Use of Multi-criteria Decision Approach to Identify an alternative solid waste dump site around Lae City

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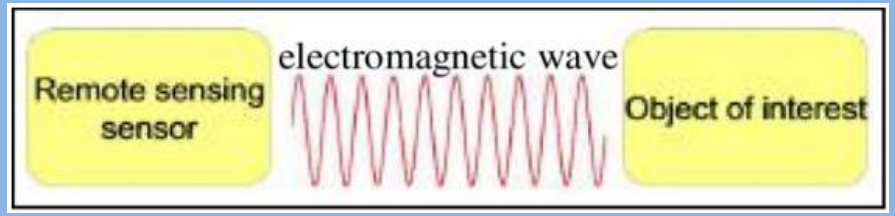
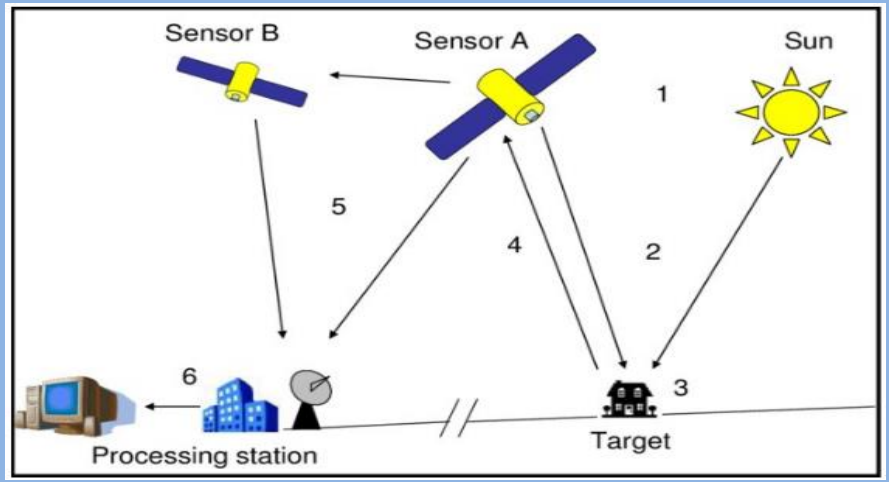
Introduction

- The major problem related to the environment that the world is facing today is disposing and managing of the waste.
- This type of problems are mostly faced by developing countries like Papua New Guinea and Lae city is no exception.
- Remote sensing (RS) and geographical information system (GIS) are the most powerful tools that can be used to identify dumpsites and can be utilised to manage solid waste in the Lae city.

Introduction: Satellite Remote Sensing

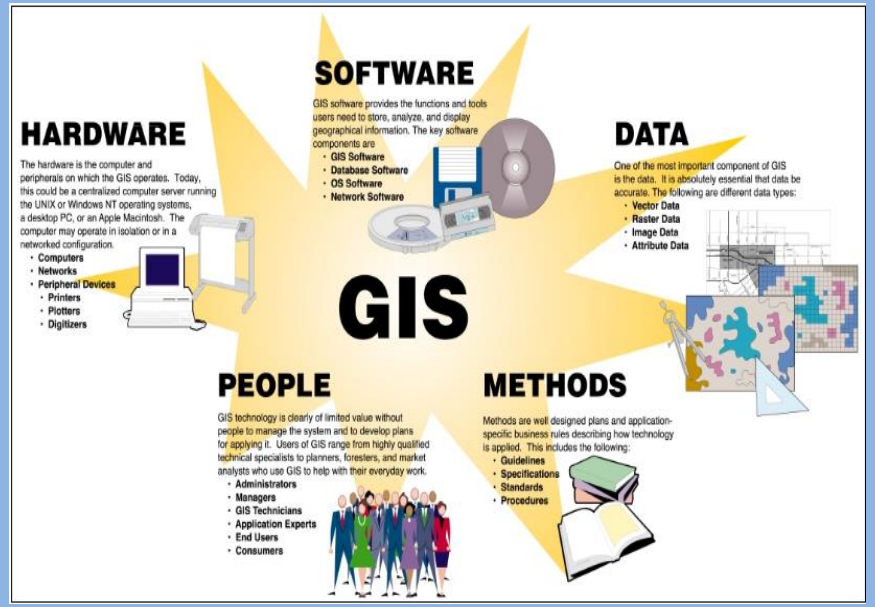
- **Satellite Remote Sensing** is the process of accruing information about an object or phenomenon by measuring its reflected and emitted radiation without making physical contact at a distance (typically from satellite).





