Kathmandu, Nepal 14–16 November
REGIONAL CONFERENCE 2024
Climate Responsive Land Governance and Disaster Resilience: Safeguarding Land Rights

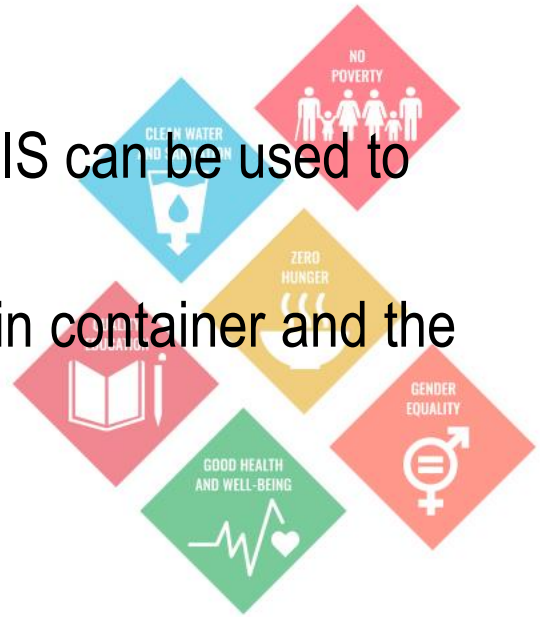
Integrated Approach to Waste Management in Banepa Municipality: Combining Geographic Information System, Analytical Hierarchy Process and Network Analysis for Landfill Site Selection and Route Optimization

Authors:

Ashish Rijal
Ayusha Kumari Sah
Rakshya Khatri
Sujan Sapkota
Aayushma Timalsina
Soniya Mehta
Shristi Paudel

INTRODUCTION

- Transportation costs for collected waste represent over 50% of total Integrated Solid Waste Management (ISWM) expenses in major developed cities and approximately 85% in developing countries.
- These costs can be reduced with Proper planning and geospatial analysis.
- MCDM approaches like AHP when combined with geospatial software like ArcGIS can be used to find the optimal location for a landfill site considering various criteria.
- Network analysis tools can be used to find the optimal locations for the shared-bin container and the least cost path for the commutes of the garbage truck.

