Journal Of Environmental & Science Education* (Vol. 14, Issue 7). <http://www.ijese.com>

- Cheniki, K., Baziz, A., & Boudiaf, B. (2019b). Evaluating Relationship between Mixed-land Use and Land-use Compatibility in Algiers Bay. In *International Journal Of Environmental & Science Education* (Vol. 14, Issue 7). <http://www.ijese.com>
- Cox, A. (2005). *Universities of Leeds , Sheffield and York*. 31, 527–540.
- Dadi, T. Stellmacher, H. Azadi, G. Kelboro, P. Lebailly, M. Ghorbani, (2020) The impact of industrial investments on land use and smallholder farmers' livelihoods in Ethiopia, *Land Use Pol.* 99 (2020), 105091, <https://doi.org/10.1016/j.landusepol.2020.105091>.
- Dadras, M., Shafri, H. Z. M., & Ahmad, N. (2015). Spatio-temporal Analysis of Urban Growth from Remote Sensing Data in National Authority for Remote Sensing and Space Sciences Spatio-temporal analysis of urban growth from remote sensing data in Bandar Abbas city, Iran. *The Egyptian Journal of Remote Sensing and Space Sciences*, 18(1), 35–52. <https://doi.org/10.1016/j.ejrs.2015.03.005>
- Dempwolf, C. S. (2010). *An Evaluation of Recent Industrial Land Use Studies: Do Theory and History Make Better Practice*.
- Gebre-Egziabher, E. Abera, in: Fantu Cheru, A.O. , (2019). Urbanization and Industrial Development in Ethiopia, Oxford University Press, Oxford.
- Mansourihanis, et al. (2023a). A Computational Geospatial Approach to Assessing Land-Use Compatibility in Urban Planning. *Land*, 12(11), 1–19pp. <https://doi.org/10.3390/land12112083>
- Mansourihanis, O., et al. (2023b). A Computational Geospatial Approach to Assessing Land-Use Compatibility in Urban Planning. *Land*, 12(11). <https://doi.org/10.3390/land12112083>
- Nourian, F. (2021). *Land use compatibility assessment using neighborhood focal analysis in Geographic Information System*. <https://www.researchgate.net/publication/352573237>.
- Oqubay, A. (2018). Industrial policy and late industrialisation in Ethiopia, Report No.: 303, C^ote d'Ivoire, Abidjan, <https://www.afdb.org/en/documents/publications/working-paper-series/>.
- Raji, A. A. (2021). *Compatibility Analysis of Land Use Activities in LAUTECH*. August 2019. <https://doi.org/10.13140/RG.2.2.26082.04806> 0–26pp.

- Stewart, T. J., & Janssen, R. (2014). A multi objective GIS-based land use planning algorithm. *Computers, Environment and Urban Systems*, 46, 25-34.
- Storie, C. D. (2013). Intra-Urban Analysis of Commercial Locations A GIS-Based Approach. *International Journal of Applied Geospatial Research (IJAGR)*, 4(1), 1-16.
- Taleshi, M., & Bishehii, S. (2012). *Residential and Industrial Compatibility By Mixed Land Use, Zoning and Urban Design Case Study Vardavard Near Tehran Metropolis*.
- Tanku, M., & Woldetensae, B. (2023). Industrial development and urban spatial planning practices: The case of Galan and Dukem cities in Ethiopia. *Heliyon*, 9(7). <https://doi.org/10.1016/j.heliyon.2023.e17554>.
- Tarhan, C., & Deniz, D. (2013). Sustainable Urban Planning and Risk Assessment of Earthquake Hazards in Turkey. *ISPRS-International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 1(1), 113-117.
- UNIDO. (2019). International Guidelines for Industrial Parks. *Inclusive and Sustainable Industrial Development*, 1–66pp. https://www.unido.org/sites/default/files/files/2019-11/International_Guidelines_for_Industrial_Parks.pdf (Accessed 11 May 2021)
- Vesely, J., & Taylor, N. (2019). *Land Use Compatibility, Environmental Air Quality Assessment Proposed 1157-1171 North Shore Boulevard East Development Toronto*.
- Wadud, Z (2013) *Using meta-regression to determine Noise Depreciation Indices for Asian airports*. *Asian Geographer: a geographical journal on Asia and the Pacific Rim*, 30 (2). 127 - 141.

