AN INTEGRATED APPROACH FOR OPTIMIZED LANDFILL SITE SELECTION IN KISUMU CITY, KENYA

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COURSE: GEOG 596A

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Overview

- Project motivation
- Background
- Objective
- Methodology
- Analysis processes
- Anticipated results
- Time frame
- References

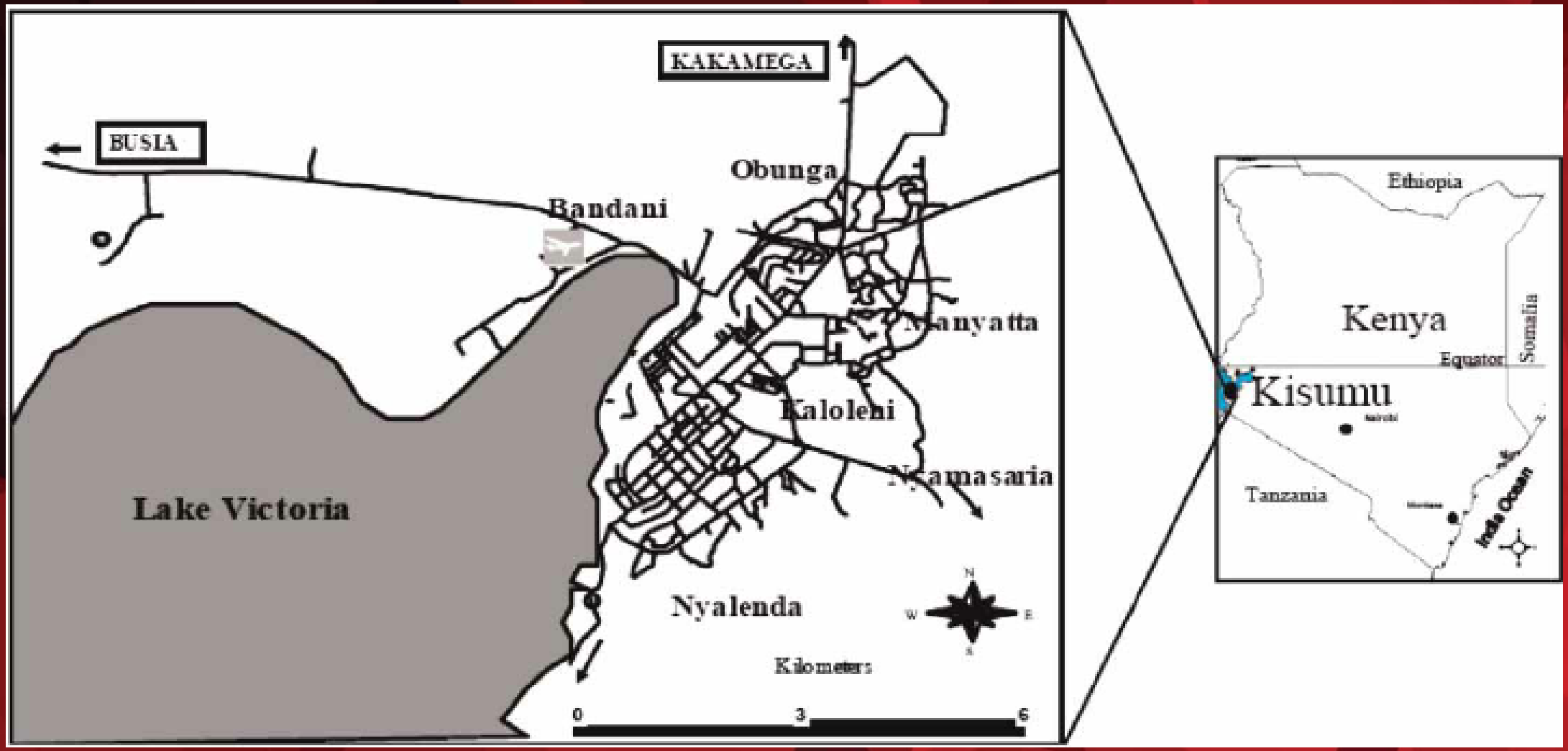
Project Motivation

- Personal experience
  - Grew up in Kisumu
  - Witnessed how waste was poorly managed
  - Understand the need for systemic change
- Shortage of GIS professionals
  - There are a few GIS experts in Kenya
  - So far, no Kenyan university offers a masters program in GIS
  - Determined to use the knowledge/skills acquired through Penn State's MGIS Program to impact change

Background

- About Kisumu
- Problem- Inefficient Solid Waste Management System
- Affected parties
  - Community- mostly informal settlements
  - Stakeholders in waste management
    - Private stakeholders
    - Municipal Council of Kisumu

Map of the Study Area in Relation to the Vulnerable Informal Settlements



State of the Main Dumpsite (Kachok Dumpsite)

- About 4 decades old
- Waste generation has increased over time
- Dumpsite is overflowing
- Substantial risks associated with it

Stakeholders in waste management

Challenges Encountered by Stakeholders

- Financial constraints
- Poor planning
- Some waste collection areas are inaccessible
- Only 20% of the 400 tons generated daily is transported to dumpsite
- Remaining 80% piles up in residential and commercial areas

