

Developing Geospatial-based Land grading information System: A Case of Adama City, Oromia, Ethiopia



Wondosen Negash

A thesis submitted to the Department of Geomatics Engineering,

School of Civil Engineering and Architecture

Office of Graduate Studies

Adama Science and Technology University

June, 2024

Adama, Ethiopia

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DECLARATION

I declare hereby this research thesis entitled “Developing Geospatial-based land grading information system: a case of Adama city, Oromia, Ethiopia” is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this proposal have been duly acknowledged through citation.

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Recommendation

I/we, hereby certify that the recommendation and suggestion given by the proposal review committee are appropriately incorporated into final thesis/dissertation proposal entitled “Developing Geospatial-based land grading information system: a case of Adama city, Oromia, Ethiopia” by Wondasan Negash.

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Approval page

We, the advisors of the thesis entitled “Developing Geospatial-based land grading information system: a case of Adama city, Oromia, Ethiopia” and developed Wondasan Negash hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Bayisa Bekele have read and evaluated the thesis entitled “Evaluation of cadastral information system with the standard framework: A case of Adama city, Oromia, Ethiopia” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geoinformatics Engineering.

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LIST OF ACRONYMS

GIS - Geographic information system

LULC - Land use Land cover

MCDA - Multi criteria decision analysis

AHP - Analytical hierarchy process

ABSTRACT

Land grading is a pivotal aspect of land use planning, infrastructure development, and urban growth management. Its purpose is to assess and modify the topography of land to ensure its suitability for various purposes, including residential, commercial, agricultural, or industrial use. The reliance on traditional manual assessments in land grading processes introduces inconsistencies and inefficiencies that can compromise the suitability of land for different purposes. Developing a GIS-based land grading system that utilizes geospatial data and analysis The general objective of the research is to analyze land grading system of Adama city using geospatial technology. The general objective of the research is to analyze land grading system of Adama city using geospatial technology. The data collection phase involves gathering various geospatial data sources essential for land grading assessments, such as topographic DEM, aerial imagery, land cover information, infrastructure data and any other relevant datasets. It is crucial research is to analyze land grading system of Adama city using geospatial technology. Data Analysis Techniques carried out using AHP and weight overlay methods. The indicators and their correlation for analyzing with the techniques of AHP are asphalt road is of equal importance to asphalt road, water supply is of equal importance to water supply, electric supply is of equal importance to electric supply, educational centers is of equal importance to educational centers, health centers is of equal importance to health centers and DEM is of equal importance to DEM. Buffering and rastering are the analysisi procedures the map overlayed produced as a result ,which shows the hih,medim,moderate and less land grading.In a broader context, map overlay refers to combining the attributes of intersecting features represented in two or more georegistered data layers.

Key words: Land grade, AHP, weight overlay

CHAPTER I: INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Land grading is a pivotal aspect of land use planning, infrastructure development, and urban growth management. Its purpose is to assess and modify the topography of land to ensure its suitability for various purposes, including residential, commercial, agricultural, or industrial use. Accurate and efficient land grading is crucial for making informed decisions regarding land development and optimizing land utilization (Carr and Zwick, 2007).

However, traditional land grading methods predominantly rely on manual assessments and subjective judgments, which can introduce inconsistencies and inefficiencies into the decision-making process. These conventional approaches are prone to human error, resulting in suboptimal land grading outcomes. Additionally, the manual approach is time-consuming and labor-intensive, rendering it impractical for large-scale land grading projects (Contreras et al, 2008).

To address these challenges, this research proposal aims to develop a Geographic Information System (GIS)-based land grading system. Geographic Information System (GIS) technology enables the integration and analysis of geospatial data, providing a powerful tool for land evaluation and decision-making in urban planning. By leveraging GIS capabilities, the proposed system intends to enhance the accuracy and efficiency of land grading processes.

The GIS-based land grading system will utilize various geospatial data sources, including topographic maps, aerial imagery, and land cover information. These data will undergo processing and analysis using advanced techniques such as spatial interpolation and multi-criteria decision analysis. Through the integration of these data and analysis techniques, the system will generate reliable land grading results.

Compared to traditional methods, the proposed system offers several advantages. Firstly, it reduces reliance on subjective judgments, ensuring more consistent and unbiased grading outcomes. Objective data analysis minimizes the potential for human error and bias, leading to more reliable decisions regarding land use. Secondly, the automation of the grading process improves efficiency, enabling faster decision-making and reducing project timelines. This efficiency is particularly beneficial for large-scale land grading projects where manual assessments can be time-consuming and impractical. Lastly, the integration of geospatial

data and analysis techniques provides a comprehensive understanding of the land, facilitating informed land use planning and development.

The research will involve designing and implementing the GIS-based land grading system. It will encompass the development of models for data processing, analysis, and visualization. The system will undergo testing and validation using real-world land grading scenarios to assess its effectiveness and performance.

In conclusion, the proposed research seeks to develop a GIS-based land grading system that leverages geospatial data and analysis techniques to enhance the accuracy and efficiency of land grading in urban planning. By automating and streamlining the grading process, this system has the potential to revolutionize land use decision-making, ensuring optimal land utilization and sustainable urban development (Zhang et al., 2020).

1.2 STATEMENT OF THE PROBLEM

Land grading is a critical aspect of land use planning, infrastructure development, and urban growth management, as it determines the suitability of land for different purposes. However, the reliance on traditional manual assessments in land grading processes introduces inconsistencies and inefficiencies that can lead to inaccurate decisions (Goicoechea et al,1982). This inaccuracy has the potential to affect the appropriate use of land for residential, commercial, agricultural, or industrial purposes. To overcome these limitations, it is necessary to develop a GIS-based land grading system that utilizes geospatial data and analysis techniques to improve the accuracy and efficiency of land grading in urban planning (Gordon, 1985).

Manual land grading assessments are subjective and prone to human error, resulting in inconsistent grading outcomes. Different individuals may interpret and evaluate land characteristics differently, leading to discrepancies in decision-making. These inconsistencies can have significant implications for land use planning and infrastructure development, as they may result in suboptimal land utilization and inefficient resource allocation. Additionally, manual assessments are time-consuming and labor-intensive, especially when evaluating large areas of land in urban settings with extensive land development. The inefficiencies associated with manual grading processes can cause delays in decision-making, project timelines, and overall urban development (Hajkowicz, 2007).

To address these challenges, a GIS-based land grading system is necessary. GIS technology provides a powerful platform for integrating and analyzing geospatial data, enabling more objective and consistent land grading assessments. By leveraging GIS capabilities, the

proposed system will enhance the accuracy and efficiency of land grading processes in urban planning.

By addressing the research problem of improving the objectivity, consistency, and effectiveness of land grading, this research aims to contribute to better land use planning and infrastructure development in urban areas. The proposed GIS-based system will provide a reliable and standardized approach to land grading, reducing subjectivity and human error. This will lead to more informed decision-making regarding land use, promoting optimal land utilization and sustainable urban development.

In conclusion, the reliance on traditional manual assessments in land grading processes introduces inconsistencies and inefficiencies that can compromise the suitability of land for different purposes. Developing a GIS-based land grading system that utilizes geospatial data and analysis techniques is crucial to enhance the accuracy and efficiency of land grading in urban planning. By addressing this research problem, the proposed system aims to improve the objectivity, consistency, and effectiveness of land grading processes, ultimately contributing to better land use planning and infrastructure development in urban areas.

1.3 GENERAL OBJECTIVE.

The general objective of the research is to analyze land grading system of Adama city using geospatial technology.

SPECIFIC OBJECTIVE

1. Identify the key factors that should be considered in the land grading
2. Analyze the land grading process using AHP techniques
3. Extract the level of land grade information from multi criteria's weight Overlay analysis.

1.3 RESEARCH QUESTIONS

1. What are the key factors that should be considered in the land grading?
2. How land grading information processed using AHP techniques in GIS?
3. How Land grading information extracted from overlaid analysis?

1.4 SIGNIFICANCE OF THE STUDY

The significance of the proposed research on developing a GIS-based land grading system is multifaceted. Firstly, the system will enhance the accuracy and objectivity of land grading assessments by leveraging geospatial data and analysis techniques, reducing subjective judgments and human error. This will ensure optimal land utilization and minimize the risks

associated with improper land development. Secondly, the automation of the land grading process through the GIS-based system will improve efficiency and save time, particularly for large-scale projects, by expediting decision-making and reducing delays. Thirdly, the system will establish a standardized approach to land grading assessments, promoting fairness and transparency in the land use planning process. Fourthly, the research outcomes will contribute to sustainable urban development by facilitating informed land use planning, considering factors such as slope, drainage, soil composition, and land use regulations. This will help optimize land utilization, minimize environmental impacts, and support the development of resilient and sustainable urban areas. Lastly, the research will involve real-world testing and validation of the GIS-based system, ensuring its practical application and scalability to different urban contexts. Overall, this research will have practical implications and advance land grading practices in urban areas, benefiting urban planning and infrastructure development endeavors.

1.5 SCOPE OF THE STUDY

The research scope for developing a GIS-based land grading system encompasses several key areas relevant to land grading processes, geospatial data integration, analysis techniques, system development, and application in urban planning. The geographical scope of the research will focus on urban areas where land grading is integral to infrastructure development and land use planning. The applicability of the GIS-based system will be assessed in diverse urban contexts, accounting for variations in topography, land cover, and land development patterns. Data collection and integration will involve relevant geospatial data sources, such as topographic maps, aerial imagery, and land cover information, with a focus on data preprocessing techniques to ensure quality, compatibility, and consistency for analysis. The research will explore and apply spatial interpolation techniques and multi-criteria decision analysis methods to estimate values at unsampled locations, fill data gaps, and prioritize factors and criteria for land grading assessments. The scope also includes the design and implementation of a GIS-based land grading model, incorporating components for data processing, analysis, visualization, and automation of the grading process. The model will be tested and validated using real-world land grading scenarios, evaluating its performance in terms of accuracy, efficiency, and reliability compared to manual assessments. Real-world case studies in urban planning and infrastructure development projects will be conducted to assess the model's effectiveness in supporting informed decision-making, optimal land utilization, and sustainable urban development. The research will involve the evaluation and comparison of the model's outcomes against traditional

manual assessments, focusing on improvements in objectivity, consistency, and effectiveness. The findings will be analyzed and presented in a comprehensive report, which will also include recommendations for further improvements, future research directions, and considerations regarding the system's potential scalability and applicability. It is important to acknowledge that while the research aims to develop and evaluate the GIS-based land grading system, its practical implementation and adoption may require additional considerations, such as data availability, technological infrastructure, and stakeholder engagement, which may fall outside the immediate scope of the research but should be taken into account during the system's implementation and integration into existing urban planning processes.

CHAPTER II: LITRATURE REVIEW

2.1. GIS APPLICATION IN URBAN LAND GRADING

Land grading is a critical aspect of urban planning and infrastructure development, as it influences the suitability and efficient utilization of land for various purposes. In recent years, there has been a growing interest in integrating Geographic Information Systems (GIS) into land grading processes (Klosterman, 1999). GIS technology offers a powerful platform for data integration, analysis, and visualization, which can significantly enhance the accuracy and effectiveness of land grading in urban planning.

GIS-based land grading systems have been successfully applied in various urban planning contexts. conducted a case study in a rapidly growing urban area, where the system was utilized to support land grading decisions for infrastructure development. Their research demonstrated the system's effectiveness in providing objective and consistent land grading assessments, aiding in sustainable urban development.

The application of GIS-based land grading systems extends beyond individual projects to broader urban planning contexts. For example, conducted a study that integrated land grading assessments with urban growth modeling. By considering future development scenarios and their impact on land grading factors, the research provided insights into the long-term sustainability of urban areas and supported informed decision-making in urban planning processes. Land grading is a critical aspect of urban planning and infrastructure development, as it influences the suitability and efficient utilization of land for various purposes. In recent years, there has been a growing interest in integrating Geographic Information Systems (GIS) into land grading processes (Klosterman, 1999).

Moreover, the integration of GIS-based land grading systems with other urban planning tools, such as transportation planning or environmental impact assessment, has been explored. This interdisciplinary approach allows for a more comprehensive understanding of the interactions between land grading factors and other planning considerations, facilitating more holistic and sustainable urban development.

Overall, the literature review demonstrates the continuous advancements in GIS-based land grading systems, including data integration, analysis techniques, system development, and their application in urban planning. These developments contribute to more accurate, objective, and efficient land grading assessments, supporting sustainable land use planning and informed decision-making in urban development projects.

GIS-based land grading systems can be integrated with geospatial decision support systems (DSS) to provide a comprehensive platform for land use planning. Geospatial DSS combines spatial data, analysis tools, and decision models to support decision-making processes. By integrating land grading assessments with other planning considerations, such as transportation networks, environmental factors, and social equity, geospatial DSS enables a holistic evaluation of land use options. This integration enhances the efficiency and effectiveness of decision-making processes, leading to more sustainable and well-informed land use planning decisions.

2.2 ANALYTIC HIERARCHY PROCESS (AHP)

GIS-based land grading systems continue to advance through the integration of remote sensing data, uncertainty analysis, 3D visualization, geospatial decision support systems, and the exploration of emerging technologies. These developments contribute to more accurate assessments, improved decision-making processes, and sustainable land use planning. The ongoing research and technological advancements in this field hold great potential for addressing the complex challenges associated with land grading and urban development.

The theory of decision making, the analytic hierarchy process (AHP), also analytical hierarchy process is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology(*Forman, et al 2001*). It was developed by Thomas L. Saaty in the 1970s; Saaty partnered with Ernest Forman to develop Expert Choice software in 1983, and AHP has been extensively studied and refined since then. It represents an accurate approach to quantifying the weights of decision criteria. Individual experts' experiences are utilized to estimate the relative magnitudes of factors through pair-wise comparisons. Each of the respondents compares the relative importance of each pair of items using a specially designed questionnaire. The relative importance of the criteria can be determined with the help of the AHP by comparing the criteria and, if applicable, the sub- criteria in pairs by experts or decision-makers. On this basis, the best alternative can be found(Fabianek, et al, 2020).AHP is targeted at group decision making, and is used for decision situations, in fields such as government, business, industry,[4] healthcare and education. Rather than prescribing a "correct" decision, the AHP helps decision makers find the decision that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. Once the hierarchy is built, the decision makers evaluate its various

elements by comparing them to each other two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, and they can also use their judgments about the elements' relative meaning and importance. Human judgments, and not just the underlying information, can be used in performing the evaluations (Saaty, et al, 2008). The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision-making techniques. In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action. While it can be used by individuals working on straightforward decisions, the Analytic Hierarchy Process (AHP) is most useful where teams of people are working on complex problems, especially those with high stakes, involving human perceptions and judgments, whose resolutions have long-term repercussions (Bhushan, et alary 2004).

- Choice – The selection of one alternative from a given set of alternatives, usually where there are multiple decision criteria involved.
- Ranking – Putting a set of alternatives in order from most to least desirable
- Prioritization – Determining the relative merit of members of a set of alternatives, as opposed to selecting a single one or merely ranking them
- Benchmarking – Comparing the processes in one's own organization with those of other best-of-breed organizations
- Quality management – Dealing with the multidimensional aspects of quality and quality improvement (Saaty, et al, 2008).

The applications of AHP include planning, resource allocation, priority setting, and selection among alternatives.

The weights of the AHP judgement matrix may be corrected with the ones calculated through the Entropy Method. This variant of the AHP method is called AHP-EM(Wu et al, 2017).

As can be seen in the material that follows, using the AHP involves the mathematical synthesis of numerous judgments about the decision problem at hand. It is not uncommon for these judgments to number in the dozens or even the hundreds. While the math can be

done by hand or with a calculator, it is far more common to use one of several computerized methods for entering and synthesizing the judgments. The simplest of these involve standard spreadsheet software, while the most complex use custom software, often augmented by special devices for acquiring the judgments of decision makers gathered in a meeting room. The procedure for using the AHP can be summarized as:

- Model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives.
- Establish priorities among the elements of the hierarchy by making a series of judgments based on pairwise comparisons of the elements. For example, when comparing potential purchases of commercial real estate, the investors might say they prefer location over price and price over timing.
- Synthesize these judgments to yield a set of overall priorities for the hierarchy. This would combine the investors' judgments about location, price and timing for properties A, B, C, and D into overall priorities for each property.
- Check the consistency of the judgments.
- Come to a final decision based on the results of this process(Saaty, et al, 2008).

These steps are more fully described below.

