ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

GIS-BASED MULTICRITERIA DECISION MAKING ANALYSIS FOR ABATTOIRSITE SELECTION IN SHASHAMANE TOWN, ETHIOPIA

THESIS

SUMMITED TO THE SCHOOL OF ENGINERING IN PARTIAL FULFILMENTS OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN GEODESY AND GEOMATICS ENGINERING

BY

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JUNE, 2017

ADAMA, ETHIOPIA

Abstract

Abattoirs are one important urban functions that need suitable site to be compatible with the Surrounding geographic features. However, they are observed being located at in appropriate site posing environmental hazard to their surrounding and are additionally influenced by some adjacent activities. The present study was conducted to find the most suitable abattoir site in shashamane town. In order to do this it was discovered essential to experience the national urban planning establishment of Ethiopia, and thus reviewing the experience of urban land use planning for sitting basic environmental issues like abattoir.An integrated Remote sensing and GIS approach was observed to be extremely useful to assign abattoir site in the study area. Factors that were found to be significant in distinguishing the site in the study area were; land use/cover, elevation, slope, streams, distance from the roads, distance from the high tension lines, distance from social services, distance from industrial areas, and boreholes. These factors were weighted in hierarchical order using MCE approach to produce the suitability map of abattoir site. From the overall suitability map, suitability level of areas was calculated. Major findings of the study revealed that, 12.46% of the study area covers a highly suitable area of abattoir, 22.91% area is suitable, 16.70% of areas is moderately suitable and the unsuitable area covers 47.93% of the study area. The highly suitable areas are mainly located in the south west, west and north of the study area. These areas falls in bare land uses. The suitable areas are located near the periphery of built up areas. Finally, the unsuitable areas site are located in the developed part of the town. Generally, locating the abattoir within highly suitable area can ensure minimizing the impact of abattoir on the surrounding environment in the form of liquid wastes,solid waste,airborne wastes and noise : reducing the impact of nearby activities on the abattoir through dust and smoke emitting industries.

Key words: Multi-criteria Evaluation, Abattoirs, Shashamane, GIS, RS

ACKNOWLEDGEMENT

First and foremost, I would like to thank, the Almighty GOD. Who made it possible to begin and finish this study successfully.

I would like to extend my deepest gratitude and appreciation to my supervisor, Dr. Hasan Raja Navqi for his expert guidance and concerned supervision throughout all steps of the research. His critical comments has contributed immensely to the completion of the thesis. I am so grateful for that provided sharp eyed comments and critical assistance. This thesis would not be in its current shape without his continuous exertion and support.

I gratefully acknowledge the Hawassa University for granting me the chance to pursue my studies in the Adama Science and Technology University.

I am thank full to Mr Alemayew Tegegn,Mr Abiyo Jemal,Mr Adem Mohammed,Sr Hirut Wendimu the figurative oficials in Shashamane town Administration staff for their support and provision of necessary data and information related to the thesis.

Finally, I would like to express my gratitude to all my families and my friends for their encouragements and support. Especially my appreciation goes to my wife Genet Tesfaye.

Table of Contents

Contents **Page**

List of Tables

List of figures

List of Abbrivations

AHP:	Analytic Hierarchy process
A.M.S:	Above mean sea level
CR:	Consistency ratio
DEM:	Digital elevation system
EMA:	Ethiopian mapping agency
ERDAS:	Earth resource data analysis system
EPA:	Environmental protection authority
FAO:	Food and agricultural organization
GIS:	Geographic information system
Ha:	Hectare
KM:	kilometer
LMA:	Live stoke marketing authority
LU/LC:	Land use /Land cover
MCA:	Multi criteria analysis
MCDM:	Multi criteria decision making
MCE:	Multi criteria evaluation
MoARD:	Ministry of agriculture and rular development
NUPI:	National urban planning institute
PMGE:	Provisional military government of Ethiopia
TGE:	Transitional government of Ethiopia
USGS:	United States geological survey
UTM:	Universal Transverse Mercator
WLC:	Weighted linear combination

CHAPTER ONE

1. INRTODUCTION

1.1. Background of the Study

Abattoir is defined as any premises that is approved and registered by the controlling authority in which animals are slaughtered and dressed for human consumption, (Codex Alimentarius , 1993).The purpose of an abattoir is to produce hygienically prepared meat by the human handling of the animal using hygienic techniques for slaughtering and dressing . At the same time, it enables proper meat inspection to be carried out. The resulting waste materials are thus suitably handled to remove any potential danger or meat-borne infectious agents reaching the public or contaminating the environment (FAO, 1992). The needs for abattoirs have increased with the growing population and urban expansion.The municipal abattoir facilities are nowdays incorporated in the urban master and land use planning. So as to meet social needs.In most developing countries this facility is not well considered in land use planning. The discussion so far provides a general overview of varied characteristic of abattoirs necessitating unique locations that comply with environmental and land use policies. However, a number of examples in different towns of Ethiopia can be mentioned which portray the existence of serious problems in this regard. The most notable ones include, in many cases the sites lack a reasonable time dimension so that they are soon encroached by other urban land uses (housing and commercial activities). Ultimately, the abattoirs become subject to relocation earlier than expected. Furthermore, abattoirs are sometimes found near waste disposal site being exposed to pollution. Typical example is Teppi town (G/Egziabher, 2001). In some places such as Durame town, abattoirs are found being constructed within the central business center, indicating a serious problem of incompatibility. In other situations such as in Gimbi town, abattoirs are noted being built so close to water supply dams that the liquid waste disposed of joins the water, representing serious hygienic hazard (G/Egziabher, 2001) , and more other similar problems are encountered. The implication is that each planning team of NUPI would be confronted with problems of these kinds to which appropriate or optimal solutions should be sought.

Continuing the traditional practice of abattoir has posed a devastating effect on our environment, the quality of the public health and the residence in particular. One of the important research steps along with the planning for the abattoir is locating factors and finding a suitable place of their settlement. Several criteria are involved in order to find the suitable location of abattoir that they have their particular importance and make restriction on the choices either. Final goal of these criteria is to find a location that will pose minimal adverse environmental effects on the surrounding natural environment (Fard.et.al, 2012). The quickly changing pattern of urban development has offered ascend to new issues for urban planning and redevelopment. This development has been connected with expanding pressure on land for human settlements and related urban administrations. In this manner, quick consideration is required from the the perispective of physical planning of towns and urban cities. A significant goal of urban land use planning is to assess the preferences and weaknesses of one utilization of land parcels when contrasted with another. Urban areas and towns in most developing countries encounter a growing pressure of population on limited assets and an absence of modern economic association, which may alleviate this pressure (Harris, B, 1990). Urban planning happens in a spatial setting. A lot of this planning needs to do with the utilization of land and how the diverse sorts of land uses identify with each other. This implies urban planning must contend with numerous conflicting objectives and conditions. A desire to give an amendable and effective urban environment clashes with the need to moderate assets. The foresight of quick development requires the arrangement of facility which may not be required at once. Planning for the future will require a level of foreknowledge which is hard to accomplish in a dynamic and uncertain environment. Moreover, most investments in structures, factories and infrastructures have their physical area in towns and urban cities. These ventures have a long life expectancy and depend for their working and proficiency on the urban zone to which they have a place (Bruijn, 1990).

(Harris, B., 1990) explains that the mixture of issues which should all be determined together, covering a few sorts of land uses and a considerable measure of public facilities which show the characteristic complexity in urban planning makes as circumstance in which numerous options must be attempted, consolidated, enhanced, and tried by examination, by investigation and by open discussion. Additionally the interdependency amongst investments and their surroundings, also, the need to incorporate all gatherings of occupants in urban society under not too bad living conditions, make urban planning at all level of government a prime concern, (Kassaye., 1999).

Geographic information have been traditionally displayed in map form. Land suitability investigation is regularly finished with map overlay and it used to be done manually.

(McHarg, 1969) Describes how using manual map overlaying can do systematic land use planning. GIS has boundless potential, perceived however not completely acknowledged, for taking care of environmental and human administration issues, its application is constrained just by the creative power of the individuals who utilize it.

This is the reason a GIS application for taking care of real world issues, where geographically referenced information is required, is perceived as avital research area of the field .GIS is utilized for site selection for various terrains of single facilities with exceptional area necessities, for which the suggestions as to activity, contamination, relocations of other activities, usefulness of the new facility, and soon can be investigated (Bruijn, A., 1990).

An alternate set of issues emerges when the present and future area of frameworks of facilities are considered. Here, all the questions at single facility level emerge, but contend and supplement each other, so that no two facilities must be excessively near one another, and no customer requiring service should be too far away from the closest facility (Harris.B, 1990). The compelling utilization of GIS relies upon the purpose for which it is applied and the context in which that application happens .Moreover, a superior comprehension of GIS technology by clients, directors, and leaders is significant to the proper utilization of the Technology (Aronoff, 1989). Shashamane town has only one abattoir owned by the town municipality.The most notable problems in existing abattoir of the study area include; clossness by other urban land uses (housing and commercial activities) through time dimension and clossnes to river. According to the NUPI, the duration of plan implementation for a given town ends within ten years and considering the expansion and scope of the service delivery, the revision and modification of the existing plan might be mandatory. In most cases this is either to renew old areas or due to complete utilization of land allocated during the last planning period. Eventhough the town has implemented plan the previous site allocation of abattoir in the study area seems out of date against the application of multi-criteria support techniques relevant for specific location of urban facility. Therefore compared to population and expansion of the town it needs to relocate the existing abattoir.

A multi-criteria evaluation (MCE) technique can serve to identify, classify, analyze and helpfully arrange the accessible data concerning decision conceivable outcomes in urban land use planning. It is predominantly required with how to combine the data from a several criteria to form a single index of evaluation.

Traditional decision support technique do not have the capacity to simultaneously consider these viewpoints. It is utilized to manage challenges that leaders experience in taking care of a lot of complex data. Suitability strategies decision makers and environmental managers to analyze the collaborations among locations, development activities and environmental components. Several parameters were collected from various sources in vector and raster GIS formats, and then, used within the GIS-based WLC analysis to select suitable abattoir site.The present study heps to overcome the abattoir lacation problem in shashamane town and to give information to urban planners to practice right judgement on the planning of best area for the construction of abattoir.

1.2. Statement of the Problem

One of the real tasks performed by National Urban Planning Institute is examining essential urban capacities or services and proposing them at fitting area. Abattoirs are among the numerous services which National Urban Planning Institute plans in urban land use development. The activities included in abattoirs pose environmental hazards to the neighboring areas. These are showed as fluid wastes, storm water pollution, solid wastes, airborne wastes, diseases, and noise (EPA, 2002). On the other hand, abattoirs could be influenced by certain close-by incompatible activities. Illustrations are industrial activities that transmit smoke and tidy.The existing abattoir of shashamane town was established in 1972 to give slaughtering service of ten cattles daily, having population of 70,000. Nowadays the population number of the town has been increased to 238,310 and the number of cattles slaughtered was increased to 130 per day.from this perispective due to the increment of population and the expansion of the town the existing abattoir does not satisfy the interest of users. The present development of residential areas, closeness to stream water (on which generally urban low wage classes depend) for domestic uses, and other urban facilities

like business centers liable to make the area of existing abattoir inconvenient. As regard to waste management, it is not adequately managed. Solid wastes are discarded as refuse in and outside the fence. Moreover, scattered bones and hairs are more observed in the surrounding environment of the abattoir. The liquid wastes containing blood, infected liver and kidney from the abattoir directly discharged to the nearby river. Generally solid and liquid wastes generated from the abattoir are not properly managed, treated and separated. Therefore, they are polluting the surrounding environment particularly the nearby rivers which in turn affects the health of people and living down stream.

In abattoir operation, certain prerequisite programmes have to be considered to provide basic environmental and operating conditions that are necessary for production of safe food.

These prerequisite programmes include good manufacturing practices, good hygiene practice and standard operating procedures. Hence, in considering these prerequisite programmes, the fundamental issues is an appropriate site for the construction of abattoir. Therefore, the establishment of abattoirs at fitting site considers the recognizable proof of huge number of factors to settle on spatial decisions and the degree of the interrelationship among these factors and difficulties in decision making (Malczewski J. , 1999).

Most privious studies were focused on municipal abattoir operation and waste management practices, suitability of meat and byproducts, and predominace of cattle diseases in Ethiopia and the world at large. Only few studies have used the application of GIS for urban planning in Ethiopia with particular reference to abattoir site suitability analysis.For instance (Melese, 2002) studied site suitability analysis for kulito town. His study was mainly based on the urban planning institute experience. However, the study did not consider the multi-criteria decision making analysis. The ability to manipulate the spatial data and corresponding attribute information and to integrate different types of data in a single analysis and a higher speed are unmatched by any manual methods (Aronoff, 1989). The current study considers multi-criteria decision making techniques. As can be noted like most spatial decision making problems, the land allocation problem associated with abattoirs is multi-criteria in nature, involving economic, social, environmental dimensions. Moreover, the pattern of geographical features varies from place to place and time to time. Geographically, the study town, Shashamane, is typically different from Kulito. Thus, the criteria applied for site suitability analysis of abattoir in Shashamane may not be similar with Kulito town. These may include variation in slope, hydrologic system.There are no existing literature on the site suitability seletion for abattoir establishment in the study area. The role of geographic information technology is of prime importance to make numerous sorts of work more productive and works more viable; it empowers better decision, in light of better data

Therefore, this study fills the gap and looks for the selection of the appropriate site for abattoir in shashamane town considering sustainable development of the town using GIS as a tool.

1.3. Objective of the Study

1.3.1. General Objective

The general objective of this study is to select suitable abattoir site using GIS based multi-criteria analysis and remote sensing for Shashamane town.

1.3.2. Specific Objectives

In accordance with accomplishing the general objective the study sets the following specific objectives:

- To identify spatial factors for abattoir suitable site selection.
- To develop a site suitability model in order to select the most suitable site for abattoir.
- To map landuse/cover of shashamane town from abattoir suitability analysis.
- To investigate the impact of abattoir site on local community and environment.