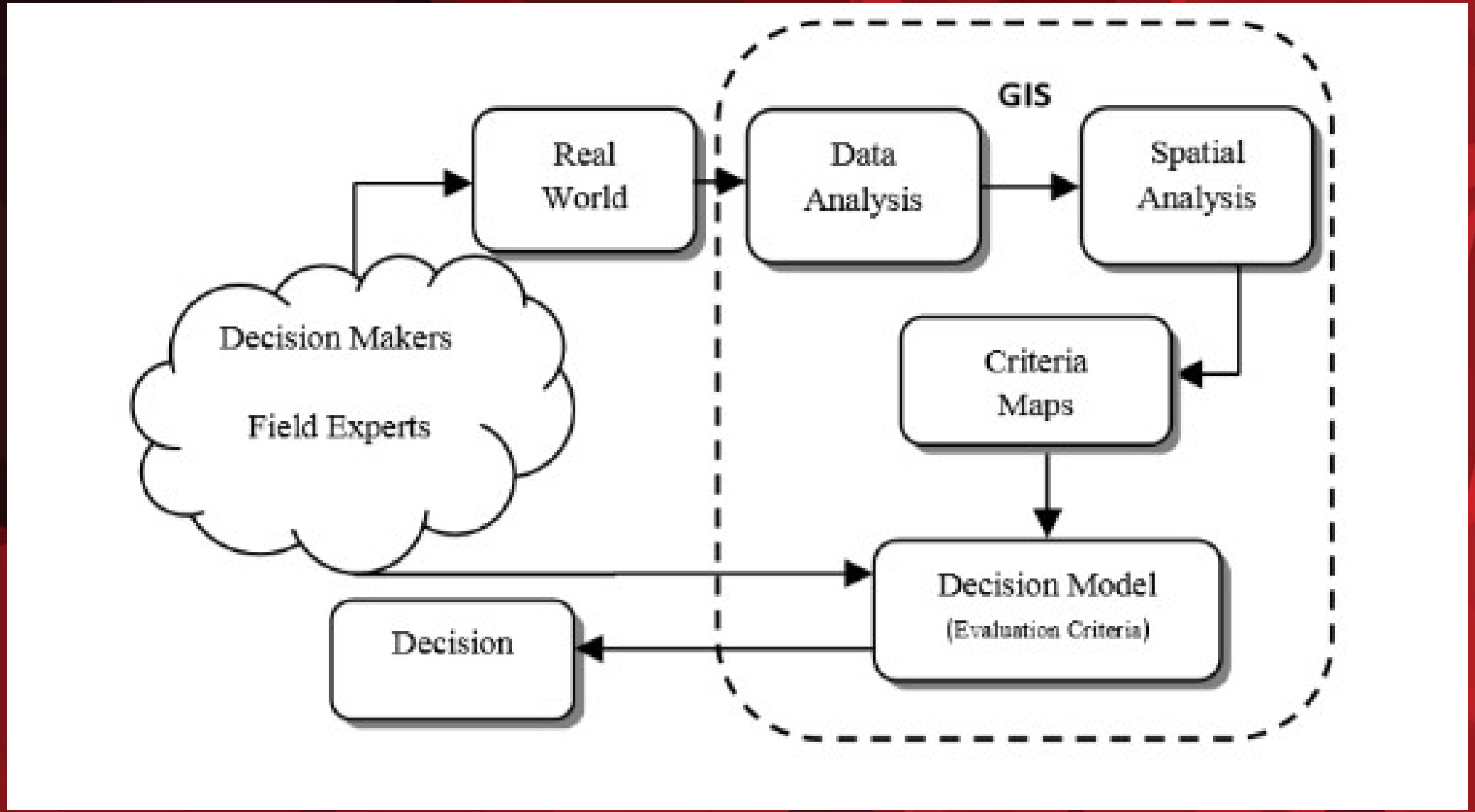
Interventions and Shortcomings

- The predicament of waste facilities in Kisumu has been acknowledged by several researchers (Awuor et al., 2019; Munala & Moirongo, 2011; Schlueter, n.d.; Sibanda et al., 2017).
- Researchers recommended several measures for sustainable waste management.
  - Waste minimization/reduction.
  - Waste recycle/reuse.
  - Waste disposal in landfills.
- Landfill siting is still challenging.
  - No researcher has employed a robust methodology for landfill siting in Kisumu.
  - Government of Kisumu is seeking to evacuate the old dumpsite to a new parcel of land.
    - So far, considerations have been based on land availability.
    - Potential problems could arise if multiple factors are not evaluated.
  - The National Environmental Management Authority (NEMA) performs environmental assessments in Kenya but has never evaluated waste disposal sites in Kisumu using GIS/MCDA integrated approach.

Project Objective

- The primary goal is to identify suitable landfill sites that optimize collection and transportation of wastes as well reduces the risks posed to human lives and the environment.