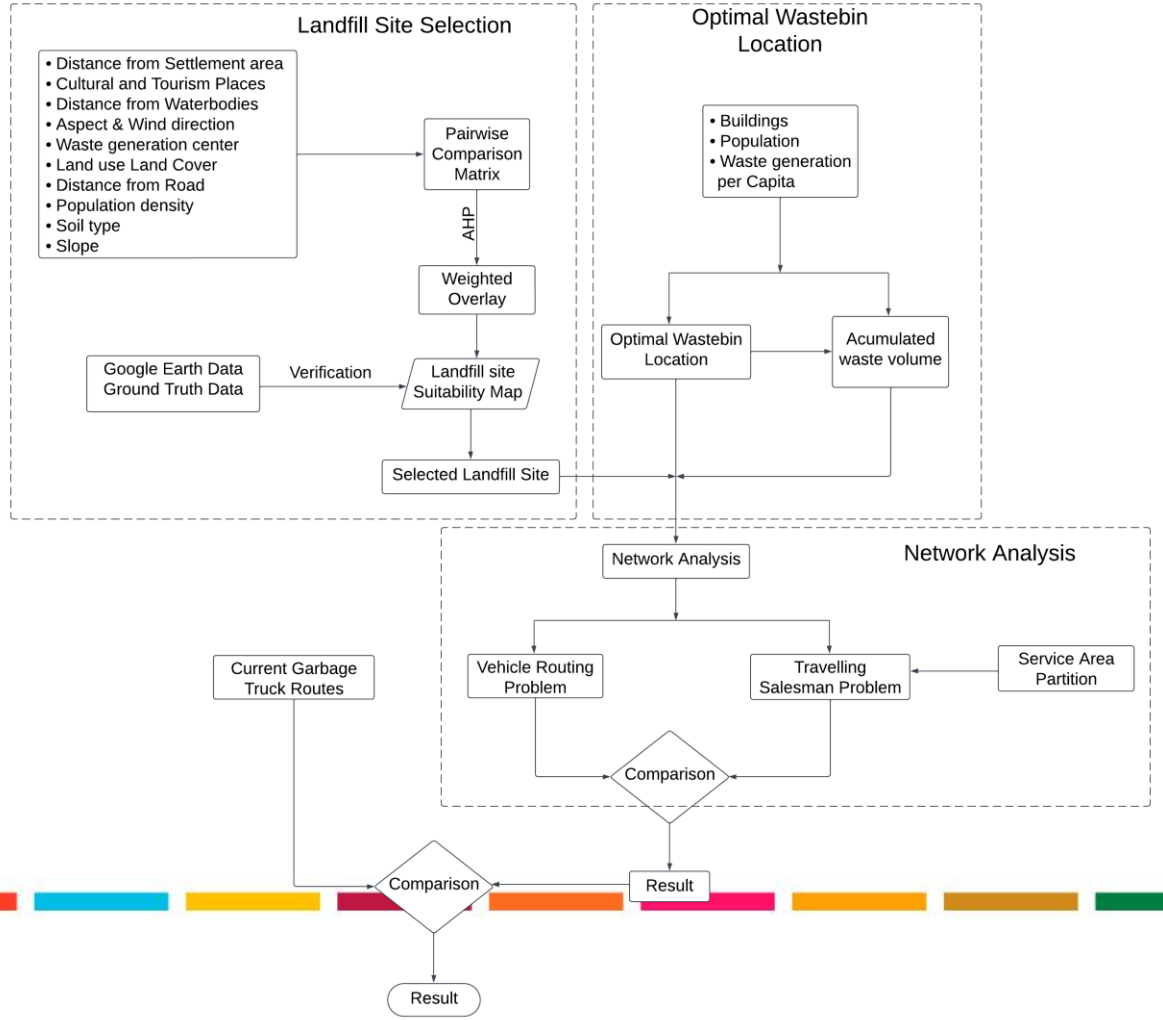


OBJECTIVES

The objectives of this study were :

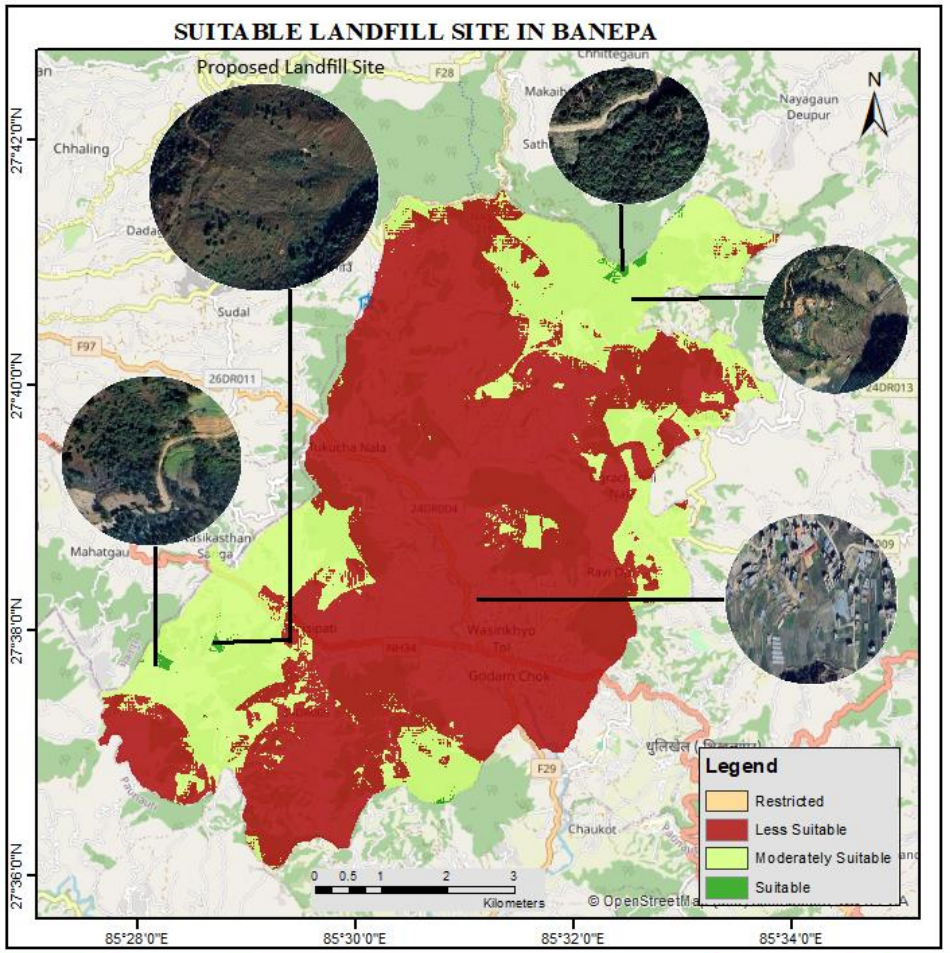
- To determine a suitable landfill site location, to allocate the shared bin positions, and to find the least cost routes for garbage trucks.
- To Analyse and compare the present routes and proposed routes.

