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SCHOOL OF EARTH SCIENCE, REAL ESTATE, BUSINESS AND INFORMATICS (SERBI)

DEPARTMENT OF GEOSPATIAL SCIENCE AND TECHNOLOGY (DGST)

ASSESSMENT OF SOLID WASTE DISTRIBUTION IN COASTAL AREAS

CASE STUDY COCO AND MSASANI BEACH DAR ES SALAAM

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REGISTRATION: 25519/T.2020

GS 392: DISSERTATION

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A Dissertation Submitted to the Department of Geospatial Sciences and Technology (DGST) in Partial Fulfillment of the Requirement for the Award of Bachelor of Science Degree in Geographical Information System and Remote Sensing (B.Sc. GIS&RS) of the Ardhi University.

CERTIFICATION AND COPYRIGHT

The undersigned certify that they have proof read and hereby recommend for acceptance of a dissertation proposal entitled "**ASSESSMENT OF SOLID WASTE DISTRIBUTION IN COASTAL AREAS** " for University Examination.

……………………………. ……………………………

Dr. Hayola Joseph **Mr. Maziku Joseph**

(First Supervisor) (Second Supervisor)

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I MOHAMED OMARY A declare that this proposal is my own original work and that to the best of my knowledge, it has not been presented to any other University for a similar or any other degree award except where due acknowledgements have been made in the text.

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MOHAMED, OMARY A.

(25519/T.2020)

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DEDICATION

I dedicate this dissertation to my Father Mr. Athuman Mohamed and my Mother Miss Fatuma Saidi who has been a constant source of support and encouragement during the challenges of school and life. I also dedicate this dissertation to my brother Meysam Mohamed and adoring sister Stumai Mohamed for always supporting, advising and encouraged me all the way and whose encouragement have made sure that I give it all it takes to finish that which I have started

ABSTRACT

The effective management of solid waste in coastal areas is of utmost importance to protect the environment and maintain the ecological balance of these vulnerable areas. This study employs multi-criteria analysis methods, including Analytic Hierarchy Process (AHP) and weight overlay analysis, to assess the distribution of solid waste and identify suitable areas for placing waste collectors by considering population density, land cover, slope, and elevation.

AHP was utilized to assign relative importance and weights to the criteria involved in the analysis. Weight overlay analysis applied to integrate and overlay spatial data layers representing population density, land cover, slope, and elevation, resulting in a composite suitability map.

The findings revealed spatial patterns of solid waste distribution in coastal areas, identifying areas with higher waste generation rates based on population density. Analysis of land cover data highlights areas with intensive human activities that are likely to contribute to significant solid waste generation. Additionally, consideration of slope and elevation aids in identifying accessible areas suitable for efficient waste collection.

Through the integration of these criteria using weight overlay analysis, suitable locations for waste collectors was determined, prioritizing areas with higher population density, diverse land uses, moderate slopes, and convenient access. These identified locations serve as strategic points for waste collection interventions, aiming to optimize waste management operations and mitigate the environmental impact of solid waste in coastal areas.

Based on the results, practical recommendations provided for the placement of waste collectors in suitable coastal areas. The study advocates for the implementation of integrated waste management strategies that prioritize areas with higher population density, diverse land uses, manageable slopes, and convenient accessibility. Following these recommendations will enable policymakers and waste management authorities to establish effective waste collection systems, mitigate solid waste pollution, and safeguard the coastal environment.

In conclusion, this research demonstrates the application of multi-criteria analysis, including AHP and weight overlay analysis, to evaluate solid waste distribution in coastal areas. The study identifies appropriate locations for waste collectors based on population density, land cover, slope, and elevation. Implementing the recommendations will empower decision-makers and waste management authorities to optimize waste collection efforts, minimize pollution, and promote sustainable waste management practices in coastal areas.

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ACRONYMS AND ABBREVIATIONS

GIS	Geographical Information System
TIFF	Tag Image File Format
USGS	United States Geological Survey
Shp.	Shapefile
NBS	National Bureau of Statistics
GADM	Global Administrative Areas
GPS	Global Positioning System
GIS	Geographical Information System
AHP	Analytical Hierarchy Process
SRTM	Shuttle Radar Topography Mission
DEM	Digital Elevation Model
RS	Remote Sensing
CR	Consistency Ratio

CHAPTER ONE

INTRODUCTION

1.1Background of study

The increase of urban solid waste as well as the consumption of disposable items and the inappropriate ways in which this waste is collected and disposed of lead to a worldwide crisis in urban solid waste management (UN-HABITAT, 2010). Solid waste management is the one of the most challenging problems faced by the world`s municipalities (UN-HABITAT, 2010).

Coastal zones are even more exposed to this crisis due to the lack of appropriate landfill sites, wide seasonal population variation, extensive commercial enterprises and proximity to the marine environment with its fragile ecosystems. Through the presence of different activities done in the coco beach area there is increasing of production of different types of solid waste on which may contribute to the environment pollution (Abdulai, 2015)

There are different causes of random distribution of solid waste in coastal areas which are behavior of people, inadequate administration on how to remove waste, and absence of areas on which solid waste collectors to be placed. All above causes only the last one can be done by using the knowledge and skills of GIS and Remote Sensing through suitability analysis on which the proper and suitable areas on which we can placing solid waste collectors so as to reduce the problem of random distribution of waste in coastal areas. The management and monitoring of solid waste had become a critical concern for coastal areas due to the increasing population, urbanization, and industrialization along coastlines. Improper disposal of solid waste, including plastic debris, poses a significant threat to the ecological integrity and aesthetic value of coastal environments. Traditional methods of assessing and monitoring solid waste distribution in these areas can be time-consuming, expensive, and limited in spatial coverage (NEMC, 2012).

Remote sensing technology offers a promising approach to address these challenges by providing a cost-effective and efficient means of mapping and monitoring solid waste distribution along coastal areas. Remote sensing refers to the acquisition of information about an object or phenomenon without making physical contact, typically through the use of sensors on satellites or aircraft. It allows for the collection of data across large spatial scales and at regular intervals, enabling the identification and tracking of solid waste hotspots, changes over time, and trends in coastal pollution (Paul, 2012).

By utilizing various remote sensing techniques, such as optical, thermal, and radar imagery, it becomes possible to detect, classify, and quantify different types of solid waste in coastal environments. Optical sensors, for instance, can capture visible and near-infrared light, enabling the identification of floating plastics and other debris on the water surface. Thermal sensors can detect temperature anomalies caused by decomposing waste or industrial discharges. Radar sensors, with their ability to penetrate cloud cover and provide day and night imaging, can help identify and monitor waste accumulation on coastal land areas.

The application of remote sensing in solid waste management has several advantages. It allows for regular and systematic monitoring of coastal areas, providing valuable data for decision-makers and environmental managers. The spatial information generated through remote sensing can assist in identifying pollution sources, evaluating the effectiveness of waste management practices, and developing targeted mitigation strategies. Additionally, remote sensing data can be integrated with other environmental and socio-economic datasets, facilitating a comprehensive understanding of the factors influencing waste distribution and its impact on coastal ecosystems and communities (Karsauliya, 2013).

However, despite the potential benefits, there are also challenges associated with using remote sensing for solid waste assessment in coastal areas. These include the need for accurate calibration and validation of remote sensing data, the development of appropriate algorithms for waste detection and classification, and the integration of remote sensing data with ground-based observations. Addressing these challenges requires interdisciplinary collaborations among remote sensing experts, waste management specialists, and coastal scientists.

In conclusion, the utilization of remote sensing technology offers great potential for assessing the distribution of solid waste collectors in coastal areas. By providing comprehensive and up-to-date information on waste distribution, remote sensing can support effective waste management strategies, facilitate targeted interventions, and contribute to the preservation and restoration of coastal ecosystems. However, further research and development are needed to overcome the technical and methodological challenges associated with remote sensing-based solid waste assessment in coastal environments

1.2 Problem statement

Coastal areas are facing increasing of solid waste pollution due to human activities and natural phenomena. Traditional methods of monitoring and managing waste in these regions are often insufficient, and there is a need for more advanced technologies to access the distribution of solid waste. The combination of remote sensing together with GIS offers a promising approach to understanding the spatial and temporal patterns of waste accumulation in coastal areas. Through this research can enable exploring the potential of remote sensing and GIS technologies in assessing the distribution of solid waste in coastal areas and to identify challenges and opportunities for using these technologies in waste management strategies. The main problem in this topic is the absence of areas where the waste collector can be placed in order to reduce the accumulation and improper distribution of waste in the beach even though challenging due to vastness and complexity of the coastal ecosystem. Also changes or establishment of common dumpsite which is originated from massive distribution of solid waste on coastal areas, thus led to water pollution and destroying marine species.