Methodology: Integrated GIS/MCDA Approach



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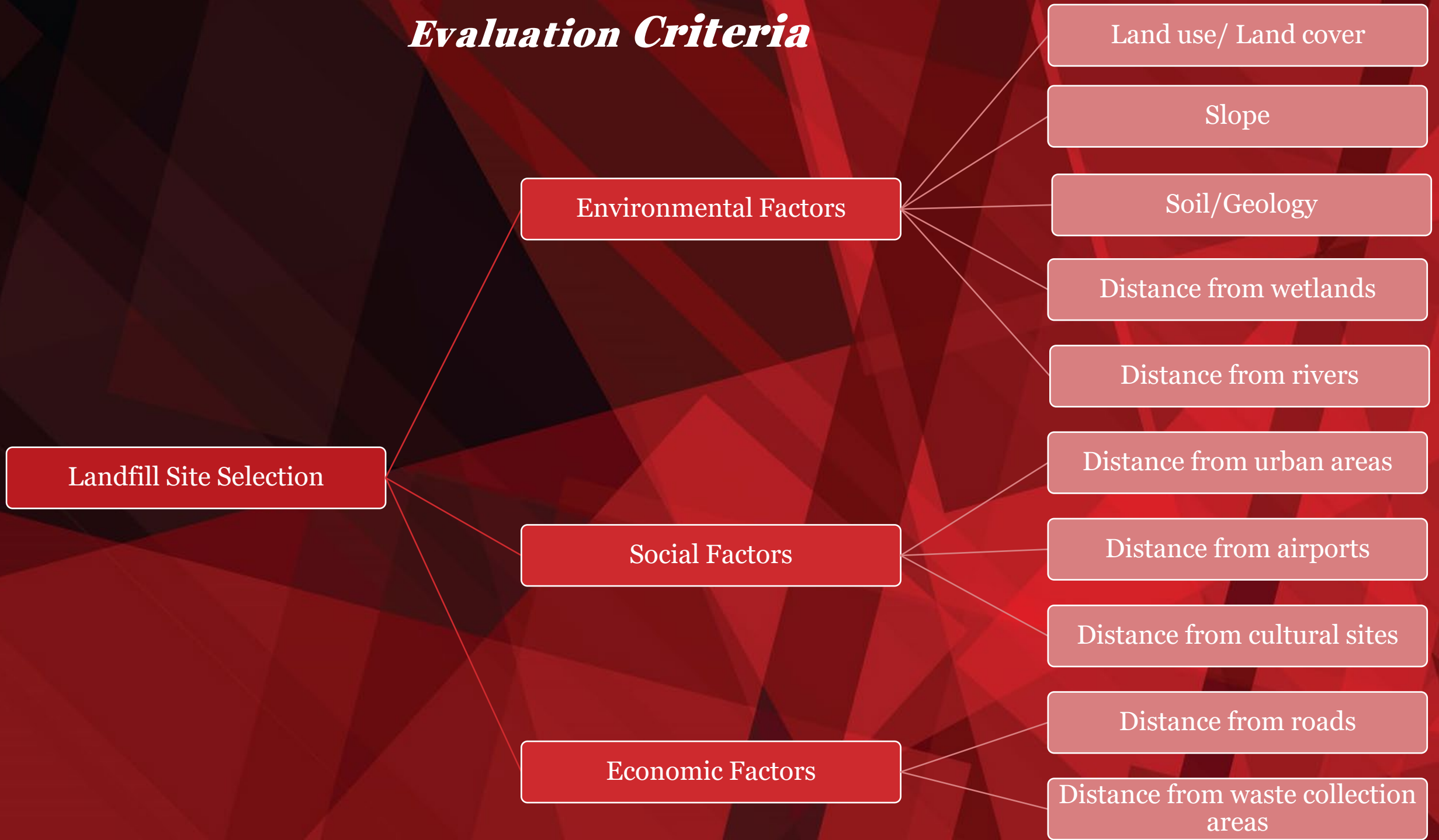
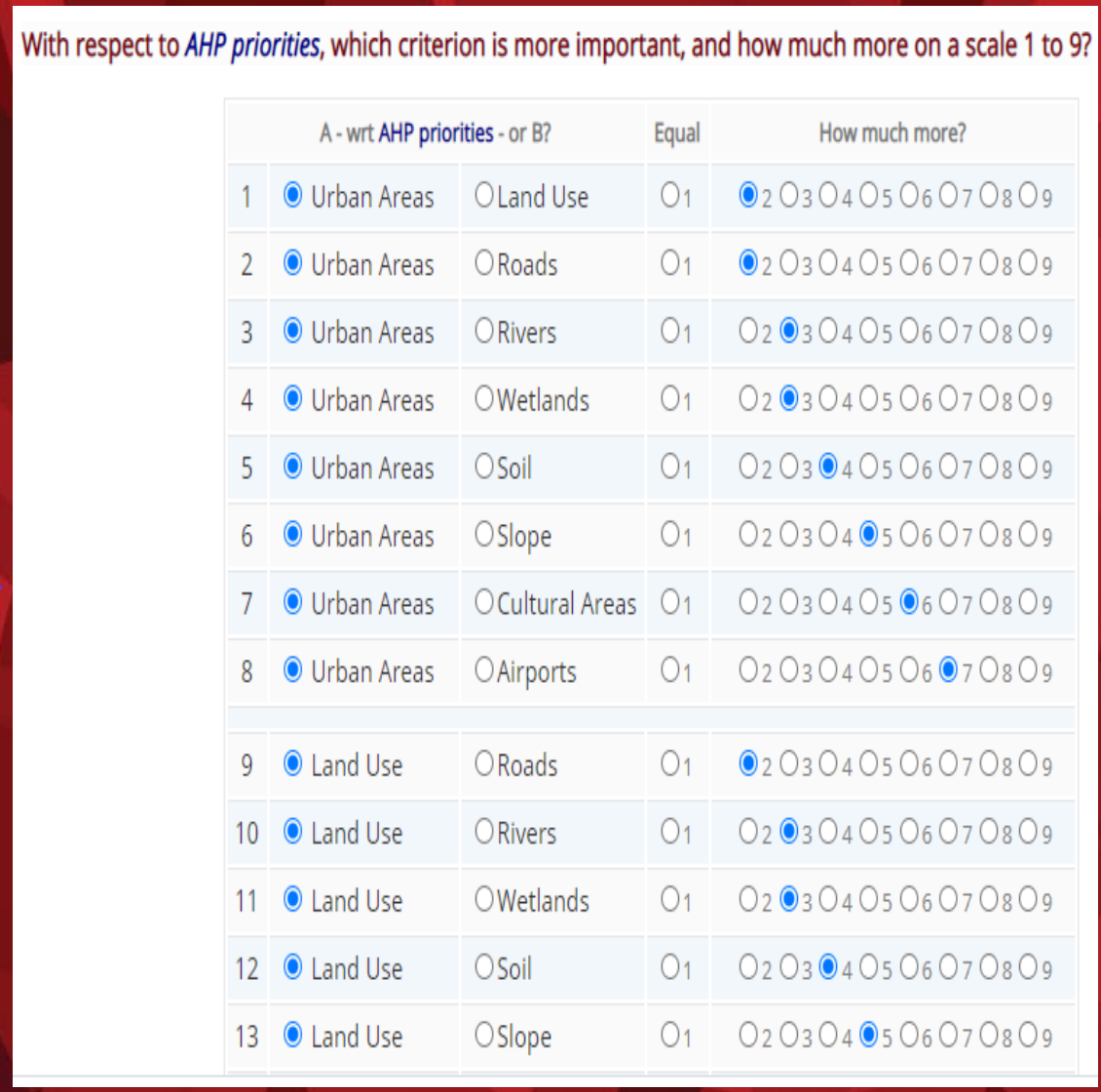
Evaluation Criteria