1.4. Research Questions

- What are the factors that should be considered for selecting a suitable site for abattoir?
- What areas are selected by the GIS-based Multi-Criteria Analysis methods as appropriate places for abattoir in shashamane?
- Would the GIS-based Multi-criteria analysis method be useful tool for the future urban planning in shashamane?

1.5. Significance of the Study

The study aims to create appropriate site location map for abattoir in Shashamane town. The data created by this study is believed to give helpful information to urban planners to practice right judgment on the planning of best area for building abattoir facility Organizations working on environmental issues like sanitation problems related with pollution of air, waste water and noise would benefit from the study.

1.6. Organization of the thesis

This thesis is divided into five chapters. The first chapter provides an introduction to the study, which consists of different sections: background of the study, statement of the problem, objectives, Significance of the study and its limitations. The second chapter deals with review of related literatures. Which mainly included the over view of urban planning, urban development planning in Ethiopia,current planning practice undertaken by NUPI,master plan,development plan, role of geographic information system and remote sensing in site selection, abattoirs as an important urban functions including their basic features,environmental problems associated with abattoirs,planning issues,application of multicriteria decision making,abattoir site selection criteria . The third chapter deals with the materials and methods employed in the research. These include; description of the study area,and conceptual framework and flowchart of the analysis.In chapter four, data analysis, result and discussions, criteria map generation and classification, calculation of the criteria and class weights and final suitable site has been identified for the study area. chapter five is about conclusion and recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. An Overview of Urban Planning

The urban areas in developing countries have witnessed tremendous changes as far as population growth and urbanization. Without appropriate urban administration practice, uncontrolled and quick increment in population pose enormous difficulties to governments in giving sufficient safe house to the a large number of homeless and poor in urban areas (Raghunath, 2006). This has additionally posed great concern among urban planners. Irregular urban development prompts the change of land use and land cover in numerous urban areas around the world, particularly in developing countries This is bringing about weakening of infrastructure facilities, loss of rural lands, water bodies, open spaces, and reduction of ground water aquifer zones, water contamination, air pollution, health hazards and numerous miniaturized scale climatic changes. Urban land-use planning is a multi-part and multi-disciplinary process, which requires more than a solitary strategy for sensible results. (Hauser, 1982).The primary worry of urban land use planning is the distribution of suitable sites for the fitting area employments.

It is the crucial work and the vital substance of general land utilize planning, which requires a scientific approach, in expansion to guide advancement, avoidance of mistakes in decision making and over-venture, for economical usage of land assets. Most urban development falls outside formal planning controls, in this way expanding economic and social pressures and fueling health and cleanliness issues. In the arrangement of environmentally compatible urban improvement plan it is an essential to comprehend linkages and communications that exist between various segments of the urban environment. Furthermore, the information gathered on various parts of the urban environment needs to be interpreted into helpful data with the end goal of urban development. There is likewise a need to total this data as indicated by managerial/characteristic and various leveled units (Das, 2013). Fundamental necessity for this is the accessibility of systematic, detailed, reliable, timely and precise information on different features of urban environment (Bhavana.N, 2013).

Urban planning should concern the utilization of land and plan of the urban environment, counting air and water and infrastructure going into and out of urban areas with it. Planning is a generally acknowledged approach to handle complex issues of assets designation and decision making. It includes the utilization of aggregate insight and foreknowledge to outline direction, arrange harmony and gain ground in public movement identifying with human environment and general welfare. With a specific end goal to give more powerful and important direction for better planning and advancement important support of the organization has gotten to be crucial. Consequently, the requirement for a reasonable data framework is progressively being felt in all planning and developmental activities, whether these are for urban or rural areas. (Harris, B., 1990). The modern technology of remote sensing which incorporates both aerial and additionally satellite based systems, permit us to gather lot of physical data rather effectively, with speed and on redundant premise, and together with GIS helps us to analyze the information spatially, offering potential outcomes of producing different alternatives (modeling), consequently optimizing the entire planning process.

2.2. Urban Development Planning Exercise in Ethiopia

It was just in the late 1950's that Ethiopia initially begun offering regard for urban development planning by defining suitable advancement techniques (Kassaye S. , 1999). This implies the historical background of urban development planning in Ethiopia can be assessed to be just one half a century old. The emphasis at that time was to a great extent on the issue of land utilize control. A progression of three unique sorts of 5-year plans were set up somewhere around 1958 and 1974. The center of these plans in general was improvement of infrastructure, development of agriculture and manufacturing industry, and amplification of development and achievement of better standard of life (Kassaye, 1999). In 1964 the principal huge planning project with the point of preparing master plan for forty towns of the country was initiated and finished in 1967. The responsible government arm was Ministry of Interior and the agreement was given to three Italian Companies. Later the improvement and planning part of the urban sector was taken care of by the Ministry of Urban Development and Housing, which was set up through proclamation No. 126/1977. The different plans prepared, notwithstanding, were not responsive of course due predominantly to lack of integration of the different parts of urban development planning, (for example, social, economic, cultural and physical concerns of the towns).

Disregard of the interactions of the towns with their comparing quick hinterlands was likewise vital factor. As urban issues in the country got more and more complex, the worry of the government and the significance of having sound urban planning practice got to be eminent. To that end, the Military Government of Ethiopia set up the present National Urban Planning Institute in 1987 (PMGE, 1987). The proclamation enables the institute: to get ready distinctive sorts of plans for towns and cities of the country in view of suitable study and research; to get ready plans for regional urbanization, and urban centers; and; to enroll the required labor fundamental for executing the previously mentioned obligations. The conventional planning power of the central government was decentralized to Regional and local authorities taking after government change in 1991.Regional governments have been offered power to prepare and implement urban plans under their jurisdiction. Be that as it may, for reasons connected with absence of proper technical manpower, and equipment's, regional governments would at present require specialized and different helps from the centeral government in preparing, monitoring and implementing urban development plans (Kassaye, 1999). The Ministry of Works and Urban Development has additionally the duty of socio economic studies identified with urban areas, preparing master plans for them and giving technical assistance to regional governments during implementation. This implies the fundamental on-screen characters occupied with urban development planning in Ethiopia are ministry of Construction and Urban Development, NUPI (Kassaye, 1999). and a few regional governments (to minor degree).

2.3. Current Planning Practice Undertaken by NUPI

NUPI, the main plan preparation agent of the government, has been utilizing three basic ways to deal with urban plan preparation (for different town of the country). The approaches incorporate master planning, development planning and action planning. In light of the planning practice received by NUPI, these essential planning sorts have much closeness in essence.

The separating highlights, however not sound, are identified with the time measurements the plans are relied upon to serve, the organization of the experts included, the extension and content the plan harp on. Right now, in any case, NUPI has totally deserted preparing master plans (Kiristos, 2001) for motivations to be cleared up in a matter of seconds. The basic traits of thes plan types are briefly discussed here below.

2.3.1. Master Plans

Basic attributes of and major activities involved in master plans include (Kiristos., 2001): embrace multidisciplinary planning team, involve production of maps with accompanying textual documents, specifying land use categories, road structure, and other physical standards, usually provide a city-level guidance for development activities; and provide long-term (a twenty-year) framework. Such plans, however, are subject to review every five year (though this has been done for no town by NUPI). According to (Kiristos, 2001), NUPI has terminated (as mentioned a bit earlier) preparing master plans merely in favor of shorter plans apparently to facilitate investment and settlement programs across centers in the country. He further identified some drawbacks related to master plans. These include; taking longer time to prepare, lacking estimate of cost of development; assumptions are not based on realistic evaluations of economic potentials and likely population growth. Generally characterized by longer time perspective, and proposals are aimed at being implemented over longer time period. This makes the plans rather rigid and inflexible to the extent that it would be difficult to control socio-economic dynamics.

2.3.2. Development Plans

Development Plans are medium-term plans intended as an attempt to alleviate the drawbacks inherited in master plans. They are more detailed and relatively more efficient (i.e., in NUPI's context) than master plans. Development plans focus on areas which should be developed and redeveloped. Specifically, they define the sites of proposed roads, buildings and open spaces, allocate land for agricultural, industrial and other uses. They also provide the ground for development coordination.

Their drawbacks incorporate the level of detail they propose and definition of broad strategies inherited from master plans (Kiristos, 2001). Development plans are not merely implemented immediately once prepared. Instead, NUPI applies further division upon them, resulting in three distinct components. These are district, action area and subject plans that are intended to serve as implementation tools within a broader framework of a city wide structure.

2.4. The Role of GIS and Remote Sensing in site selection

These days, remote sensing (RS) and geographic information system (GIS) are two important techniques for information gathering and managing, and they have been generally utilized in broad scope of geo-location-related studies. GIS is a computer based system and manages geographic issues, and geospatial data is utilized to analyze in this system (data with its location information, for example, longitude, latitude, height).

AGIS system has a full procedure from gathering data, handling information and visualization. Along with them, lots of new techniques are being quickly created to fulfill the necessities of scientific projects. A long with these new methods, multi-criteria analysis (MCA) is one of the best techniques for leaders to a systematic and scientific decision after considering various factors derived from abundant geospatial data (Roesenberger and Strager , 2006). Choosing an optimal facility location is a multi-criteria decision method, which has been generally utilized in both private and public organizations, with a specific end goal to pick the optimal location and relocate operation sites (Yang and Lee, 1997).Due to the contribution of GIS technology, various types of factors can be considered when decided to make a project work.

Natural factors and humancoused factors are two principle parts of factor compensation, which could make the model more efficient and precise. Furthermore, along with the advancement of GIS technology, multi-criteria analysis (MCA) is turning out to be increasingly popular in GIS processing for designing models (Tims, 2009). Multicriteria analysis is a sort of technology used to make decisions, and those decisions are generally influenced by complex factors.

Multicriteria analysis is regularly utilized as a part of huge projects where the decision makers have numerous choices or criteria to consider, and the result might be altogether different depending how the criteria are assessed. The point is to weight different criteria against each other and combine them so that the best possible solution can be discovered. Many studies have utilized GIS-based multi-criteria analysis for site selection. For site selection, in light of various geographic components, GIS could do works like integration, visualization, management and analysis, it could discover useful information from a large amount of data; it is an important tool for optimal site selection and common decision making (Cheng et al, 2007). In 1997, Gordon and his colleague were using GIS technique to choose the location of public health service (Womersley and Gordon, 1997).

Hare and Barcus were used the geographical distributions of heart-related hospitals along with travel times to figure out the accessibility of heart-related hospitals in Kentucky (Hare and Barcus, 2007). In 2008, an investigation of selecting optimal site for the supermarket has been done. In this study, it discussed the fundamental factors influencing the supermarket location and the methods for deciding the location. In the study, geographic information system (GIS) as investigation platform for analysis and neural network analysis is additionally introduced in this study (Wei et al, 2008). A study presented by (Chuvieco and Congalton, 1989). In their study, GIS and remote sensing are used to develop a forest fire hazard map of a small area in Spain. In their study, they got high resolution satellite images from Landsat TM to classify vegetation and some other objects. There are five influencing factors considered in the study, they are vegetation species, elevation, slope, aspect and roads. The rank order according to the significance of the factors vegetation, slope, aspect, proximity to roads and elevation (Chuvieco and Congalton , 1989). From this study they can say that vegetation species is a critical influencing factor for optimal site selection. GIS-based site selection have been widely used recently in China. In 2009, (Gao and Qiu, 2009) did a research of siting evaluation of resort areas in Nan Kun mountain. Seven factors were considered in the study, they are national policy and local planning, slope, climate, aspect, transportation and vegetation coverage, they are analyzed and weighted, the result perfect location for resort areas.

(Church, 2002), describes tha more site selection application will be performed in the future and the relationship with GIS will be closer. This conclusion based on the specialization of GIS technology, the spatial data collection, process. More over these functions, GIS software supports spatial data analysis, which could be applied in many traditional location selection analysis.

For instance, GIS visualization could simplify massive data and realize communications between project target and decision makers demands. Along these lines the decision makers could easily to make a reasonable and scientific decision (Hernandez, 2007). Another case relies upon the powerful graphic representation of GIS technology, along with efficient data organization and mass spatial data analysis, GIS-based technology plays a very important role in optimal commercial facility site selection.

More cases are done by GIS based technology make GIS become one of the most popular visualization platform site selection studies (Wei et al , 2008) As said above, both remote sensing and GIS techniques are perfect tools for site selection and land use by managing them in an accurate and efficient way.

The advantage of using GIS-based MCA is that it is an open and resettable analysis process. The weights can be changed by the time in different situations, and determine of weights is changeable during different situations as well. The more important purpose behind using MCA to do the optimal site selection is the result can be directly used for making decision in the next researches or upcoming cases.

2.5. Abattoirs as Important Urban Functions

2.5.1. Basic Features

In spite of the fact that not accomplished by all, the real exercises required in the operation of an abattoir are: receiving and holding of domesticated animals; butcher and carcass dressing of animals; chilling of carcass products; carcass boning and packaging; solidifying of completed body and cartooned products; rendering processes; drying of skins; treatment of wastewater; and transport of processed materials. A definitive reason or significance of building up abattoirs is, in this manner, (LMA, 2000) to give cleaner and hygienic animal butchering services; to guarantee appropriate use of animal by-products including hide, skin, horns, bones; to build up what's more, control principles, and to create income for the service's rendered; and to improve effect on the environment by controlling the waste disposal system.

2.5.2. Environmental Problems Associated with Abattoirs

The characteristics of abattoirs are such that they can pose serious problems to environment unless these problems are enough valued and proper measures are taken. The issue could be examined regarding liquid wastes, solid wastes, airborne wastes, disease and noise (EPA, 2002).

Liquid Wastes: One essential attribute of abattoirs, in addition to other things, is that they consume expansive amount of water in their animal processing operation mostly for hygienic reasons. Such circumstance creates expansive amount of wastewater which must be dealt with.

In general, the impact of liquid wastes could be clarified as far as effluent salinity and wastewater and in addition storm water qualities.

Effluent Salinity: Effluent created from dry salting skin protection technique is exceedingly saline, has a high biochemical oxygen demand. It contains large amounts of fluoride. This may prompt salinity issues if the emanating is utilized for irrigation, furthermore to fluorosis issues with vegetation.