- Model the problem as a hierarchy

The first step in the analytic hierarchy process is to model the problem as a hierarchy. In doing this, participants explore the aspects of the problem at levels from general to detailed, then express it in the multileveled way that the AHP requires. As they work to build the hierarchy, they increase their understanding of the problem, of its context, and of each other's thoughts and feelings about both.[26]

- Hierarchies defined

A hierarchy is a stratified system of ranking and organizing people, things, ideas, etc., where each element of the system, except for the top one, is subordinate to one or more other elements. Though the concept of hierarchy is easily grasped intuitively, it can also be described mathematically.[27] Diagrams of hierarchies are often shaped roughly like pyramids, but other than having a single element at the top, there is nothing necessarily pyramid-shaped about a hierarchy.

Human organizations are often structured as hierarchies, where the hierarchical system is used for assigning responsibilities, exercising leadership, and facilitating communication.

Familiar hierarchies of "things" include a desktop computer's tower unit at the "top", with its subordinate monitor, keyboard, and mouse "below."

In the world of ideas, we use hierarchies to help us acquire detailed knowledge of complex reality: we structure the reality into its constituent parts, and these in turn into their own constituent parts, proceeding down the hierarchy as many levels as we care to. At each step, we focus on understanding a single component of the whole, temporarily disregarding the other components at this and all other levels. As we go through this process, we increase our global understanding of whatever complex reality we are studying.

- Hierarchies in the AHP

An AHP hierarchy is a structured means of modeling the decision at hand. It consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal. The criteria can be further broken down into sub criteria, sub-sub criteria, and so on, in as many levels as the problem requires. A criterion may not apply uniformly, but may have graded differences like a little sweetness is enjoyable but too much sweetness can be harmful. In that case, the criterion is divided into sub criteria indicating different intensities of the criterion, like: little, medium, high and these intensities are prioritized through comparisons under the parent criterion, sweetness. Published descriptions of AHP applications often include diagrams and descriptions of their hierarchies; some simple ones are shown throughout this article. More complex AHP hierarchies have been collected and reprinted in at least one book (Ernest H. Forman, 1992). The design of any AHP hierarchy will depend not only on the nature of the problem at hand, but also on the knowledge, judgments, values, opinions, needs, wants, etc. of the participants in the decision-making process. Constructing a hierarchy typically involves significant discussion, research, and discovery by those involved. Even after its initial construction, it can be changed to accommodate newly-thought-of criteria or criteria not originally considered to be important; alternatives can also be added, deleted, or changed. Such a hierarchy can be visualized as a diagram like the one immediately below, with the goal at the top, the three alternatives at the bottom, and the four criteria in between. There are useful terms for describing the parts of such diagrams: Each box is called a node. A node that is connected to one or more nodes in a level below it is called a parent node. The nodes to which it is so connected are called its children.

To reduce the size of the drawing required, it is common to represent AHP hierarchies as shown in the diagram below, with only one node for each alternative, and with multiple lines connecting the alternatives and the criteria that apply to them.. The lines may be thought of

as being directed downward from the parent in one level to its children in the level below. Once the hierarchy has been constructed, the participants analyze it through a series of pairwise comparisons that derive numerical scales of measurement for the nodes. The criteria are pairwise compared against the goal for importance. The alternatives are pairwise compared against each of the criteria for preference. The comparisons are processed mathematically, and priorities are derived for each node.

In many suitability analyses, some eligibility criteria are more important than others. Often, it is the expectation in a location search to be able to compare several suitable candidates whether, and how strongly, they meet a set of criteria of differing importance. By using the layer principle, one can easily extend the overlay by assigning levels of importance to each criterion.

2.3 Weight overlay

Among the most powerful and commonly used tools in a geographic information system (GIS) is the overlay of cartographic information. In a GIS, an overlay is the process of taking two or more different thematic maps of the same area and placing them on top of one another to form a new Inherent in this process, the overlay function combines not only the spatial features of the dataset but also the attribute information as well. A common example used to illustrate the overlay process is, “Where is the best place to put a mall?” Imagine you are a corporate bigwig and are tasked with determining where your company’s next shopping mall will be placed. How would you attack this problem? With a GIS at your command, answering such spatial questions begins with amassing and overlaying pertinent spatial data layers. For example, you may first want to determine what areas can support the mall by accumulating information on which land parcels are for sale and which are zoned for commercial development. After collecting and overlaying the baseline information on available development zones, you can begin to determine which areas offer the most economic opportunity by collecting regional information on average household income, population density, location of proximal shopping centers, local buying habits, and more. Next, you may want to collect information on restrictions or roadblocks to development such as the cost of land, cost to develop the land, community response to development, adequacy of transportation corridors to and from the proposed mall, tax rates, and so forth. Indeed, simply collecting and overlaying spatial datasets provides a valuable tool for visualizing and selecting the optimal site for such a business endeavor. Several basic overlay processes are available in a GIS for vector datasets: point-in-polygon, polygon-on-point, line-on-line, line-

in-polygon, polygon-on-line, and polygon-on-polygon. As you may be able to divine from the names, one of the overlay dataset must always be a line or polygon layer, while the second may be point, line, or polygon. The new layer produced following the overlay operation is termed the “output” layer. The point-in-polygon overlay operation requires a point input layer and a polygon overlay layer. Upon performing this operation, a new output point layer is returned that includes all the points that occur within the spatial extent of the overlay. In addition, all the points in the output layer contain their original attribute information as well as the attribute information from the overlay. For example, suppose you were tasked with determining if an endangered species residing in a national park was found primarily in a particular vegetation community. The first step would be to acquire the point occurrence locales for the species in question, plus a polygon overlay layer showing the vegetation communities within the national park boundary. Upon performing the point-in-polygon overlay operation, a new point file is created that contains all the points that occur within the national park. The attribute table of this output point file would also contain information about the vegetation communities being utilized by the species at the time of observation. A quick scan of this output layer and its attribute table would allow you to determine where the species was found in the park and to review the vegetation communities in which it occurred. This process would enable park employees to make informed management decisions regarding which onsite habitats to protect to ensure continued site utilization by the species. As its name suggests, the polygon-on-point overlay operation is the opposite of the point-in-polygon operation. In this case, the polygon layer is the input, while the point layer is the overlay. The polygon features that overlay these points are selected and subsequently preserved in the output layer. For example, given a point dataset containing the locales of some type of crime and a polygon dataset representing city blocks, a polygon-on-point overlay operation would allow police to select the city blocks in which crimes have been known to occur and hence determine those locations where an increased police presence may be warranted. A line-on-line overlay operation requires line features for both the input and overlay layer. The output from this operation is a point or points located precisely at the intersection(s) of the two linear datasets (Figure 7.7 "Line-on-Line Overlay"). For example, a linear feature dataset containing railroad tracks may be overlain on linear road network. The resulting point dataset contains all the locales of the railroad crossings over a town's road network. The attribute table for this railroad crossing point dataset would contain information on both the railroad and the road over which it passed. The line-in-polygon overlay operation is similar to the point-in-polygon overlay, with that

obvious exception that a line input layer is used instead of a point input layer. In this case, each line that has any part of its extent within the overlay polygon layer will be included in the output line layer, although these lines will be truncated at the boundary. For example, a line-in-polygon overlay can take an input layer of interstate line segments and a polygon overlay representing city boundaries and produce a linear output layer of highway segments that fall within the city boundary. The attribute table for the output interstate line segment will contain information on the interstate name as well as the city through which they pass. The polygon-on-line overlay operation is the opposite of the line-in-polygon operation. In this case, the polygon layer is the input, while the line layer is the overlay. The polygon features that overlay these lines are selected and subsequently preserved in the output layer. For example, given a layer containing the path of a series of telephone poles/wires and a polygon map contain city parcels, a polygon-on-line overlay operation would allow a land assessor to select those parcels containing overhead telephone wires. Finally, the polygon-in-polygon overlay operation employs a polygon input and a polygon overlay. This is the most commonly used overlay operation. Using this method, the polygon input and overlay layers are combined to create an output polygon layer with the extent of the overlay. The attribute table will contain spatial data and attribute information from both the input and overlay layers (Figure 7.10 "Polygon-in-Polygon Overlay"). For example, you may choose an input polygon layer of soil types with an overlay of agricultural fields within a given county. The output polygon layer would contain information on both the location of agricultural fields and soil types throughout the county. The overlay operations discussed previously assume that the user desires the overlain layers to be combined. This is not always the case. Overlay methods can be more complex than that and therefore employ the basic Specifically, the union overlay method employs the OR operator. A union can be used only in the case of two polygon input layers. It preserves all features, attribute .

Alternatively, the intersection overlay method employs the AND operator. An intersection requires a polygon overlay, but can accept a point, line, or polygon input. The output layer covers the spatial extent of the overlay and contains features and attributes from both the input and overlay. The symmetrical difference overlay method employs the XOR operator, which results in the opposite output as an intersection. This method requires both input layers to be polygons. Following the clip, all attributes from the preserved portion of the input layer are included in the output. If any features are selected during this process, only those selected features within the clip boundary will be included in the output. For example, the clip tool

could be used to clip the extent of a river floodplain by the extent of a county boundary. This would provide county managers with insight into which portions of the floodplain they are responsible to maintain. This is similar to the intersect overlay method; however, the attribute information associated with the clip layer is not carried into the output layer following the overlay. The erase geoprocessing operation is essentially the opposite of a clip. Whereas the clip tool preserves areas within an input layer, the erase tool preserves only those areas outside the extent of the analogous erase layer (part (f)). While the input layer can be a point, line, or polygon dataset, the erase layer must be a polygon dataset. Continuing with our clip example, county managers could then use the erase tool to erase the areas of private ownership within the county floodplain area. Officials could then focus specifically on public reaches of the countywide floodplain for their upkeep and maintenance responsibilities. The split layer must be a polygon, while the input layers can be point, line, or polygon. For example, a homeowner's association may choose to split up a countywide soil series map by parcel boundaries so each homeowner has a specific soil map for their own parcel. A spatial join is a hybrid between an attribute operation and a vector overlay operation. A spatial join results in the combination of two feature dataset tables by a common attribute field. Unlike the attribute operation, a spatial join determines which fields from a source layer's attribute table are appended to the destination layer's attribute table based on the relative locations of selected features. This relationship is explicitly based on the property of proximity or containment between the source and destination layers, rather than the primary or secondary keys. The proximity option is used when the source layer is a point or line feature dataset, while the containment option is used when the source layer is a polygon feature dataset. When employing the proximity (or "nearest") option, a record for each feature in the source layer's attribute table is appended to the closest given feature in the destination layer's attribute table. The proximity option will typically add a numerical field to the destination layer attribute table, called "Distance," within which the measured distance between the source and destination feature is placed. For example, suppose a city agency had a point dataset showing all known polluters in town and a line dataset of all the river segments within the municipal boundary. This agency could then perform a proximity-based spatial join to determine the nearest river segment that would most likely be affected by each polluter. When using the containment (or "inside") option, a record for each feature in the polygon source layer's attribute table is appended to the record in the destination layer's attribute table that it contains. If a destination layer feature (point, line, or polygon) is not completely contained within a source polygon, no value will be appended. For example,

suppose a pool cleaning business wanted to hone its marketing services by providing flyers only to homes that owned a pool. They could obtain a point dataset containing the location of every pool in the county and a polygon parcel map for that same area. That business could then conduct a spatial join to append the parcel information to the pool locales. This would provide them with information on each land parcel that contained a pool and they could subsequently send their mailers only to those homes. Although overlays are one of the most important tools in a GIS analyst's toolbox, there are some problems that can arise when using this methodology. In particular, slivers are a common error produced when two slightly misaligned vector layers are overlain. For example, most vegetation and soil maps are created from field survey data, satellite images, and aerial photography. While you can imagine that the boundaries of soils and vegetation frequently coincide, the fact that they were most likely created by different researchers at different times suggests that their boundaries will not perfectly overlap. To ameliorate this problem, GIS software incorporates a cluster tolerance option that forces nearby lines to be snapped together if they fall within a user-specified distance. Care must be taken when assigning cluster tolerance. Associated with the overlay process is error propagation. Error propagation arises when inaccuracies are present in the original input and overlay layers and are propagated through to the output layer. These errors can be related to positional inaccuracies of the points, lines, or polygons. Alternatively, they can arise from attribute errors in the original data table(s). Regardless of the source, error propagation represents a common problem in overlay analysis, the impact of which depends largely on the accuracy and precision requirements of the project at hand.

A numerical weighting factor is assigned to each thematic layer according to its relative importance compared to all other layers. After that, the weighted layers are overlaid as before. This process is called term weighted overlay. In principle, weighted overlay is possible with rasters and vectors just like Boolean overlay.

Since the input criteria layers will be in different numbering systems with different ranges, to combine them in a single analysis, each cell for each criterion must be reclassified into a common preference scale such as 1 to 10, with 10 being the most favorable. An assigned preference on the common scale implies the phenomenon's preference for the criterion. The preference values are on a relative scale. That is, a preference value of 10 is twice as preferred as a preference value. The preference values should not only be assigned relative to each other within the layer but also have the same meaning between the layers. For example, if a

location for one criterion is assigned a preference of 5, it will have the same influence on the phenomenon as a 5 in a second criterion (Wang and Donaghy 1995).

2.4. Integration with Geospatial decision support system

GIS-based land grading systems can be integrated with geospatial decision support systems (DSS) to provide a comprehensive platform for land use planning. Geospatial DSS combines spatial data, analysis tools, and decision models to support decision-making processes. By integrating land grading assessments with other planning considerations, such as transportation networks, environmental factors, and social equity, geospatial DSS enables a holistic evaluation of land use options (Lyle and Stutz 1983). This integration enhances the efficiency and effectiveness of decision-making processes, leading to more sustainable and well-informed land use planning decisions.

The field of GIS and land grading is continuously evolving, and emerging technologies are being explored for their potential applications. For example, the integration of unmanned aerial vehicles (UAVs) or drones with GIS-based land grading systems allows for high-resolution data acquisition and real-time monitoring of land grading activities [12]. Additionally, the integration of artificial intelligence (AI) and machine learning techniques holds promise for automating various aspects of land grading assessments, such as data processing, feature extraction, and decision-making. These emerging technologies have the potential to further enhance the accuracy, efficiency, and sustainability of GIS-based land grading systems.

In conclusion, GIS-based land grading systems continue to advance through the integration of remote sensing data, uncertainty analysis, 3D visualization, geospatial decision support systems, and the exploration of emerging technologies. These developments contribute to more accurate assessments, improved decision-making processes, and sustainable land use planning. The ongoing research and technological advancements in this field hold great potential for addressing the complex challenges associated with land grading and urban development.

CHAPTER III: RESEARCH MATERIAL AND METHODOLOGY

3.1. DESCRIPTION OF THE STUDY AREA

The study area (**Fig.3.1**) viz. Adama City is extending between geographic coordinates of at $8^{\circ} 30' 52.1172''$ N latitude and $39^{\circ} 16' 9.3252''$ E longitude at some 80 Kilometers away from Addis Ababa City. The maximum elevation of the city is 1712 meters above mean sea level. Owing to its geographical proximity to international port of Djibouti within the distance of about 777 Kilometers, the city is one of the preferred destinations for trade and industry.