AHP Pairwise Comparison Scale

Numerical Rating	Verbal Judgements or Preferences
1	Equally Preferred
2	Equally to Moderately
3	Moderately Preferred
4	Moderately to Strongly
5	Strongly Preferred
6	Strongly to very Strongly
7	Very Strongly Preferred
8	Very Strongly to Extremely
9	Extremely Preferred

(Bio et al., 2015)



https://bpmsg.com/ahp/ahp-calc.php

AHP Weighting Decision Matrix

Resulting Priorities

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Urban Areas	25.3%	1	8.8%	8.8%
2	Land Use	21.7%	2	7.8%	7.8%
3	Roads	15.1%	3	4.7%	4.7%
4	Rivers	10.5%	4	3.0%	3.0%
5	Wetlands	10.5%	4	3.0%	3.0%
6	Soil	7.4%	6	3.2%	3.2%
7	Slope	5.3%	7	2.9%	2.9%
8	Cultural Areas	2.3%	8	1.1%	1.1%
9	Airports	1.8%	9	0.9%	0.9%

Number of comparisons = 36
Consistency Ratio CR = 5.8%

Decision Matrix

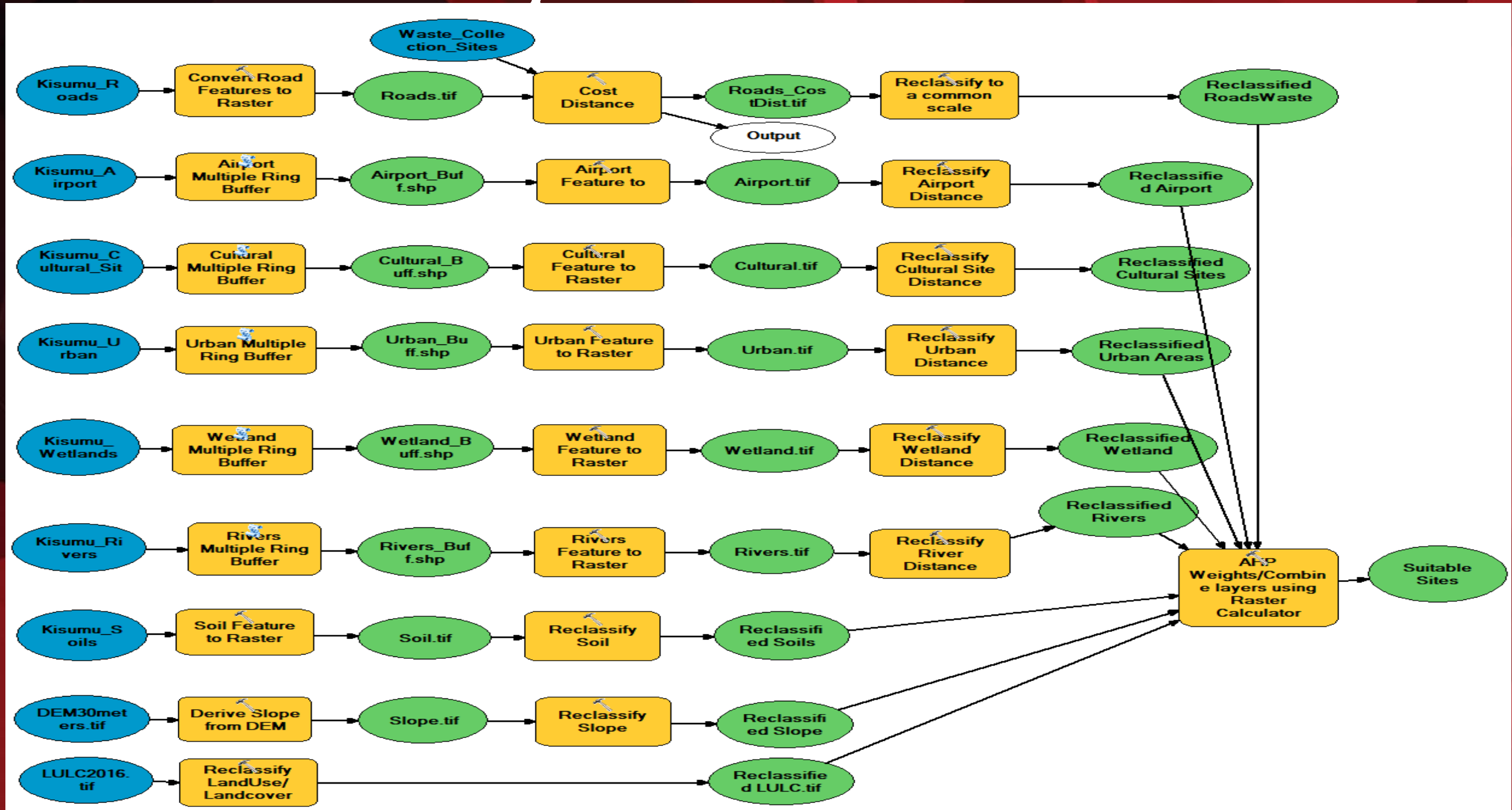
The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4	5	6	7	8	9
1	1	2.00	2.00	3.00	3.00	4.00	5.00	6.00	7.00
2	0.50	1	2.00	3.00	3.00	4.00	5.00	6.00	7.00
3	0.50	0.50	1	2.00	2.00	3.00	4.00	5.00	6.00
4	0.33	0.33	0.50	1	1.00	2.00	3.00	6.00	7.00
5	0.33	0.33	0.50	1.00	1	2.00	3.00	6.00	7.00
6	0.25	0.25	0.33	0.50	0.50	1	2.00	6.00	7.00
7	0.20	0.20	0.25	0.33	0.33	0.50	1	5.00	6.00
8	0.17	0.17	0.20	0.17	0.17	0.17	0.20	1	2.00
9	0.14	0.14	0.17	0.14	0.14	0.14	0.17	0.50	1