Appendix

1. Existing residential and Industrial land use digitized and taken from city administration plan.



Existing industrial and residential land use.

2. Digitized Industrial land use and their locations

OBJECTID	parcel Name (LU)	X_coord	Y_Coord	Area in Meter	Area_hec
1	Manufacturing Industry	486049	975340	19018.7	1.902
2	Manufacturing Industry	485967	975165	20513.4	2.051
3	Manufacturing Industry	486009	975491	20094.7	2.009
4	Manufacturing Industry	485477	975312	29489.9	2.949
5	Manufacturing Industry	484564	975600	22182.6	2.218

6	Manufacturing Industry	484741	975565	59234.0	5.923
7	Manufacturing Industry	484871	975432	46978.8	4.698
8	Manufacturing Industry	485113	975427	74813.6	7.481
9	Manufacturing Industry	485020	975617	45135.3	4.514
10	Manufacturing Industry	485027	975840	15948.1	1.595
11	Manufacturing Industry	485270	975676	18802.9	1.880
12	Manufacturing Industry	485155	975752	15368.3	1.537
13	Manufacturing Industry	484940	975910	5604.7	0.560
14	Manufacturing Industry	484891	975144	32933.2	3.293
15	Manufacturing Industry	484765	975251	9775.8	0.978
16	Manufacturing Industry	484652	975296	12050.1	1.205
17	Manufacturing Industry	484516	975379	17850.5	1.785
18	Manufacturing Industry	484604	975195	30735.2	3.074
19	Manufacturing Industry	484324	975238	36767.0	3.677
20	Manufacturing Industry	484446	975257	11703.5	1.170
21	Manufacturing Industry	484396	975091	21901.7	2.190
22	Manufacturing Industry	483971	975149	10016.0	1.002
23	Manufacturing Industry	484213	975463	15306.8	1.531
24	Manufacturing Industry	484099	975383	19311.8	1.931
25	Manufacturing Industry	484091	975496	19943.2	1.994
26	Manufacturing Industry	484098	975600	14108.4	1.411
27	Manufacturing Industry	483775	975650	10221.3	1.022
28	Manufacturing Industry	483714	975550	10273.2	1.027
29	Manufacturing Industry	483488	975457	14961.3	1.496
30	Manufacturing Industry	483569	975357	4903.2	0.490
31	Manufacturing Industry	483608	975627	6187.1	0.619
32	Manufacturing Industry	483562	975552	11322.7	1.132
33	Manufacturing Industry	483228	975524	4261.9	0.426
34	Manufacturing Industry	483146	975538	7408.1	0.741

35	Manufacturing Industry	483042	975623	10592.7	1.059
36	Manufacturing Industry	483143	975621	5128.8	0.513
37	Manufacturing Industry	483265	975613	11850.8	1.185
38	Manufacturing Industry	483340	975521	13907.4	1.391
39	Manufacturing Industry	483424	975693	11223.3	1.122
40	Manufacturing Industry	483498	975722	5478.1	0.548
41	Manufacturing Industry	483553	975683	14840.9	1.484
42	Manufacturing Industry	483435	975593	7162.5	0.716
43	Manufacturing Industry	483325	975721	13081.7	1.308
44	Manufacturing Industry	483250	975730	7236.7	0.724
45	Manufacturing Industry	483190	975734	9268.8	0.927
46	Manufacturing Industry	483094	975770	13840.3	1.384
47	Manufacturing Industry	483059	975694	5848.7	0.585
48	Manufacturing Industry	482790	975762	20144.1	2.014
49	Manufacturing Industry	482673	975824	8403.4	0.840
50	Manufacturing Industry	482508	975891	1944.2	0.194
51	Manufacturing Industry	483103	976001	48824.4	4.882
52	Manufacturing Industry	483318	975970	45081.3	4.508
53	Manufacturing Industry	483668	975930	47804.1	4.780
54	Manufacturing Industry	483495	975948	24177.7	2.418
55	Manufacturing Industry	483821	975905	15299.7	1.530
56	Manufacturing Industry	483951	975876	16552.4	1.655
57	Manufacturing Industry	484085	975842	15072.1	1.507
58	Manufacturing Industry	484393	975784	50498.2	5.050
59	Manufacturing Industry	484252	975869	18848.3	1.885
60	Manufacturing Industry	484621	975987	15745.8	1.575
61	Manufacturing Industry	484505	976053	11042.1	1.104
62	Manufacturing Industry	484370	976122	23906.8	2.391
63	Manufacturing Industry	484479	975942	37678.2	3.768