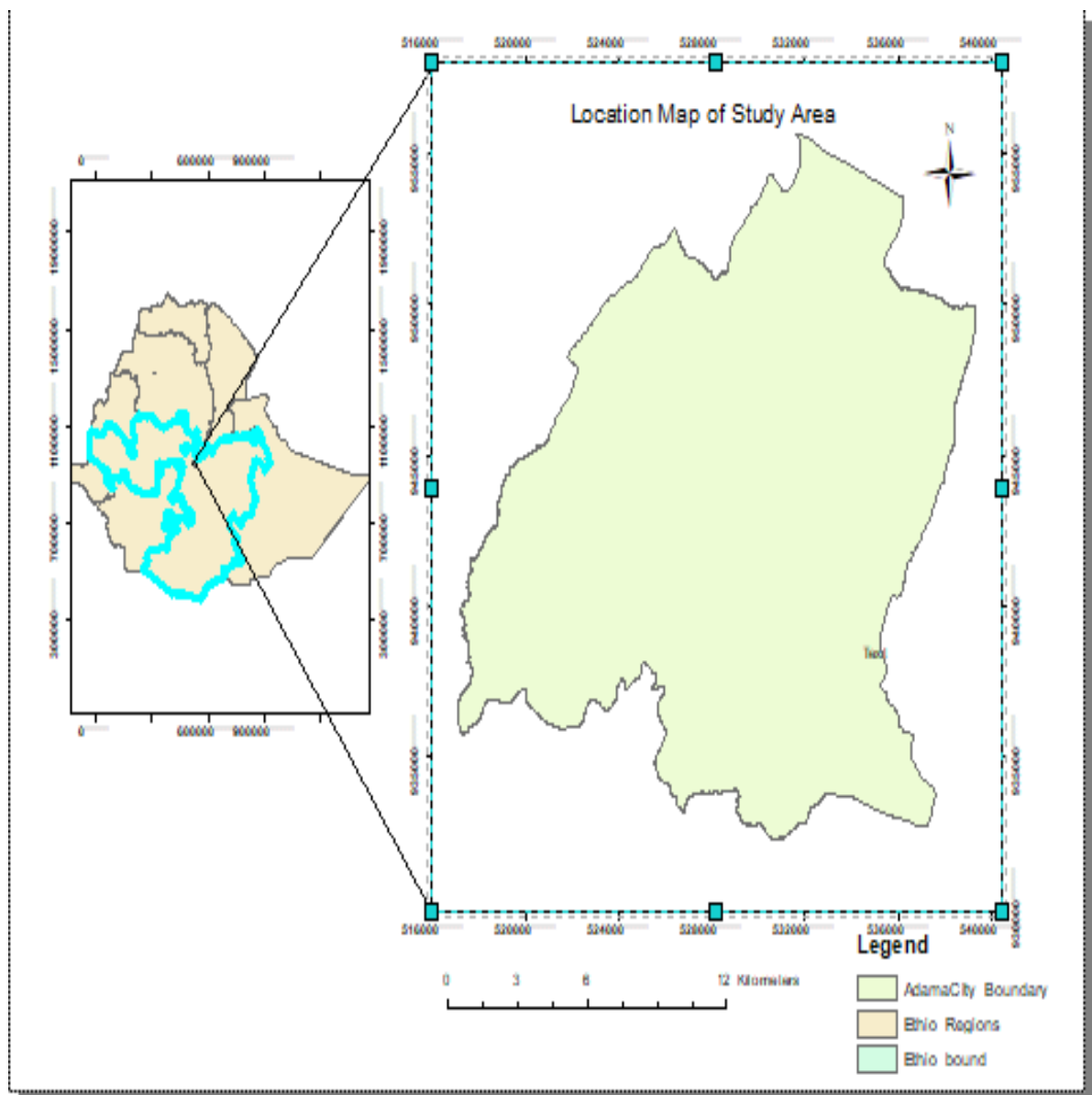


Figure 3.1 Location map Adama city

3.2. DESCRIPTION OF METHODOLOGY

The methodology begins by collecting data, which is followed by the integration of the collected data. Once the data integration is complete, an analysis is conducted.

INTRODUCTION

Land grading is a critical aspect of urban planning and infrastructure development, as it influences the suitability and efficient utilization of land for various purposes. In recent years, there has been a growing interest in integrating Geographic Information Systems (GIS) into land grading processes [11]. GIS technology offers a powerful platform for data integration, analysis, and visualization, which can significantly enhance the accuracy and effectiveness of land grading in urban planning.

This literature review seeks to examine the existing research and advancements in GIS-based land grading systems. The review will focus on several key areas, including data integration, analysis techniques, system development, and application in urban planning.

Firstly, the review will explore the importance of data integration in GIS-based land grading systems. It will examine how different types of geospatial data, such as topographic maps, aerial imagery, and land cover information; can be effectively integrated into the system. The review will highlight the benefits of integrating diverse data sources and discuss the challenges associated with data integration, such as data quality, compatibility, and interoperability.

Secondly, the review will investigate various analysis techniques employed in GIS-based land grading systems. It will explore spatial interpolation methods, multi-criteria decision analysis, and other analytical approaches used to assess land characteristics and determine grading decisions. The review will evaluate the strengths and limitations of these techniques and discuss their applicability in different urban planning scenarios.

Furthermore, the review will examine the development of GIS-based land grading systems. It will explore the design and implementation of these systems, including the development of algorithms, models, and user interfaces. The review will analyze the key features and functionalities of these systems and discuss the considerations for system scalability, flexibility, and usability.

Lastly, the review will investigate the application of GIS-based land grading systems in urban planning. It will examine how these systems have been utilized to support decision-making processes, land use planning, and infrastructure development in real-world scenarios. The review will discuss the benefits and challenges of implementing GIS-based

land grading systems in urban planning contexts and identify areas for future research and improvement.

By conducting this literature review, a comprehensive understanding of the existing research and advancements in GIS-based land grading systems will be gained. The review will provide insights into the integration of geospatial data, analysis techniques, system development, and application in urban planning. The findings from this review will contribute to the knowledge base in the field and inform the development of a GIS-based land grading system that enhances land utilization and supports sustainable urban growth.

3.2.2 INTEGRATION OF DATA

Effective data integration is crucial for GIS-based land grading systems. emphasized the importance of integrating various geospatial data sources, including topographic maps, aerial imagery, and land cover information, to obtain a comprehensive understanding of land characteristics. They proposed a data fusion approach that combines remote sensing data and ground-based measurements to enhance the accuracy of land grading assessments.

3.2.3 DATA COLLECTION

The data collection phase involves gathering various geospatial data sources essential for land grading assessments, such as topographic maps, aerial imagery, land cover information, and any other relevant datasets. It is crucial to acquire data from reliable sources to ensure its accuracy and quality. Once the data is collected, it needs to be organized and preprocessed to make it suitable for analysis, taking steps to ensure compatibility, consistency, and data quality.

The integration of collected geospatial data into a common coordinate system is a crucial step in the data processing workflow. By aligning the data to a standardized coordinate system, it becomes possible to accurately overlay and analyze different datasets, ensuring spatial consistency and compatibility. Additionally, developing methods for data fusion and harmonization is essential to address potential discrepancies or variations among the collected data sources. This involves reconciling differences in data formats, resolutions, and projections to create a unified and consistent dataset. To enhance the quality and reliability of the integrated data, various data preprocessing techniques are applied. These techniques include data cleaning to remove errors or outliers, filtering to remove noise or irrelevant data, and transformation to normalize or enhance the data's characteristics. By employing these preprocessing techniques, the integrated data becomes refined and optimized for subsequent analysis, improving the overall quality and reliability of the dataset.

To undertake research on developing a GIS-based land grading system that improves the precision and efficiency of land grading in urban planning, the following data and software components are required. Firstly, geospatial data encompassing various datasets pertaining to the land being graded, including digital elevation models (DEM), aerial imagery, land cover data, and other pertinent geospatial datasets specific to the study area. These datasets must be in a compatible format that allows for seamless analysis and integration within the GIS software framework.

Secondly, land use data is crucial in evaluating the suitability of land for different purposes. This information encompasses current land use patterns, zoning regulations, and future land use plans within the study area. Understanding these factors aids in making informed land grading decisions.

Thirdly, infrastructure data plays a vital role in assessing the impact of existing infrastructure networks, such as roads, utilities, and drainage systems, on land grading considerations. Having access to this data facilitates a comprehensive analysis of the potential implications and constraints associated with land grading.

Lastly, the inclusion of ground truth data obtained through field surveys, soil sampling, or other on-site measurements is essential. These ground truth data points serve as a means of validating the accuracy of the land grading system and provide a reference for comparison, ensuring the reliability and precision of the developed GIS-based model.

The studies will mainly be supported by geospatial datasets gathered from different sources.

Table 3.1: Data and their sources

No	Data	Source
1	Orthophoto	Adama municipality
2	Base map	GIS online
3	Adama Administration boundary data	Adama municipality
4	Elevation Data	USGS
5	Infrastructure data like Asphalt Road Network, Electric power distribution, water supply distribution, Healthy centers, Gov't schools,	Adama municipality
6	Land use Grading Questionary	Researcher

Basemap

A basemap is a fundamental layer that provides geographical context to maps and other dataset layers. It serves as a visual reference, allowing mapmakers to build upon it by adding additional information. Orthophoto basemaps display ground features from a top-down perspective, often using satellite imagery or aerial/drone photography. They allow you to see Earth's features in detail, including buildings and streets. Examples include Google Satellite Imagery and Esri Imagery. Satellite basemaps provide an aerial view captured from space. They're useful for visualizing features from above.

Asphalt road data

Asphalt (also known as tarmac) is a black, sticky, and highly viscous liquid derived from petroleum. It is widely used as a road surface for highways, city roads, parking lots, driveways, and pavements. Asphalt is recyclable, cost-effective, and environmentally friendly.

Water Supply distribution

A water distribution system is a crucial component of a water supply network. It ensures that potable water reaches consumers, meeting residential, commercial, industrial, and firefighting needs. These are laid within public rights-of-way and are called water mains. Water mains transport water within the distribution system. Large-diameter water mains, known as primary feeders, connect water treatment plants to service areas. Secondary feeders link primary feeders to distributors.

Healthcare Distribution

The essential role of healthcare distribution and how it impacts the availability of medical supplies in various facilities.

Healthcare Distributors play a crucial role in ensuring that hospitals, clinics, and other healthcare providers have access to the necessary medical products.

Within the framework of non-theatrical media, educational rights include schools, colleges, universities, public and academic libraries.

Electric power distribution

Electric power distribution is the final stage in the delivery of electricity. It involves carrying electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage using transformers.

Adama city Terrain analysis

Slope refers to the steepness or incline of a line. It describes how much a line rises or falls as you move from left to right. Mathematically, the slope of a line represents the ratio of the vertical change (rise) to the horizontal change (run) between two points on the line.

Software Used

In the research and development of a GIS-based land grading system, the following software components are necessary. Firstly, a Geographic Information System (GIS) software package is crucial for integrating, analyzing, and visualizing data. Options such as

- ArcGIS,
- QGIS, or specialized software designed for land grading and geospatial analysis can be utilized. It facilitates efficient data retrieval, storage, and ensures seamless management of the data required for the land grading system Secondly, depending on the availability and characteristics of remote sensing data,
- specific software tools like ERDAS Imagine may be required for processing and analyzing satellite or Orthophoto.

3.2.4 ANALYSIS TECHNIQUES

Spatial interpolation techniques are implemented to estimate values at unsampled locations and fill data gaps within the geospatial data utilized for land grading assessments. These techniques leverage the available data points to infer values in areas where data is missing or not directly measured. By employing spatial interpolation, the land grading model ensures comprehensive coverage of land characteristics, resulting in a more accurate representation of the entire study area.

Multi-criteria decision analysis methods are applied to evaluate and prioritize various factors and criteria for land grading assessments. These methods take into account factors such as slope, drainage, soil composition, and land use regulations, among others, to assess the suitability of land for different purposes. Through the utilization of multi-criteria decision analysis methods, a systematic approach is employed to weigh and combine different criteria, enabling objective and consistent land grading evaluations. This approach enhances the decision-making process by providing a structured framework to assess and compare various factors, ultimately supporting informed land grading assessments. Spatial interpolation techniques are widely utilized in GIS-based land grading systems to estimate values at unsampled locations and fill data gaps. [17] compared different interpolation methods, including inverse distance weighting, kriging, and spline interpolation, for land

grading applications. Their study highlighted the importance of selecting an appropriate interpolation technique based on data characteristics and desired accuracy levels.

Multi-criteria decision analysis methods have been extensively applied in GIS-based land grading systems to evaluate and prioritize different factors and criteria. [15] employed the Analytic Hierarchy Process (AHP) to assess land grading factors such as slope, drainage, soil composition, and land use regulations. Their research demonstrated the effectiveness of AHP in integrating diverse criteria and providing objective land grading evaluations.

In the realm of spatial interpolation techniques, researchers have explored advanced methods to improve the accuracy of land grading assessments. For instance, [19] proposed a geographically weighted regression (GWR) approach, which accounts for spatial heterogeneity in the relationships between land grading factors. By considering local variations, the GWR method enhanced the precision of land grading predictions, especially in areas with diverse characteristics.

Multi-criteria decision analysis methods have also been extended to include participatory approaches in GIS-based land grading systems. Incorporated stakeholder preferences and expert opinions through a participatory GIS approach, allowing for a more inclusive and transparent decision-making process. This integration of social perspectives alongside technical criteria provided a comprehensive evaluation framework for land grading assessments.

In weighted overlay analysis, we follow the same steps as in general overlay analysis:

- Define the problem.
- Break the model into sub models.
- Identify input layers (criteria).

Each input layer (raster) is assigned a weight in the suitability analysis. Values within the rasters are reclassified to a common suitability scale (e.g., 1 to 10). A higher value indicates greater favorability for the phenomenon being modeled. The reclassification process ensures that each cell for each criterion is on a common preference scale.

Weighting Criteria:

- Not all criteria are equally important.
- You can assign **weights** to criteria based on their relative importance.
- For instance, in a housing suitability model, aspects (long-term conservation) might be more critical than short-term costs (slope and distance to roads).

Weighted overlay combines multiple criteria layers, assigns weights, and reclassifies values to create a comprehensive suitability map.

3.3. DESIGN OF METHODOLOGY

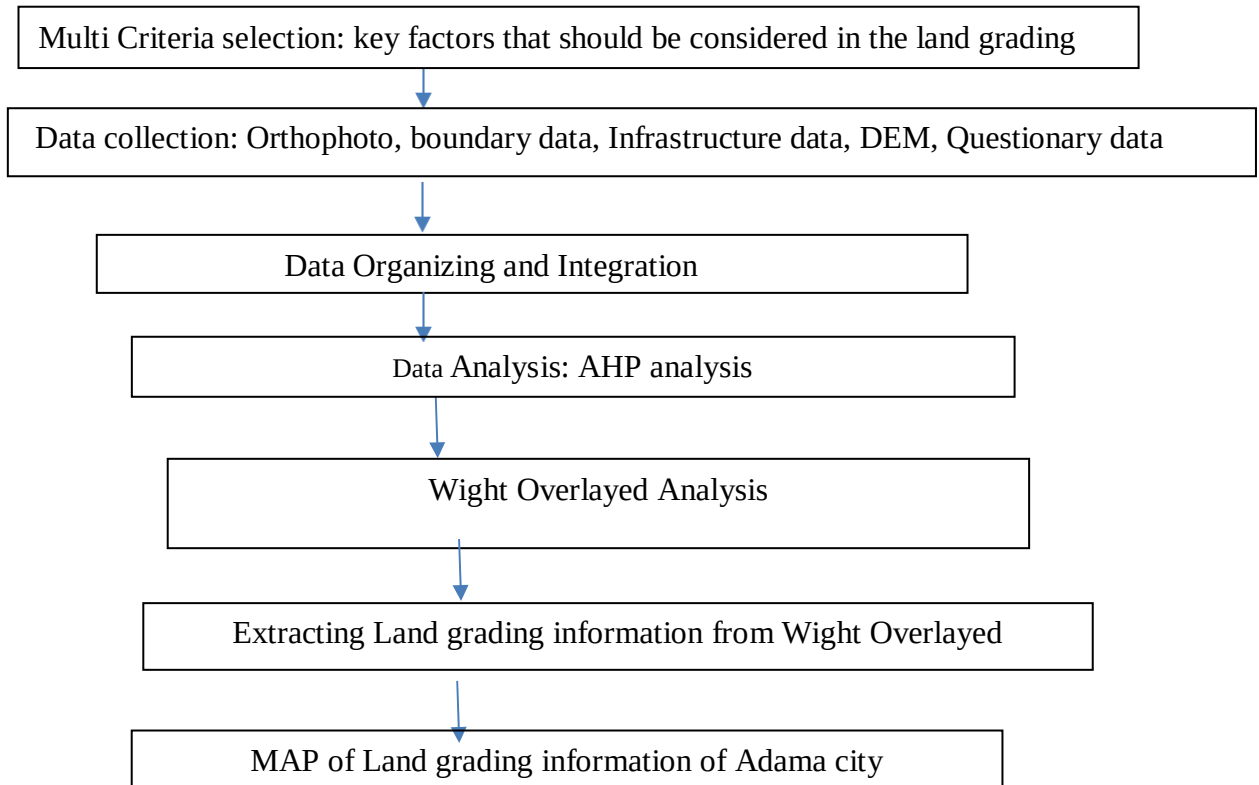


Figure 3.2 Technological Work flow of the study

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 INDICATORS FOR RANKING LAND GRADING INFORMATION

In line with the global research justifications, the criteria affecting the land grading are

- the area of the parcel,
- the shape of the parcel,
- the terrain of the parcel,
- the distance of the parcel to the road,
- the distance of the parcel to the water supply,
- the distance of the parcel to the electric,
- the distance of the parcel to the school
- the distance of the parcel to the health parcel,

4.2 ANALYZING LAND GRADING USING AHP TECHNIQUES

The indicators and their coorelation for analyzing with the techniques of AHP describes as follows.