Wastewater: Wastewater created in animal butcher areas commonly has a high biochemical oxygen request. It is additionally very saline and has high level of nutrients, suspended solids and bacterial pollution.

Storm water: There is a possibility for storm water to get contaminated when it comes into contact with animal holding pens, sludge, store and treated wastewater irrigation area. This contaminated storm water can have hindering environmental impacts on the surrounding ecosystem.

Solid wastes: Solid wastes produced from inside an abattoir may have distinctive sources Counting animal holding areas, slaughterhouse and processing areas, waste treatment plant, unwanted hide or skin and pieces, and unwanted carcass and carcass parts.

Airborne wastes: Airborne wastes can refer to smells, tidies (dusts) and fuel burning outflows.

Smells: potential wellsprings of disagreeable odors in abattoir operation comprise of the rendering process, water effluent treatment plants, slaughterhouses, product storage and handling areas, material drying areas, waste disposal techniques, for example, burning dead stock, animal holding pens, domesticated animals transport vehicles, holding of carcass before transfer, odors from skin taking care of and smells from skin sheds.

Dusts: potential source of dusts emissions at an abattoir incorporate unsealed roads, enclosures, deal yards and holding pens, stockpiled products and materials, and construction activities.

Fuel burning emissions: Fuel burning prompts air emanations. Materials burned at an abattoir fuse coal or gas fuel for boilers and steam generation, unhealthy animals, sludge, packaging and unusable skins.

Noise: In an abattoir noise can be produced from various sources including animals, processing activity inside the slaughterhouse, plant machinery, and service vehicles.

2.5.3. Utilities for Abattoirs

New sites for abattoirs are typically situated on empty undeveloped area. In such cases, it is essential that the vital infrastructure, facilities and utilities are accommodated the best possible working of an abattoir. The discussion beneath depends on the guideline provided by (LMA, 2000).

Water Supply: as already discussed, the different operations happening in an abattoir include the utilization of extensive amount of water. More often than not such water requirements are fulfilled from the corresponding municipal town's water supply system. In any case, where such water supply system is insufficient or absent, deep wells should be borehole.

Power Supply: Among different things, laboratory activities are conducted in an abattoir. In arrange for the laboratory to give consistent services, there ought not to be an interruptible electric supply. For meat examination, the intensity of the light ought to be 540 lux and in other working spots it could be 220 lux or 110 lux relying upon the circumstance.

Road Accessibility: Access roads to abattoirs ought to be at least compacted gravel road according to the Ethiopian Road Authorities road standard. The arrangement of such facility, obviously, relies on upon the budgetary limit of the corresponding municipality.

Waste disposal and Drainage Systems: It is prescribed that for effective waste transfer and waste system, the topography of the abattoir site preferably be gentle slope.

2.5.4. Planning Issues

Investigations of the circumstances and effects of soil, water, and air pollution and noise nuisance and hazard reveal progressively that the land use planning should play an important role in the prevention of pollution. Practically every pollution issue has both a spatial and a temporal dimension. Along these lines, suitable land use planning, considering the prevention and arrangement of environmental issues is fundamental. To the extent abattoirs are concerned, land utilize planning could help, in addition to other things, in assigning proper sites and provision of buffer zones. Site selection is the basic Environmental issue for abattoirs (EPA, 2002). As can be noted like most spatial decision making issues, the land allocation issue connected with abattoirs is multi-criteria in nature, including financial, social, environmental and, political measurements. To make things clear, the site characteristics for an abattoir are assessed in light of different suitability viewpoints including:

Planning suitability: this refers to whether a site is appropriate and suitable for the expected land use. The information required for assessment join site capacity, present land use, planned land use (zoning and restriction), possession/land control, and environmental effect.

Physical suitability: this identifies with the physical qualities that impact the suitability of the site for development. Information are required on general topography, slope, flood hazard, and so on.

Infrastructural suitability: this is connected with the existing and supplementary physical infrastructures that are vital for the best functioning of the abattoir and incorporate get to road, electric power and water supplies.

Locational suitability: this refers to the separation from the expected site to certain geographic elements, for example, rivers/streams, residences, high tension electric lines, air terminals etc.

Financial suitability: this identifies with the money related results of development of the site. Important information contain obtaining and compensation costs, site development cost, and so forth.

2.5.5. Application of Multi-Criteria Decision Making

One of the great issues in decision hypothesis or multi-parameter is the determination of the relative significance (weights) of each parameter concerning the other. This is an issue which requires human judgment supplemented by mathematical tools. Finding a satisfactory area for urban infrastructure is one of the essential subjects in urban development planning. To express the significance of this subject for instance, management and finding location for urban infrastructure precisely such as slaughterhouses, are considered as one of the fundamental pillars of sustainable development (Krizek et al, 1996). The integration of MCDM technique with GIS has impressively advanced the conventional map overlay ways to deal with the land-use suitability analysis (Malczewski, 1999). GIS-based MCDA can be considered as a procedure that combines and changes spatial data into a resultant decision (output).

The MCDM procedure (or decision rule) characterize a relationship between the input maps and the output map. The techniques include the utilization of geographical data, the decision maker's preferences and the manipulation of the data and preferences as indicated by specified decision rule. Appropriately, two considerations are of basic significance for MCDA: The GIS capabilities of data acquisition, storage, retrieval, manipulation and analysis, and the MCDM capabilities for combining the geographical data and the decision maker's preferences into multi-dimensional values of alternative decisions. Various multi- criteria decision rules have been implemented in the GIS environment for handling land-use suitability problems.

2.5.6. Abattoir Site Selection Criteria

Site selection requires thought of an exhaustive arrangement of factors and adjusting of different objectives in deciding the suitability of a specific area for a characterized land use. The selection of abattoir site includes a complex array of critical factors drawing from physical, demographical, economic, policies, and environmental disciplines (Collins et al, 2001).

The current spatial decision making could profit by more efficient strategies for taking care of multi-criteria problems while considering the physical suitability conditions. Traditional decision support technique do not have the capacity to simultaneously consider these viewpoints.

Suitability strategies decision makers and environmental managers to analyze the collaborations among locations, development activities and environmental components. This empowers investigators to outline interactions in various ways (Collins et al, 2001).The process for land-use suitability investigation includes evaluation and grouping of particular areas of land in terms of their suitability for a defined use.

2.5.7. Land use and land cover

The differences of the types of land use suitability studies can be credited to the diverse ways the term land use is characterized by different applications and the context of its utilization. For instance, it is likely that the urban planners and the agricultural specialists would have different view of the term. To this end, it is essential to make refinement between two thoughts; land use and land cover (Malczewski, 2004).

Broadly speaking land cover describes the physical state of the earth’s surface and immediate subsurface in terms of the natural environment, (for example, vegetation, soils, and surfaces and ground water) and the man-made structures (e.g. buildings). Besides, the term land use may have distinctive connotations relying upon the spatial scale. At the large scales it is regularly considered as a resource and subsequently land use implies resource use. Conversely, at the urban scale it is characterized as far as the potential utilization of the land’s surface for the location of different activities (Chapin and Kaiser , 1979).This essence of the term land use is understood with regards to urban and regional planning.

The description of land use, at a given spatial level and for a given area, usually includes indicating the mix of land use types, the specific pattern of these land use types, the areal extent and intensity of utilization connected with each types. One of the the most valuable application of GIS for planning and management is the land use Suitability mapping and analysis. Land use suitability analysis goes for identifying the most suitable spatial pattern for future land use as per determined necessities, preferences, or indicators of some activity (Collins et al, 2001).

2.5.8 Topography

Topography depicts the surface shape and relief of the land. It refers to different landforms (Physical features) which represent to the external shape of the earth. It determines the pattern Furthermore, type of numerous other landform and land cover features. Moreover, elevation and slope should be considered when selecting site for abattoir construction project.

Elevation: To assess the nature and element of an area making the landscape what areas are appropriate for the determination of abattoir site. It is important to consider the position, angle and stage. As indicated by (Fard et al, 2012); abattoirs could be constructed in area lower than the city level to keep the spread of contamination. The elevation classes are evaluated based on the basis of suitability of landscape for urban land use allocation.

Slope: Slope is a vital criteria in hilly landscape for finding suitable sites for urban development. Slope is connected with building cost. Building the abattoir is less expensive on low slope. The slope also closely related to surface drainage characteristics of the site. Desirable slope for abattoir site is recommended to be gently sloping area (LMA, 2000), which ranges from 2 to 10 percent. Slope values less than 2 percent are not reasonable from safe drainage point of view.

Surface water

Waste water from abattoir is one of the significant source of pollution in river. An extensive amount of water is utilized in abattoir operations. If released to controlled waters it will have an ecological effect by righteousness of volume and quality water run off Pollution and subsequent damage of watercourses. Surface water quality could be influenced by various factors during abattoir operations (EPA, 2002). Animals will store significant amount of dung and urine during unloading and storage, with the danger of consequent wash-off into storm drains or local watercourses. Correspondingly, by-products, for example, blood and stomach contents pose risk to surface water if not properly contained.

Abattoir site must not be situated in close proximity to surface water (streams, rivers, lakes, and ocean). In order to avoid possible contamination of river or stream and to keep the abattoir from being overflowed, the site should not lie within 200 meters of rivers or streams.

Proneness to continuous flooding, acquires extra cost as well as influences the sanitary condition, both inside the abattoir compound and the downstream localities. Besides, if abattoirs are built close to rivers, septic tanks (if not appropriately lined) may get filled with ground water and ground water pollution may happen, too.

The criterion is important from the point of view of both environmental and economic concerns because in addition to causing pollution problems, it may require an efficient drainage system with high expenses (Gemitzi et al, 2007) used minimum of 200 m buffer distance for site selection of abattoir.

Roads: Roads refers to any transportation facility. It is likewise a critical criteria in site suitability analysis. The need to transport processed meat, remains, slaughter animals, and so on is subject to the nearness to transportation facility. It is fundamental that the site should be in nearness to a transport facility, all together that at least one sidings might be obtained for bringing animal to the abattoir, to encourage the work of sending away the meat, manure, and so forth. (Ayling, 1908). Besides, keeping in mind the end goal to discover better accessibility to the existing road, buffer zones have been made by taking distances between 20 and 400 meter distance from the existing major road to produce accessibility map (LMA, 2000).

2.5.9. Environmental Constraints

These are criteria that constrain, or limit the areas for abattoir site. For this situation, the constraints separate areas, or options that one can consider appropriate for the area of abattoir site, or options that are not appropriate. They characterize areas or choices regarding a consistent measure of suitability and in actuality improve or take away from the choices under thought outside the areas that have been constrained. There are numerous more criteria/limitations that can be included into the assessment of suitable site for the location of abattoir. Some these are mentioned here: power sources, social services, industrial areas, ground wells, and so forth.Along these lines, buffer zones are especially vital as measures to isolate conflicting land uses and to minimize any harmful impacts of new developments in environmentally sensitive areas. Sufficient buffer distances from nearby land uses are the best way of avoiding these problems.

High tension lines: These are power transmission lines. In order to avoid possible accidents that could be encountered as because of big flying birds (e.g. scavengers) floating over the abattoir, the site should be located at least 500 meters from high tension lines.

Industrial areas: To minimize the effect of neighborhood activities upon the abattoir, polluting industries are considered especially, dust and smoke emitting industries can create chemical and other type of pollution. Abattoir should be situated at least 300 meters from dust emitting industries.

Hydro wells: Wells are facilities required by the abattoir in the event that the water supply of the town is not sufficient and they are likewise spatial substances subject to contamination if located close to the abattoir.

As per (LMA, 2000), on average, a 300-meter distance should be kept between an abattoir and boreholes with a specific end goal to shield them from being contaminated through ground water stream.

Social services: In order to avoid the disturbance of sounds generated from the abattoir the site should be located at least 300 meters from social services (health services, schools, worship places and recreational areas).

Ideally, for site selecting of a slaughterhouse there are no fixed and defined standards in any case, for a large portion of the variables used in the given study, reliable reasons could be found that due to environmental constraints and capability of every area returning of that criteria is a top priority (Fard et al, 2012). In order to locate an appropriate site as a preliminary and starting guideline, the following articles could be followed:

Location in respect to the city: The site location should be inside of the city limit. In addition site selecting must not be on the way of the city development.

Distance to the city: The legal separation from an large slaughterhouse to a town border is around 6 km, for a moderate size one is 3km and for small ones is considered 2 Km.

The position in relation to communication road: The site could be situated close to one of the arterial roads or broad link to the arterial road.

In urban areas that are situated on the railroad track, it is more accurate to choose a place for slaughterhouse close to the railroad and if possible make a branch line to be observed.

Prevailing winds: It must not situate on the way of prevailing wind. This may reduce the diffusion of bad smell into the city. The wind direction was considered regarding the prevailing local winds.

The emphasis is on easing conceivable negative effects that the abattoir can pose on the surrounding environment and the vice versa.

Agricultural /Vacant land use: The site should preferably lie on agricultural/empty land use for the purpose of reducing site acquisition cost.

Future land use: The suitability of candidate site for abattoir will at last be assessed taking into account the future expected land utilization of the area.

Required water: It should be developed in area which in the required water can be accessible. Because of high utilization of water, tap water is not recommended. In this task drilling deep or semi-deep wells are favorable.

Location of polluting industries: Slaughterhouse should not be exposed to pollution from industrial operations, dusts, smoke, ash, and so on.

Access to electricity network: In the terms of the necessity of a slaughterhouse to electricity, site selection must be located in a place that the power network is legally permissible. In large Slaughterhouses the required power could be set up by the utilization of a generator rather than power network but it is not suggested except in emergencies.