1.3 Objectives

1.3.1 Main objective

To perform suitability analysis for the areas on which solid waste collector can be placed by assessing their distribution in the coastal areas.

1.3.2 Specific objectives

1. Identify multi-criteria for locating solid waste collectors.
2. To apply analytical hierarchy process and weighted overlay analysis in solid waste collectors site selection.
3. To create a map showing the suitable sites for locating solid waste collectors.

1.4 Research questions

1. What are criteria used in locating solid waste collectors?
2. How useful are analytical hierarchy process and weighted overlay analysis in solid waste collectors site selection?
3. What are the suitable sites required for locating solid waste collectors?

1.5 Software package

The software that are going to be utilized in this study;

Arcgis10.8, Drawing.io (20.6.2), Microsoft Visio (2013), Microsoft Excel.

• This software is going to be used in pre-processing steps such as data cleaning and perform data processing so as to generate final output. Also used in drawing of diagram used in the research.

1.6 Scope and Limitations of the Research

Scope of using GIS for assessment of solid waste on coastal areas;

- Spatial analysis

GIS can provide a visual representation of the distribution of solid waste in coastal areas.

- Data integration

GIS can be used to integrate data from multiple sources, including maps, satellite images, and field surveys, providing a comprehensive overview of the waste situation.

- Decision support

Through uses of GIS can be used to identify areas with have high accumulation of waste on coastal areas, helping decision-makers prioritize their response effort

Limitation of the research in that not all coastal areas in Dar es salaam but based on coco beach and msasani beach on which are highly populated also there are many activities done in this area.

1.7 Significance of the research

- Decision making
- Transparency and collaboration of stakeholders in decision making process
- Monitoring and evaluation of waste management activities.
- Encourage healthy and safety of community life
- Enhance proper solid wastes disposal

1.8 Beneficiaries of the research

Expected users of this research results will include;

- Environmental management authority

The different sectors concerning about environment management and pollution may have good advantages since it provide information on how to create better ways of reducing problems related to solid waste on environment.

- Researchers

  The outcomes of this study will enable future researchers to use this study as a starting point for their own research, resulting in improved methodology or better strategies for generating better research results.

- Urban and Rural Planners

  The decisions made on the designing of different types of infrastructure that may have proper impact on the storage and channel of waste to pass through.

- Community

  Through the proposed recommendation on the accumulation of solid wastes on coastal areas may be reducing the diseases eruption on which community will be well maintained on how to follow on the preservation of environment

CHAPTER 2

LITERATURE REVIEW

2.1 About Waste and Solid waste

Waste

Waste is unwanted or undesired material left the completion of a process. “Waste” is a human concept: in natural processes there is no waste, only inert end products. Waste can exist in any phase of matter (solid, liquid, or gas) (Hussain, 2007).

Solid waste

Solid waste refers to the type of wastes which are in solid form, including food remnants, paper, bones, dead animal, stones, furniture, demolishing debris, biomedical debris, textile material, etc (Ammar, 2007).

2.2 Contribution of GIS&RS to solid waste

Geographic Information Systems (GIS) play a crucial role in solid waste management by providing valuable tools and analysis capabilities for effective planning, monitoring, and decision-making. Here are some contributions of GIS to solid waste management:

Waste Collection Routing: GIS can optimize waste collection routes by analyzing factors such as population density, waste generation rates, road network, and vehicle capacities. By identifying the most efficient routes, GIS helps reduce fuel consumption, minimize travel distances, and optimize collection schedules.

Site Selection for Facilities: GIS can assist in identifying suitable locations for waste management facilities such as recycling centers, transfer stations, composting sites, and landfills. By considering factors such as proximity to waste sources, land use compatibility, environmental constraints, and community impacts, GIS aids in informed decision-making for facility siting (Al-Hanbali, 2011).

Spatial Analysis of Waste Generation: GIS allows for spatial analysis of waste generation patterns by integrating data on population density, land use, demographics, and socioeconomic factors. This analysis helps identify areas with high waste generation rates, enabling targeted waste reduction campaigns, infrastructure planning, and resource allocation.

Monitoring and Asset Management: GIS facilitates real-time monitoring and management of waste collection activities and infrastructure assets. It can track the location and status of waste collection vehicles, monitor container fill levels, and identify maintenance needs of infrastructure. This information enables efficient resource allocation and timely maintenance to improve service delivery (Solano, 2005).

Environmental Impact Assessment: GIS aids in assessing the environmental impact of waste management activities. It can analyze factors such as proximity to sensitive ecosystems, water bodies, and residential areas. By considering these factors, GIS helps in minimizing negative environmental impacts and ensuring compliance with regulations (Siddiqui, 1996).

Emergency Planning and Response: GIS can be used in emergency planning and response during natural disasters or other crisis situations. It can assist in identifying alternative waste management facilities, evacuation routes, and areas for temporary waste disposal.

Public Participation and Communication: GIS provides a platform for engaging the public and stakeholders in solid waste management. It can visualize data, present scenarios, and facilitate interactive decision-making processes. GIS-based maps and applications allow residents to locate recycling facilities, report illegal dumping, and access information on waste management practices.

2.3 AHP as applied in solid waste collectors.

The Analytical Hierarchy Process (AHP) is a decision-making method that can be employed in suitability analysis for determining the placement of solid waste collectors. It helps evaluate and prioritize various criteria and alternatives in a structured manner to make well-informed decisions.

Here's a simplified explanation of how AHP can be applied to suitability analysis for placing solid waste collectors:

Identify Criteria: Identify the relevant factors that influence the placement of waste collectors, such as population density, proximity to waste sources, accessibility to roads, environmental impact, cost, and community acceptance (Wedley, 1988).

Establish a Hierarchy: Create a structure with the main objective at the top, criteria in the middle, and potential locations for waste collectors at the bottom (Harker, 1987).

Pairwise Comparisons: Compare each criterion or alternative against each other to determine their relative importance or preference using a scale from 1 to 9.

Derive Priority Weights: Use the pairwise comparisons to calculate the priority weights for each criterion and alternative, reflecting their relative importance in achieving the objective (P.J. Schoemaker, 1982).

Consistency Check: Check the consistency of the pairwise comparisons to ensure the reliability of the judgments.

Aggregation and Analysis: Multiply the criterion weights by their corresponding weights at the higher level to calculate overall weights for each alternative. Summing up the weights provides a ranking of the suitability of the locations for waste collectors (Q. Wang, 1989).

Sensitivity Analysis: Perform sensitivity analysis to assess the stability and robustness of the results by considering the impact of changes in judgments or criteria weights (Forman., 1990).

Decision and Implementation: Based on the AHP analysis results, select the most suitable locations for waste collectors, taking into account rankings, practical constraints, and other relevant information. Implement the decision by establishing waste collection infrastructure in the chosen locations.

By utilizing the AHP, suitability analysis for placing solid waste collectors can be carried out in a systematic manner, considering multiple criteria and preferences. This approach enhances decision-making and promotes efficient waste management practices.

2.4 Consistency ratio as applied in AHP

The consistency ratio holds significance in the Analytical Hierarchy Process (AHP) as it plays a crucial role in evaluating the reliability and consistency of judgments made during pairwise comparisons. Its importance can be summarized as follows:

Reliability of Judgments: The consistency ratio helps determine the reliability of judgments by assessing their consistency. Inconsistent or contradictory judgments can lead to unreliable results, and the consistency ratio helps identify such inconsistencies (Wedley, 1988).

Confidence in Results: Having confidence in the final rankings or prioritizations is crucial in AHP. The consistency ratio provides a quantitative measure of the consistency of judgments, and a lower ratio indicates higher confidence in the results (Q. Wang, 1989).

Decision Quality: Consistency in judgments is vital for accurate derivation of priority weights, which influence the final rankings or preferences. By checking the consistency ratio, decision-makers can ensure more reliable weights and make better-informed decisions (Harker, 1987).

Sensitivity Analysis: The consistency ratio also plays a role in sensitivity analysis. It helps assess the impact of inconsistent judgments on the stability and robustness of the results under different scenarios (Forman., 1990).