64	Manufacturing Industry	484258	976034	15925.4	1.593
65	Manufacturing Industry	484742	975870	18858.0	1.886
66	Manufacturing Industry	484895	975948	5774.8	0.577
67	Manufacturing Industry	484832	975998	9209.3	0.921
68	Manufacturing Industry	485394	975854	19561.6	1.956
69	Manufacturing Industry	485504	976050	23148.7	2.315
70	Manufacturing Industry	485266	976223	23969.2	2.397
71	Manufacturing Industry	485147	976295	9452.9	0.945
72	Manufacturing Industry	485291	976392	7454.4	0.745
73	Manufacturing Industry	485239	976423	11325.8	1.133
74	Manufacturing Industry	485623	976160	11340.0	1.134
75	Manufacturing Industry	485545	976220	18649.4	1.865
76	Manufacturing Industry	485472	976264	7587.0	0.759
77	Manufacturing Industry	485440	976294	5663.4	0.566
78	Manufacturing Industry	485401	976312	7574.2	0.757
79	Manufacturing Industry	485364	976341	6978.9	0.698
80	Manufacturing Industry	485328	976366	6658.4	0.666
81	Manufacturing Industry	485599	976381	10025.0	1.003
82	Manufacturing Industry	485346	976493	13028.2	1.303
83	Manufacturing Industry	485375	976561	15037.4	1.504
84	Manufacturing Industry	485491	976481	5009.4	0.501
85	Manufacturing Industry	485547	976441	5009.4	0.501
86	Manufacturing Industry	485448	976422	5017.7	0.502
87	Manufacturing Industry	485700	976476	14808.6	1.481
88	Manufacturing Industry	485780	976424	9387.6	0.939
89	Manufacturing Industry	485823	976582	29631.3	2.963
90	Manufacturing Industry	485648	976899	30336.4	3.034
91	Manufacturing Industry	485900	976721	22486.4	2.249
92	Manufacturing Industry	485786	976808	13114.5	1.311

93	Manufacturing Industry	485489	977004	17570.3	1.757
94	Manufacturing Industry	485510	976618	20761.1	2.076
95	Manufacturing Industry	485658	976744	18807.6	1.881
96	Manufacturing Industry	485569	976711	9733.7	0.973
97	Manufacturing Industry	485665	976643	8028.7	0.803
98	Manufacturing Industry	485608	976550	13353.4	1.335
99	Manufacturing Industry	485445	976849	30026.0	3.003
100	Manufacturing Industry	485279	976802	17522.5	1.752
101	Manufacturing Industry	485378	976719	23474.4	2.347
102	Manufacturing Industry	485327	977018	37096.1	3.710
103	Manufacturing Industry	486323	976221	359522.1	35.952
104	Manufacturing Industry	486147	975791	28084.4	2.808
105	Manufacturing Industry	485122	976503	25853.6	2.585
106	Manufacturing Industry	485099	977078	43676.1	4.368
107	Manufacturing Industry	483740	976368	99017.8	9.902
108	Manufacturing Industry	484285	975572	16905.5	1.691
109	Manufacturing Industry	484698	975768	9409.1	0.941
110	Manufacturing Industry	484643	975704	14935.8	1.494
111	Manufacturing Industry	484847	975793	20456.3	2.046
112	Manufacturing Industry	484929	975725	13010.6	1.301
113	Manufacturing Industry	485272	975259	17437.7	1.744
114	Manufacturing Industry	485450	975596	38339.3	3.834
115	Manufacturing Industry	485057	975973	8646.2	0.865
116	Manufacturing Industry	484886	976102	8915.7	0.892
117	Manufacturing Industry	485446	975953	14264.2	1.426
118	Manufacturing Industry	485299	975962	16340.0	1.634
119	Manufacturing Industry	485380	976100	18049.6	1.805
120	Manufacturing Industry	483562	975477	7389.3	0.739
121	Manufacturing Industry	483416	975417	6563.8	0.656