An unsuitable area that has potential for reasonable action could bring about numerous environmental, social and economic damages. Consequently, it is essential that in the development and operation of urban areas, environment management and nature preservation be given priority. Accordingly, site selection is a basic environmental issue for abattoirs. Careful site selection can greatly reduce the natural nuisance. Significant site information should included; the closeness to existing and future housing developments, and to land zoned to allow housing or other land uses not compatible with the proposed development; the site hydrology, site drainage and closeness to water courses and groundwater resources used for domestic, agricultural or town water supply, the prevailing wind conditions; the landform and the likely direction of drift of smell or effects of noise, the sufficiency of the land area to house all projected activities, the erosion hazard, the local road network, social services corridors for power and other services; and suitability of the site for possible land disposal (GDARD, 1999).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location of the study area

Shashemene was founded in 1903 E.C accordingly for the sake of south east trade movement along the town. It is the largest city of West Arsi Zone of Oromia Regional State, with area of 10408ha. Geographically the town is located at 7^0 08’ 50’’ to 7^0 18’ 17’’latitudes and 38^0 32’43’’to 38^0 40’58’’ longitudes, with an elevation ranging from 1845- 2053 m above msl and found at 250 km South West of Addis Ababa the capital city of Ethiopia (Figure 3.1). Presently the town has 33 administrational offices and 7 kebeles having vast population. Eventually, the town is growing more in political leading aspect, social strength and economical developments.

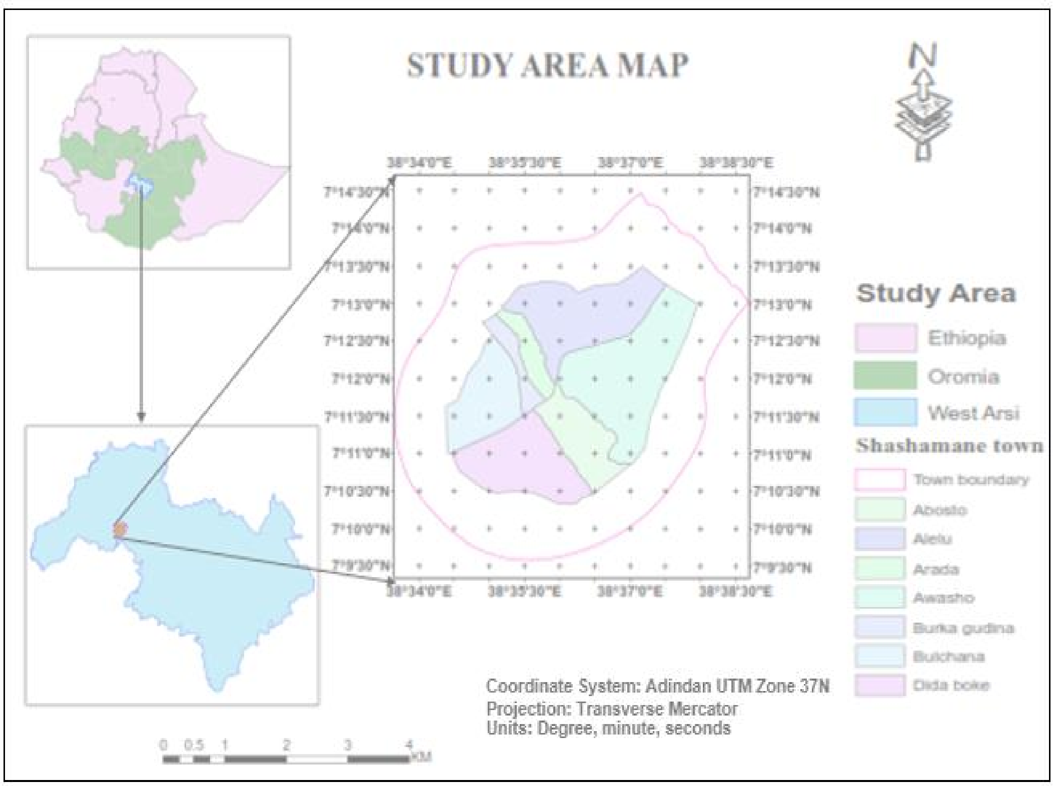

Figure 3.1: Location map of study area

3.1.2. Establishment of the city

Shashemene was established in 1903 E.C. Shashemene has been the focus of investments both at the national and regional levels. Investment in industry, trade and hotel tourism, construction and social services constituted the largest shares. Due to the comparative advantage the city has potential for economic growth in these and other sectors including administration, commerce and agriculture. The city has an extensive expansion area in all directions of the existing boundary of the city, (Ababu, 1997).The population and demographic characteristics of the city showed that the population has been growing at high rate, the current population of the city (2007 E.C) is 238,310 and its population density is 42.4 people per sq.km

3.1.3. Climate

The climate in Shashamanne is characterized by the average maximum and minimum temperature of 24.3°C in May and 7.5°C in December, respectively. The average annual rainfall in Shashamanne amounts to 1200mm. The main wet season takes place from June to September, causing about 70% of annual rainfall with the highest peak in August. Another small peak of rainfall is observed in April (OUPI, 2010).

3.1.4. Topography

Shashamanne extends to the south-eastern escarpment of the Rift Valley. The town is located on a plateau with an elevation ranging from 1,845 to 2053 meters a.m.s. The mountain ridge in the south-east of the town is called Abaro ridge. The urbanized area of the town is slightly dissected by numerous valleys formed by the three major river systems crossing the city from south-east to north-west. Some of the general physical characteristics of the study area, the slope of the area ranges from 0 (Flat) to 26 (steep) degrees (OUPI, 2010).

3.1.5 Socio-economic Characteristics

Being one of the major centers of conurbation in the southern Oromia, and a hub for commercial activities, the town has significant economic importance. The majority of the land use pattern consists of built-up areas (residential, industrial, commercial, institutional, recreation area, road, infrastructure, and utilities) and non-built (agriculture, forest, bare land, and water bodies). As far as the establishment history of the town is concerned, Shashamanne was formally founded as an urban settlement in 1915.

The town, which began with small trade during this period, gradually developed into a big commercial center as communication and transport net-works expanded. According to a document from the municipality, the town of Shashamanne first attained the municipal function in 1943, which was followed by the first developmental plan introduced in 1950. The second master-plan for the town was carried out in 1961/62. However, both the former and the latter plans were not implemented due respectively to the unavailability at the town level, and incompleteness of the plan itself. Therefore, the complete master plan for the town only began to be implemented in 1967, as to (OUPI, 2010).

3.2. RESEARCH METHODOLOGY

3.2.1. Data Acquisition

This study focuses on site suitability analysis for abattoir in Shashamane town using GIS based multi-criteria decision support techniques. Firstly, the primary data were generated from satellite image, and aerial photographs .The secondary data were gathered from municipality which includes; boundary maps, the demographic and socio-economic figures, which are based on the population census of 2007. In addition, Ethiopian mapping agency, and online searching are also contacted for the collection of necessary information and literatures. Moreover Table below clarifies sources of data with their format.

Table 3.1: List of data used and their original source

Data	Data source	Purpose
Landsat image of 2016(30m)	Usgs.gov	LULC classification
ASTER DEM (30m)	Jpl.Nasa.gov	To derive slope and elevation
Aerial photograph(15*15 cm)	Shashamane municipality	For digitization of roads
Topographic map(1:50000)	EMA	To extract point datas
Boundary map	Shashemene municipality	To delineate the study area

3.2.2. Software used in the Analysis

The thematic maps were prepared, edited, overlaid and visualized on the basis of the site suitability analysis for abattoir using ArcGIS 10 software of ESRI. The application of GIS for overlaying thematic layers to establish land databases requires that all the layer maps need to be converted into a common coordinate system.

ArcGIS 10 concurrent use with spatial analyst extension was used for geo-referencing Topographic maps, proximity analysis and producing maps and graphics. It was also used for statistical manipulation and report generation. ERDAS Imagine 2014 was used to classify land use/cover map of the study area and IDRISI 32 used for weight derivation. Other soft-wares used in this research include Microsoft Internet, word, Excel.

3.3. METHODS

3.3.1. Research Geo-Database Design

Urban land use, elevation, slope, road, streams, high tension lines, social services, boreholes, industrial area and existing abattoir were stored in the geo-database in order to store the collected data and the analysis results in a logical arrangement. The factors involved were examined according to their relative importance towards designating areas of high suitability classes and assigned weights. The classes in each factor layers were also compared one another and ranked by their contribution to the output. The collected data were automated (digitized, and clipped by the study area boundary) and organized into logical groupings of the factors. The factor layers were grouped into five according to their nature as:

- Urban land use factors: built-up area, waterbodies,Forest, Agricultural land and bare lands
- Topographical: elevation, slope
- Accessibility: distance from major roads
- Surface water: streams/rivers
- Constraints: location in terms of the distance, high tension lines, social services, boreholes, Industrial area and existing abattoirs,streams.The research geo-database was then designed to include the input datasets, their derived datasets, the weighted analysis maps, and the final result.The vector files were exported to the Corresponding feature data sets and the raster files were exported as individual raster datasets in the geo-database.

The coordinate system selected to be used for analysis was projected coordinate system, UTM. Thus, the geo-database was set to this spatial reference and all the maps were projected to it while exporting to geo-database.

3.3.2. Spatial Multi-Criteria Decision Making (MCDM)

The main objective of this research is using spatial Multi-Criteria Decision Making (MCDM) Approach integrated with Geographic Information System (GIS) techniques in order to determine suitable site for abattoir. Spatial Multi-Criteria Decision Making (MCDM) is a process that combines and transforms geographical data into a decision (Malczewski, 1999) MCDM, combined with GIS data, is a powerful approach to systematically and comprehensively analyze a problem. The fundamental components of a multi-criteria problem are human value judgment and assessments of the importance of criteria. The main purpose of the multi-criteria evaluation techniques is to investigate a number of alternatives in the light of multiple criteria and conflicting objectives (Malczewski, 1999).

3.3.3. Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is a widely used method in MCDM and was introduced by (Saaty, 1980). It is easily implemented as one of the MCDM techniques. AHP is adecision support tool, which can be used to solve complex decision problems. It uses a multilevel hierarchical structure of objectives, criteria, sub criteria and alternatives.AHP uses fundamental scale of absolute numbers to express individual preferences or judgment below this scale consists of nine points(Table3.2).

In general, nine objects are the most which an individual can simultaneously compare and consistently rank. The score of differential scoring assumes that the row criterion is of equal or greater importance than the column criterion. The reciprocal values (1/3, 1/5, 1/7, 1/9) have been used where the row criterion is less important than the column criterion. To ensure the credibility of the relative significance used, AHP also provides measures to determine inconsistency of judgments mathematically. Based on the properties of reciprocal matrices, the consistency ratio (CR) can be calculated. CR <0.1 indicates that level of consistency in the pair wise comparison is acceptable. Saaty (1980) Suggests that if CR is smaller than 0.10, then the degree of consistency is fairly acceptable. But if it is larger than 0.10, then there are inconsistencies in the evaluation process, and AHP method may not yield meaningful results.

Table 3.2: The preference scale for pair wise comparison in AHP

Intensity of importance	Definition
1	Equal importance- two activities contribute equally to the objective.
3	Moderate importance- Experience and judgment slightly favour one activity over another.
5	Essential or strong importance- Experience and judgments strongly favour one activity over another
7	Very strong / demonstrated importance-An activity is strongly favoured and its dominance is demonstrated in practice
9	Extreme importance- The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	intermediate values between the two adjacent judgments when the above numbers compromise is needed
1/2,1/3,1/4,1/5,1/6,1/7, 1/8,1/9	Reciprocal values of the previous appreciation

Source: Adopted from (Saaty, 1980)

3.3.4. Weighted Linear Combination

The weighted linear combination (WLC) approach is the most commonly used GIS-based decision rules technique (Hopkins, 1977). One of its most common applications is to solve land use suitability analysisand site selection, WLC, otherwise known as weighting, is based on the concept of a weighted average in which continuous criteria are standardized to a common numeric range, and then combined using a weighted average. The decision maker determines and assigns the weights of relative importance directly to each attribute map layer. The total score for each alternative is the product of the importance weight assigned to each attribute multiplied by the scaled value given for that attribute to the alternative and then summing the products over all attributes. The scores are calculated for all of the alternatives. The one chosen is that with the highest overall score.

The method can be executed using any GIS system with overlay capabilities.The use of the method allows the evaluation criterion map layers to be combined in order to determine the resulting composite map layer. Both raster and vector GIS environments can be used to implement this technique. With the weighted linear combination, factors are combined by first applying a weight to each factor, followed by a summation of the results to yield a suitability map:

$$S = \sum wi\, xi$$

Where S is suitability, wi is weight of factor i, and xi is the criterion score of factor i. This method is highly popular mainly due to the ease associated with its Implementation within the GIS environment using map algebra operations and cartographic modeling (Tomlin, 1990). The method is intuitive, simple to comprehend and thus appealing to decision makers.

3.4. Conceptual framework and flowchart of the analysis

There were four important steps to produce site suitability map for abattoir. These are: (1) Finding suitable factors to be used in the analysis, (2) assigning factor priority, weight and class weight (ranking) to the parameters involved, (3) generating land suitability map of abattoir, and (4) determining suitable areas for abattoir. The details of the conceptual framework and each processing step are shown in (Figure 3.2). MCDA technique is applied to incorporate decision maker's judgment and preferences using the AHP method. This method includes the selection of the criteria for the spatial Multi-Criteria Evaluation (MCE) technique for the suitability analysis for abattoir. The final step involved in AHP is the aggregation of the relative weights obtained at each level of the hierarchy to calculate the suitability index. ArcGIS is used to combine the spatial data with suitability index so that a continuous land suitability map is generated. The output is a suitability map for abattoir site.

Figure 3.2 summarizes the overall methods, techniques and approaches used to carried out this study, so as to identify suitable site for Abattoir in the study area.