Introduction: Geographic Information System

Geographic Information System (GIS) is a system of hardware, software and procedures to efficiently capture, store, manipulate, analyse and display all forms of spatial and non-spatial (attribute) data to solve complex problems regarding planning and management of resources.



Components of a GIS

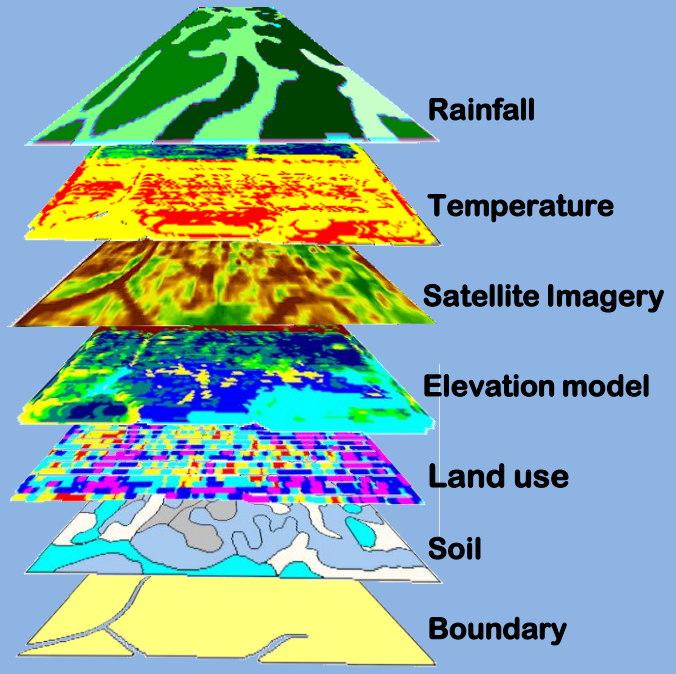
Introduction: Concept of Layers

In GIS, layers are collections of geographic data.

Layers are the contents of a map. They include a wide range of information, like terrain, roads, political boundaries, building footprints, utility lines, land use, soil texture, hydrology etc.

Each layer is used to display and work with a specific GIS dataset.

GIS Layering of Information



Introduction: Solid Waste

A solid waste is any material that is discarded by being abandoned.

Municipal solid waste is commonly known as trash or garbage.

Waste is a problem as there are too much of it, it's toxic, and it hurts our health and environment.

Landfills pollute air and water with potentially toxic chemicals.