Principal eigen value = 9.670
Eigenvector solution: 6 iterations, delta = 9.4E-8

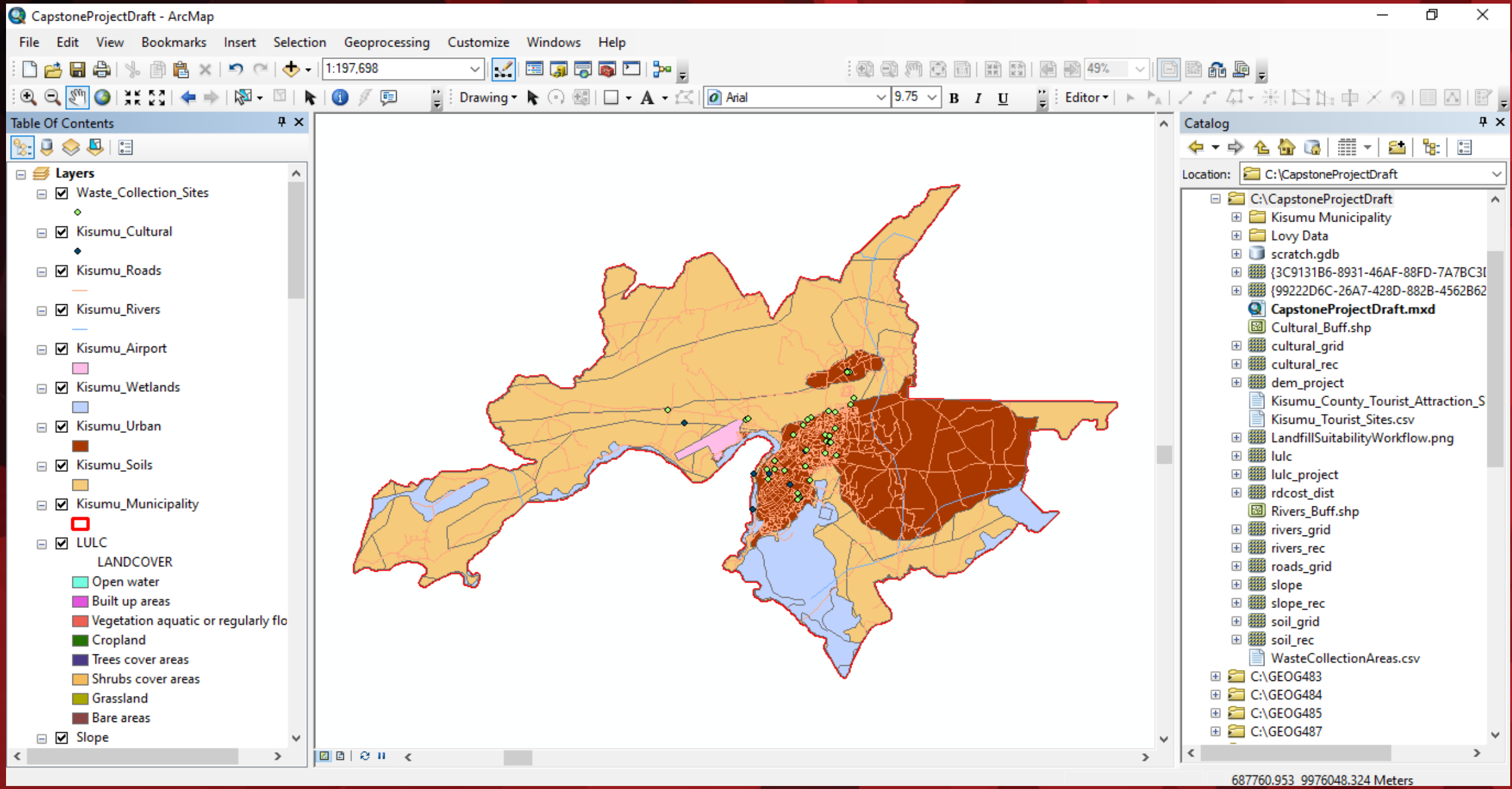
https://bpmsg.com/ahp/ahp-calc.php

Conceptual Workflow Model

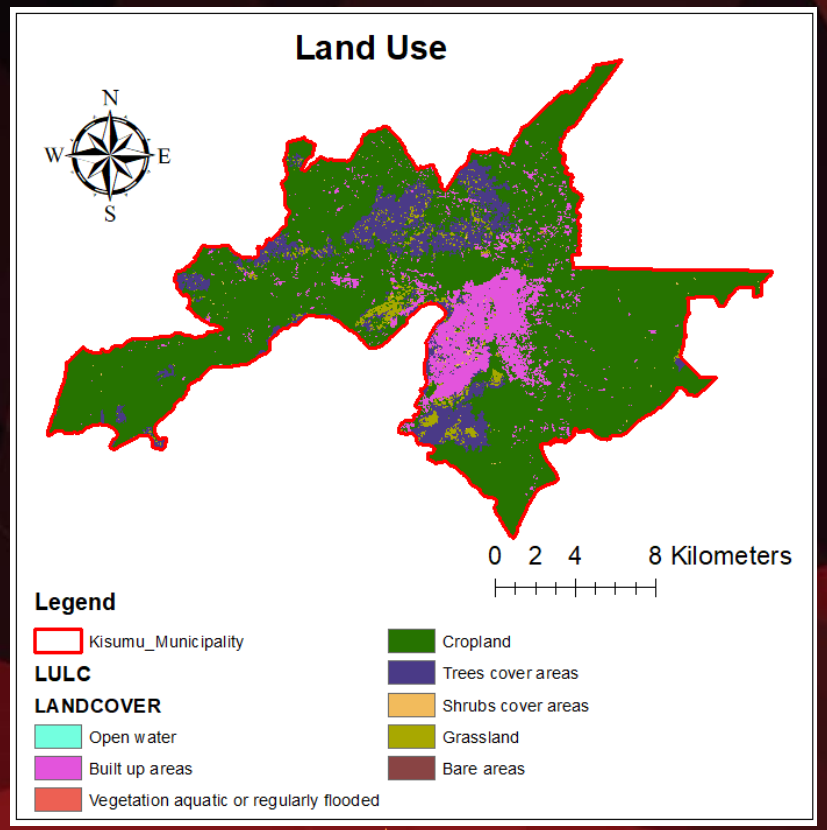


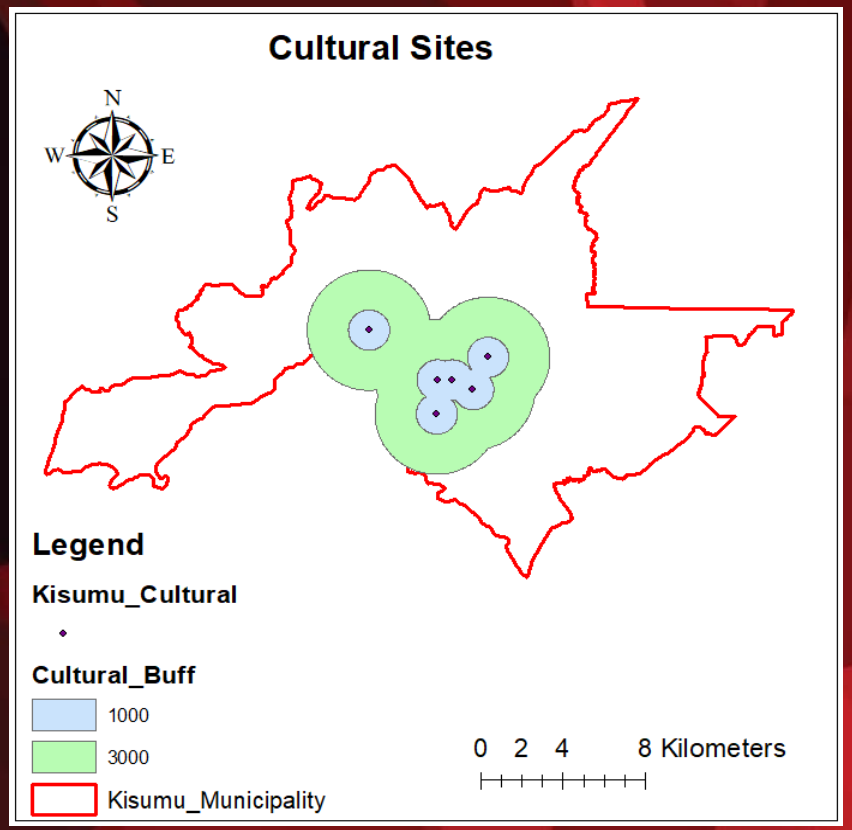
DATA	TYPE	SOURCE
Land use/Land cover	TIF raster image	Regional Centre for Mapping of Resources for Development (RCMRD)
30M DEM	TIF raster image	World Resources Institute (WRI)
Soil/Geology	Esri shapefile (vector)	International Soil Reference and Information Centre (ISRIC)
Urban Areas	Esri shapefile (vector)	World Resources Institute
Waste Collection Points	CSV	National Environmental Management Authority (NEMA-KENYA)
Waste Transfer Locations	CSV	National Environmental Management Authority (NEMA)
Roads	Esri shapefile (vector)	National Environmental Management Authority (NEMA-KENYA)
Airport	Esri shapefile (vector)	National Environmental Management Authority (NEMA-KENYA)
Tourist Sites	CSV	ESRI Data Hub
Rivers	Esri shapefile (vector)	ESRI Data Hub
Wetlands	Esri shapefile (vector)	World Resources Institute
Kenya Boundary	Esri shapefile (vector)	Map Library
Kisumu Boundary	Esri shapefile (vector)	National Environmental Management Authority (NEMA)