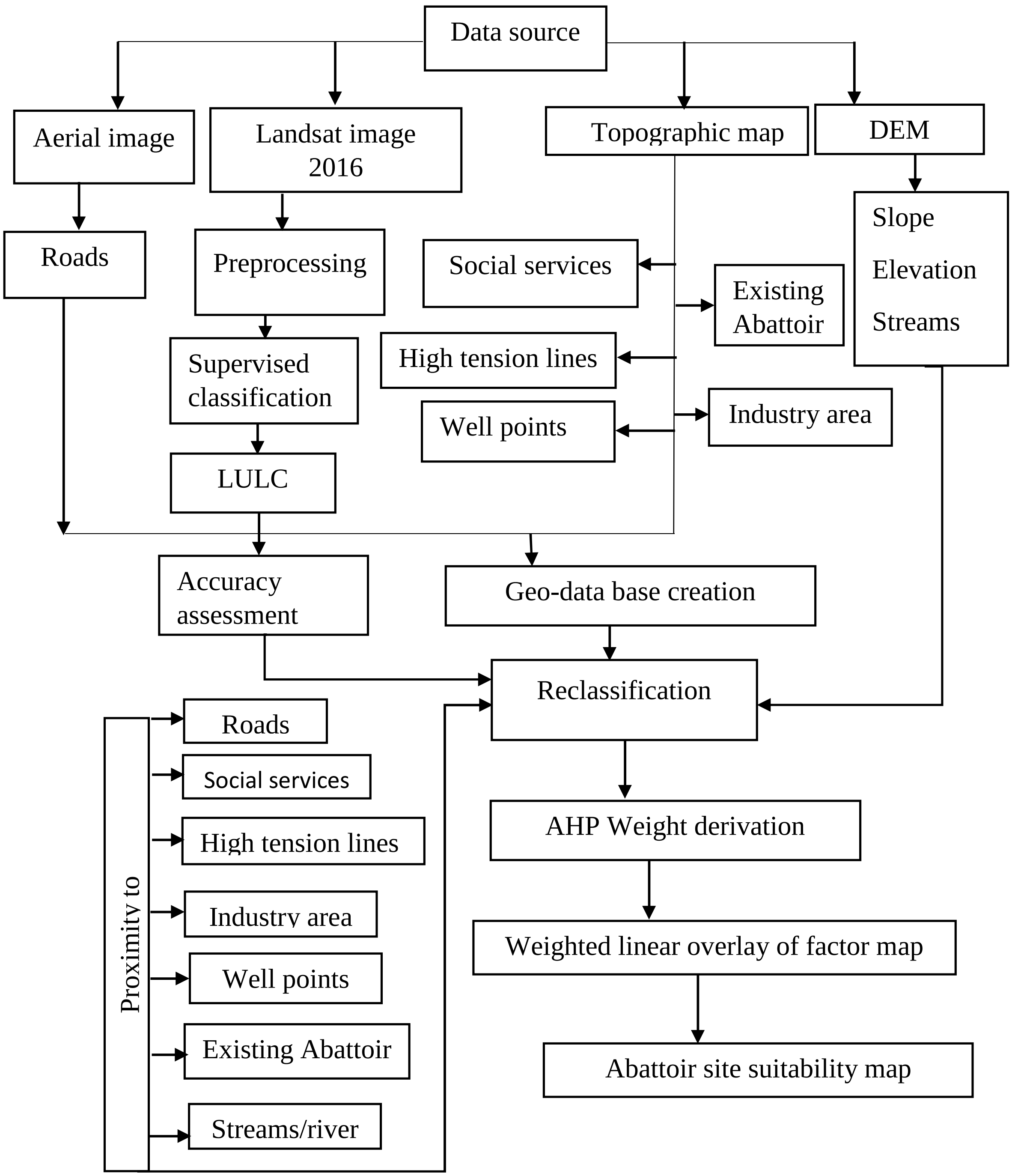

Figure: 3.2 General work flow of the study

CHAPTER FOUR

4. DATA ANALYSIS, RESULT AND DISCUSSION

This part discusses the determination of criteria and classification of factors for the selection of suitable abattoir site and the final results were also presented. The suitability of a site for an abattoir is influenced by the various characteristics of the site. However, each characteristic only reflects an aspect of the overall suitability for the specific land use. The area found suitable for abattoir might be preferable for the other urban land use. Several land uses may compete for the same site however the necessary choices are the subject of the overall urban development planning. A GIS-based spatial analyzing information system for suitable site selection criteria should be identified and integrated in to a GIS database in the form of map layers with associated attributes. The set of spatial analyzing information system criteria for abattoir site selection have been identified based on different literature reviews and relevant expert‘s opinion. Almost all the criteria identified are geographic in nature so that they reference a particular location.

4.1. Criteria Maps Generation and Classification

As a spatial decision making, site suitability analysis involves several steps or procedures. Among other things, identifying site selection criteria is a critical step. Table 4.1: Shows the criteria for site suitability of abattoir location (LMA, 2000). The criteria serve as a framework for better understanding of the various specific objectives and spatial entities involved in the overall suitable site designation process for abattoir. As can be noted the overall objective is todesignate suitable site for an abattoir. Towards fulfilling this objective, the following site selection criterias are considered.

Table 4.1: The criteria for site suitability of abattoir location

No	Spatial data	Layer name	Criteria
1	Road network	Road	Between 20 and 400m from the existing road
2	Slope	Slope	Between 2 to 10%
3	Elevation	Elevation	Lower level of the city
4	High tension line	HT line	500m away from HT lines
5	Rivers/streams	Rivers/streams	200m away from rivers
6	Bore holes	Bore holes	300m away from bore holes
7	Social services	Social services	300m away from social services
8	Industry area	Industry area	300m away from Industry
9	Bare land/agriculture	bareland/agriculture	Select bare land / agriculture land
10	Site capacity	Site capacity	greater than or equal to one hectare
11	Town boundary	Boundary	With in the municipal boundary

Source: Environmental protection agency, (LMA, 2000) and (MoARD, 2008)

4.2. Classification of Criteria Maps

The criteria discussed above can be summarized as constraints and factors. Constraints are those criteria that constrain, or limit the areas for abattoir site. In this case, the constraints differentiate areas, or alternatives that one can be considered suitable for abattoir site, or alternatives that are not suitable. Factors, however, are criteria that define some degree of suitability for all geographic areas. They define areas or alternatives in terms of a continuous measure of suitability and in fact enhance or detract from the alternatives under consideration outside the areas that have been constrained. Thus, therefore, all factors/constraints in the form of GIS-based layers incorporated for site suitability evaluation for abattoir. note that these factor maps were overlaid together for final suitability classification of the study area.

However, in this process the data of all the selected factors are kept, displayed, and managed individually. Because the factors have different scales of measurement; they cannot be compared by their raw scores. Therefore, in order to allow comparability, the factor maps were standardized. Standardization allows comparison of criterion scores within one alternative. In order to standardize, the raster features of all the factors were reclassified into a common scale range.

4.2.1. Urban land use/cover

The land use of the study area was classified using Landsat ETM+ acquired in 2016. Classified pixels were clustered into the following five general categories: built up lands, agricultural lands, forest lands, and water bodies(Fig 4.1). The classification of urban land use/cover involves evaluation and grouping of specific areas of land in terms of their suitability for a defined use. Then each of the land use/cover types was reclassified into 4 classes based on their importance to evaluate suitable site to locate abattoir for overlay analysis. These are Built up,water, bare lands, Agriculture land and Forest(Table4.3). According to national urban planning institute experience, bare lands and agricultural lands are more preferable for the location of abattoirs. This is mainly due to the low cost of construction for abattoir . Thus,barren lands are ranked as highly suitable, Agriculture lands are ranked as suitable, Forest are ranked as moderately suitable, built-up lands and water surfaces are ranked as un suitable. (Figure4.2).

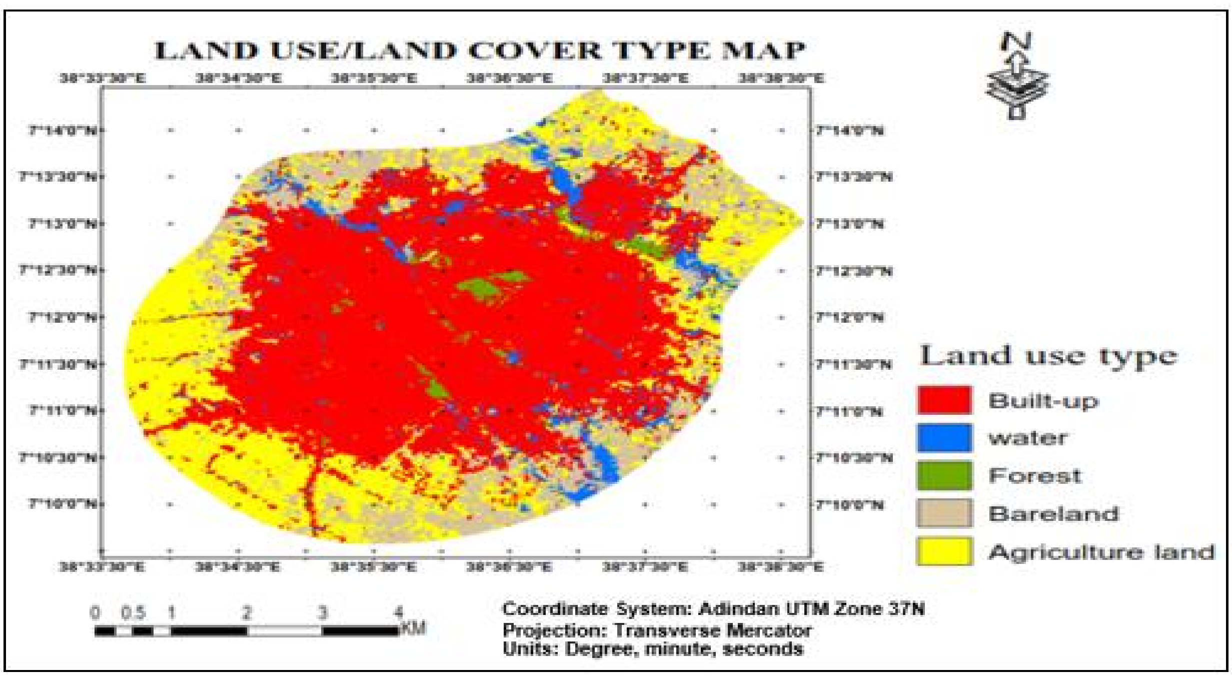

Figure 4.1: Major land use/cover types classified from landsat image

Accuracy Assessment

The accuracy assessment technique was made through a confusion or error matrix. A confusion matrix contains information about actual and predicted classifications done by a classification system. The pixel that has been categorized from the image was compared to the same site in the field. The result of an accuracy assessment typically provides the users with an overall accuracy of the map and the accuracy for each class in the map. Besides the overall accuracy, classification accuracy of individual classes was calculated in a similar manner. The two approaches are user's accuracy and producer's accuracy. The producer's accuracy is derived by dividing the number of correct pixels in one class divided by the total number of pixels as derived from reference data. In this study, the producer's accuracy measures how well a certain area has been classified. It includes the error of omission which refers to the proportion of observed features on the ground that is not classified in the map. Meanwhile, user‟s accuracy is computed by dividing the number of correctly classified pixels in each category by the total number of pixels that were classified in that category.

Table 4.2: Error matrix showing classification accuracy of the land cover

Class name	Total reference	Total classified	Correct Number of classified	Producers Accuracy	Users Accuracy
Built-up	54	58	54	100.00%	93.10%
Bare land	33	33	31	93.94%	93.94%
Agriculture	60	57	54	90.00%	94.74%
Water	1	1	1	100.00%	100.00%
Forest	14	13	13	92.86%	100.00%
Total	162	162	153		

Overall classification Accuracy = 94.44%, Overall Kappa Statistics = 0.944

Overall Accuracy

It is computed by dividing the total number of correctly classified pixels by the total number of reference pixels. It shows an overall result of the tabular error matrix. The overall accuracy performed in the study was 94.44% (Table 4.2). As stated by Anderson *et al*. (1976) for a reliable land cover classification, the minimum overall accuracy value computed from an error matrix should be 85%.

Therefore, the overall accuracy for the study land use/cover map was above 85% based on Anderson's criteria. The 2016 supervised classification with an overall accuracy of 94.44% was achieved with a Kappa coefficient (K) of 0.944. This value implies a strong agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy. Therefore, the K value of 0.944 represents a probable 94.44% better accuracy than if the classification resulted from a random assignment.

Table 4.3 Reclassified land use/land cover

Urban land use type	Value	Level of suitability
Built up/ water	1	Un suitable
Forest	2	Moderately suitable
Agricultural land	3	Suitable
Bare lands	4	Highly suitable

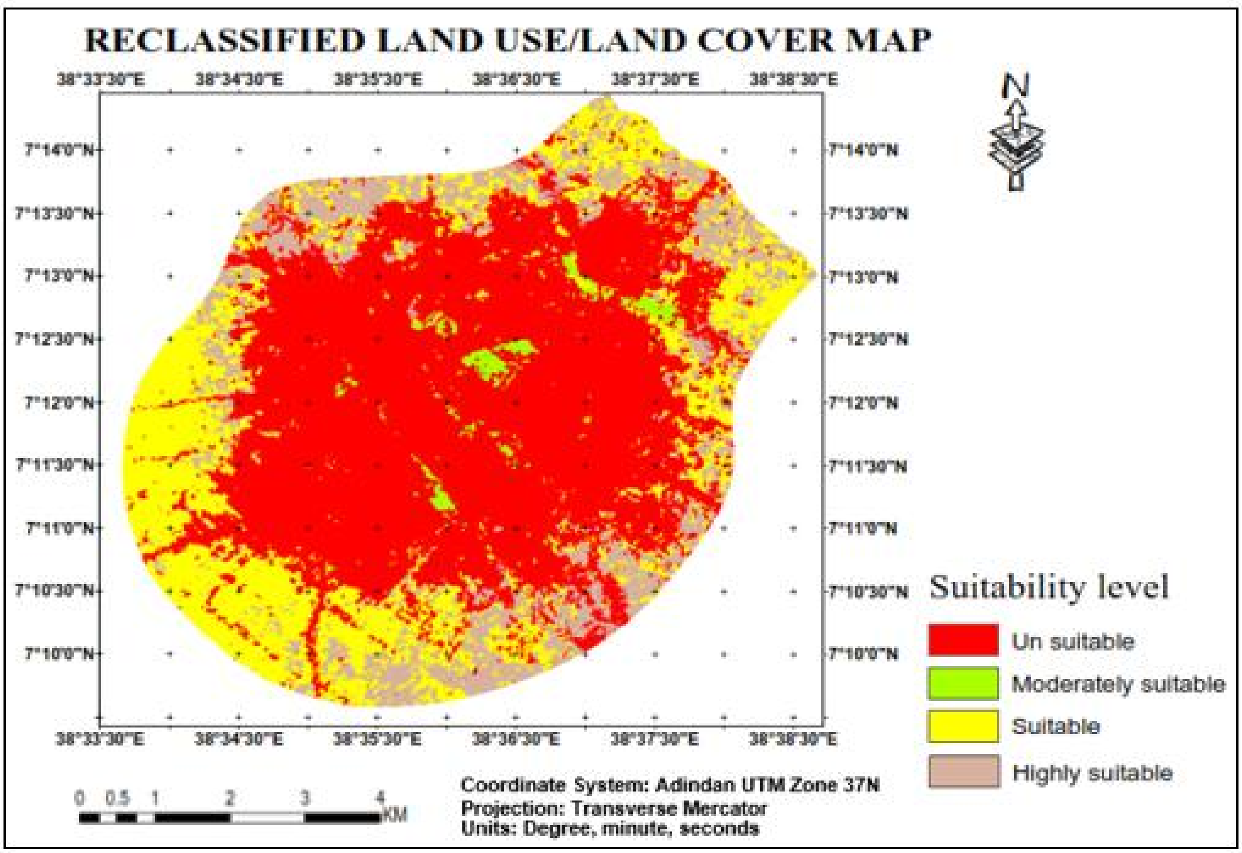

Figure 4.2: The reclassified land use/cover map of the study area

4.2.2. Topographical factor

Topography describes the surface shape and relief of the land. It refers to various landforms (physical features) which represent the external shape of the earth. It determines the patterns and form of many other landform and land cover features. Furthermore, elevation and slope should be considered when selecting site for abattoir construction project.