- Asphalt road is of equal importance to Asphalt Road
- Water supply is of equal importance to water supply
- Electric supply is of equal importance to Electric supply
- Educational centers is of equal importance to Educational centers
- Health centers is of equal importance to Health centers
- DEM is of equal importance to DEM

Asphalt road importance compared to others factors:

- Asphalt road is of equal and moderate importance than water supply
- Asphalt road is of equal and moderate importance than electric supply
- Asphalt is road of moderate importance than educational centers
- Asphalt is road of moderate importance than health centers
- Asphalt is road of strong importance than DEM

Water supply importance compared to others factors:

- Water supply is of equal importance to electric supply
- Water supply is of moderate importance than educational centers
- Water supply is of moderate importance than Health centers
- Water supply is of moderate and strong importance than DEM

Electric supply importance compared to others factors:

- Electric supply is of equal and moderate importance than educational centers
- Electric supply is of equal and moderate importance than Health centers
- Electric supply is of moderate importance than DEM

Educational centers are of importance compared to others factors:

- Educational centers are of equal importance to Health centers
- Educational centers are equal and moderate importance than DEM
- Health centers are equal and moderate importance than DEM

By using the layer principle, one can easily extend the overlay by assigning levels of importance to each criterion. A numerical weighting factor is assigned to each thematic layer according to its relative importance compared to all other layers. After that, the weighted layers are overlaid as before. This process is called term weighted overlay. In principle, weighted overlay is possible with raster's and vectors just like Boolean overlay. The preference values should not only be assigned relative to each other within the layer but also have the same meaning between the layers. For example, if a location for one criterion is assigned a preference of 5, it will have the same influence on the phenomenon as a 5 in a second criterion. In a simple housing suitability model, you may have three input criteria: slope, aspect, and distance to roads. The slopes are reclassified on a scale of 1 to 3, with the flatter being less costly; therefore, they are the most favorable and are assigned the higher values. As the slopes become steeper, they are assigned decreasing values, with the being assigned a 1. You do the same reclassification process to the 1-to-3 scale for aspect, with the more favorable aspects—in this case, the more southerly—being assigned the higher values. The same reclassification process is applied to the distance to roads criterion.

Table 4.1 Pair-wise weighting

	Asphalt road	Water supply	Electric supply	Educational centers	Health centers	Terrain analysis
Asphalt road	1	2	2	3	3	5
Water supply	0.5	1	1	3	3	4
Electric supply	0.5	1	1	2	2	3
Educational centers	0.333	0.333	0.5	1	1	2
Health centers	0.333	0.2	0.5	1	1	2
Terrain analysis	0.2	0.25	0.333	0.5	0.5	1
Sum	2.866	4.783	5.333	10.5	10.5	17

Table 4.2 Normalized Pair-wise comparison matrix

	Asphalt road	Water supply	Electric supply	Educational centers	Health centers	Terrain analysis
Asphalt road	1/2.866	2/4.783	2/5.333	3/10.5	3/10.5	5
Water supply	0.5/2.866	1/4.783	1/5.333	3/10.5	3/10.5	4
Electric supply	0.5/2.866	1/4.783	1/5.333	2/10.5	2/10.5	3
Educational centers	0.333/2.866	0.333/4.783	0.5/5.333	1/10.5	1/10.5	2
Health centers	0.333/2.866	0.2/4.783	0.5/5.333	1/10.5	1/10.5	2
Terrain analysis	0.2/2.866	0.25/4.783	0.333/5.333	0.5/10.5	0.5/10.5	1

Table 4.3 Pair-wise comparison matrix criteria weight

	Asphalt road	Water supply	Electric supply	Educational centers	Health centers	Terrain analysis	criteria wt
Asphalt road	0.349	0.418	0.375	0.286	0.286	0.294	0.335
Water supply	0.174	0.209	0.188	0.286	0.286	0.235	0.230
Electric supply	0.174	0.209	0.188	0.190	0.190	0.176	0.188
Educational centers	0.116	0.070	0.094	0.095	0.095	0.118	0.098
Health centers	0.116	0.042	0.094	0.095	0.095	0.118	0.093
Terrain analysis	0.070	0.052	0.062	0.048	0.048	0.059	0.056

Criteria
wt=rows
sum/6

Table 4.4 Calculate consistency

	Asphalt road	Water supply	Electric supply	Educational centers	Health centers	Terrain analysis	weighted sum value
Asphalt road	0.335	0.460	0.376	0.294	0.279	0.28	2.024
Water supply	0.168	0.230	0.188	0.294	0.279	0.224	1.383
Electric supply	0.168	0.230	0.188	0.196	0.186	0.168	1.136
Educational centers	0.112	0.077	0.094	0.098	0.093	0.112	0.585
Health centers	0.112	0.046	0.094	0.098	0.093	0.112	0.555
Terrain analysis	0.067	0.058	0.063	0.049	0.0465	0.056	0.339

Sum of wt= rows su(crieia wt times weigh)

Table 4.5 pair wise comparison matrix

	Asphalt road	Water supply	Electric supply	Educational centers	Health centers	Terrain analysis	wt sum	criteria wt	sum/criter
Asphalt road	0.335	0.460	0.376	0.294	0.279	0.28	2.024	0.335	6.042
Water supply	0.168	0.230	0.188	0.294	0.279	0.224	1.383	0.230	6.013
Electric supply	0.168	0.230	0.188	0.196	0.186	0.168	1.136	0.188	6.043
Educational centers	0.112	0.077	0.094	0.098	0.093	0.112	0.585	0.098	5.969
Health centers	0.112	0.046	0.094	0.098	0.093	0.112	0.555	0.093	5.968
Terrain analysis	0.067	0.058	0.063	0.049	0.0465	0.056	0.339	0.056	6.054

$$\text{Lamdmax} = (\text{sum/criter})/6 = 6.014833333$$

$$\text{CI} = \text{Lamdmax} - 6/6 - 1 = 0.014833333$$

$$\text{CR} = \text{CI}/\text{RI} = 0.002392473$$

CR..consistanty ratio

CI..consistancy Index

RI...Random index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

4.3 WEIGHT OVERLAY ANALYSIS FOR LAND GRADING INFORMATION

The Weighted Overlay function applies one of the most used approaches for overlay analysis to solve multicriteria problems such as site selection and suitability models. In a weighted overlay analysis, each of the general overlay analysis steps is followed. As with all overlay analysis, in weighted overlay analysis, you must define the problem, break the model into submodels, and identify the input layers. Since the input criteria layers will be in different numbering systems with different ranges, to combine them in a single analysis, each cell for each criterion must be reclassified into a common preference scale such as 1 to 3, with 3 being the most favorable. An assigned preference on the common scale implies the phenomenon's preference for the criterion. The preference values are on a relative scale. That is, a preference value of 3 is twice as preferred as a preference value of 1. The preference values should not only be assigned relative to each other within the layer but also have the same meaning between the layers. For example, if a location for one criterion is assigned a preference of 3, it will have the same influence on the phenomenon as a 3 in a second criterion.

Pairwise comparison is the process of comparing a set of options using head-to-head pairs to judge which one is the most preferred overall. Also known as “pairwise ranking”, it is a popular research method used for ranking people’s preferences, informing strategic decisions, and conducting voting at scale.

The design of hierarchy will depend not only on the nature of the problem at hand, but also on the knowledge, judgments, values, opinions, needs, wants, etc. of the participants in the decision-making process.

Even after its initial construction, it can be changed to accommodate newly-thought-of criteria or criteria not originally considered to be important; alternatives can also be added, deleted, or changed. Such a hierarchy can be visualized as a diagram like the one immediately below, with the goal at the top, the three alternatives at the bottom, and the four criteria in between. There are useful terms for describing the parts of such diagrams: Each box is called a node. A node that is connected to one or more nodes in a level below it is called a parent node. The nodes to which it is so connected are called its children.

To reduce the size of the drawing required, it is common to represent AHP hierarchies as shown in the diagram below, with only one node for each alternative, and with multiple lines connecting the alternatives and the criteria that apply to them. Once the hierarchy has been constructed, the participants analyze it through a series of pairwise comparisons that

derive numerical scales of measurement for the nodes. The criteria are pairwise compared against the goal for importance. The alternatives are pairwise compared against each of the criteria for preference. The comparisons are processed mathematically, and priorities are derived for each node.

Weight overlay in % give percentage based on their importance

Accessibility of Road.....	33.5%....
Water supply.....	23%...
Electric supply.....	18.8%....
Educational centers... ..	9.8%,,,,
Health centers	9.3%....
Terrain analysis.....	5.6%.....
	=100%

Steps in Weighted Overlay Analysis:

- Problem Definition: Clearly define the problem you want to solve (e.g., finding suitable locations for a new facility).
- Sub models: Break down the analysis into sub models based on different criteria (e.g., slope, aspect, distance to roads).
- Input Layers: Identify the input layers (roasters) representing each criterion.
- Reclassification: Reclassify the values of each input layer into a common preference scale (e.g., 1 to 10), where 10 represents the most favorable condition.
- Relative Preferences: Assign preference values on a relative scale. For example, a preference value of 10 is twice as preferred as a value of 5.
- Weighting: Assign weights to each criterion based on its importance. Some criteria may be more critical than others.
- Overlay: Multiply the suitability value of each cell by its weight and combine the layers to create a composite suitability map.
- Weighting:
 - You decide that better aspects are more important than short-term costs (slope and distance to roads).
 - Therefore, you weight the aspect values twice as much as the other criteria.
- Overlay:
 - Combine the weighted layers to create a suitability map,

Weighted overlay considers multiple factors simultaneously, adjust weights and reclassifications based on specific project requirements.

The resulting suitability map provides a clear visualization of suitable areas.

Each of the criteria in the weighted overlay analysis may not be equal in importance. You can weight the important criteria more than the other criteria. For instance, in our sample housing suitability model, you might decide that because of long-term conservation purposes, the better aspects are more important than the short-term costs associated with the slope and distance to roads criteria.

Therefore, you may weight the aspect values as twice as important as the slope and distance to roads criteria.

- Adama city Asphalt is one of the basic indicators in land grading system. In this research the power far away upto 300m catagorizes as 1st land use grade.
- Adama city water distribution is one of the main indicators in land grading system. In this research the power far away upto 500m catagorizes as 1st land use grade.
- Adama city Electrical power availability is one of the main indicators in land grading system. In this research the power far away upto 500m catagorizes as 1st land use grade.
- Education is one of the main factors in land grading system and in this research the land far away upto 500m catagorizes as 1st land use grade.
- Above 1500m to 1700m above mean sea level catagorizes in the first land grades.