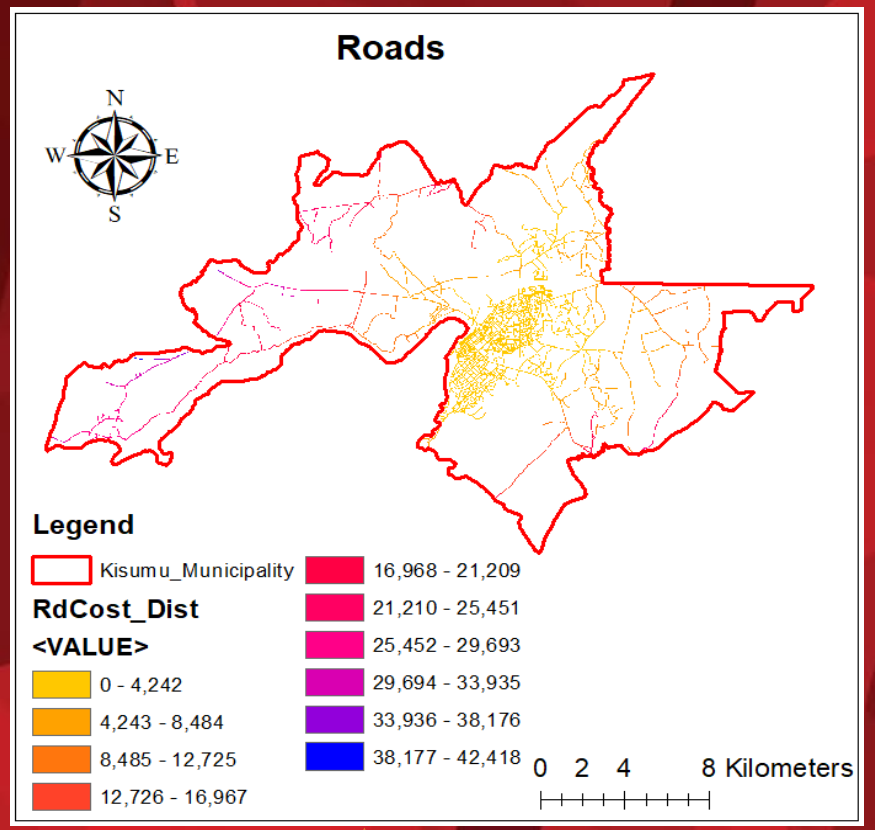
Caption of all Datasets



Preliminary Analysis





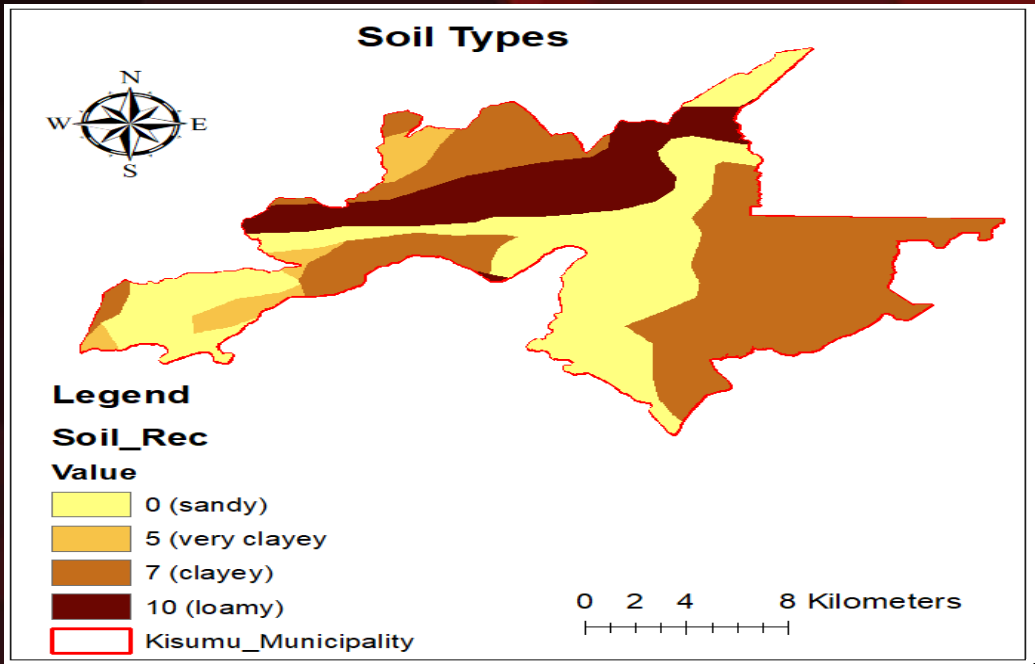


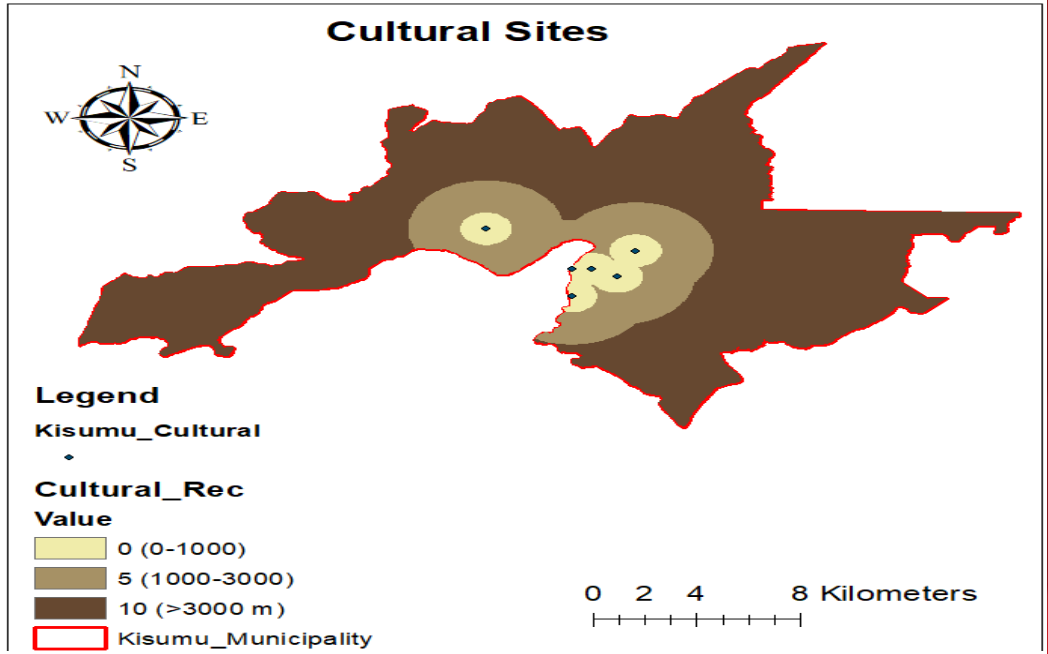
Mask (Environment Setting)