Elevation: In this study, elevation factor was generated from the Aster digital elevation model using the ArcGIS spatial analyst extension of surface module, which enabled to classify the area according to the level of elevation. Then, the elevation raster was reclassified in to four classes by examining the value and the frequency of elevation in the study area(Figure 4.3) According to (Fard et al, 2012); abattoirs might be constructed in an area lower than the city level in order to prevent the spread of contamination.Therefore, areas with high altitude ranked as un suitable, and areas with low altitude ranked as highly suitable for site selection(Table4.4).

Table 4.4 Reclassified elevation values

Elevation(m)	Value	Level of Suitability
1993-2053	1	Unsuitable
1948-1993	2	Moderately suitable
1903-1948	3	Suitable
1845-1903	4	Highly suitable

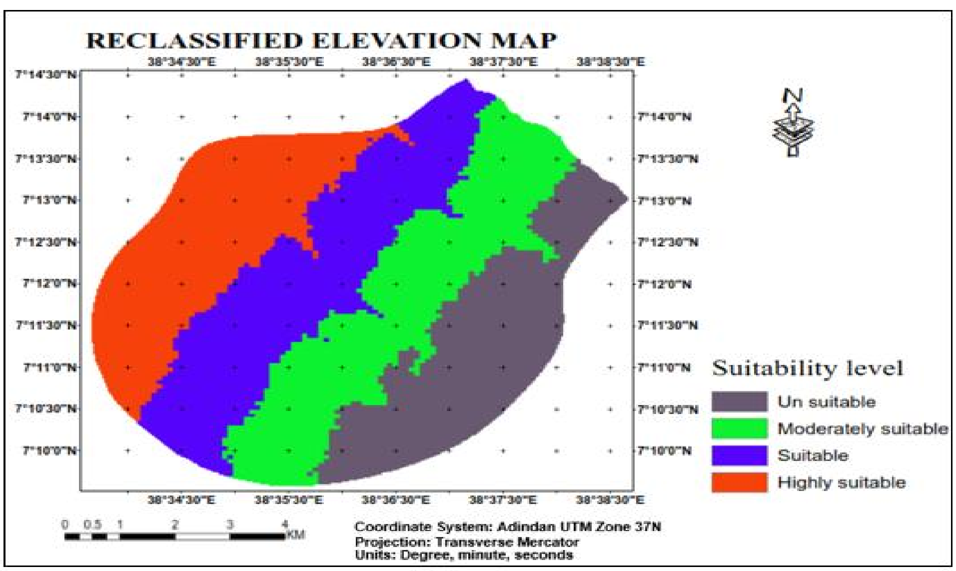

Figure 4.3:Reclassified elevation map genetated from DEM

Slope: Slope is an important criterion in hilly terrain for finding suitable sites for urban development. In this study slope factor was generated from the Aster digital elevation model using the ArcGIS spatial analyst extension of surface module, which enabled to classify the area according to the steepness and the gentleness of the terrain. The Slope function could calculate the maximum rate of change between each cell and its neighbors. Every cell in the output raster had a slope value. The lower the slope value, the flatter the terrain is and the higher the slope value the steeper is the terrain. Then the slope raster was reclassified in to four classes of slope percent by examining the value and the frequency of slope percent in the study area (Fig 4.4). The reclassified slope was given a rank value 1 to 4 with the higher value of 1 showing un suitable, while the lower value of 4 showing highly suitable. Thus, as recommended by (LMA, 2000) the desirable slope for abattoir site is suggested to be gently sloping area, which ranges from 2 to 10 percent. Slope values below 2 percent are not suitable from safe drainage point of view(Table4.5)

Table 4.5 The Reclassified slope suitability class

Slope(%)	Value	Level of Suitability
>26	1	Unsuitable
15-26	2	Moderately suitable
10-15	3	Suitable
2- 10	4	Highly suitable

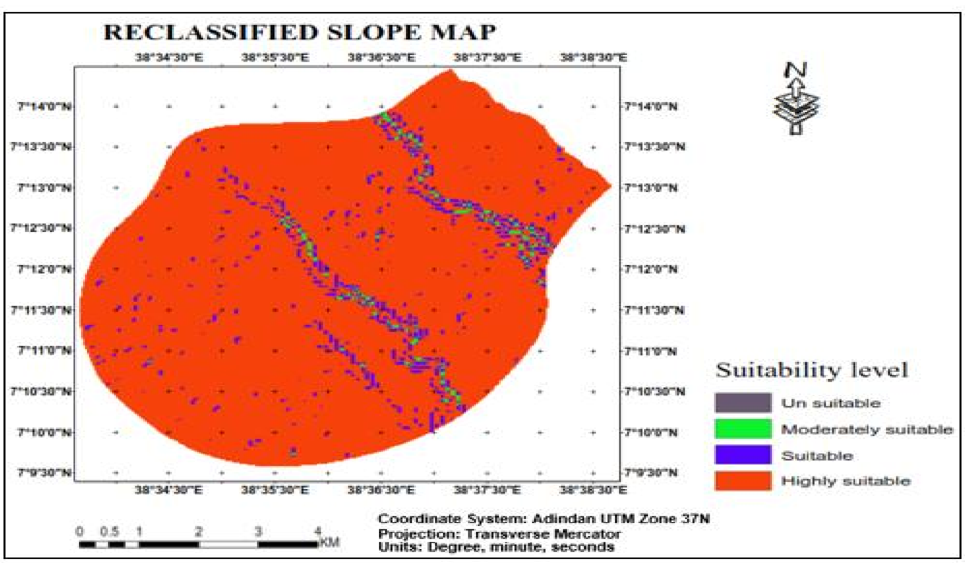

Figure 4.4 Reclassified slope map generated from DEM

4.2.3. Accessibility

Roads: Road is also an important criterion in site suitability analysis.The need to transport processed meat and slaughter animal is dependent on the proximity to transportation facility.Therefore, efforts were made to locate the site nearer to any existing road if possible. Moreover, in order to find out better accessibility to the existing road, buffer zones have been created by taking distances between 20 to 400 meter from the existing major roads (LMA, 2000) to generate suitable accessibility map. Then the buffer distance zones have been categorized into four levels based on the level of proximity to abattoir site. Accordingly, the low buffer distance ranked as highly suitable whereas the longer buffer distances ranked as un suitable (Figure 4.5). Thus, the rank value of four was given for highly suitable road buffers and the rank value one was given for unsuitable road buffers (Table 4.6).

Table 4.6: Reclassified distance of main road networks

Road(m)	Value	Level of Suitability
>1200	1	Unsuitable
800-1200	2	Moderately suitable
400-800	3	Suitable
20- 400	4	Highly suitable

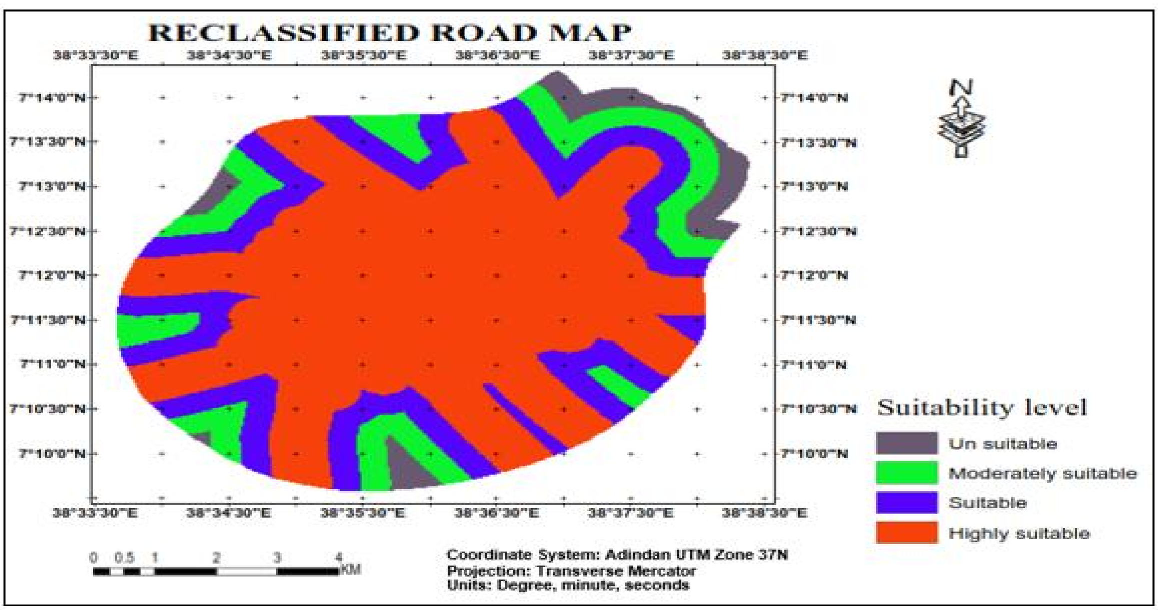

Figure 4.5: Reclassified road map digitized from aerial photograph

4.2.4. Surface Water

Streams/ river

Abattoir site must not be located in close proximity to surface water (streams, rivers, lakes, sea). The criterion is important from the point of view of both environment and economic concerns because in addition to causing pollution problems, it may require an efficient drainage system with high expenses. The streams/river factor was generated from the digital elevation model (DEM) using the ArcGIS spatial analyst extension of hydrology module. Then it was buffered based on the 200m distance standard criteria set by (EPA, 2002), to locate abattoirs from critical environmental resources such as streams/rivers. Thus, four buffer zones have been drawn around streams and rivers, and relative suitability rank was assigned; buffers from rivers are highly suitable, while buffers near to streams are unsuitable (Table 4.7).

Table 4.7 : Reclassified distance from streams

River(m)	Value	Level of Suitability
< 200	1	Unsuitable
400-600	2	Moderately suitable
600-800	3	Suitable
>800	4	Highly suitable

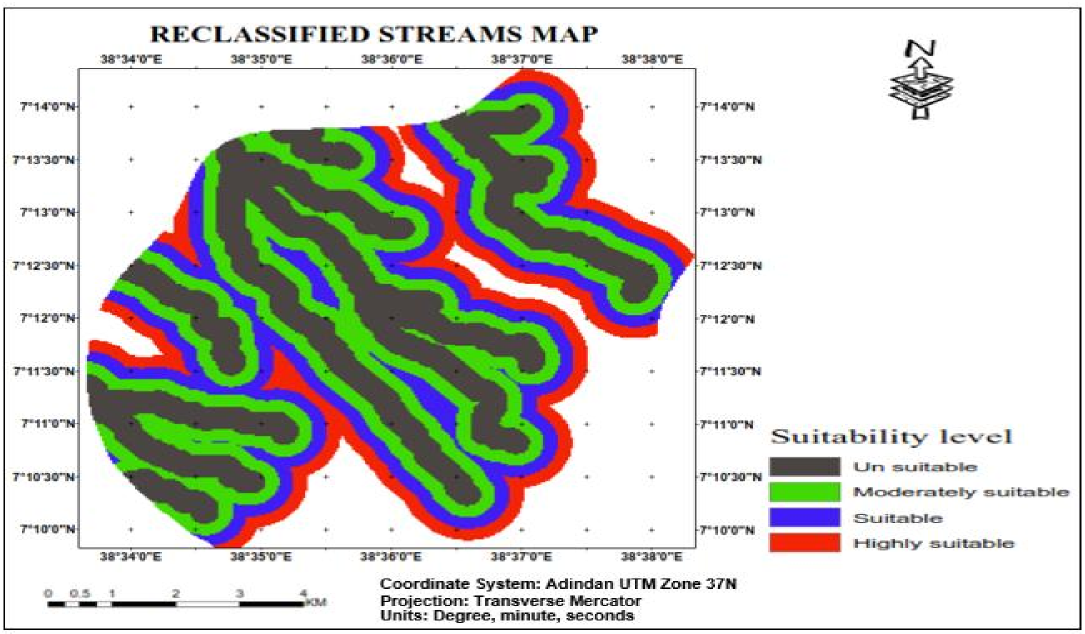

Figure 4.6 : Reclassified maps of streams generated from DEM

4.2.5. Constraints

The constraints in this study include; social services, high tension line, boreholes and industrial areas. Abattoir should be situated at a significant distance away from these areas. The focus is on alleviating possible negative impacts that abattoir can pose on the surrounding environment and vice versa. The impact that the abattoir poses may manifest in the form of liquid wastes,solid waste and airborne wastes (mainly disagreeable odors), large potential for the transmission of zoogenic diseases, noise, traffic congestion, attraction of animals (such as hyenas) and big birds, etc. Therefore, a buffer zone of certain distance should be reserved around the abattoir. Thus, each of these constraints was classified based on the standard criteria using spatial analyst buffer zone distance and the reclassified optimum buffer zone of each factor was taken as suitable site for abattoir site location. According (LMA, 2000), (EPA, 2002) and NUPI experience.