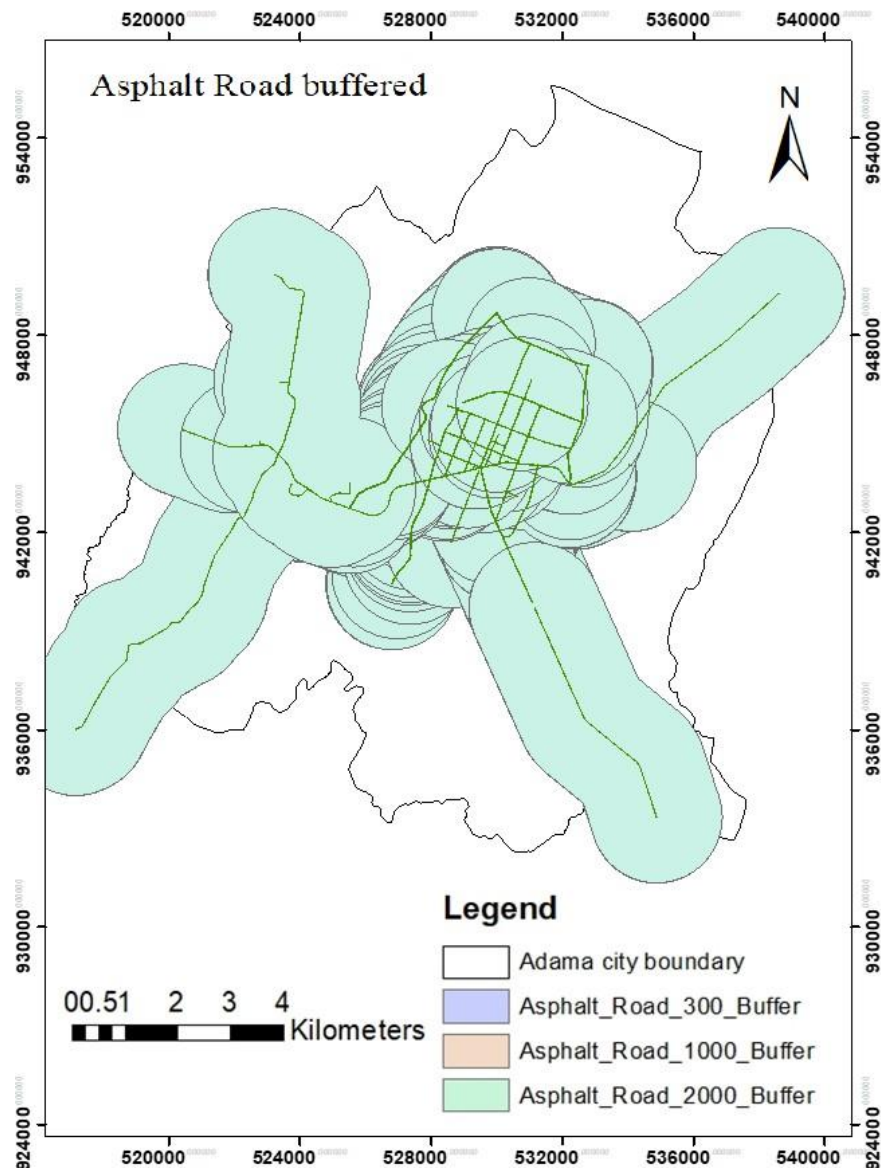


Figure 4.1 Adama city Asphalt Road buffered

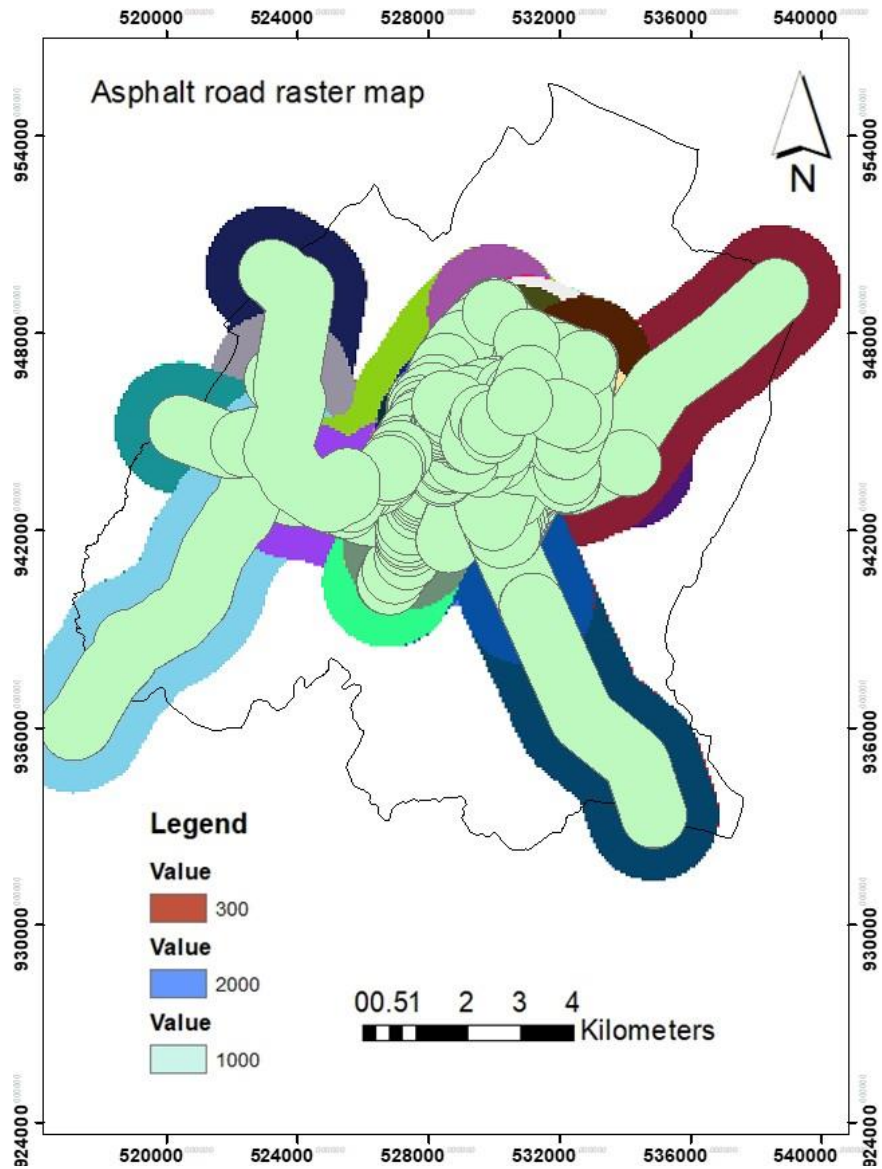


Figure 4.2 Adama city Asphalt road rasterized

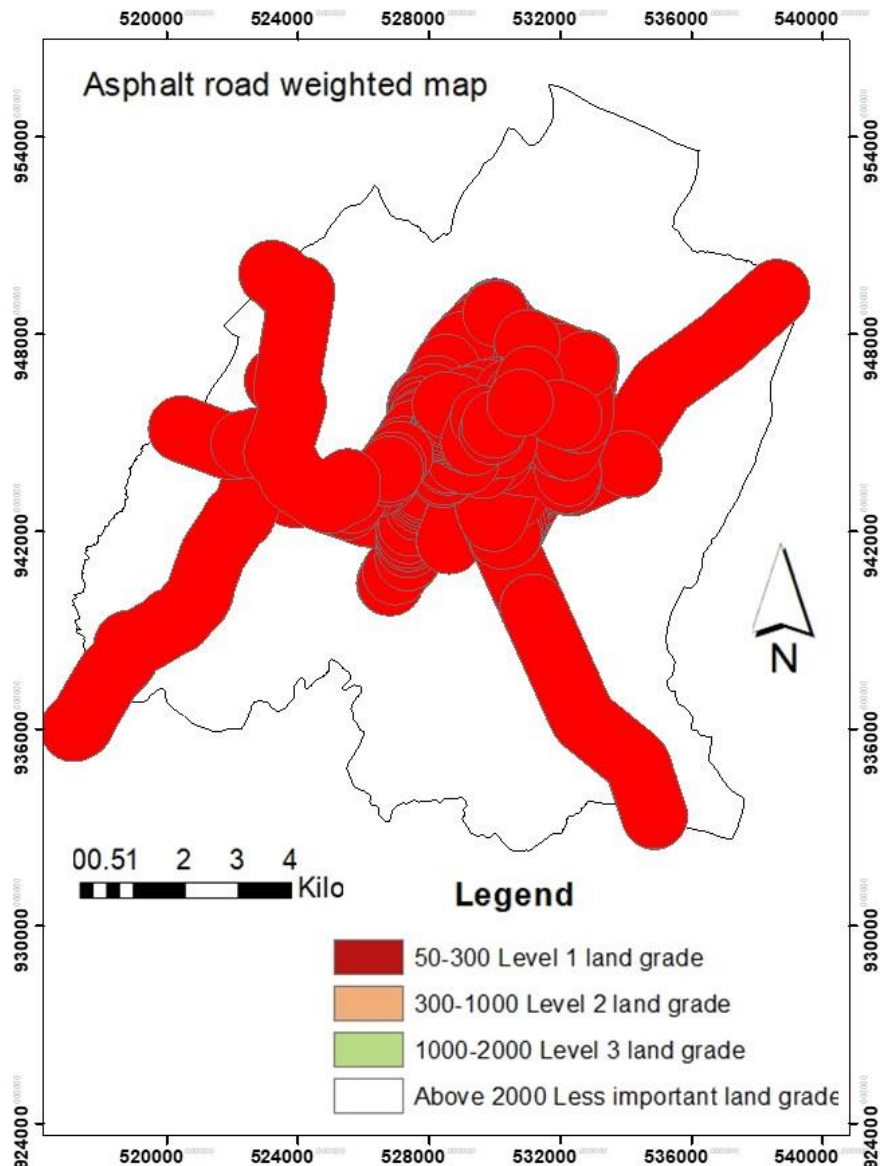


Figure 4.3 Adama city Asphalt Road weight overlay

Adama city Asphalt is one of the basic indicators in land grading system. In this research the power far away upto 300m catagorizes as 1st land use grade.

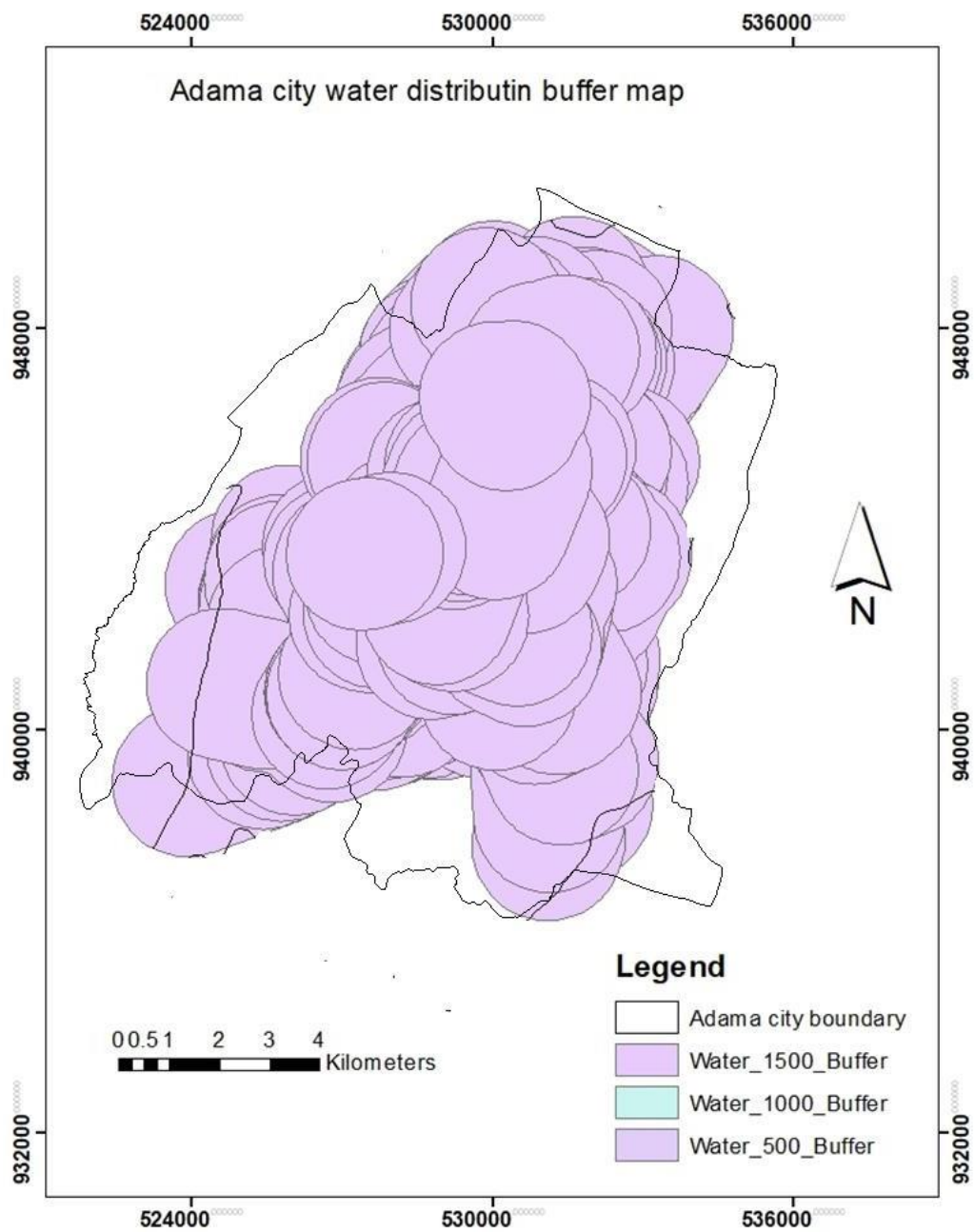


Figure 4.4 Adama city drinking water lines buffered

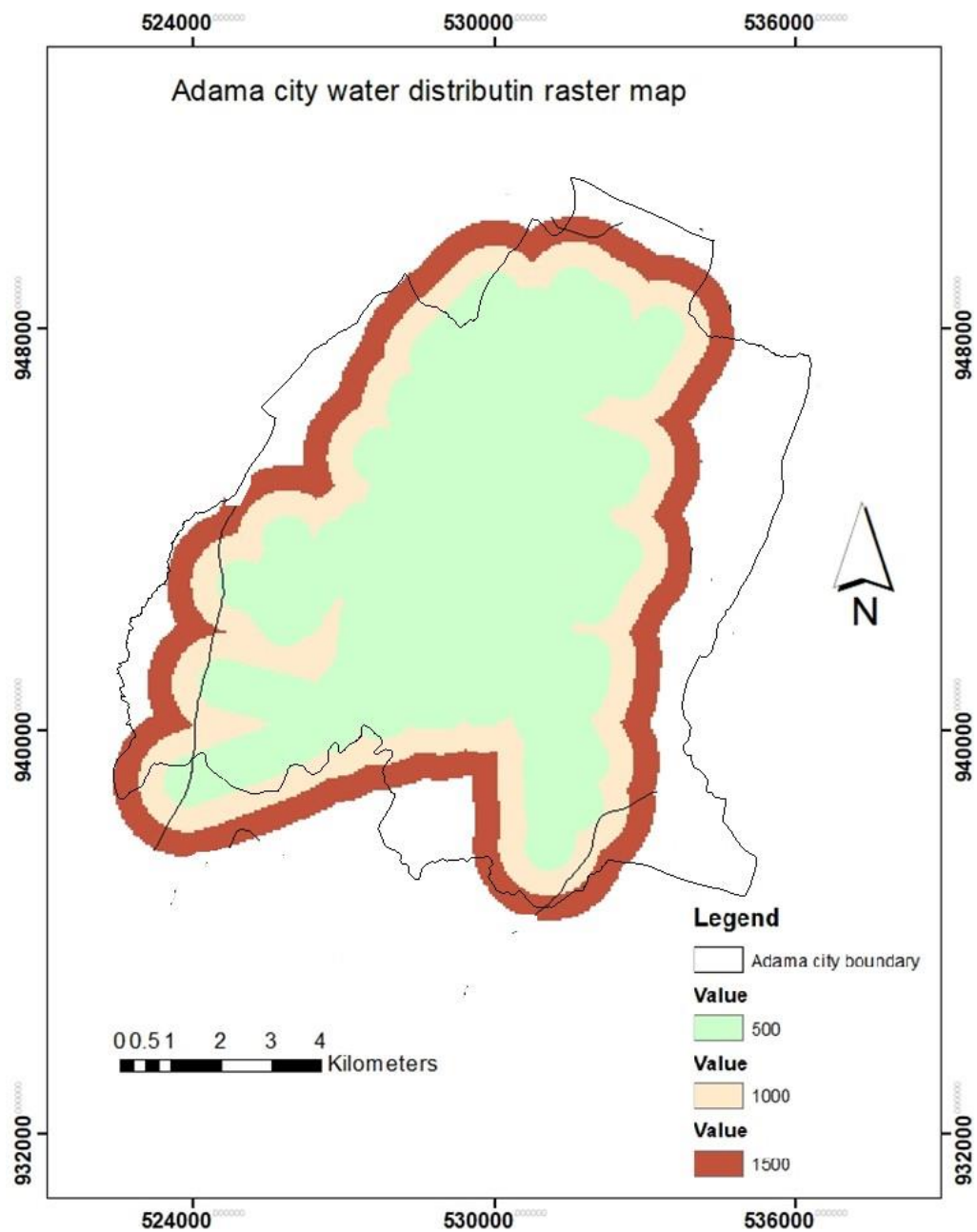


Figure 4.5 Adama city drinking water lines rasterized

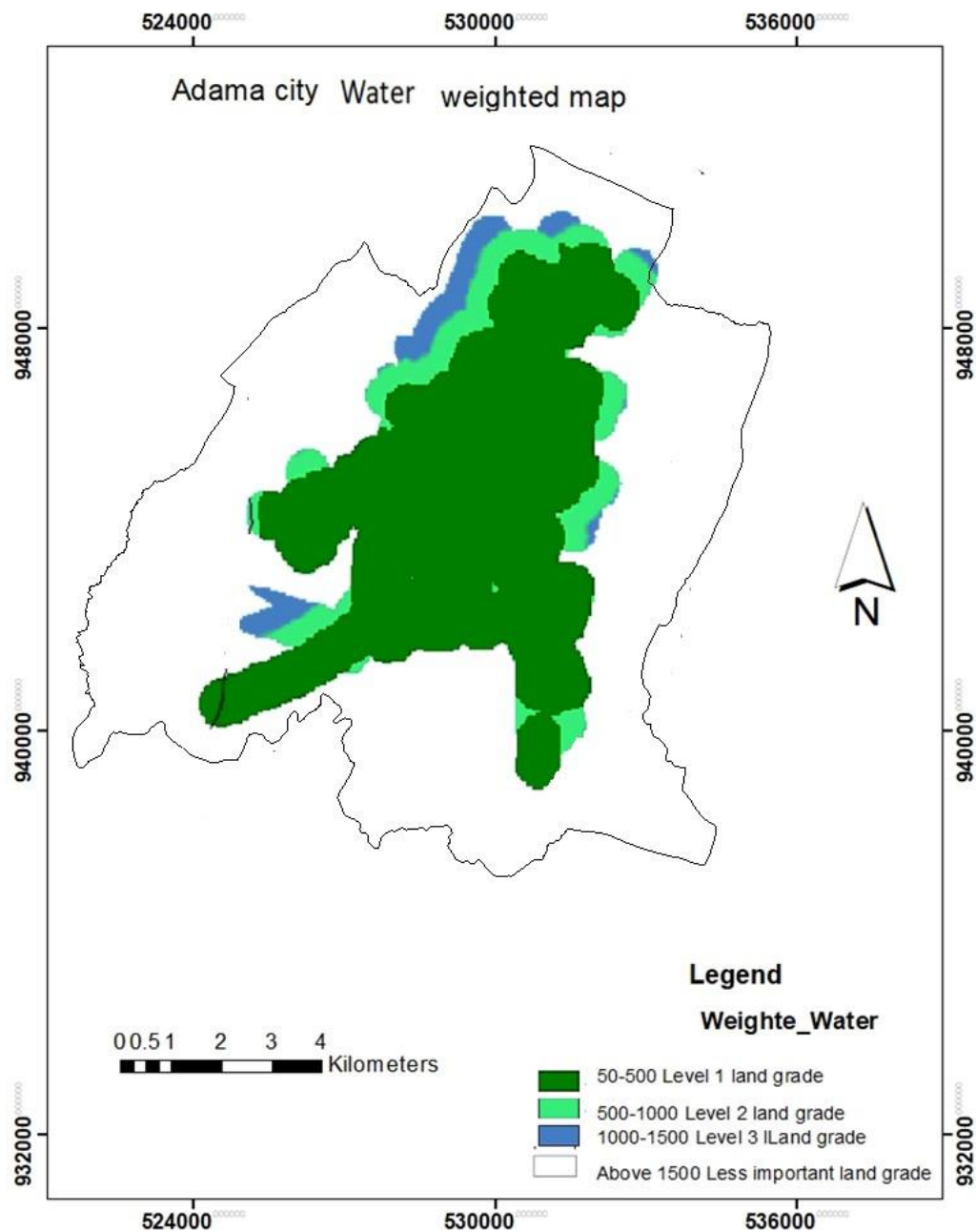


Figure 4.6 Adama city drinking water lines weight overlay

Adama city water distribution is one of the main indicators in land grading system. In this research the power far away upto 500m catagorizes as 1st land use grade.