Second seven dump site

Introduction: Aim and objectives

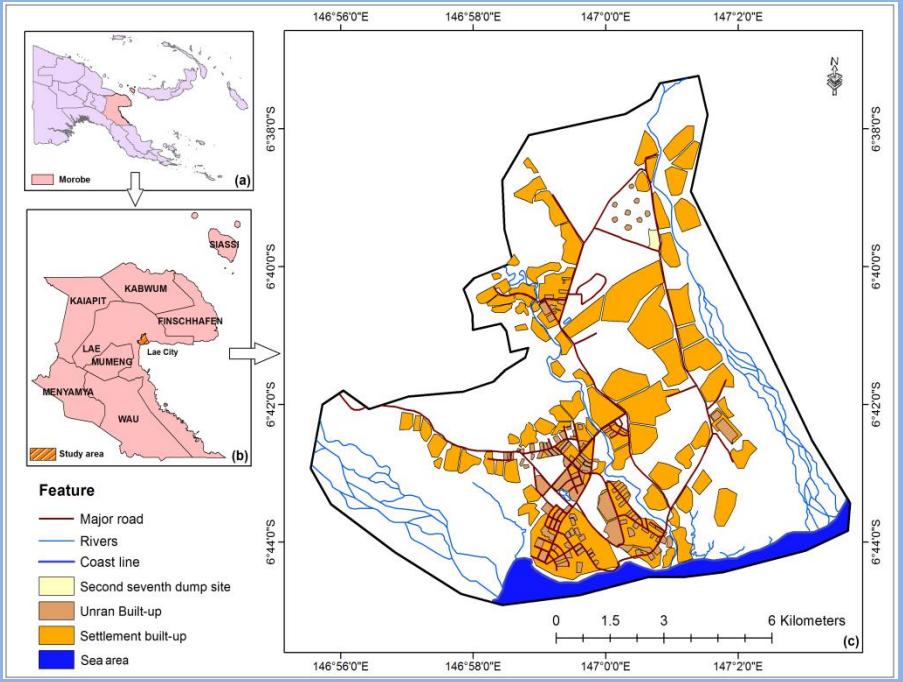
The aim of this research was to investigate and locate a sustainable suitable disposal sites for dumping urban waste.

The objectives of this study was:

1. To construct *spatial database of all required input parameters* for solid waste site suitability analysis.
2. To identifying *the best possible future solid waste dumping grounds* with minimum limitations.

Study location

- Lae city is situated on a flat plain and along the Huon coast of Morobe province. It is well known as one of the major industrial centers and the second-largest city of PNG.
- Due to the rapid growth of industrialization and urbanization migration of the population into the Lae also significantly increase for better opportunities. This leads to the total quantity of solid waste, which has been significantly increased, and the disposal of waste became a challenging issue.
- PNG's per capita household MSW generation rate is around 0.45 kg per person per day (Woodruff, 2014).



Location map of the study area: (a) PNG; (b) Morobe; (c) the study area

Methodology: Important factors

The dumpsites are designed purposely to dump waste and other unwanted materials no longer needed for individual convenience.

Before carrying out the study on identifying suitable dumping sites, it needs to consider important factors such as type of land use/land cover, distance from the rivers, streams, lakes, supermarkets, residential areas, schools, hospitals, and major institutions, topography, soil type, etc. The landfill/waste dump site should be away from the living population.

Methodology: Input Parameters

To identify the suitable waste deposal site through a multi-criteria decision approach a total of ten (10) parameters were considered as input parameters, namely-