Social services: the site should be out of areas of social services. (Health centers, schools, worship places and recreational areas) in order to reduce sound disturbances. Such areas should also be protected with a 300 meter buffer(Table4.8 and Figure4.7).

Boreholes: Proximity of abattoir site to a groundwater well is an important environmental criterion in the abattoir site selection so that wells may be protected from the runoff and leaching of the waste products from abattoirs. As some sources suggested that the location of abattoir sites should be 300m far from the groundwater wells.to increase its importance of protecting the groundwater from pollution, in addition to its direct influence on the community. In each case of the above constraints; areas around all buffer zones are taken as the most suitable and areas within the limit of the least buffer zones are taken as unsuitable for abattoir site location.

Industrial areas: To minimize the impact of neighborhood activities upon the abattoir, dust and smoke emitting industries can produce chemical and other form of pollution. Abattoir should be located at least 300 meters from dust emitting industries.

Table 4.8 Reclassified distances from social services

Social services(m)	Value	Level of Suitability
< 300	1	Unsuitable
300-800	2	Moderately suitable
800-1500	3	Suitable
>1500	4	Highly suitable

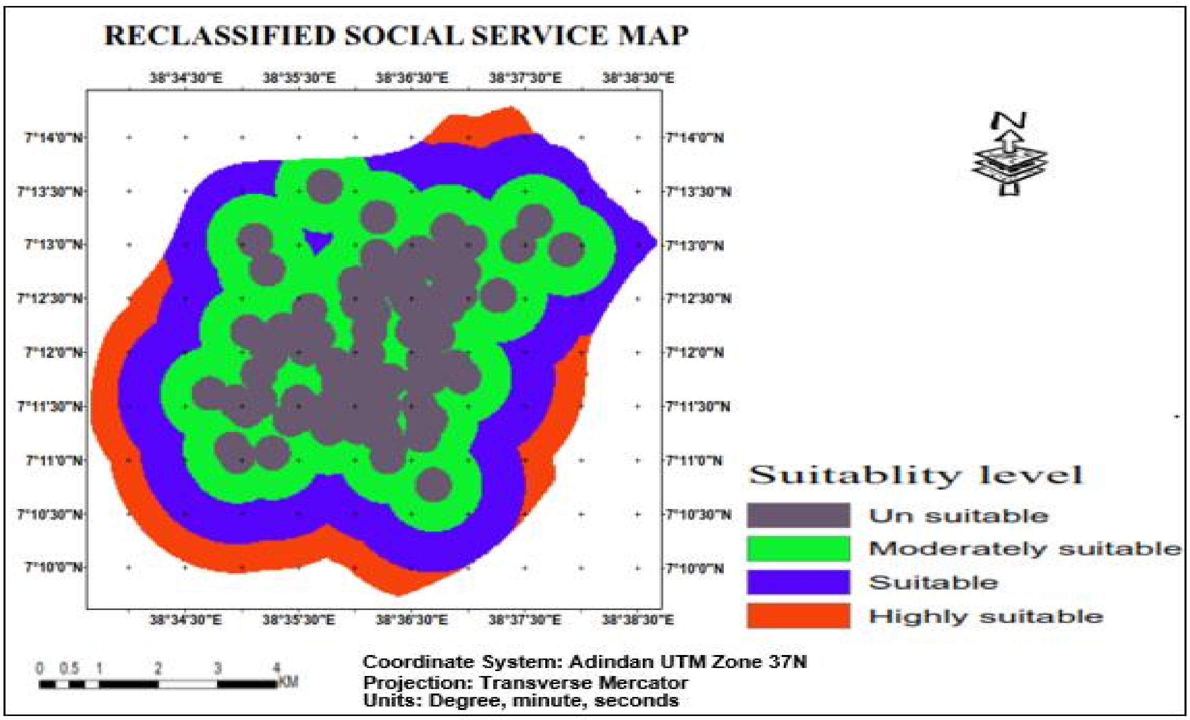

Figure 4.7: R eclassified social service map extracted from topographic map

High tension line: . in order to avoid possible accidents that could be encountered because of big flying birds (e.g. scavengers) hovering over the abattoir, the site should be at least 500 meters far awayfrom high tension lines. Table 4.9 and Figure 4.8 show the suitability of the study area for abattoir in relation to the existing network ofhigh tension power grid lines.

Table 4.9: High tension distance values

High tension Line(m)	Value	Level of Suitability
< 500	1	Unsuitable
500-1000	2	Moderately suitable
1000-1500	3	Suitable
>1500	4	Highly suitable

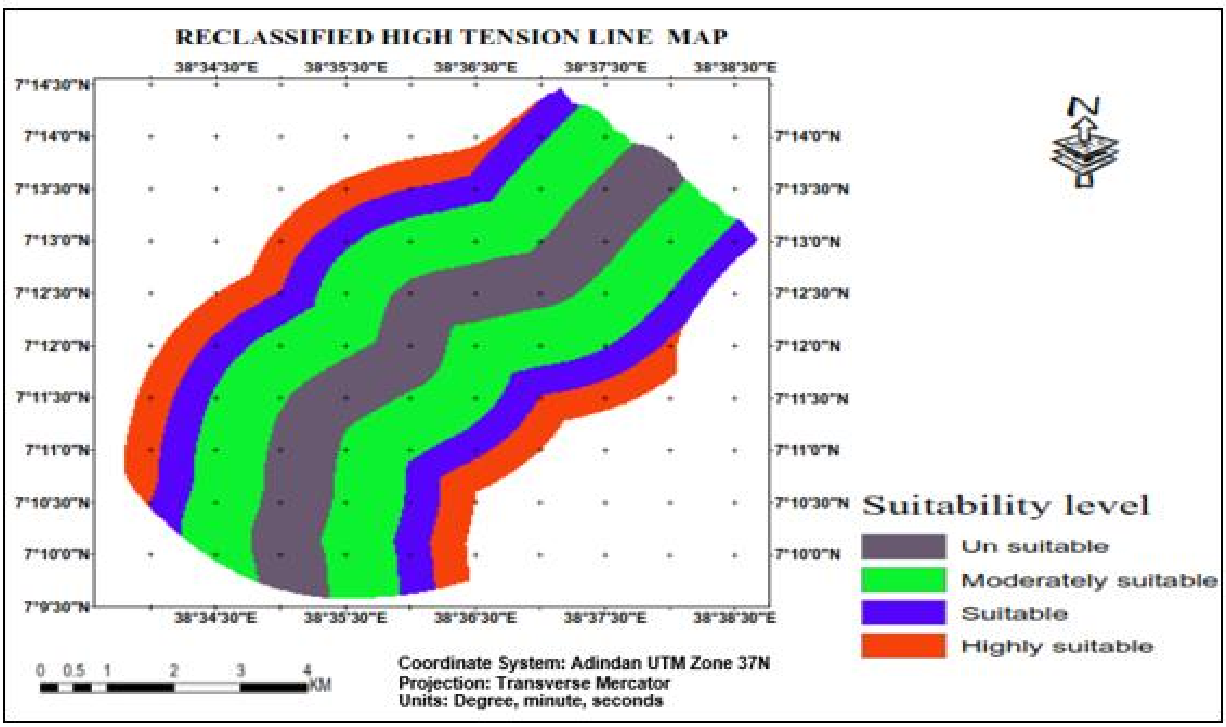

Figure 4.8: Reclassified high tension line map

4.2.6. Calculation of the Criteria and Class Weights

In order to generate abattoir site, nine interrelated components of the environment were used as input data sets (factors). Accordingly the selected input datasets were urban land use, Road network, elevation, slope, wells, streams, high tension line, industrial area and social services. Each of the factor maps were produced from remote sensing image,aerial photographs and topographic maps. Before combining them, the following procedures were taken place; first, rasterization was done for the vector data layers in order to produce similar data layers to perform GIS analysis and secondly standardization of each data set to a common scale of 1 to 4 was done in ArcGIS Software. Prior to combining the factors, weights have to be given based on Satty's Analytic Hierarchy Process (AHP), where a pair-wise comparison matrix will be prepared for each map using a nine point importance scale(Table 4.10) .Weighting is used to express the relative importance of each factor relative to other factor. The larger the weight, the more important is the factor in overall utility.

Table 4.10: pair-wise comparison of weighting scale

Criteria	LULC	Slope	Elevation	Stream	Road	HT line	Social service
LULC	1						
Slope	1/3	1					
Elevation	1/3	1/2	1				
Stream	1/3	1/3	1/3	1			
Road	1/3	1/2	1/2	1/2	1		
HT line	1/3	1/2	1/2	1/2	1/2	1	
Social service	1/3	1/3	1/3	1/2	1/2	1/2	1

In the process of AHP, the prime task of calculation is the eigen vector corresponding to the largest eigen value of the matrix. Each element in the eigenvector indicates the relative priority of corresponding factor, i.e. if a factor is preferred to another; its eigenvector component is larger than that of the other. A sum/product method is used to obtain the eigen value and the subsequent eigenvector. The weights finally derived by AHP are used for developing the suitability model. To examine the rationality of AHP,it is necessary to determine the degree of consistency that has been used in developing the judgments.

In AHP, an index of consistency, known as the consistency ratio (CR), is used to indicate the probability that the matrix judgments were randomly generated and it should be less than 0.1. In this study, the consistency ratio was found to be 0.07, which is acceptable to be used in the site suitability analysis., The computed Eigen vector is used as a coefficient for the respective factor maps to be combined in weighted overlay in ArcGIS environment(Table4.11).

Table 4.11 : Weights of classification factors after pairewise comparasio

Factor	Class	Value	Level of Suitability	Influence (%)
Urban land use	Built up /water	1	Unsuitable	0.27
	Forest	2	Moderately suitable	
	Agricultural land	3	Suitable	
	Bare land	4	Highly suitable	
Slope	>26	1	Unsuitable	0.17
	15-26	2	Moderately suitable	
	10-15	3	Suitable	
	2 - 10	4	Highly suitable	
Elevation	1993-2053	1	Unsuitable	0.14
	1948-1993	2	Moderately suitable	
	1903-1948	3	Suitable	
	1845-1903	4	Highly suitable	
Distance from road	> 1200	1	Unsuitable	0.13
	800-1200	2	Moderately suitable	
	400-800	3	Suitable	
	20 - 400	4	Highly suitable	
Stream/river	< 400	1	Unsuitable	0.15
	400-600	2	Moderately suitable	
	600-800	3	Suitable	
	>800	4	Highly suitable	
Distance from high tension	< 500	1	Unsuitable	0.06
	500-1000	2	Moderately suitable	
	1000-1500	3	Suitable	
	>1500	4	Highly suitable	
Distance from Social services	< 300	1	Unsuitable	0.08
	300-800	2	Moderately suitable	
	800-1500	3	Suitable	
	>1500	4	Highly suitable	
Consistency Ratio=0.07	which is acceptable			

4.3. Discussions and Results

4.3.1. Integration of criteria maps and preparation of final suitability map

At this stage, all the factor layers are prepared to be combined keeping in mind the end goal to identify suitable site for abattoir location in the study area. If all data sets were equally important, it could be possible to combine them simply.From the principal eigenvector calculation, the relative significance of every parameter was determined. Hence, the higher the weight, the more influence a particular factor will have in the suitable site generation. Accordingly, the factor layers were combined by applying the following equation in the raster calculator of spatial analyst extension in ArcGIS environment. It was done systematically using ArcGIS model builder.

[Lulc]*0.27+ [slope]*0.17+ [elevation]*0.14+ [road]*0.13+ [Hightensionline]*0.06+ [streams]*0.15+ [social service]*0.08 = Suitable map of abattoir.

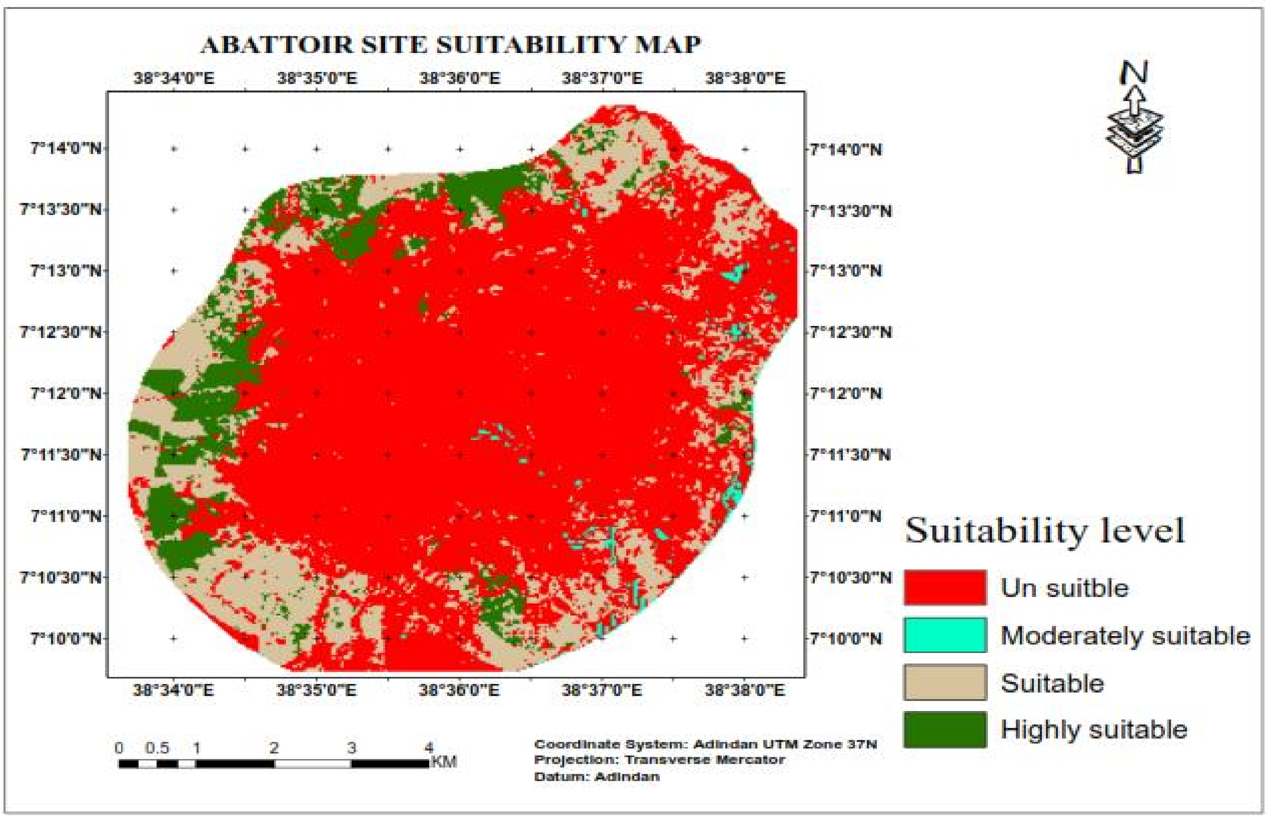

Figure 4.9: Suitability map of Abattoir

The site suitability map has been classified into four classes: highly suitable, suitable, moderate suitable, and unsuitable. Table 4.12 shows that 12.46% of the study area covers a highly suitable area whereas a total of 22.91% area is suitable, 16.70% of areas is moderately suitable and the unsuitable area covers 47.93% of the study area.