In summary, the consistency ratio in AHP is valuable for evaluating the reliability of judgments, instilling confidence in the decision-making process, improving decision quality, and facilitating sensitivity analysis. It ensures that AHP produces consistent and reliable results aligned with the decision-makers' preferences and objectives.

2.5 Reasonable range of CR

A reasonable range for the consistency ratio in the Analytical Hierarchy Process (AHP) is typically below 0.1 or 10%. The consistency ratio serves as a measure of how well the judgments made during pairwise comparisons align with each other. If the consistency ratio exceeds 0.1, it suggests a higher likelihood of inconsistent or contradictory judgments, which can affect the reliability of the results. However, the specific threshold for an acceptable consistency ratio can vary depending on the context and the decision problem. Factors such as the number of criteria and alternatives being compared and stakeholders' preferences may also influence what range of consistency ratio is considered reasonable in a given situation (Saaty, 1980).

CHAPTER 3

METHODOLOGY

The aim of this study is to determine the area on which can be used in placing solid waste collectors in coastal areas by using Geospatial analysis that is GIS and Remote Sensing Techniques.

3.1 Description of study area

Coco and Msasani beaches are a stretch of coastline that located in the Oyster bay area of Dar es Salaam. They are more famous beaches in the city that is frequented by locals and even hosting several holiday beach parties and festivals. Due to this, there are several establishments on the beach, such as restaurants, food stands and shops renting beach equipment such as floaters. It is situated at an altitude of 0 meters, with it is coordinates being S 6° and E 39°. It is approximately more than 4km from the city center.

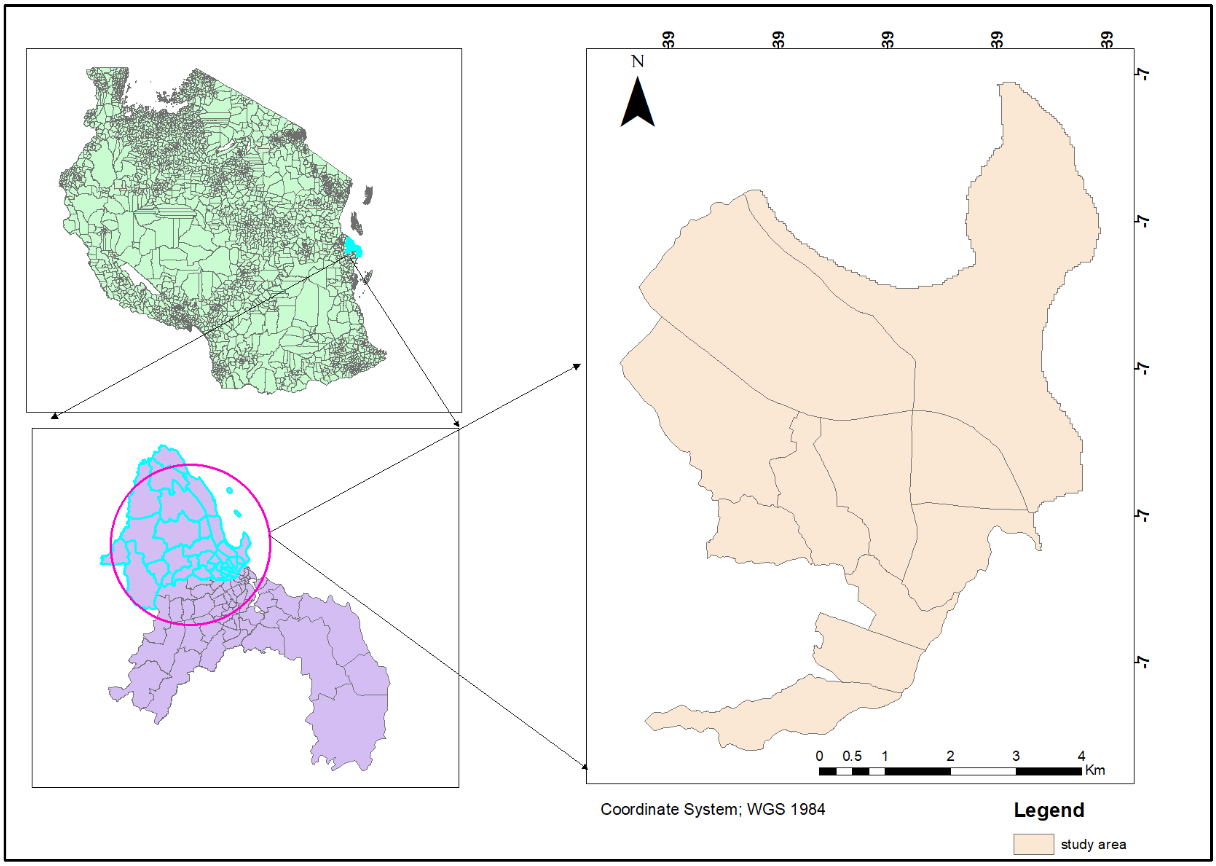

Figure 3.1 Location study area

3.2 Study methodology flow chart

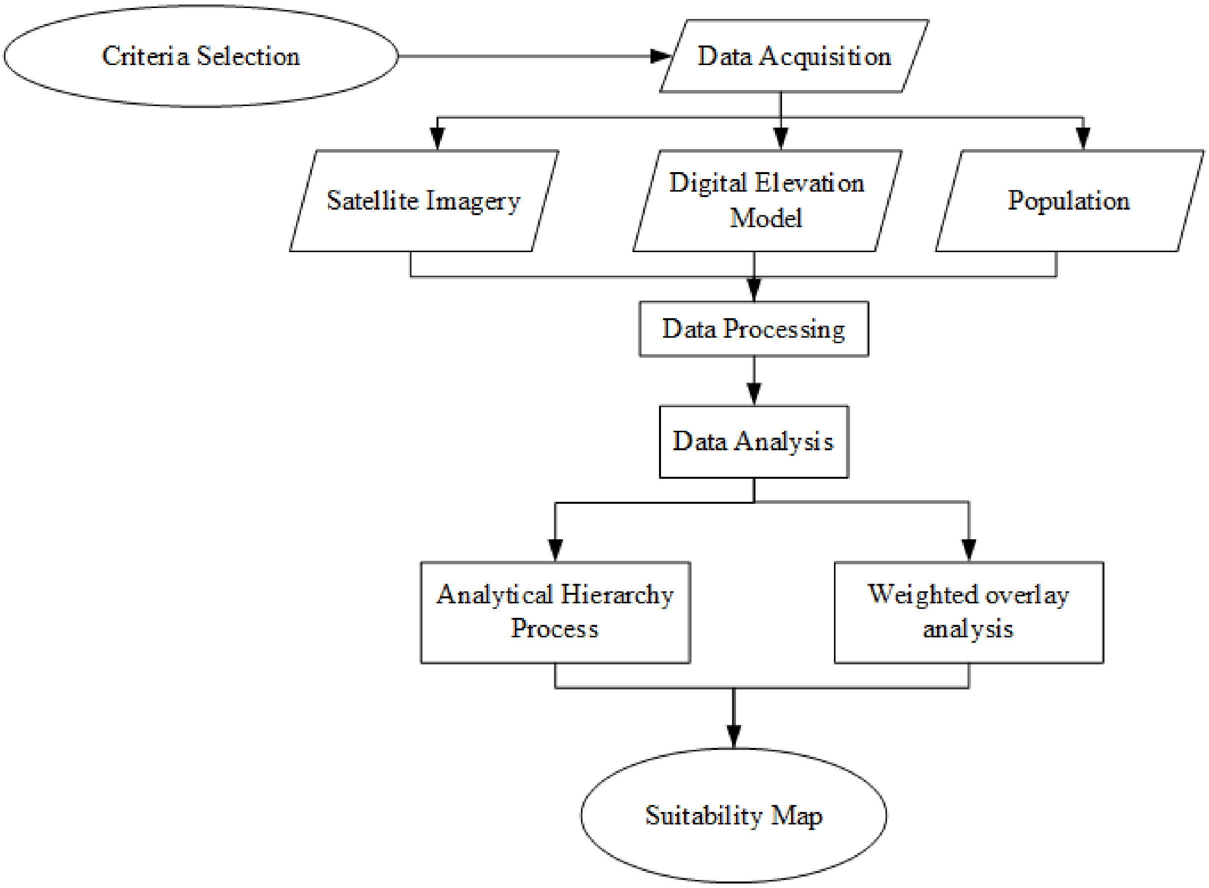

Figure 3.2 Research methodology workflow diagram

3.3 Data used

3.3.1 Primary data

Landsat 8 was downloaded on the internet so as to obtain land cover map and Srtm Digital elevation model also downloaded from USGS for slope map creation.