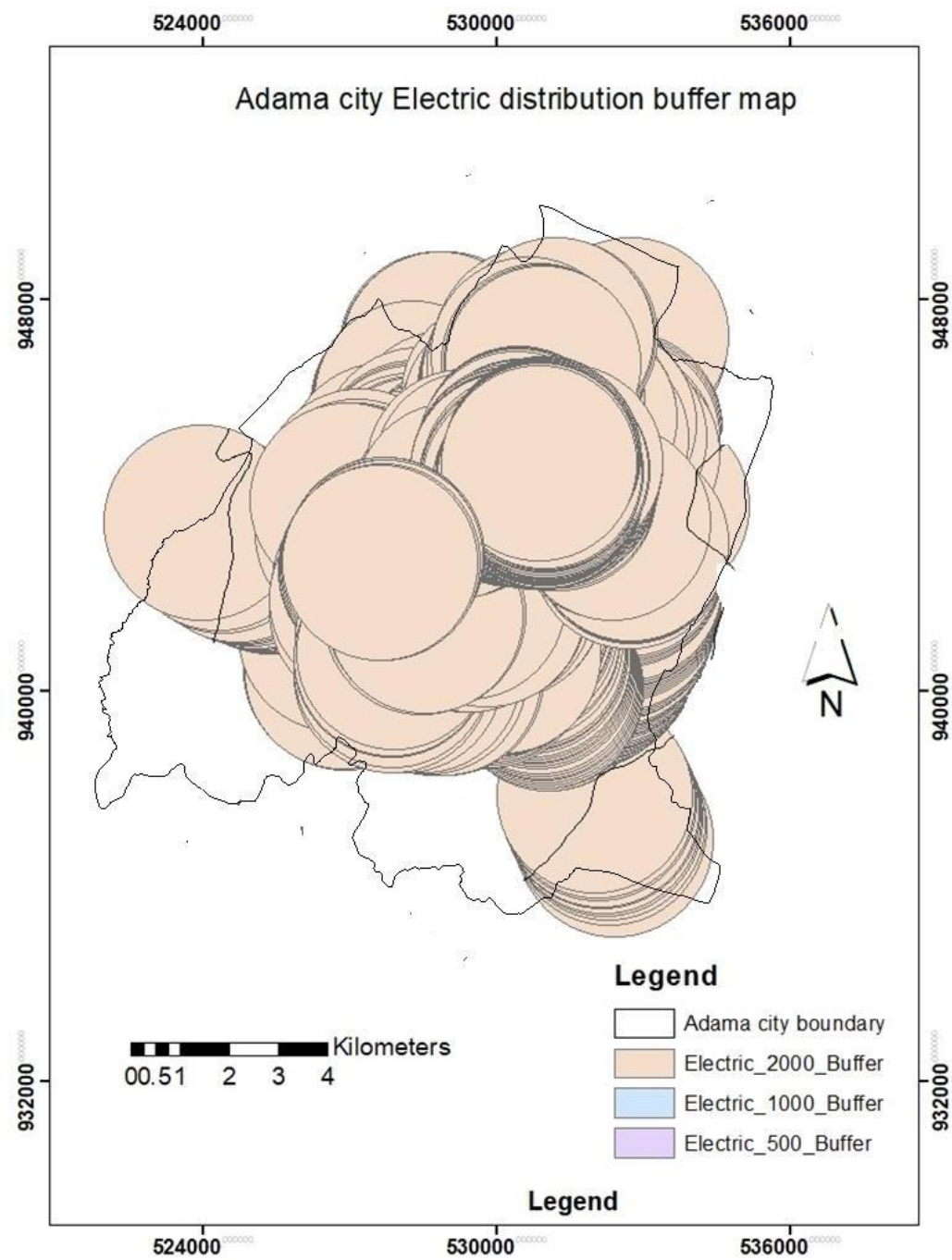


Figure 4.7 Adama city Electric distribution buffered

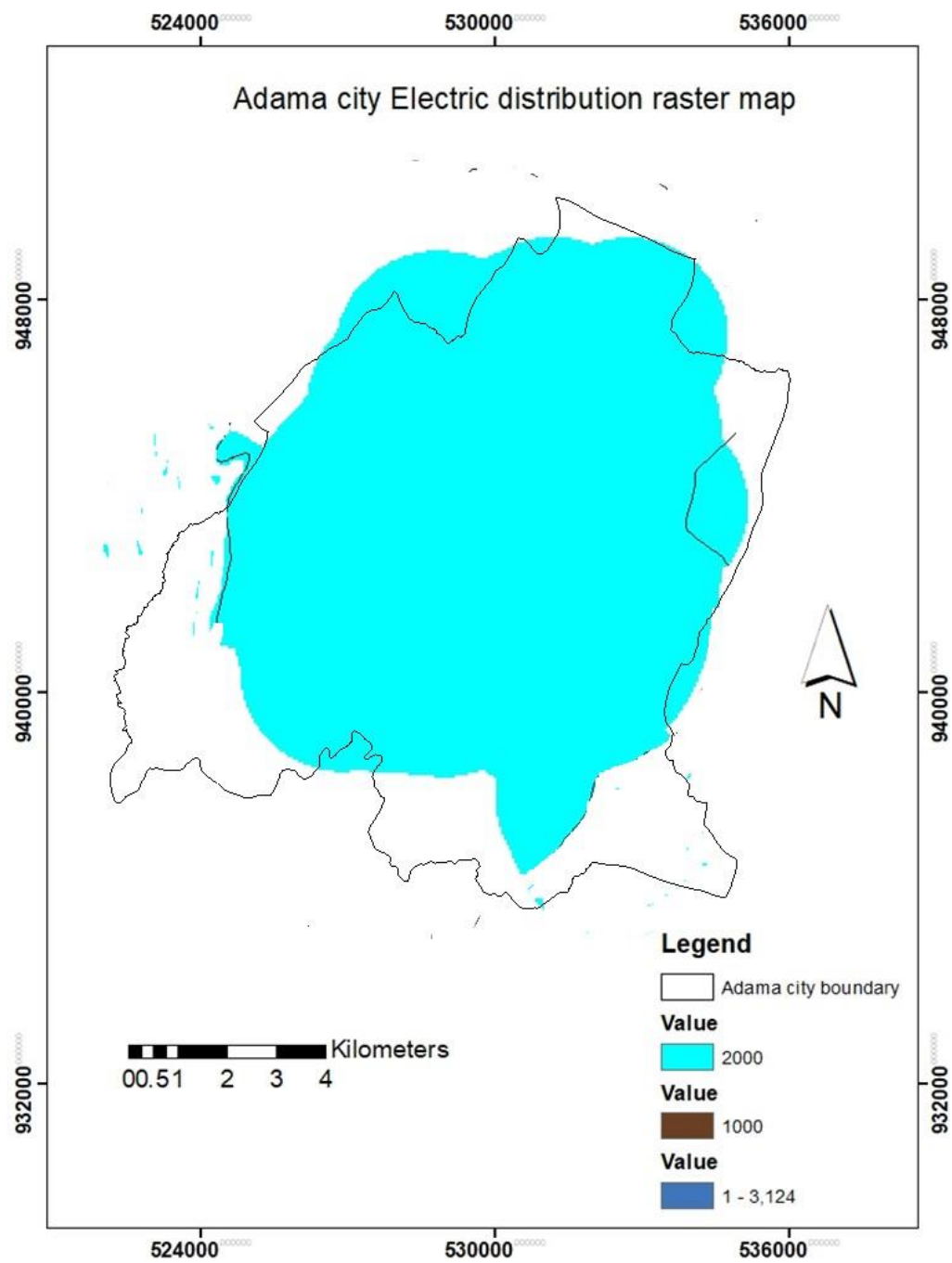


Figure 4.8 Adama city Electric distribution rasterized

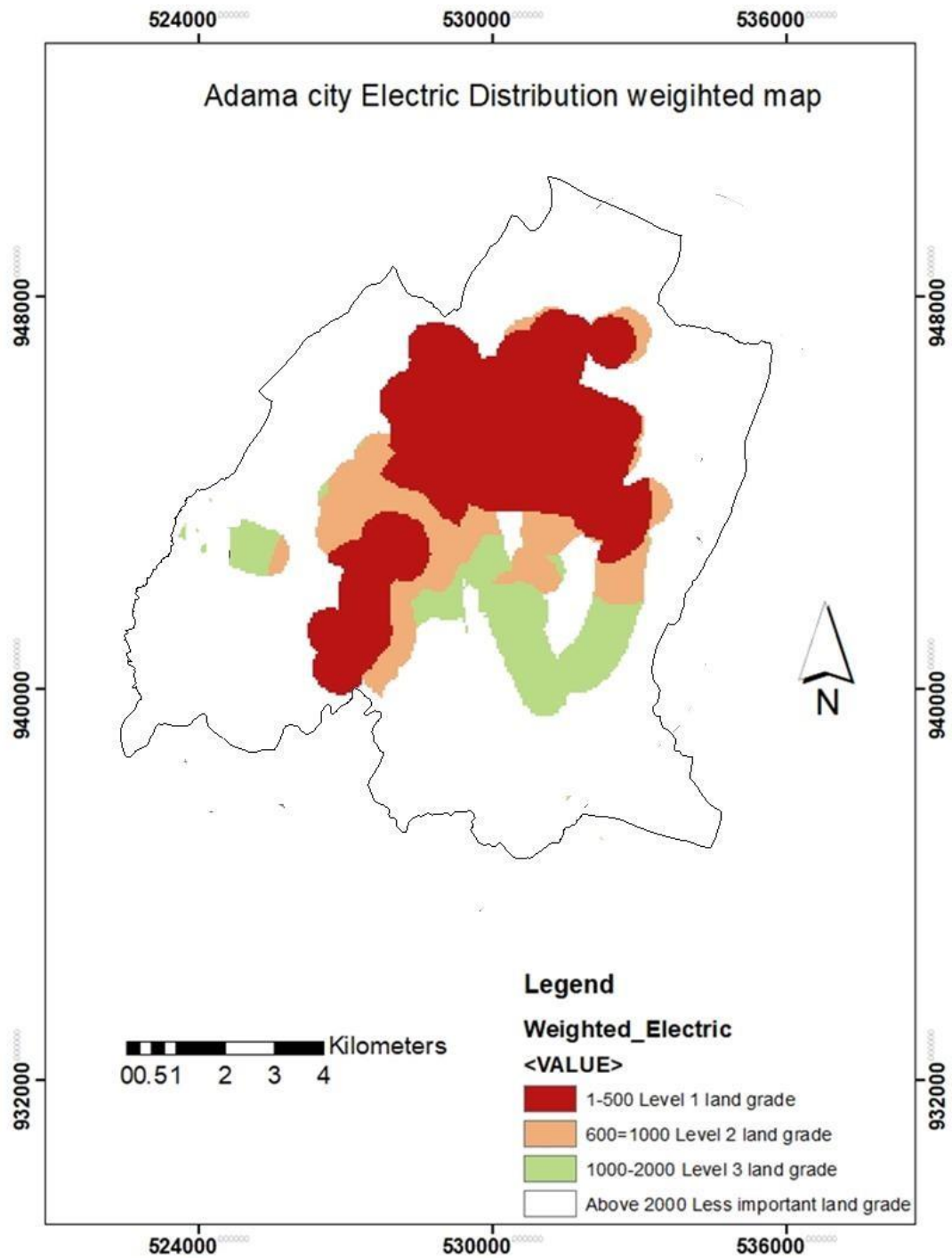


Figure 4.9 Adama city Electric distribution weight overlay

Adama city Electrical power availability is one of the main indicators in land grading system. In this research the power far away upto 500m catagorizes as 1st land use grade.