122	Manufacturing Industry	483510	975378	3648.3	0.365
123	Manufacturing Industry	484750	975090	6150.1	0.615
124	Manufacturing Industry	484710	975167	6394.1	0.639
125	Manufacturing Industry	484354	975356	10729.2	1.073
126	Manufacturing Industry	484435	975460	12047.0	1.205
127	Manufacturing Industry	483964	975960	8937.4	0.894
128	Manufacturing Industry	485815	975547	80399.7	8.040
129	Manufacturing Industry	485600	975455	21836.4	2.184
130	Manufacturing Industry	485774	975257	13269.7	1.327
131	Manufacturing Industry	485856	975332	15888.5	1.589
132	Manufacturing Industry	485927	975407	11610.6	1.161
133	Manufacturing Industry	486088	975257	8922.7	0.892
134	Manufacturing Industry	485898	975218	12694.7	1.269
135	Manufacturing Industry	485694	975346	12015.4	1.202
136	Manufacturing Industry	485692	975144	21146.1	2.115
137	Manufacturing Industry	485550	975191	30974.8	3.097
138	Manufacturing Industry	485390	975202	11826.7	1.183
139	Manufacturing Industry	485334	975142	9781.6	0.978
140	Manufacturing Industry	482710	976084	11444.4	1.144
141	Manufacturing Industry	483089	976177	19473.3	1.947
142	Manufacturing Industry	482841	976038	18775.4	1.878
143	Manufacturing Industry	482539	975882	1932.6	0.193
144	Manufacturing Industry	483375	976137	14321.6	1.432
145	Manufacturing Industry	482786	976449	3166.6	0.317
146	Manufacturing Industry	482894	975807	7333.3	0.733
147	Manufacturing Industry	484413	975626	1200.2	0.120



Industrial land use and vacant open space for greenery.



Newly building for industrial area and mixed residential area in front of manufacturing land use.

QUESTIONNAIRE AND INTERVIEW

Dear Respondent,

This questionnaire is designed to collect information for a M.Sc. research entitled “Analysis of industrial land use compatibility: a case of Gelan sub city, Ethiopia ” with a view to identifying the environmental problems posed on residents by the location of industry, identify incompatibility of land use surrounding and to examine its impact on the nearby residential properties in specific site in Tulu Guracha, Gelan sub city. I assure you that the information provided will be used strictly for academic purpose and kept confidential. Kindly complete the blank spaces and tick the appropriate boxes as applicable. Thank you.

(Please fill and tick where appropriate)

SECTION 1: RESPONDENT INFORMATION

General Information

I. Location identification

1. City/Woreda -----
2. Name of Kebele/village -----
3. Name of data collector -----
4. Date of data collection -----

II. Household demographic characteristics

1. Sex of household head: **a.** male ----- **b.** female -----
2. Age: a) less than 18 b) 18-30 c)31-40 d) 41-50 e)51-60 f) 61 and above-----
3. Place of birth: -----
4. Marital status: **a.** single **b.** married **c.** separated **d.** widowed **e.** divorced
5. Educational level: **a)** Cannot read and write **b)** can read and write **c)** primary school d) secondary school **e)** Diploma f) 1st Degree g) 2nd Degree and above.....
6. How long have you lived in the study area?
 1. less than 5 years B.5-10 years C. 10-15 years D. Above 15 years

SECTION 2: QUESTIONNAIRE TO BE FILLED BY INDIVIDUAL HOUSEHOLDERS

I. INDUSTRIAL LAND USE AND COMPATIBILITY

1. Are you aware of any industrial facilities located near your residence?
 - A. Yes
 - B. No (If no, skip to question 2)

2. What type of industries are located near your residence? (Circle all that apply)
- A. Manufacturing
 - B. Warehousing/Distribution
 - C. Power plants
 - D. Oil refineries
 - E. Chemical plants.
 - F. Other (please specify)
3. How close is the nearest industrial facility to your residence?
- A. Less than 100 meters
 - B. 100-500 meters
 - C. 500 meters - 1 kilometer
 - D. More than 1 kilometer
4. In your opinion, how compatible is the current industrial area with the surrounding residential areas?
- A. Very Compatible
 - B. Somewhat Compatible,
 - C. Somewhat Incompatible,
 - D. Very Incompatible
5. Have you experienced any conflicts due to the proximity of industrial land use? (Yes/No)
6. If yes, please describe the nature of the conflict (e.g., noise, odors, traffic).