Population data of Kinondoni wards of 2022 was downloaded from internet.

3.3.2 Secondary data

Tanzania boundary shape file.

Tanzania wards shape file.

Tanzania water bodies shape file.

Table 3. 1 Research data characteristics

DATA	FORMAT	SOURCE
Population	PDF	NBS
Satellite imagery	TIFF	USGS
Digital elevation model	TIFF	USGS
Boundary data	Shp	GADM

Table 3. 2 Multi criteria used in the research

Criteria	Specification for solid waste collectors
Population	Large number of people are highly suitable area for placing collectors
Land cover	Grassland and bare land are suitable areas (Ebistu et al., 2013).
Slope	Less than 10% (Sener et al, 2011).
Elevation	Less than 43 meters

Table 3. 3 A pair wise comparison matrix showing relative values between criteria

Criteria	**Population**	**Land Cover**	**Slope**	**Elevation**
Population	1	3	5	7
Land Cover	1/3	1	3	5
Slope	1/5	1/3	1	3
Elevation	1/7	1/5	1/3	1

Table 3. 4 The comparison scale in AHP (Saaty, 1980)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgement slightly favor one activity over another

5	Essential or equal importance	Experience and judgement slightly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and it is dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgements	When compromise is needed
Reciprocals of above nonzero	If activity, I have one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

From the AHP plugin it will enable to obtain the consistency ratio (CR) on which using Arcgis10.8 on which 0.043.(Saaty, 1980) argues if the consistency ratio is below 0.1 that CR <0.1 the judgements are considered to be strong. Hence the judgement made were feasible

3.4 Tools

3.4.1 Personal computer

Person computer was used for downloading all required data that is essential for this research. Also, performing the processing of those data so as to obtain research output for determining areas for placing collectors.

3.4.2 Software used

This includes a list of software used during the execution of this research, these software were used for data pre-processing, processing, obtaining the expected outputs and finally analyzing the output as indicated in Table; 3.5,

Table 3. 5 Software package

SOFTWARE	PURPOSE
ArcGIS (10.8)	Performing weight overlay analysis Mapping the classification outputs
Microsoft Visio (2013)	Preparing Research Schematic diagram
Microsoft Excel	Performing analytical hierarchy process Determining consistency ratio of criteria used
Drawing.io (20.6.2)	Preparing work flow diagram

3.5 Data acquisition

The acquired data were land sat 8 of 2022 which was downloaded from the internet through USGS website showing coverage of area of interest on which will be essential for placing solid waste collectors, DEM was acquired from USGS website so as to obtain slope and elevation of study area and also population available in the study area through NBS from census of year 2022.

3.6 Data pre-processing

This is a next step after data acquisition on which involve preparation of all acquired data for the further processing which is containing, sub setting, layer stacking and composition of bands.

Clipping/sub setting was performed so as to acquire interested area on which solid waste collectors are intended to be located

Layer stacking was performed through adding composition of band into RGB color space in order to acquire true representation of required features in the area. Also, the DEM acquired was in WGS 1984 while the shapefile of coco and msasani beaches was in Arc 1960, hence both two datasets was converted into same format which was WGS1984 assigned with zone which is 37S zone Dar Es Salaam for further processing.

3.7 Data processing

After the preparation of all data in the pre-processing the processing will be take place so as to generate intermediate results which are population map, land cover map, slope map and elevation map through Arcgis10.8 software as described bellow

3.7.1 Creation of population map

The population distribution map was created into two ways on which one describe the wards and the second one explaining the population of those wards into five classes based on the number of people available in those wards. All above was achieved through spatial analysis tool in Arcgis10.8.

3.7.2 Creation of land cover map

Land sat8 image of 2022 was classified in the Arcgis10.8 on which six classes were obtained through classification. The observed six classes were water class, forest class, crop land class, wood land class, built up class, and bare land class.

3.7.3 Creation of slope map

The DEM downloaded in USGS was converted into raster format by which slope map created on which the map of area of interest was overlaid to the DEM for covering the area of interest. Through spatial analysis tool in Arcgis10.8, slope tool was used so as to generate slope density map.

3.7.4 Creation of elevation map

Before the elevation to be derived, the DEM was to be generated and converted into raster format for analysis then elevation map was produced, whereby area of interest was overlaid to the DEM so as to cover that area of interest through spatial analysis tool in Arcgis10.8.

3.7.5 Post classification

The land cover used in this research was performed past classification in order to obtain accuracy assessment. The obtained classes which are water, forest, built up land, woodland, crop land and bare land were compared with true representation. All five classes were compared and accuracy obtained in comparison obtained 80.7431%.

3.7.6 Reclassification

From the above observed classified layers will be integrated in order to attain the place were solid waste collectors can be placed. The reclassified datasets are population, land cover, slope and elevation. The reclassified layers assigned of cell value on which based on three classes for all reclassified layers.

CHAPTER 04

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents the results of the research findings as well as the discussion of these results. It includes all intermediate maps after processing all required criteria which are population map, Land cover map, Slope map and Elevation map.

4.1 Intermediate maps and their discussion

These are the maps that is obtained so as to obtain reclassified map on which including population distribution map, land cover map, slope map and elevation map. These maps are very essential for creating final output which is suitable area for placing solid waste collectors.

4.1.1 Population distribution map

This is the map that showing the distribution of people on which shown in some wards where by people are many and close to the coastal beaches. Also, this map comprises of different wards name in terms of their actual number of residents.

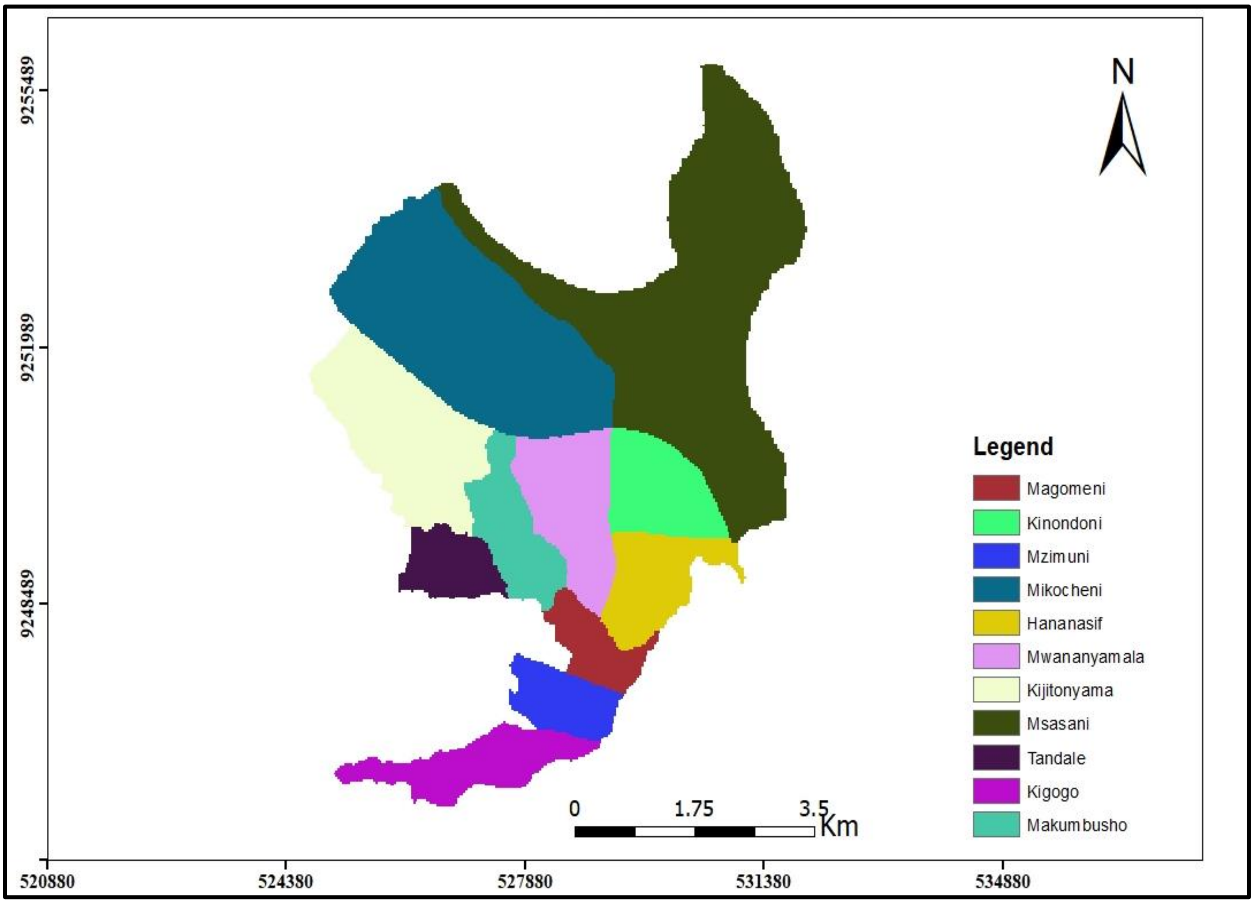

Figure 4.1 Population map of study area

4.1.2 Classified population map

After processing of wards which are related to the research, five classes were established on which based on the amount of residence which are covering the certain ward. While population density can indicate potential waste generation, focusing solely on this aspect might disregard other factors influencing waste distribution. Areas with high population might already have waste management systems in place, and waste production can also vary based on socio-economic factors.