(i) Distance from major roads

(ii) Distance from river/lake/coastline

(iii) Distance from hospital/clinic/school

(iv) Distance from residential/supermarkets/industries

(v) Height of the ground

(vi) Slope of the land

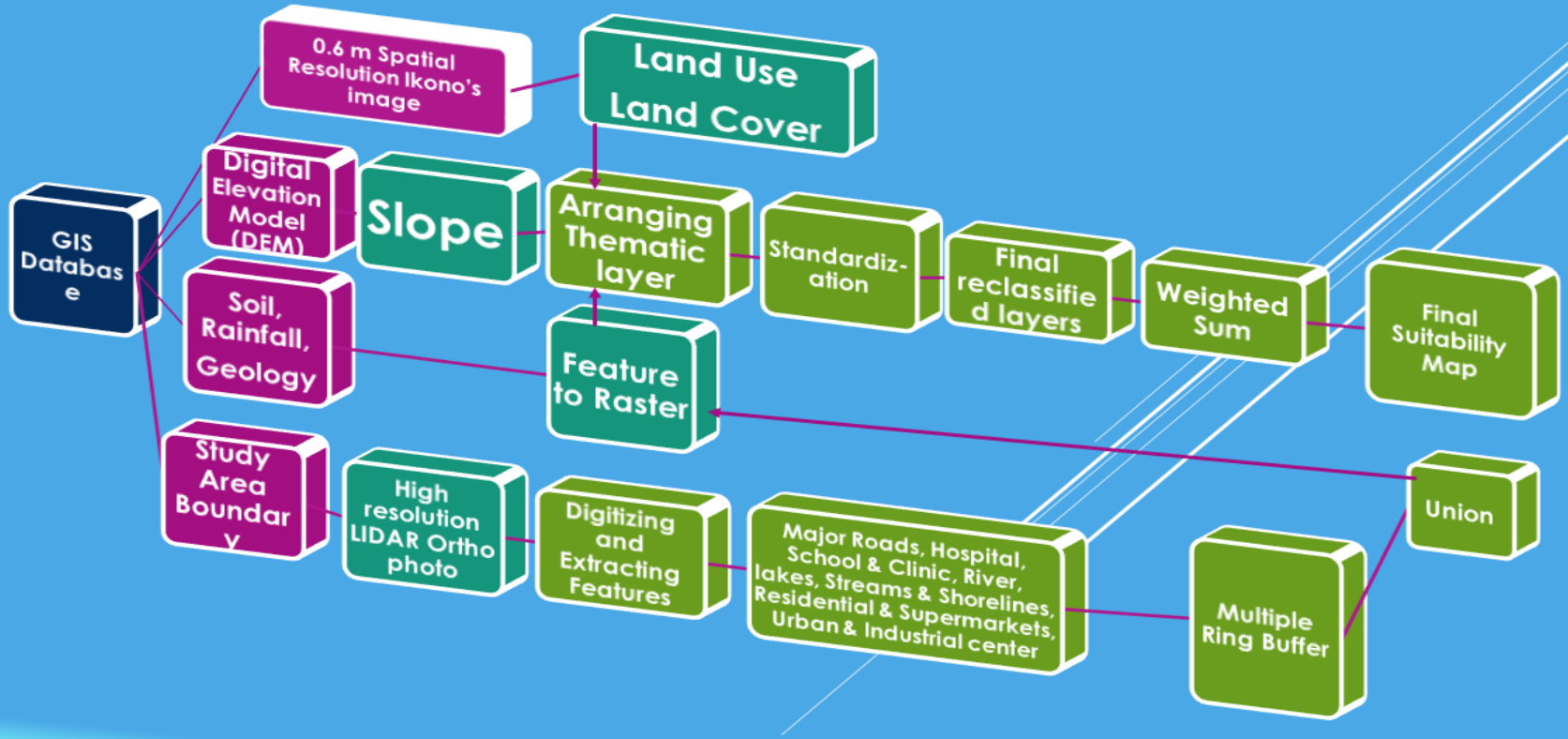
(vii) Land use and land cover

(viii) Hydrological soil group

(ix) Rainfall and

(x) Lithological setting

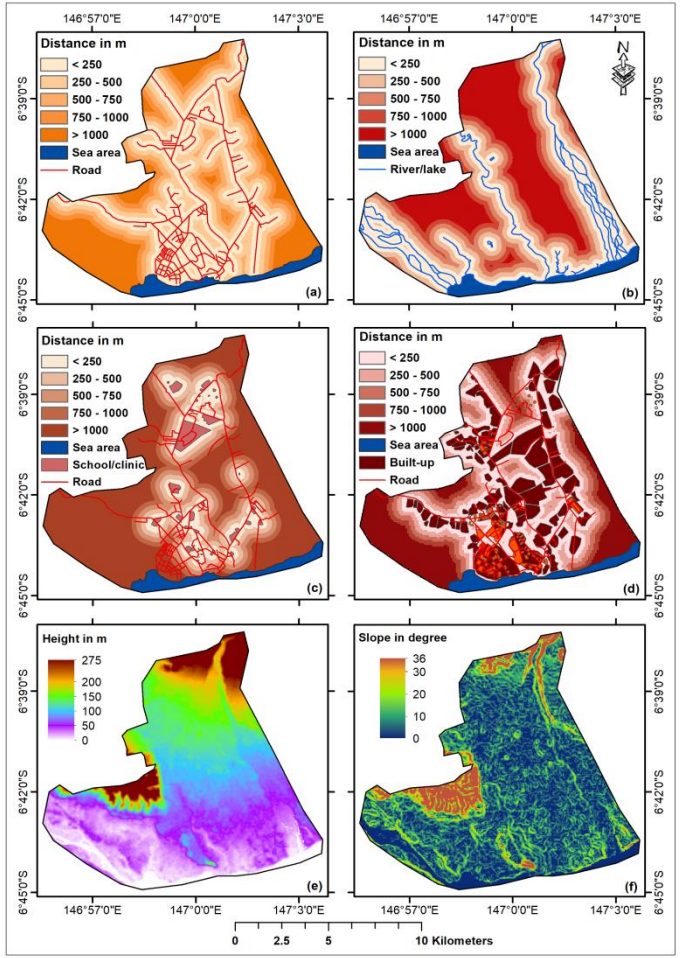
Methodological Flow Chart



Parameters: infrastructure, services, and topography

Six (6) input parameters were selected from "infrastructure, services, and topography" category:

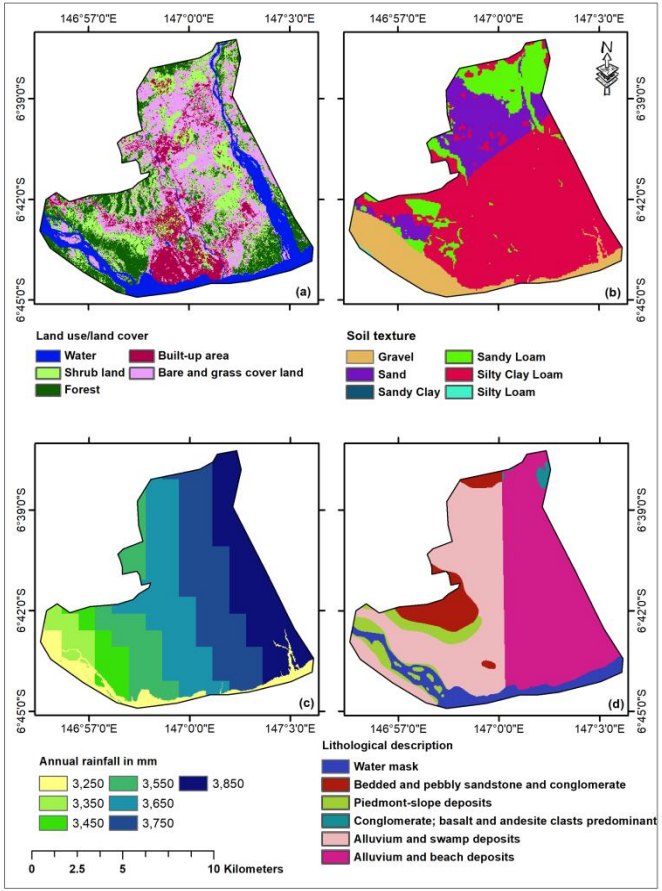
(a) Distance from roads,
(b) Distance from river/lake/coastline,
(c) Distance from hospital/clinic/school,
(d) Distance from residential/ supermarkets/ industries
(e) Height (altitude) of the land and
(f) Slope of the land



Parameters: land use, soil, climate and lithology

Four (4) input parameters were selected from land use, soil, climate and lithology category:

(a) Land use/ land cover,
(b) Soil texture,
(c) Annual rainfall and
(d) Lithological description.