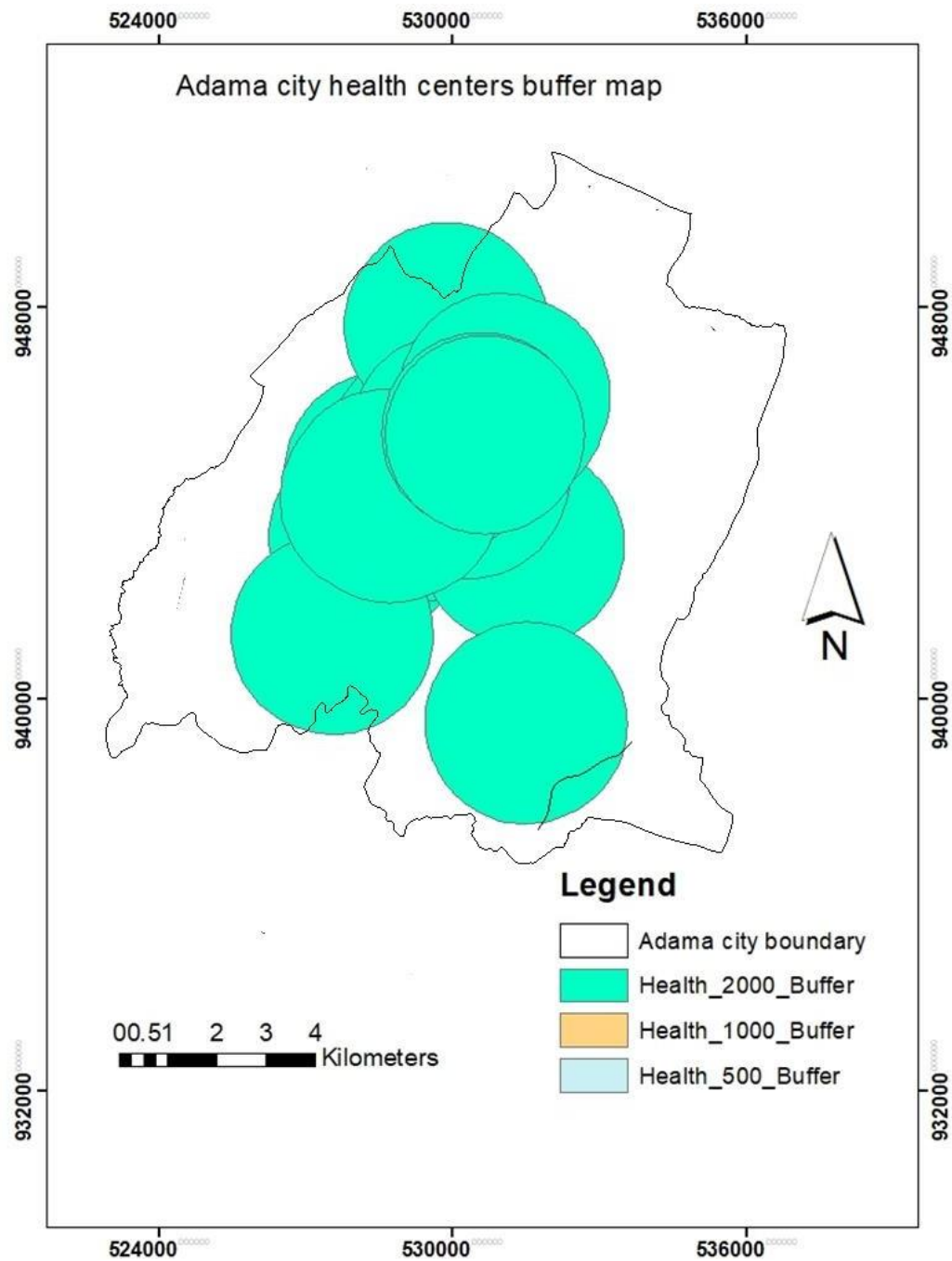


Figure 4.10 Adama city health centers buffered

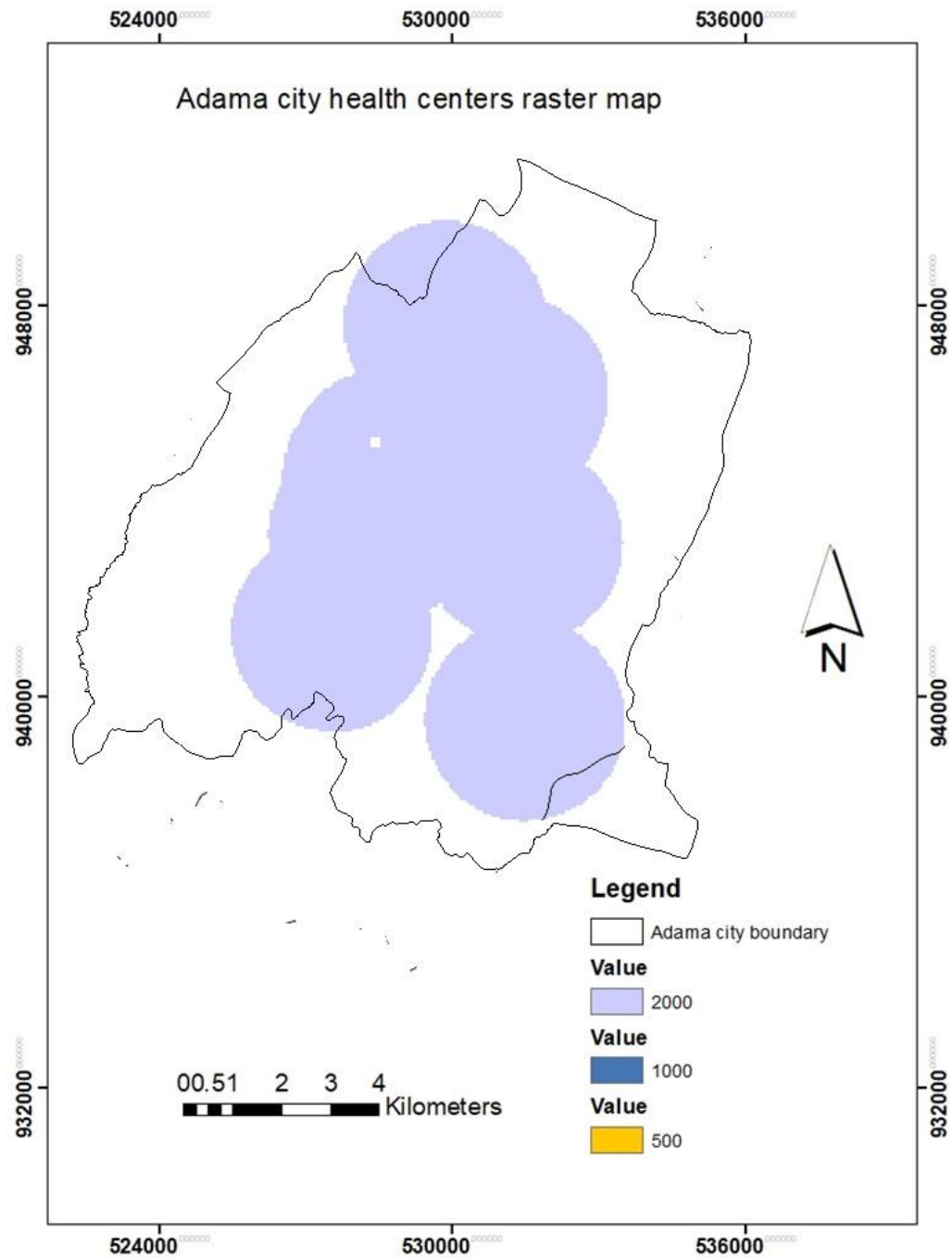


Figure 4. 11Adama city health centers rasterized

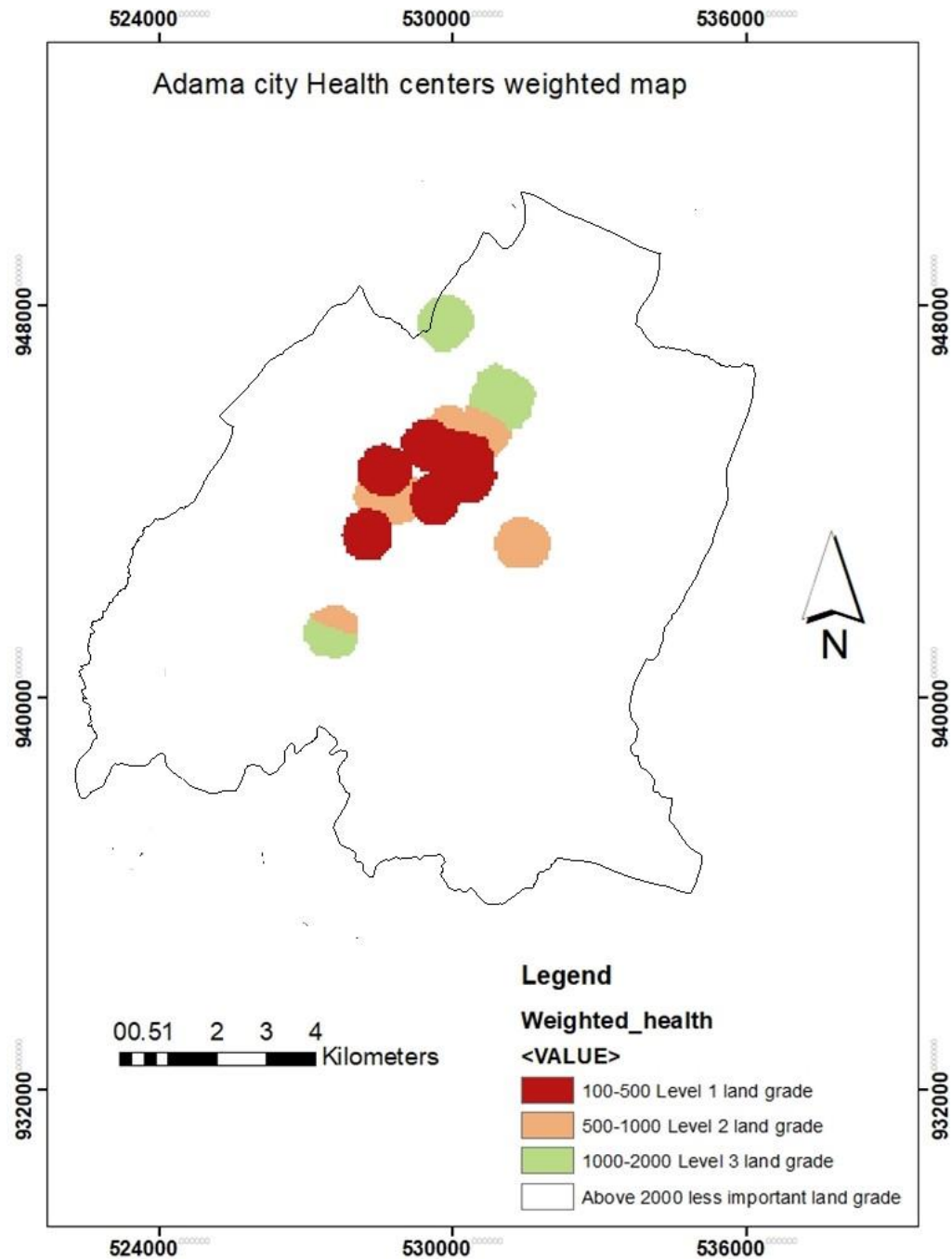


Figure 4.12 Adama city health centers weight overlay

Adama city health centers are one of the indicators in land grading system. In this research the health centers far away upto 500m catagorizes as 1st land use grade.

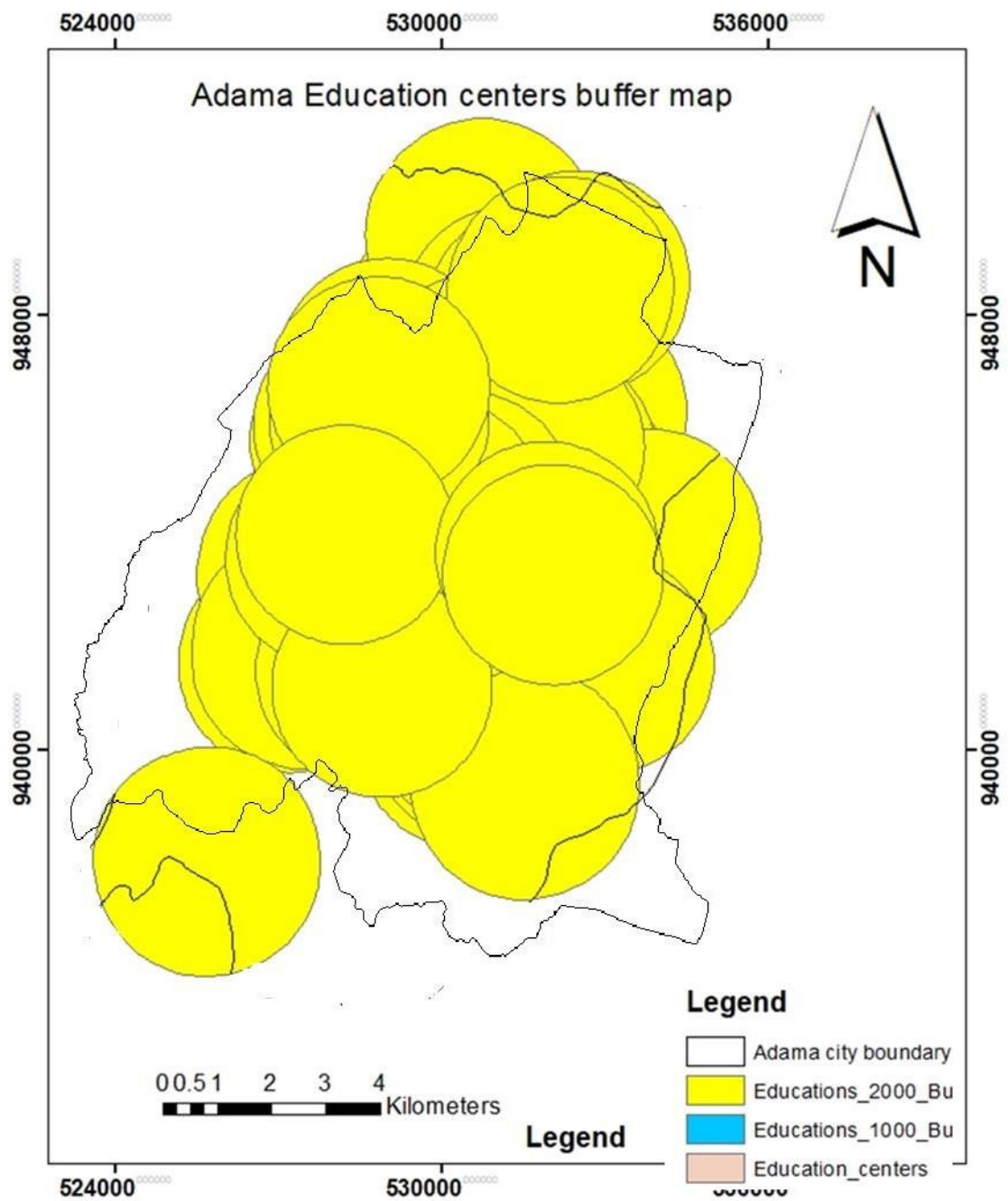


Figure 4.13 Adama city Education centers buffered

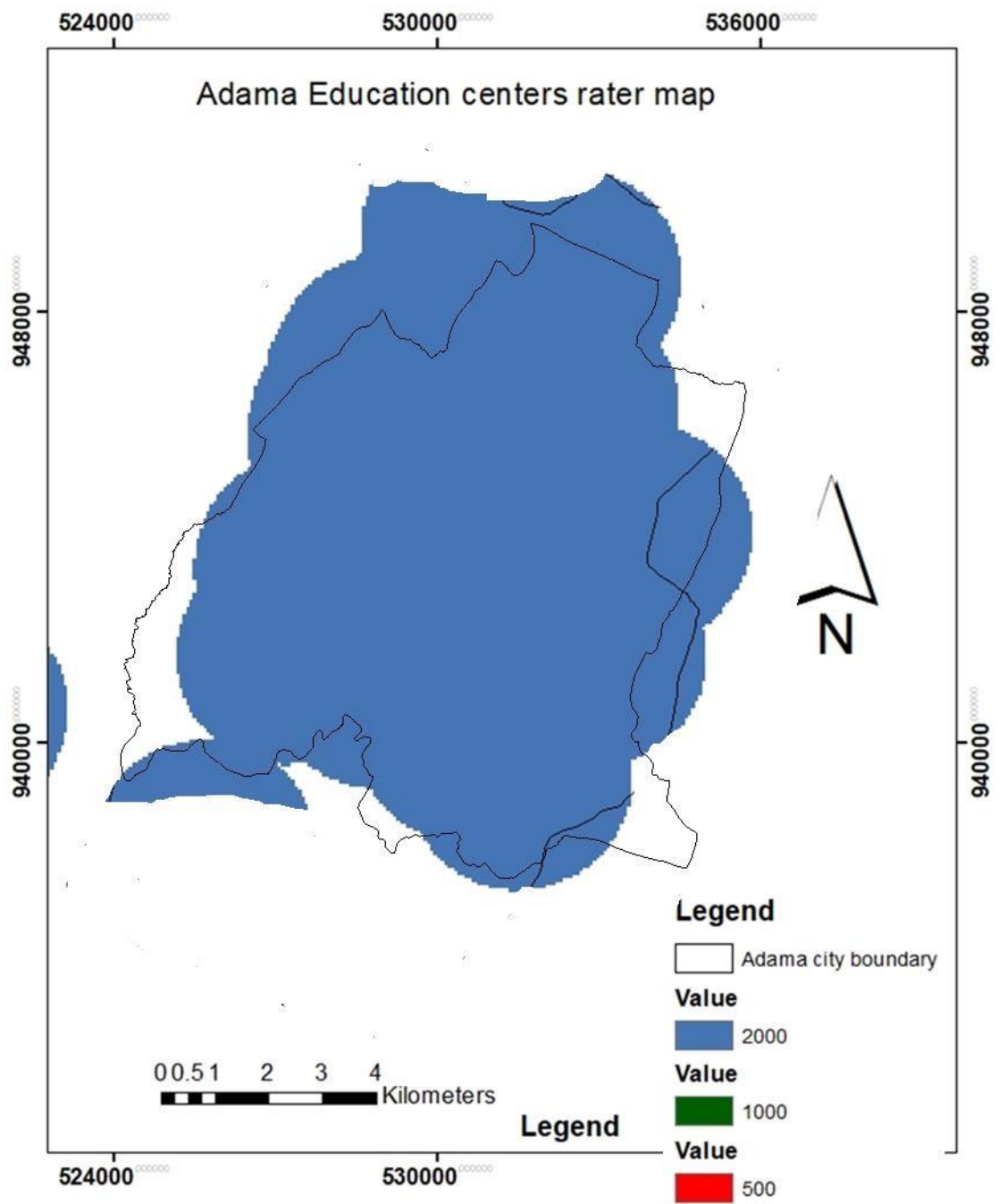


Figure 4.14 Adama city Education centers rasterized

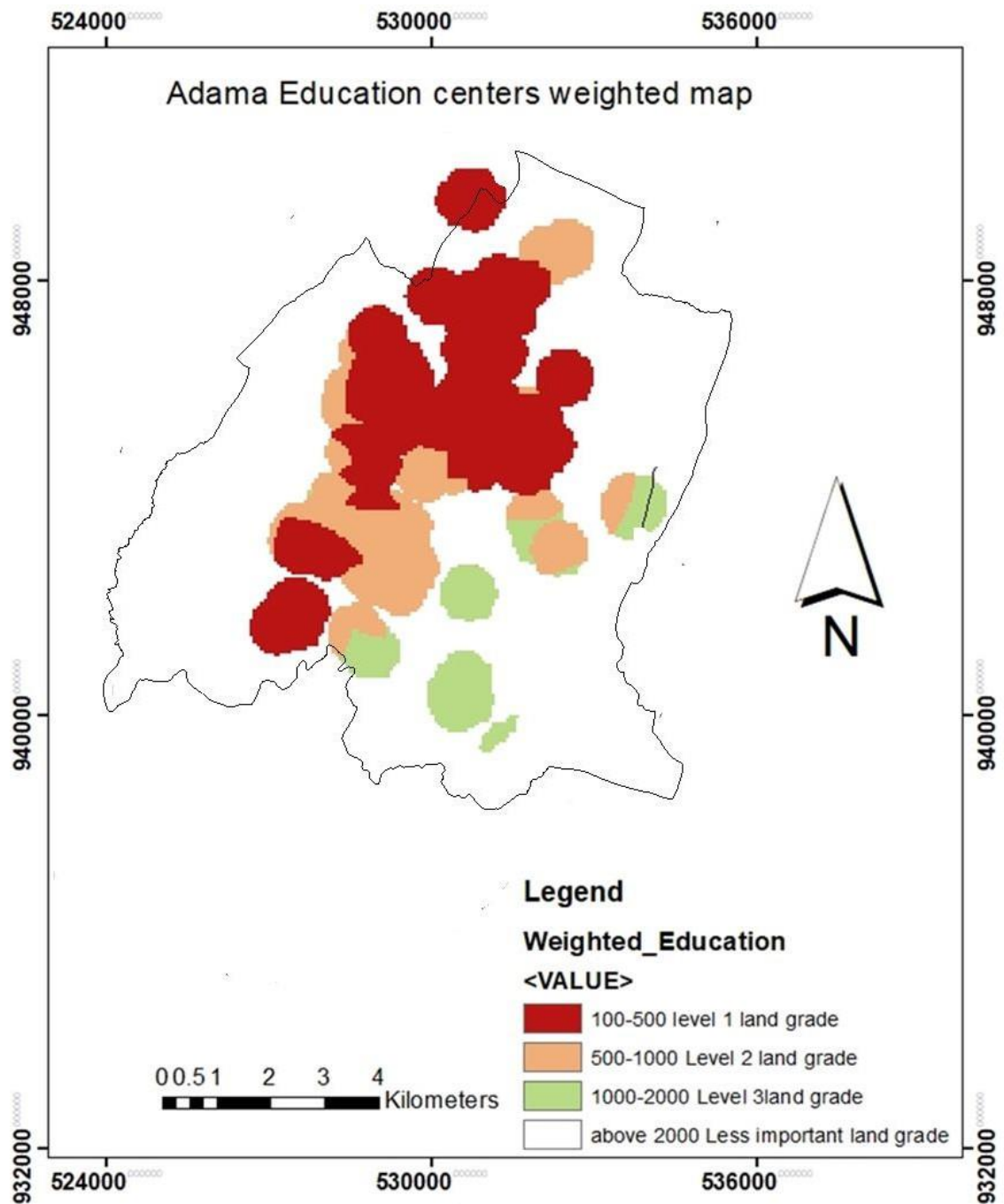


Figure 4.15 Adama city Education centers weight overlayed

Education is one of the main factors in land grading system and in this research the land far away upto 500m catagorizes as 1st land use grade.