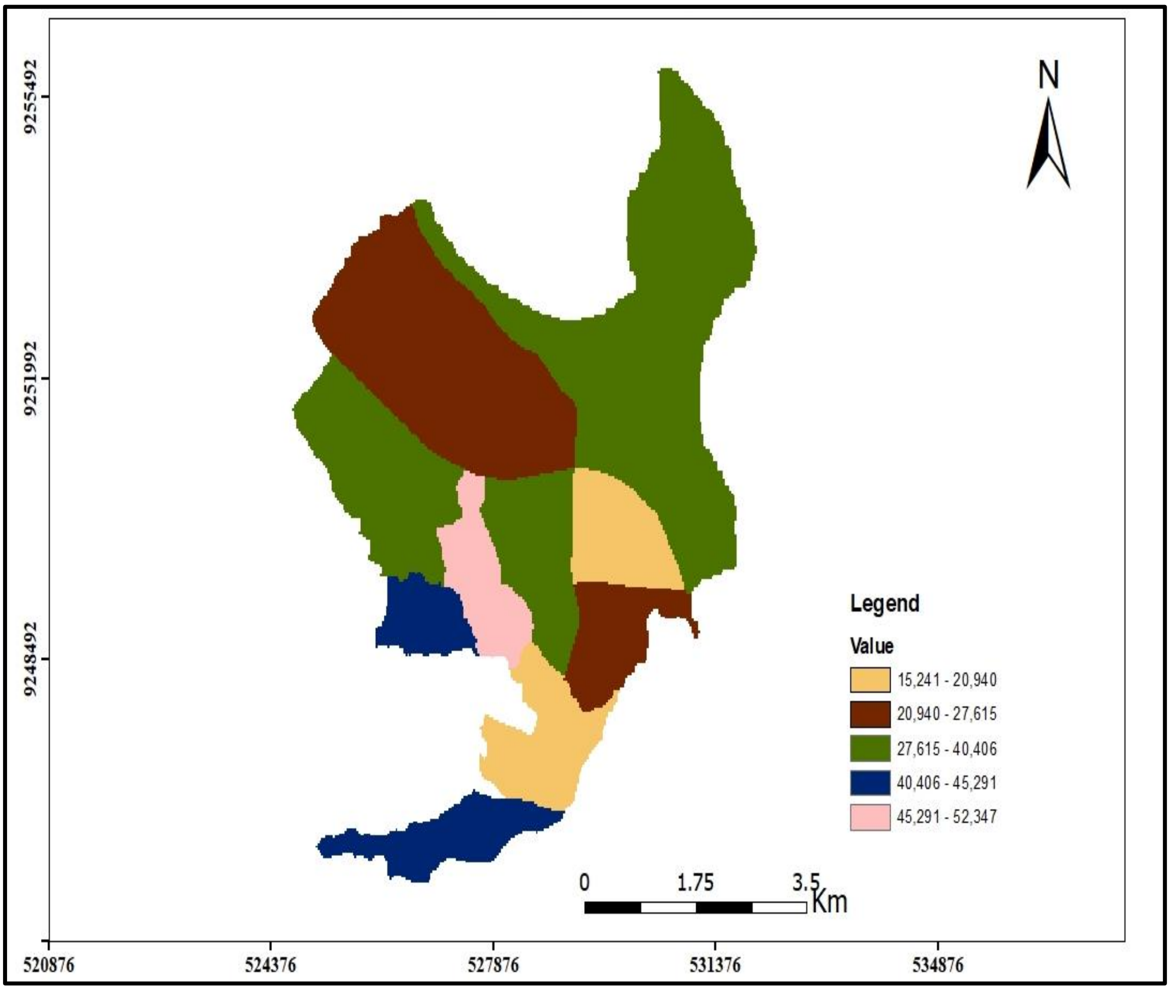

Figure 4.2 Classified population map

4.1.3 Land cover map of study area

This land cover observed into the several classes on which covering the study area, the following five classes were obtained, which are water, forest, crop land, built up land and bare land. The most or high coverage in the area is built up land followed by bare land class. Land cover plays a role in waste creation and accessibility. However, certain land cover types might not directly align with waste output (for example, a dense forest might result in lower waste generation). Additionally, some land covers could require careful consideration due to ecological sensitivities, such as wetlands (Ebistu et al., 2013).

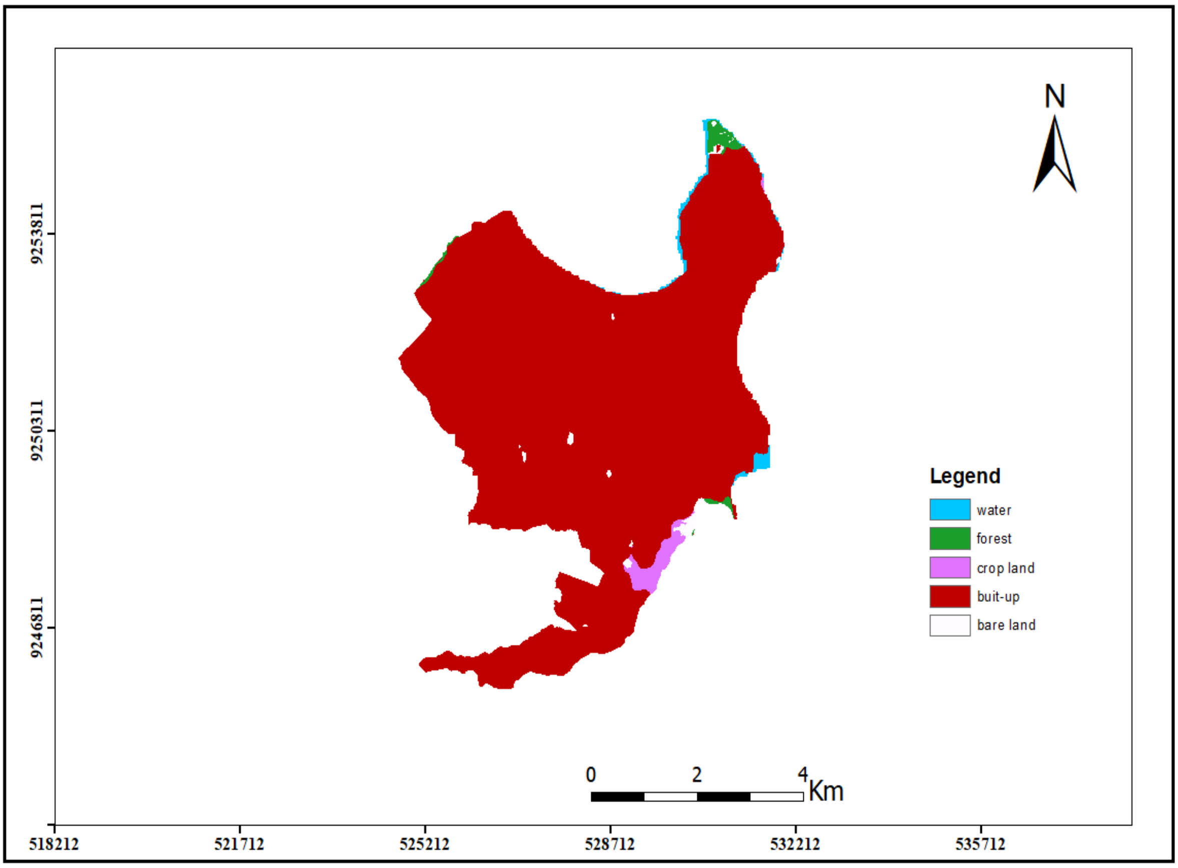

Figure 4.3 Land cover map of study area.