land use/land cover, lithology and soil

Parameters	Sub-class	Area in hectares	Coverage in percentages
Land use and land cover	Built up	1631	14
	Water	1557	14
	Natural Vegetation	2182	19
	Shrub land	2514	22
	Bare land	3554	31
	Total	11438	100
Lithological description	Water mask	938	8
	Alluvium and swamp deposits	4061	36
	Conglomerate, gravel, sand, silt: piedmont-slope deposits	710	6
	Conglomerate; basalt and andesite clasts predominant	84	1
	Bedded and pebbly sandstone and conglomerate	839	7
	Alluvium and beach deposits	4806	42
	Total	11438	100
Soil texture / hydrological soil group	Gravel - A	1454	12.71
	Sand - A	1749	15.29
	Sandy loam - A	1511	13.21
	Silt loam - B	12	0.10
	Silt clay loam - D	6708	58.65
	Sandy clay - D	4	0.03
	Total	11438	100

Methodology: Rank and weight

- All subclasses of all the selected parameters were ranked based on their preferences for the waste dumping site selection. The ranking criterion was adopted from Saaty (1987). The fundamental scale of 1 to 5, where 1 is less more favorable and 5 is highly favorable.
- The weights were assigned to each parameter to identify which criterion is a more favorable influence on the suitability analysis and which has less.
- Each ranking and weight were done according to its relative importance based on the expert's knowledge and results from other associated researches and literatures.

Methodology: Rank and weight

Factors	Sub-class	Suitability rating	Rank	Weight
River, Lake, coastline (buffer in meter)	< 250	Unsuitable	1	2
	250 - 500	Less Suitable	2	
	500 - 750	Moderately Suitable	3	
	750 – 1000	Suitable	4	
	> 1000	Highly Suitable	5	
Soil texture/ Hydrological soil group	**Gravel - A**	**Unsuitable**	**1**	**2**
	Sand - A	Unsuitable	1	
	Sandy loam - A	Unsuitable	1	
	Silt loam - B	Moderately	3	
	Silt clay loam - D	Highly Suitable	5	
	Sandy clay - D	Highly Suitable	5	
Land use and land cover	**Built up**	**Unsuitable**	**1**	**1**
	Water	Unsuitable	1	
	Natural Vegetation	Less suitable	2	
	Shrub land	Moderately suitable	3	
	Bare and grass cover land	Highly suitable	5	