Table 4.12: Statistical Analysis for the Abattoir Site Suitability map

Suitability level	**Value**	**Area(ha)**	**Percent (%)**
Un suitable	1	4988.71	47.93
Moderately suitable	2	1737.99	16.70
Suitable	3	2384.70	22.91
Highly suitable	4	1296.60	12.46

As can be seen from the suitability map (Fig 4. 9), the highly suitable (12.46%) areas are mainly located in the south west, west and north west . These areas cover mainly agricultural and bare land uses. Currently these areas are waiting for the distribution of specific urban land use development. The suitable areas are located on the periphery of built up areas . These areas are free from urban settlements and are occupied by forests, Agricultural and barelands . The highly suitable, suitable and moderate suitable areas have an appropriate site for the development of facilities. The unsuitable areas for abattoir site selection are also located in the developed part of the town(47.93%). The suitability of abattoir site can be expressed in terms of the existing features. Figure 4.10 shows the composite suitability of the constraint map and the factor maps. The areas are labeled as highly suitable, suitable, moderate suitable and unsuitable. It is still possible to make further suitability differentiation among these areas.Those parts of the selected areas that are near the existing roads are more suitable than those located further, as far as only the road factor is considered.

The constraints are usually regulations (environmental, land use etc.), which are legal constraints in essence. Obviously this is a constraining criterion that immediately limits the specified area for development. That is, such constraining criteria are considered as legal constraints and cannot be compromised. To prioritize the future land uses of the study areas the choice of two alternative sites; moderate suitable and suitable areas are relatively suitable for residential development than for locating an abattoir. If the abattoir is sited either within moderately suitable and suitable, the likelihood that it will be relocated earlier than expected (because of residential pressure or encroachment) would be greater. The highly suitable area on the other hand, is less suitable for residential development and hence it is selected as the best area for the intended abattoir. This area is located near the boundary of the town and is also located in the south west, west and Northwest of urban land use purpose. It can be therefore observed that, being located within this area, the abattoir will have prolonged life time before it can be relocated.

Cattle market: cattle markets are usually recommended to be located close to abattoir so that purchased cattle could immediately be taken to the abattoir without having to cross the town.This reduces possible traffic problems that would otherwise be created; and cattle fattening lots: this type of investment activity exists in most towns of the country. The cattle are usually fattened to be sold later. Thus, it is compatible both with the abattoir and the cattle market.

Generally, highly suitable area of abattoir can be summarized in terms of the specific objectives set at the beginning of the study. In other words, locating the abattoir within this site ensures minimizing the impact of abattoir on the surrounding environment; reducing the impact of nearby activities on the abattoir.

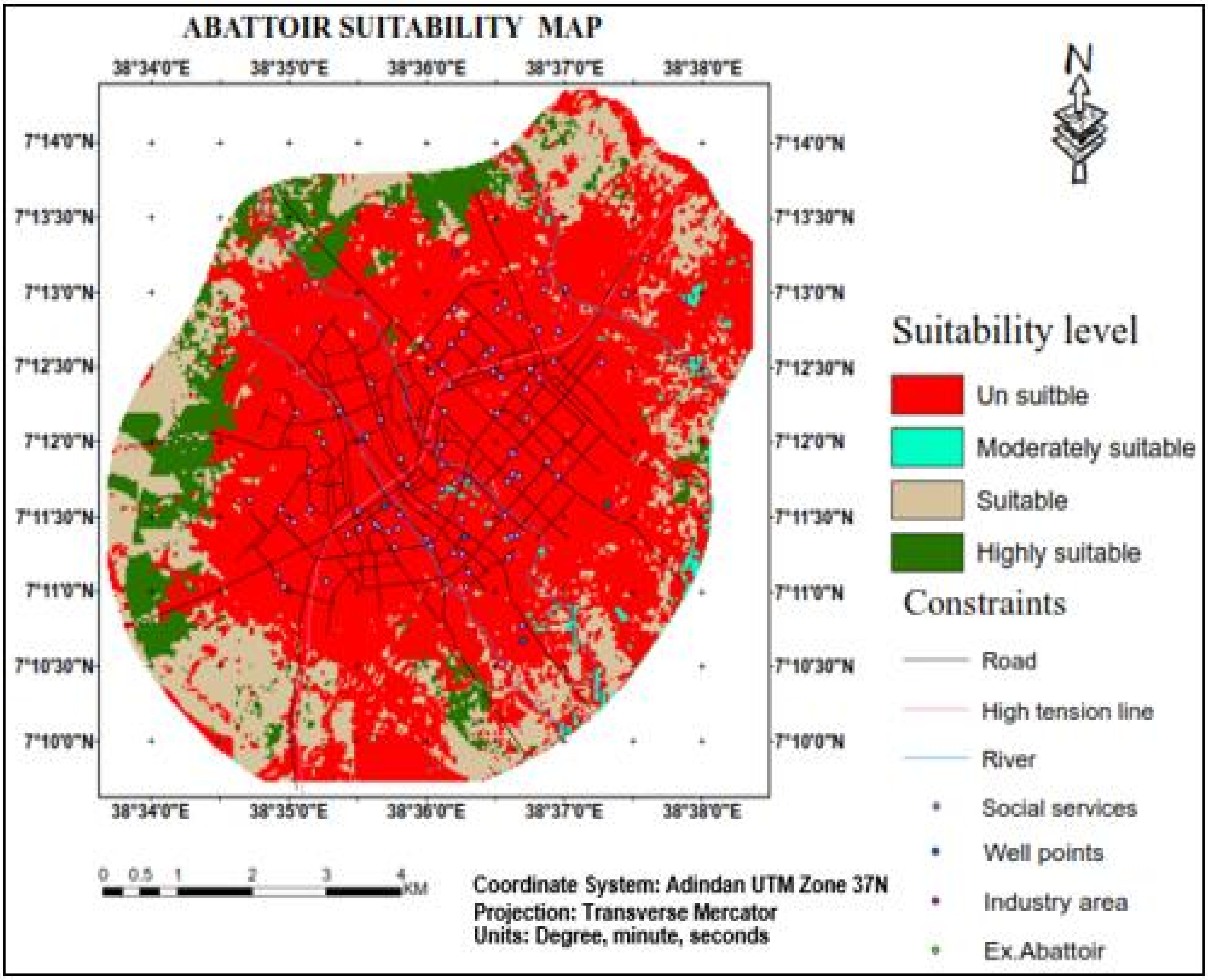

Figure 4.10: Suitability map of abattoir overlaid by factor layers

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATION

5.1. Conclusions

Abattoirs are critical urban functions that give domesticated animals processing services to the towns or urban areas they serve. A definitive motivation behind establishing abattoirs is to give cleaner and hygienic butchering services, to guarantee appropriate utilization of animal byproducts, to produce income for the service rendered, and to reduce impacts on the environment by controlling the waste disposal system. Abattoirs have some essential elements that require the search of unique location for them. Such location should satisfy some specific objective including minimizing the undesirable effects that the abattoir can pose on the encompassing environment and vice versa, ensuring the accessibility of basic facilities essential for the proper functioning of the abattoir and so on. GIS and WLC are significant tools that can support the decision makers to find best possible abattoir sites. The GIS analysis requires gathering data from various sources with different formats to create a complete uniform database. Consequently, the GIS data should be updated consistently keeping in mind the end goal to mirror the present circumstance of area under investigation. Remote sensing data can help to have updated information of the study area. Likewise, it can support the decision maker to monitor the examined area using different dates of satellite images to separate the urban land use/land cover class for instance. The analysis has taken land use/cover, slope, surface water, proximity to roads and streams and environmental constraints/ limitations as deciding factors in request to discover suitable site for abattoir.

The three candidate sites were sugested in light of the methodology and available data applied in this research. The results; 12.46%, 22.91% and 16.70% have demonstrated that three sites were chosen as highly suitable, suitable and moderately suitable respectivily. These places are far from any water sources and different factors taken into consideration in the analysis. The places are located at different parts of the town. The most appropriate site was situated at South West, West and North West of the town over bare land and agricultural areasThe planners and the decision makers can get useful information about the possible locations of abattoir sites using this methodology. Specially, the site ranking process allows for easily rearrangement of the criteria weights in the case that a sensitivity analysis is required. In any case, defining detailed and standard criteria by the Environmental Agency that agree to the local conditions can enhance the outcome of GIS models utilized for the pupose of finding an appropriate abattoir site.Generally, the suggested areas comply with the minimum requirements of the abattoir site selection. However, any GIS model is limited to the available data, which in this study; deferent parameters were considered. Therefore, any additional information such as wind direction, land price, detailed soil data, and other social and economic factors can enhance the outputs of the GIS model, and provide more realistic results. However, getting public agreement on any candidate area is a must, and cannot be avoided. Therefore, the local community should participate in the selection process of abattoir site to avoid any opposition in the future.

5.2. Recommendations

In this study, an attempt is made to develop a model for conducting abattoir site selection analysis for a shashamane town. The study demonstrated that the utilization of a GIS for land suitability analysis is proper and a need in urban development planning under Ethiopian context. For further undertaking of the system, the following recommendations are given:

- The GIS based multi criteria evaluation technique is basic and adaptable which can be utilized to investigate the potential sites for urban development and encourage open participation in the urban decision making process. Thus, planners to define suitable plan for sustainable development of the town, need to practice the application of GIS.
- The abattoir site suitability model developed in this study has been expected to be used for towns requiring one abattoir where more than one abattoir is required, additional factors, especially in connection to the spatial distribution of the abattoirs, must be considered.
- Due to the particular characteristics of the study area, certain geographic features (such as airplane terminal) are excluded in the model. Where such features are available, they should be incorpotrated in the analysis.
- This study has been planned to serve for solving of the location problems connected with municipal abattoirs. For export abattoirs, which are relied upon to prosper in the country in the future, some extra factors will probably be required to be considered, depending upon the nature and complexity of such abattoirs.

Abstract

Abattoirs are one important urban functions that need suitable site to be compatible with the Surrounding geographic features. However, they are observed being located at in appropriate site posing environmental hazard to their surrounding and are additionally influenced by some adjacent activities. The present study was conducted to find the most suitable abattoir site in shashamane town. In order to do this it was discovered essential to experience the national urban planning establishment of Ethiopia, and thus reviewing the experience of urban land use planning for sitting basic environmental issues like abattoir.An integrated Remote sensing and GIS approach was observed to be extremely useful to assign abattoir site in the study area. Factors that were found to be significant in distinguishing the site in the study area were; land use/cover, elevation, slope, streams, distance from the roads, distance from the high tension lines, distance from social services, distance from industrial areas, and boreholes. These factors were weighted in hierarchical order using MCE approach to produce the suitability map of abattoir site. From the overall suitability map, suitability level of areas was calculated. Major findings of the study revealed that, 12.46% of the study area covers a highly suitable area of abattoir, 22.91% area is suitable, 16.70% of areas is moderately suitable and the unsuitable area covers 47.93% of the study area. The highly suitable areas are mainly located in the south west, west and north of the study area. These areas falls in bare land uses. The suitable areas are located near the periphery of built up areas. Finally, the unsuitable areas site are located in the developed part of the town. Generally, locating the abattoir within highly suitable area can ensure minimizing the impact of abattoir on the surrounding environment in the form of liquid wastes,solid waste,airborne wastes and noise : reducing the impact of nearby activities on the abattoir through dust and smoke emitting industries.

Key words: Multi-criteria Evaluation, Abattoirs, Shashamane, GIS, RS

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ACKNOWLEDGEMENT

First and foremost, I would like to thank, the Almighty GOD. Who made it possible to begin and finish this study successfully.

I would like to extend my deepest gratitude and appreciation to my supervisor, Dr. Hasan Raja Navqi for his expert guidance and concerned supervision throughout all steps of the research. His critical comments has contributed immensely to the completion of the thesis. I am so grateful for that provided sharp eyed comments and critical assistance. This thesis would not be in its current shape without his continuous exertion and support.

I gratefully acknowledge the Hawassa University for granting me the chance to pursue my studies in the Adama Science and Technology University.

I am thank full to Mr Alemayew Tegegn,Mr Abiyo Jemal,Mr Adem Mohammed,Sr Hirut Wendimu the figurative oficials in Shashamane town Administration staff for their support and provision of necessary data and information related to the thesis.

Finally, I would like to express my gratitude to all my families and my friends for their encouragements and support. Especially my appreciation goes to my wife Genet Tesfaye.

Table of Contents

Contents **Page**

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