4.1.4 Slope map of study area

Slope refers to change in height across a region of surface. Slope was an important factor as it affects land suitability in the study area. Slope map was prepared from SDRTM DEM of 30m resolution using the slope tool in the Arcgis10.8 software. Slope affects waste movement and drainage. Steeper slopes can pose challenges for waste collection vehicles, and waste positioned on such slopes might be susceptible to erosion and runoff, posing environmental concerns. However, concentrating solely on slope might overlook areas with moderate slopes that are still suitable for waste collection.

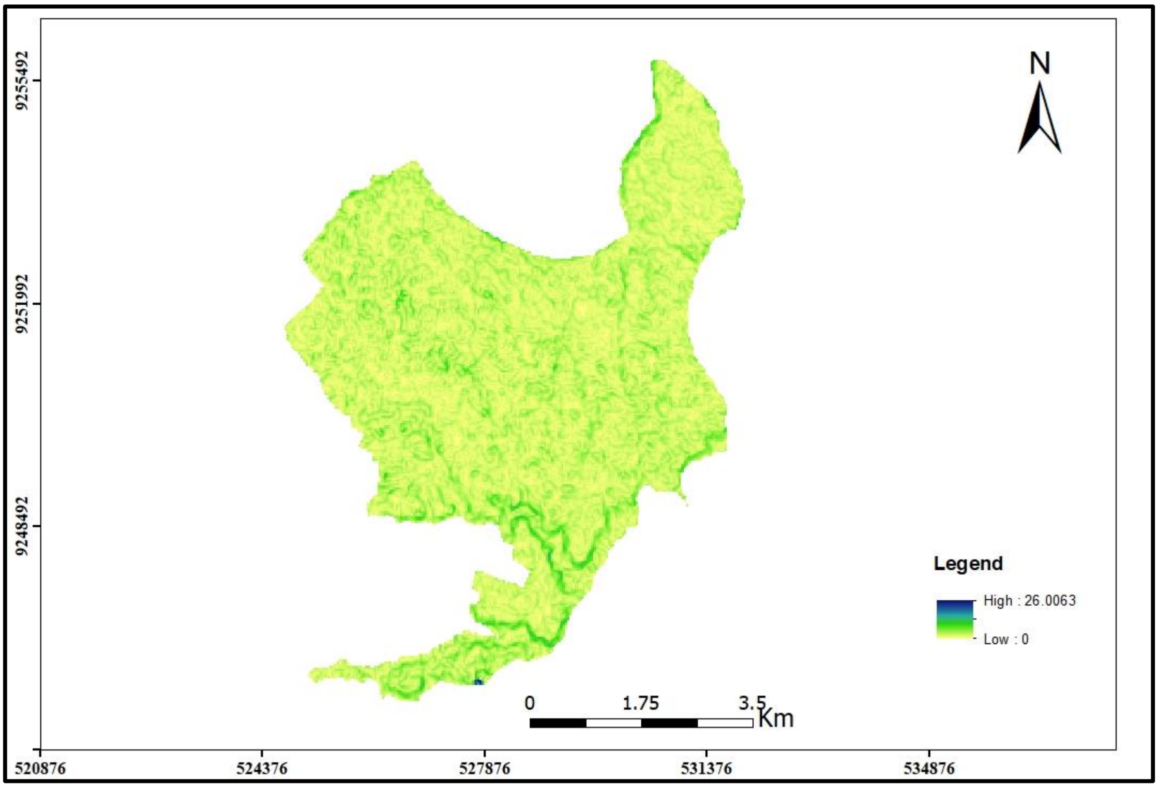

Figure 4.4 Slope map of study area.

4.1.5 Elevation map of study area

Elevation refers to the height of a point or location above a reference point typically the mean sea level. Elevation map was prepared from the downloaded SRTM DEM of a 30m resolution downloaded from the USGS. Elevation impacts accessibility and potential flooding risks. Low-lying coastal areas are prone to flooding, affecting waste collection and potentially causing environmental contamination. Nevertheless, higher elevations might not always be optimal due to transportation difficulties and increased costs.

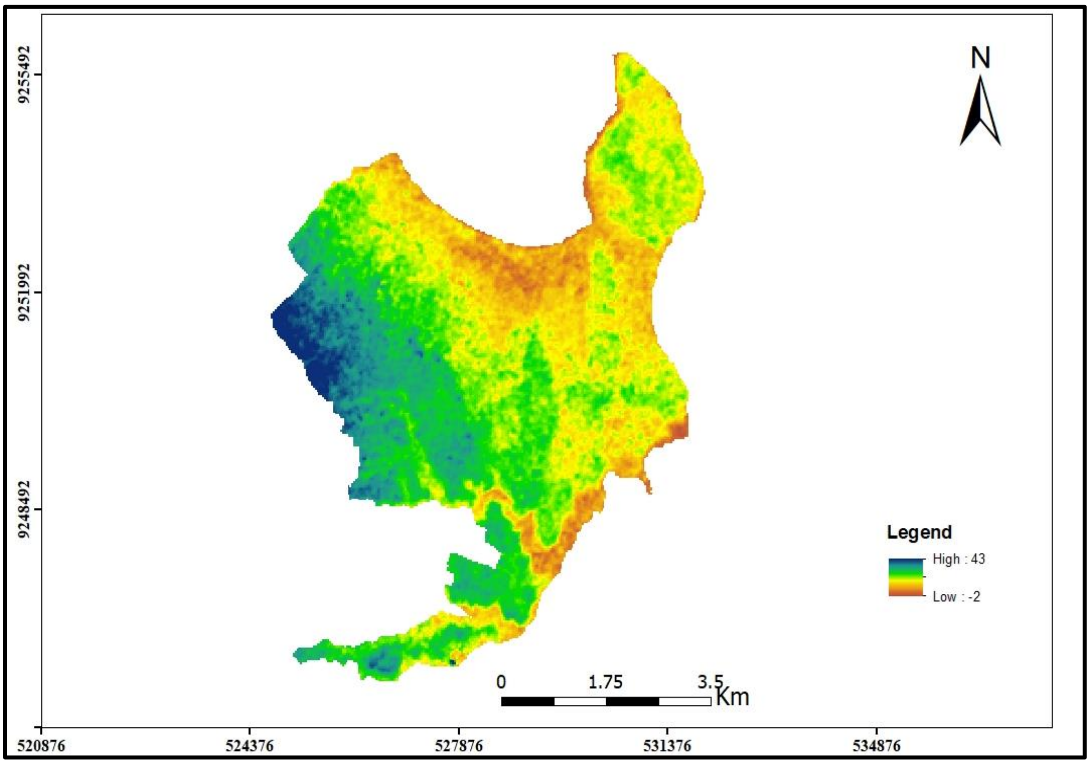

Figure 4.5 Elevation map of coco and msasani area

4.2 Reclassified layers

4.2.1 Reclassified population map

The reclassified population provides the results indicating the how the distribution of people in the area affecting the proper placing of collectors, area shaded with green color are suitable since it comprises of large number of people, hence labeled as mostly suitable, area shaded with blue color is less suitable while covered with beige color is unsuitable since it had small number of people .Reclassifying population density into suitability categories acknowledges regions with differing waste potential. "Less suitable" areas could indicate lower populations and thus less waste generation, while "highly suitable" zones might point to denser populations and greater waste production. However, solely relying on population might overlook waste variations due to socioeconomic factors or existing waste infrastructure.