Results

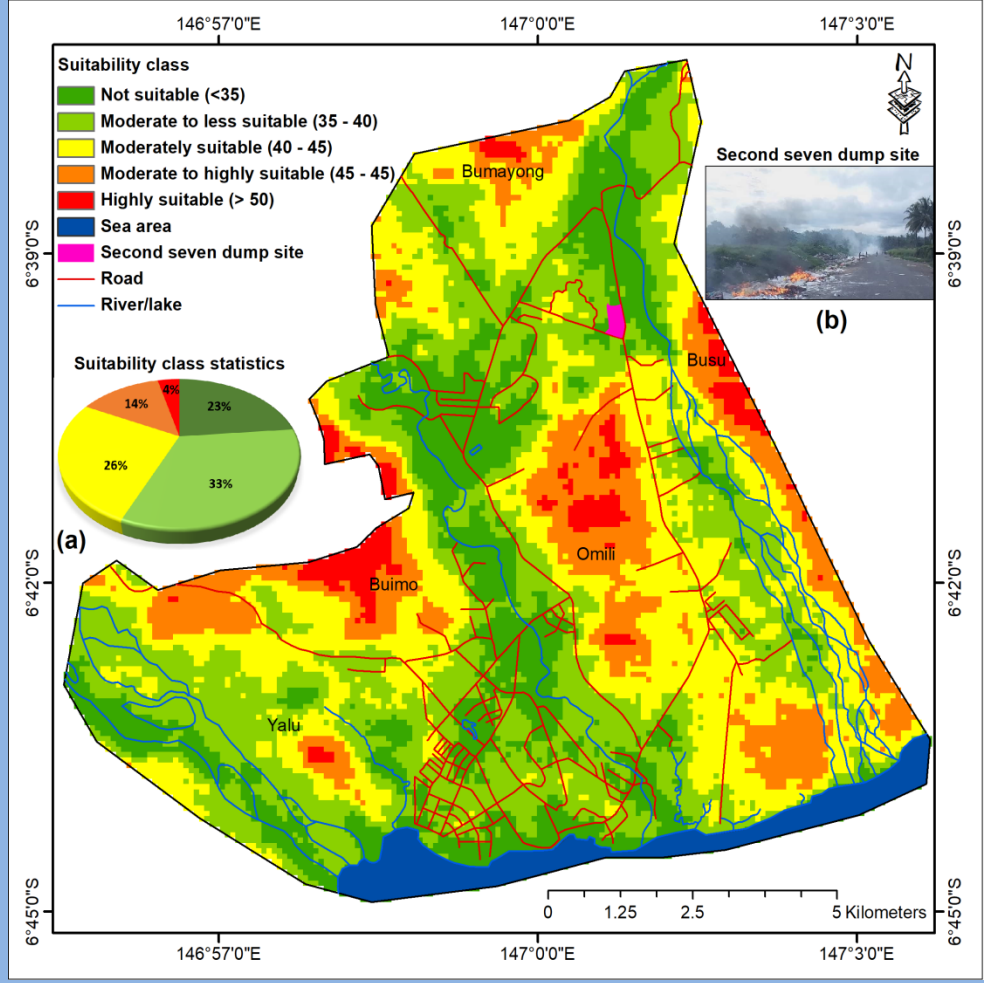
- The resulted raster dataset was derived using the weight sum analysis based on given weight to each parameter and rank of each subclass belonging to each parameter.
- The resulted output was further reclassified into five (5) suitability groups based on the suitability index value, namely:

  (i) not suitable (index value of less than 35),
  (ii) moderate to less suitable (35 to 40),
  (iii) moderately suitable (40 to 45),
  (iv) moderate to highly suitable (45 to 50) and
  (v) highly suitable (more than 50)

Results

Sl no	Suitability class /value	Area (Ha)	% of area coverage
1	Not suitable	2682	23
2	Moderate to less	3811	33
3	Moderately suitable	2944	26
4	Moderate to high	1567	14
5	Highly suitable	433	4
	Total	11438	100

The major suitable areas are labeled with their location names, such as Busu, Bumayong, Buimo, Yalu, and Omili. Some other areas with single or few red pixels were not selected as a suitable areas because of the limitation of the size/area for the dump site.



Some of the important Benefits of Using Sustainable Waste management Practices

1. Cost Savings
2. Improved Environmental Health
3. Economic Gains
4. Improved Community Engagement
5. Enhanced Resource Efficiency
6. Improved Health and Safety
7. Positive Social Impacts
8. Financial Benefits

Source: www.vanellagroupmn.com

Discussion

- The outcome of the work establishes that the proximity to roads, river/lake/coastline, hospital/clinic/school, residential/ supermarkets /industries as well as land use and land cover, soil type, and lithology have played a significant role in the selection of suitable dumpsite.
- The current second seven dumpsite for the dumping of solid waste is situated in a less suitable or not suitable area. The air pollution is very much visible around this dumpsite as it is situated along the main road and nearby settlement built-up.

Conclusion & recommendations

- The generation of solid waste has been extensively increased due to rapid urban expansion and population pressure in Lae city.
- The methodology used in this study is quite user-friendly and can be used by the city waste management authorities.
- City planners, local authorities, and the local government can adopt the results for future progress.

- Some of the proposed dump sites can be further reviewed based on the trend of population growth, infrastructure availability and choice of bigger landfills over smaller ones for a prolonged period.
- One of the effective solutions is waste minimization through recycling and reuse, and waste transformation alternatives as done in other parts of the World.

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