II. ENVIRONMENTAL IMPACT

7. Have you noticed any changes in air quality since the industrial area was established in your area? (Yes/No)
- If yes, please describe the changes (e.g., increased dust, water pollution unpleasant odors).
8. Have you noticed any changes in water quality (e.g., in nearby streams or wells)? (Yes/No)

- If yes, please describe the changes (e.g., discoloration, strange taste).
9. Do you experience noise pollution from the industrial area? (Yes/No)
- If yes, how often does it occur (daily, weekly, and occasionally)?
 - How does the noise pollution impact your daily life (e.g., difficulty sleeping, disrupted conversations)?
10. Are you aware of any waste disposal practices associated with the industrial area that concern you? (Yes/No)
- If yes, please describe your concerns.
11. What are the environmental problems posed on residents by industrial activities in your village and to what degree? Place mark or tick degree of agreement in below table

Environmental Problems	Low Environmental Problems	Problems	Moderate Environmental problems	Problems	Very High Environmental Problems
Noise pollution from factory plants and machinery and generators.	1	2	3	4	5
Dust particles	1	2	3	4	5
Water pollution	1	2	3	4	5
Offensive odour (i.e. from chemicals and industrial waste)	1	2	3	4	5
Open dump site for disposal of industrial solid waste.	1	2	3	4	5
Overstressed of infrastructural facilities.	1	2	3	4	5
Obstruction of view as a result of smoke.	1	2	3	4	5
Industrial emission as a result of burning fossil fuels from factory plants and machineries and generators.	1	2	3	4	5
Indiscriminate sewage disposal	1	2	3	4	5
Other, specify.....					

II: SOCIO ECONOMY AND EMPLOYMENT OPPORTUNITIES IN RELATION INDUSTRIAL ACTIVITIES

- a. Can you indicate employment history of your household members in your near industry site? A] employed B] unemployed
- b. Is there anyone of your family member who is hired in any of the nearby investment activities? A. yes B. no
- c. If your answer is 'yes', can you indicate the type of employment? (>= one answer possible)
A. Daily labourer B. compound keeper C. professional work, D. other, specify.....
- d. How much is the average monthly income for unskilled household member employed in industry? (in birr) A. <1000 B. 1001-2000 C. 2001-4000 D. 4001- 5000 E. >5001
- e. Does Industrial land use of Gelan affect residential property values?
A) Strongly Agree B) Agree C) Undecided D) Disagree E) Strongly Disagree
- f. How does an environmental problem posed by Gelan Industrial have Impact on nearby residential rental values?

Level of impacts: [1] Strongly Negative Impact [2] Fairly Negative Impact [3] Minor Negative Impact [4] No Negative Impact [5] Positive Impact

Variables	Level of impacts				
Economic Impact on Residential Values.	[1]	[2]	[3]	[4]	[5]
Reduction in rental values of properties					
Prolong the period to let or to sell.					
Unable to sell or let.					
Decrease in demand for residential properties in the neighborhood					
Others (Specify).....					

- g. Have you experienced any health problems you believe are related to living near industrial activities?
A. Yes (Please specify). B. No

- h. Do you feel safe living near industrial activities?
 - A. Strongly agree
 - B. Agree
 - C. Neutral
 - D. Disagree
 - E. Strongly disagree
- i. In your opinion, do industrial activities create jobs in the neighborhood?
 - A. Strongly agree
 - B. Agree
 - C. Neutral
 - D. Disagree
 - E. Strongly disagree
- j. Do you believe industrial activities contribute to the overall economic prosperity of the neighborhood?
 - A. Strongly agree
 - B. Agree
 - C. Neutral
 - D. Disagree
 - E. Strongly disagree
- k. Would you consider moving away from this neighborhood due to the presence of industrial activities?
 - A. Yes
 - B. No
 - C. Unsure
- l. Overall, how satisfied are you with the social and economic impacts of the industrial activities on your neighborhood?
 - A. Very satisfied
 - B. Satisfied
 - C. Neutral
 - D. Dissatisfied
 - E. Very dissatisfied

If you have Any comment and suggestion feel free to write here!