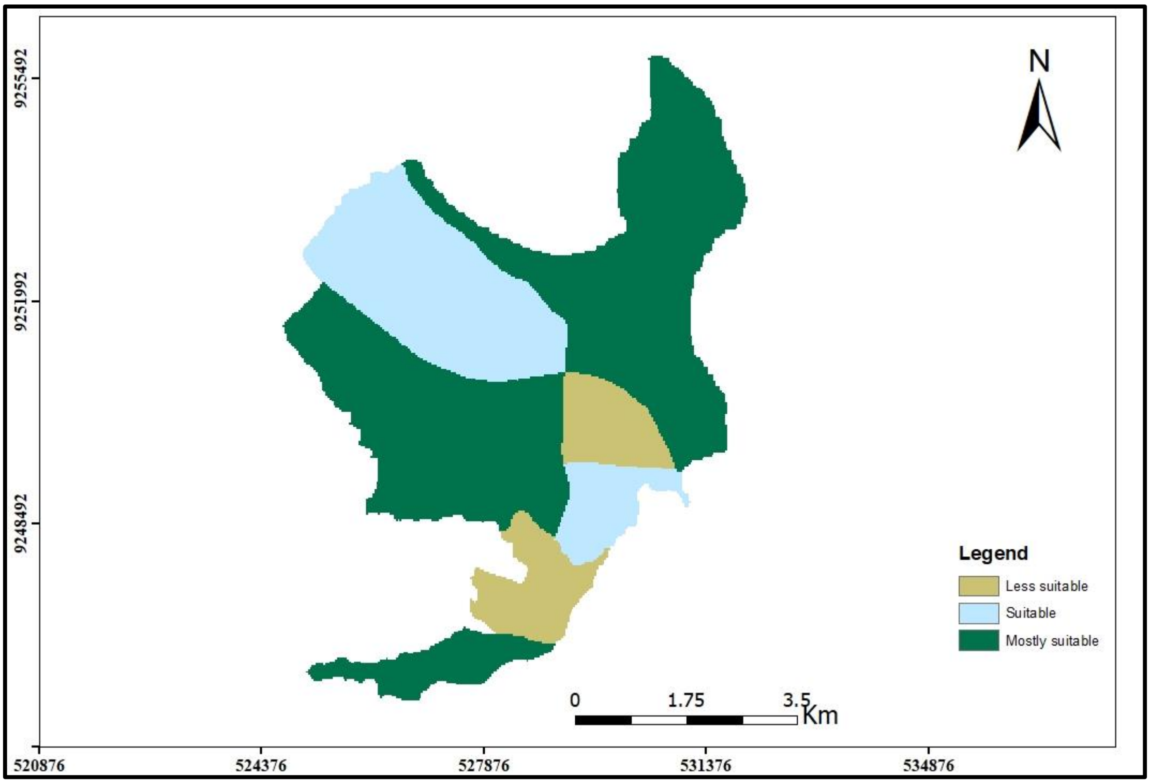

Figure 4.6 Reclassified population map of study area.

4.2.2 Reclassified Land cover map

Reclassified land cover provides the result on which area shaded with green color is mostly suitable since it covers the bare land, while area with rose color is less suitable and area shaded with blue color is unsuitable since covered with built up. Categorizing land cover into suitability segments recognizes how diverse landscapes impact waste management. "Less suitable" territories might involve land covers resulting in limited waste, such as forests or water bodies. Conversely, "highly suitable" locations could encompass urban areas generating more waste. Nonetheless, disregarding waste potential in specific "less suitable" land covers, like commercial zones, could lead to missed opportunities (Ebistu et al., 2013).

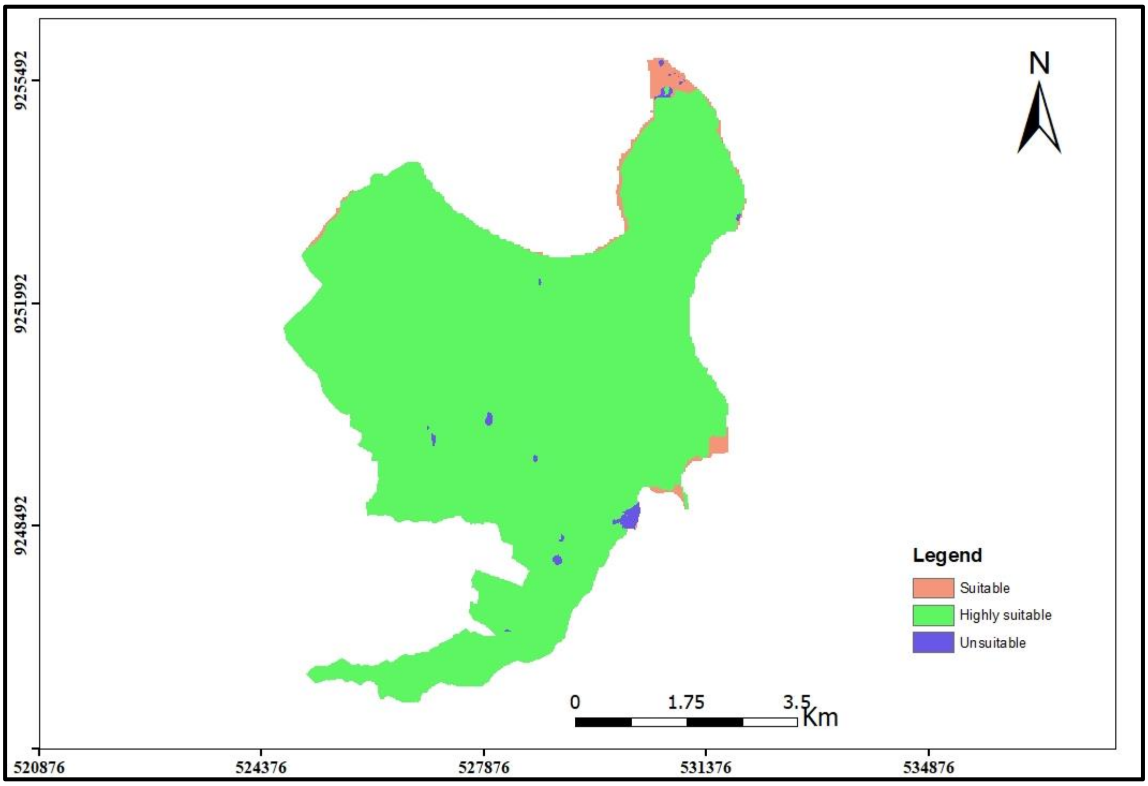

Figure 4.7 Reclassified land cover map of study area.

4.2.3 Reclassified Slope Map

Reclassified slope was categorized into 3 classes with red color appeared to be mostly suitable for solid waste collectors because it has good slope and according to (Sener et al, 2011), areas for locating solid waste collectors are supposed to have slope less than 10%. Area with blue color are suitable while those with green color are unsuitable because they appeared to have greater slope. Assigning slope to suitability groups reflects how terrain influences waste collection feasibility. "Less suitable" areas with steep slopes might hinder waste collection and operational safety. In contrast, "highly suitable" places with gentle slopes could enhance efficient waste management.

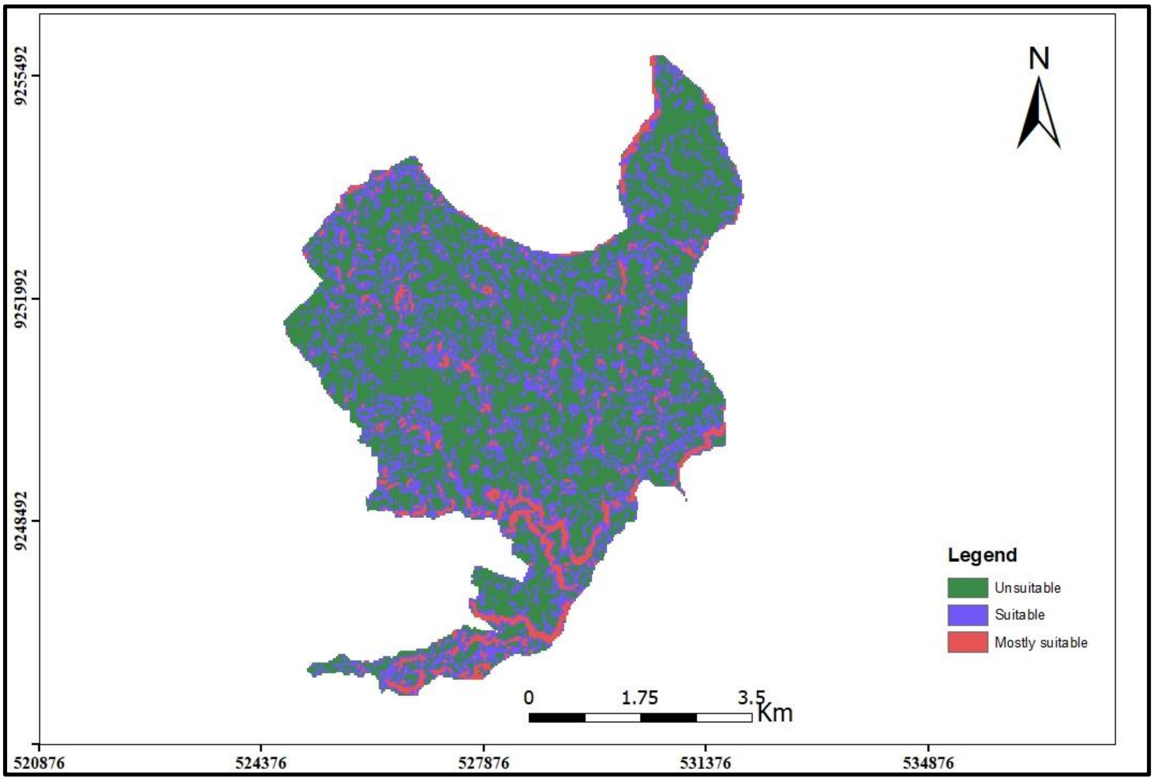

Figure 4.8 Reclassified slope map.