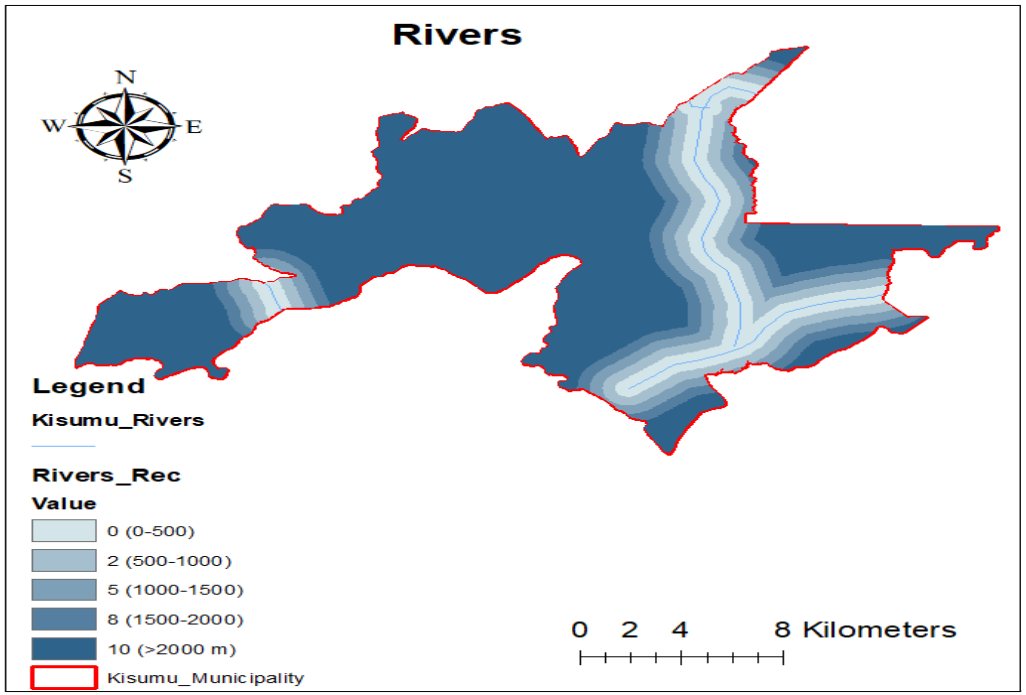
Multi-Ring Buffer

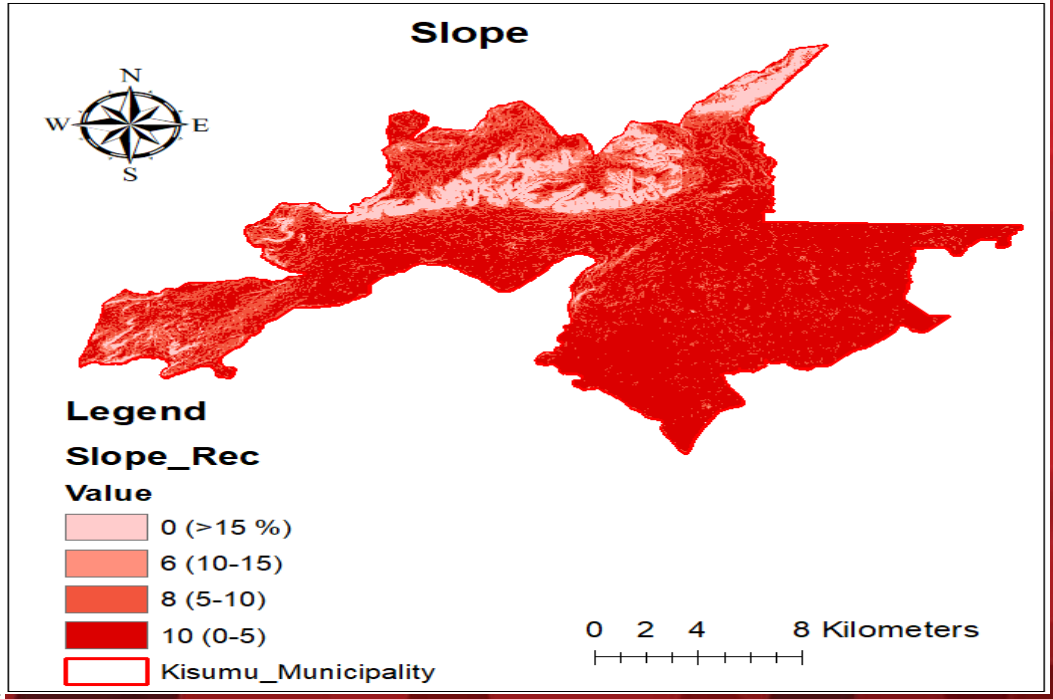
Cost Distance Analysis

Reclassified Thematic Maps









Anticipated Results

- Intend to produce a map that shows a contiguous classification of highly suitable to lowly suitable areas.
  - It would scrutinize multiple criteria.
  - Undesirable sites will be eliminated.
- If there are potential sites, I would present this methodology to stakeholders involved in waste management planning in Kisumu.
  - No costs would be incurred.
  - A better approach than simply considering any available parcel of land.
- Methodology would fill the research gap.

Timeframe for Completion

Oct-Dec 2020
Perform Analysis

Jan-April 2021
Write Report

May 2021
Conference Presentation/Journal Publication

May 2021
Graduation

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QUESTIONS?