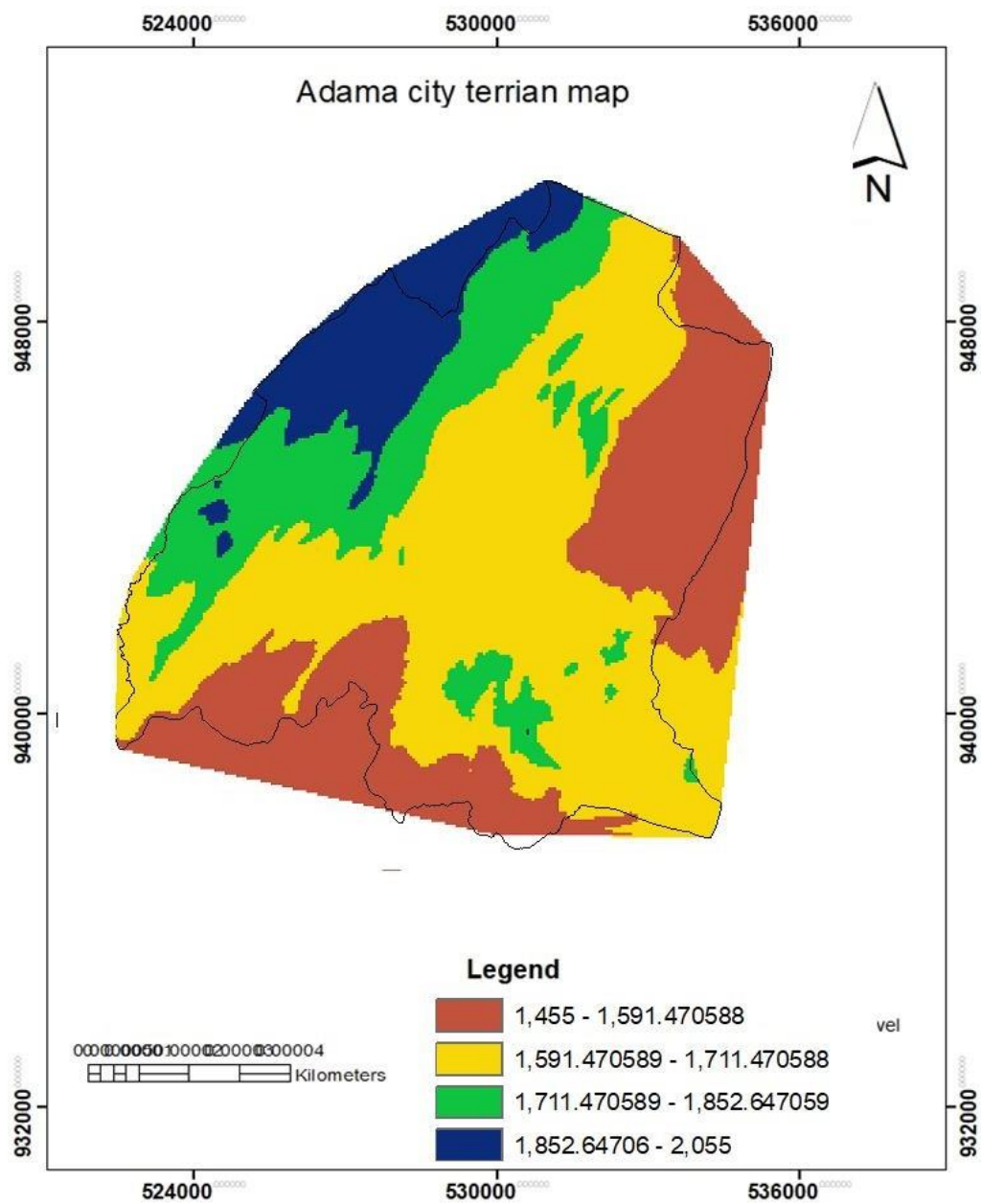


Figure 4.16 Adama city terrain analysis

Above 1500m to 1700m above mean sea level catagorizes in the first land grades

4.4 WEIGHT OVERLAY MAPPING

In a broader context, map overlay refers to combining the attributes of intersecting features represented in two or more georegistered data layers. For example, polygon and grid overlay procedures produce useful information by intersecting data layers properly georegistered. Attributes of intersecting polygons can be combined to create new features.

Layers" is not unique to GIS, of course; computer-aided design (CAD) packages and even spreadsheets also support layering. What's unique about GIS, and important about map overlay, is its ability to generate a new data layer as a product of existing layers.

- **Reclassification:** Values in each input layer (e.g., slope, aspect) are reclassified into a common suitability scale (e.g., 1 to 10). A value of 10 represents the most favorable condition.
- **Relative Preferences:** Assign preference values on a relative scale. For example, a preference value of 10 is twice as preferred as a value of 5.
- **Weighting:** Assign weights to each criterion based on its importance. Some criteria may be more critical than others. For instance, better aspects might be more important than short-term costs (e.g., slope and distance to roads).
- **Overlay:** Multiply the suitability value of each cell by its weight and combine the layers to create a composite suitability map.
- Weighting can be applied to prioritize certain criteria over others (e.g., aspects over short-term costs)

Map overlay can be implemented in either vector or raster systems. In the vector case, often referred to as polygon overlay, the intersection of two or more data layers produces new features (polygons). Attributes (symbolized as colors in the illustration) of intersecting polygons are combined. The raster implementation (known as grid overlay) combines attributes within grid cells that align exactly. Misaligned grids must be resampled to common formats. Polygon and grid overlay procedures produce useful information only if they are performed on data layers that are properly geo-registered. Data layers must be referenced to the same coordinate system (e.g., the same UTM and SPC zones), the same map projection (if any), and the same datum (horizontal and vertical, based upon the same reference ellipsoid). Furthermore, locations must be specified with coordinates that share the same unit of measure. Map overlay involves combining features from two or more georegistered data layers to create new information.

- It allows us to analyze spatial relationships, identify intersections, and generate meaningful insights by merging attributes from different layers.
- The goal is to reveal optimal locations or evaluate suitability based on combined criteria.

Vector and Raster Overlay:

- In vector systems, map overlay combines polygons from different layers.
- The intersection of polygons results in new features.
- Attributes (represented by colors) of intersecting polygons are combined.

Raster Overlay (Grid Overlay):

- In raster systems, overlay combines attributes within grid cells that align exactly.
- Misaligned grids must be resampled to common formats.
- Raster overlay is useful for analyzing continuous data (e.g., elevation, temperature, precipitation) across large areas

Among the most powerful and commonly used tools in a geographic information system (GIS) is the overlay of cartographic information. In a GIS, an overlay is the process of taking two or more different thematic maps of the same area and placing them on top of one another to form a new map. "A Map Overlay Combining Information from Point, Line, and Polygon Vector Layers, as Well as Raster Layers". Inherent in this process, the overlay function combines not only the spatial features of the dataset but also the attribute information as well.

As shown below the overlaid map shows the most important, medium and less important land grade in Adama city based on the factors

- Asphalt road
- Health center distribution
- Electric Availability
- Water supply
- Education centers availability
- And criteria suitability

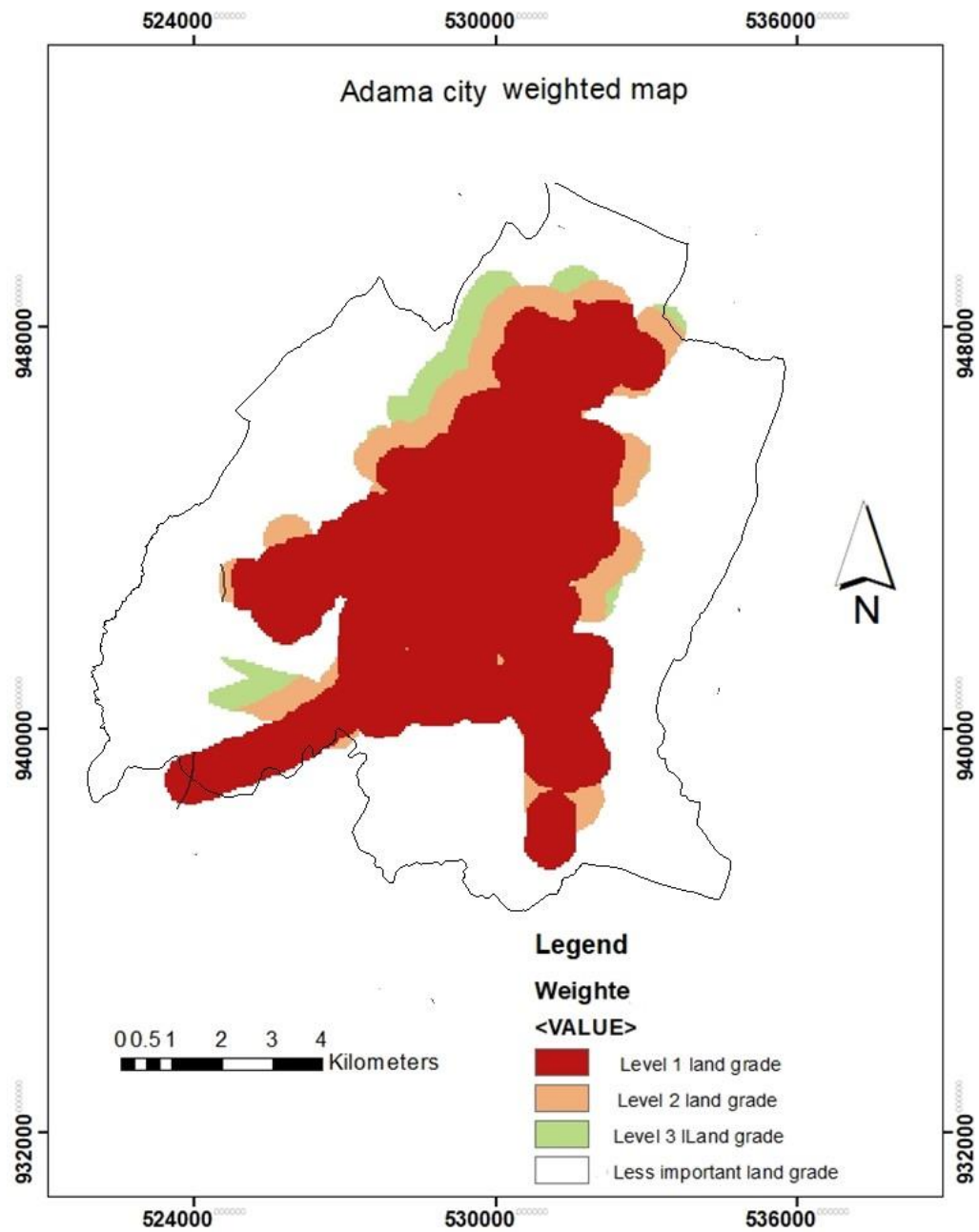


Figure 4.17 Adama city Weight overlay Map for land Grading

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This study was to develop a methodology to measure the performance of urban land grading based on International Scientific journals/desk study. The framework defines good practices and their indicators of an ideal urban land grading application.

The overlayed maps shows most important, medium and less important land grade in Adama city based on the factors

- Asphalt road
- Health center distribution
- Electric Availability
- Water supply
- Education centers availability
- And terrain suitability

This paper proposes that land grading connected to broader economic and societal issues. The framework provides a basis for systems in a more standardized and comprehensive approach. All in all, the result of this paper will enable policy makers, management officials, and implementers to follow up land management.

5.2 RECOMMENDATION

I recommended further suggestion for the development of the best cadastral information system.

- Implementing this research output is useful for the sustainable and reliable development of Adama city;
- Decision makers, politicians, and professionals should be involved in selecting the best system as their support is essential to the establishment of land grading;
- Implementing the integration of geospatial technologies with the adoption of the principles of internationally accepted standards
- Recommend that further research is to be carried out in this area to formulate best cadastral systems.

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Appendix I Questionaries

Here are some relevant questionnaires and frameworks for land grading:

1. What is the current status of land grading?
2. What are the current criteria's used to grade lands?
3. Is there any interventions that have gone beyond a focus on land grading?
4. What practices were used in land grading currently?
5. What was achieved in land grading currently?
6. What are the various organizations that determine the land grading?
7. How do laws, rules and regulations concerning land grading?
8. Questionnaire on Sustainable Land Management (SLM) Technologies
9. Is there effective land grading related to :
 - Develop confidence and trust, promote security, safety
 - Accelerate the proportion of population with tenure security;
 - Allow economic development by supporting land value capture revenue systems
 - Strengthen multi-disciplinary to achieve integrated geospatial information;
 - Contribute to smart and resilient rural and urban societies
 - Ensure participatory and inclusive land use and use planning;
 -
10. Is land grading encouraging efficient, sustainable and fair land markets, where appropriate, that take into account land tenure?

Appendix II Educational centers

Table				
Schools				
OBJECTID *	SHAPE *	SchoolName	SHAPE_Length	SHAPE_Area
1	Polygon	New Vision KG School	200.882	2316.36
3	Polygon	Green Hill School	561.301715	17899.75
5	Polygon	MaKobili School	563.718847	19090.0
7	Polygon	Abdi Boru School	457.868757	11284.26
11	Polygon	Adama Youth Academy	1025.469418	60567.2
12	Polygon	Holly Savior School	318.197872	6307.24
14	Polygon	Oda Primary School	506.081468	13979.29
15	Polygon	Abuna Georgios School	251.658971	3848.50
17	Polygon	Hawi Academy	345.117688	7101.91
19	Polygon	Excel Shool	191.668389	2209.99
21	Polygon	Nafyad School No.2	695.147967	28063.49
24	Polygon	Kamara School No.2	247.166774	3066.56
27	Polygon	Sekekelo Primary School	769.345623	36108.87
28	Polygon	Hamara Noha Academy	118.812041	775.68
32	Polygon	Awash Primary & Secondary School	476.769521	11370.33
38	Polygon	Hunde Gudina Primary School	267.737034	4084.12
39	Polygon	Adama polytecnic college	734.785408	33723.24
49	Polygon	Midland School	424.611795	9648.03
50	Polygon	Unity Academy	248.497005	3268.81
51	Polygon	Holy Angels School	256.254727	3543.10
52	Polygon	Nafyad KG School	206.157251	2306.58
54	Polygon	Abuna Georgios School	395.968337	8198.05
55	Polygon	Day-Star Academy	377.061317	8253.36
58	Polygon	Dhagaa Adi Primary School	383.750103	8890.2
59	Polygon	Guda Miju KG School	338.272949	5964.77
60	Polygon	Ambassador School	248.565918	3181.27
61	Polygon	Nigat Elementery School	297.794966	4871.98
62	Polygon	Dambela Elemantery School	1144.510713	74649.26
63	Polygon	Kidus Quran School	430.568496	5171.32
66	Polygon	Dhagaa Adi School	165.756568	1349.2
67	Polygon	Birayit Mayindis School KG-10	255.683669	4074.55
72	Polygon	Wisdom School	343.404528	7306.56
73	Polygon	Desangam School	389.642796	8598.02
74	Polygon	Oda School	1001.290275	54917.86
76	Polygon	Holy Angles Elementry School	194.848578	1765.09
77	Polygon	Eba Primary School	223.596129	3119.95
79	Polygon	Family School	336.846293	6517.08
82	Polygon	Gray Primary School	141.167706	1203.10
83	Polygon	Abuna Georgios KG School	223.559789	2489.5
84	Polygon	St.Joseph KG School	279.933287	4631.6
85	Polygon	Haylig KG School	228.772563	2862.24
87	Polygon	Adama Boset Elementary School	792.132122	30425.81
88	Polygon	Catholic Primary School	225.896322	3168.05
89	Polygon	Nafyad(Rift Valley University collage)	1041.407225	57114.15
90	Polygon	St.Joseph School	505.647205	10693.75
91	Polygon	Burka Primary & Secondary School	946.363239	53971.2

110 (0 out of 70 Selected)

Schools

Appendix III Health centers

Table					
Hospitals or Health Centers					
	OBJECTID *	SHAPE *	Name	SHAPE_Length	SHAPE_Area
▶	2	Polygon	Gada Health Center	295.920702	5276.288077
	21	Polygon	Adama Hospital	921.930858	47202.694549
	24	Polygon	Mary Stop Cilnc	176.631415	1802.569582
	25	Polygon	NGO / Marstops Hosptal /	154.51735	1447.500038
	26	Polygon	Rift Valley Hospital	179.836418	1853.216235
	31	Polygon	Family Association Clinic	163.483259	1022.908427
	86	Polygon	Hawas Health Center	389.828801	8290.696696
	87	Polygon	Adama Health Center	284.534021	4061.210769
	88	Polygon	Health Association	108.404798	733.15125
	130	Polygon	Dembela Health Center	369.491018	7516.508665
	177	Polygon	Biftu Health Center	427.933359	10588.078757
	201	Polygon	Madhanialem Hospital	209.08576	2698.721227
	238	Polygon	Sire Robi Health Center	220.991766	2978.275377
	266	Polygon	Adama General Hospital	1033.117403	65437.797537
	268	Polygon	Boku shenen Health Center	368.348835	8472.892736
	272	Polygon	Yoya Hospital	1250.644474	86012.367126
	273	Polygon	Muse Hospital	178.412908	1926.526994
	274	Polygon	Bati Hospital	172.196666	1731.637027
1 0 out of 18 Selected					
Hospitals or Health Centers					