4.2.4 Reclassified Elevation Map

The areas within a low elevation were considered as the suitable areas for placing solid waste collectors. Elevation of below than 43m was taken as the suitable area especially those with the lowest number while those with the elevation above 43m were defined as unsuitable. Categorizing elevation into suitability tiers recognizes how height impacts waste management. "Less suitable" zones at lower elevations near coasts might be prone to flooding, impacting waste collection and the environment. Conversely, "highly suitable" areas at moderate elevations might offer better access and reduced flood risks. Nonetheless, elevation alone might not consider waste generation differences tied to socioeconomic factors.

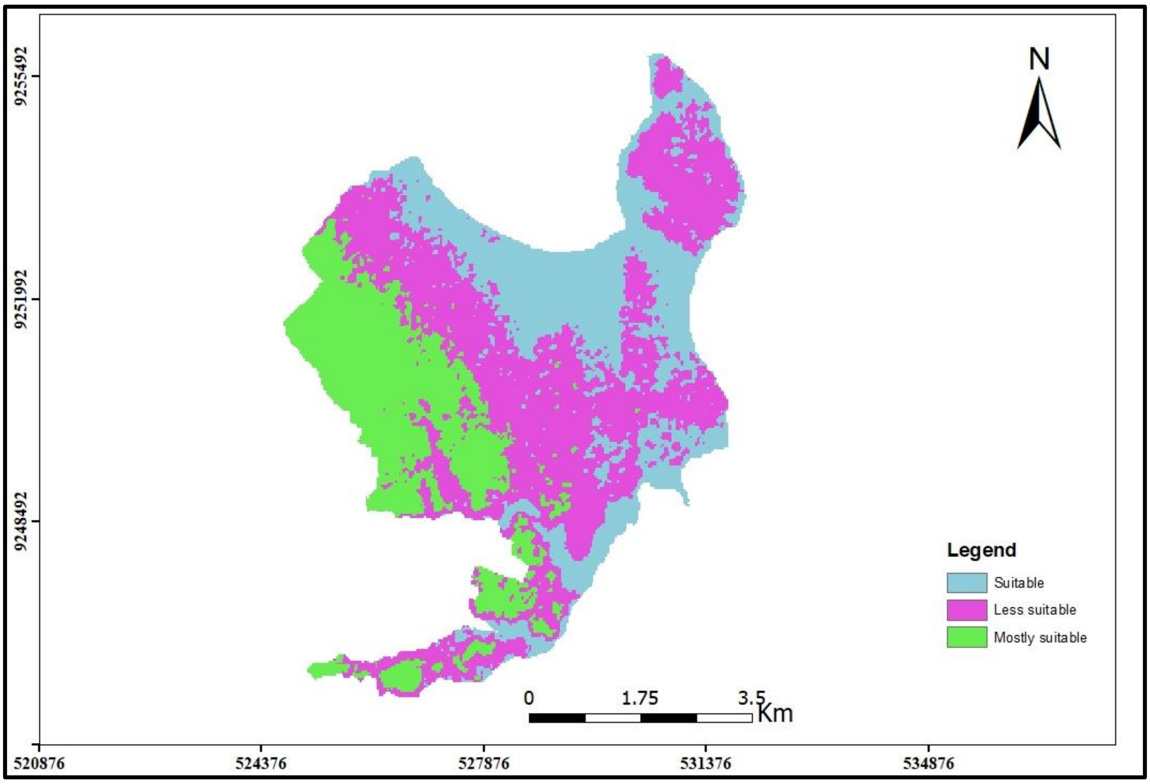

Figure 4.9 Reclassified elevation map of coco and msasani area

4.3 Final result

This is the final output on which describe the relevance of research on which it is applicable on solving the desired problem of placing solid waste collectors. Also, this output obtained after summing Weight overlay analysis of thematic layers which are reclassified population, reclassified land cover, reclassified slope and reclassified elevation. Three classes were resulted for different scale or range of site suitability comprises (green color) for Mostly suitable site, (yellow color) for suitable site and (red color) for unsuitable site.

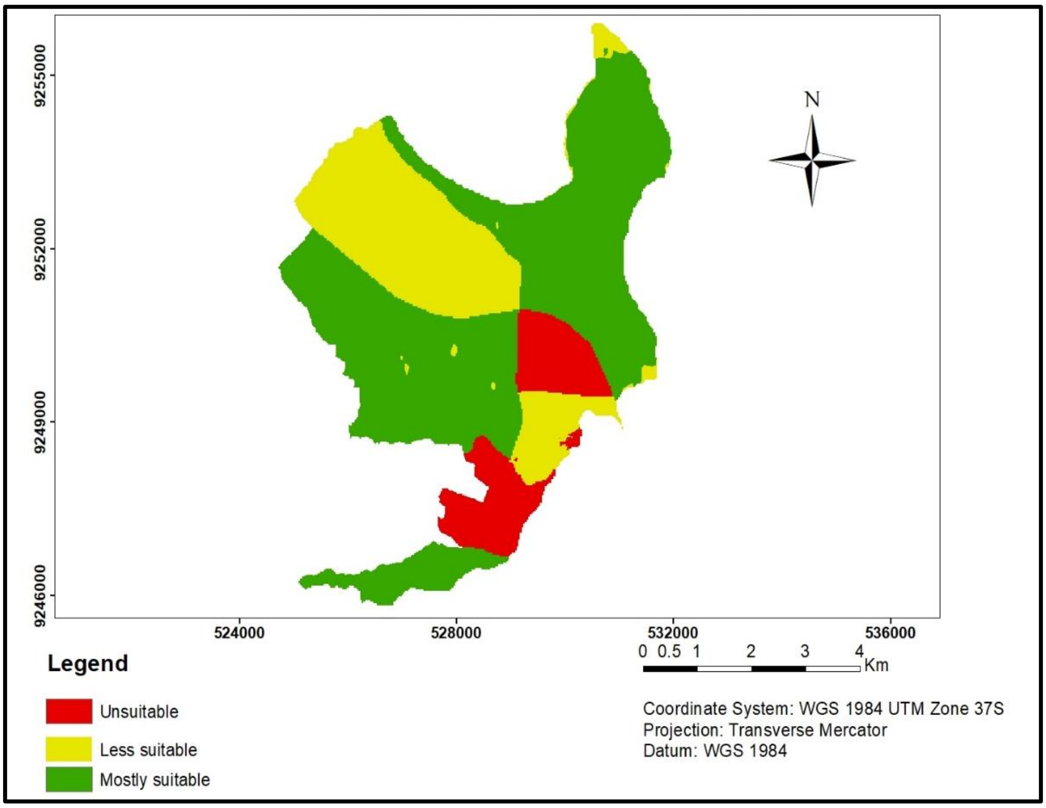

Figure 4.10 Suitability map

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Through output that is suitable area for placing collectors in this research prove that GIS and RS are the best tool to adopt so as to analyze the criteria for making different decision support. This analysis has taken the four (4) criteria namely population, slope, land cover and elevation as determining factors for appropriate determination of solid waste collectors. Also, placing of solid waste collectors depends on the above factors on which each one has contribution on the research, by implementing the below recommendations will improve the essential of this research.

5.2 RECOMMENDATION

The following are the recommendation based on performed research

- Adopted method for the selection of better areas on which collectors can be placed in other beaches
- Planners should adopt the AHP and weight overlay analysis before planning for different project development example hotels, cafe, parking, restaurant, sports and games areas
- Similar study should be done using Hyperspectral images on identifying and quantifying of different types of solid waste which is not included in this research.

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