METHODOLOGICAL FLOWCHART



LANDFILL SITE SELECTION

- Criteria:-
- Road Network, Water Bodies, Settlement Area, Slope, Aspect, Soil, Weighted Centre, Population Density, Cultural and Tourism Places, and Land Use Land Cover.
- Required landfill site area (approx ~ 2.14 ha for 15 years)
- Landfill site suitability mapping
- Landfill site verification:-
- Required area
- Google Earth Imagery
- Field verification

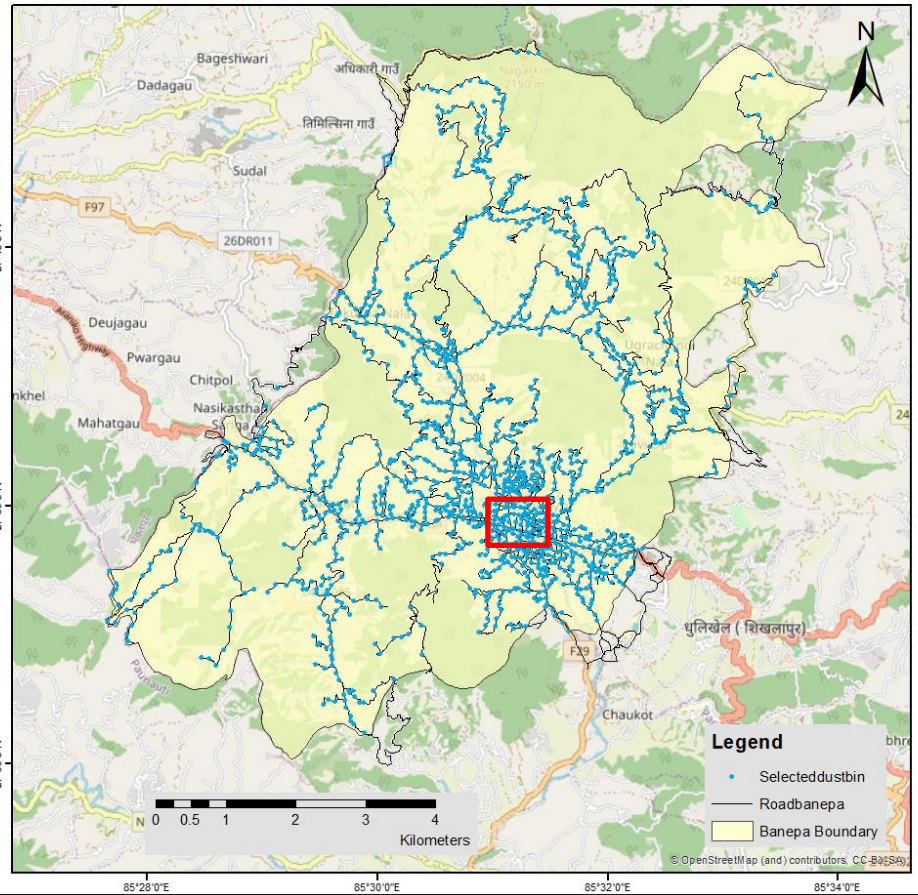

SUITABLE LANDFILL SITE IN BANEPA
Proposed Landfill Site
N
Chhaling
Nayagaun Deupur
Sudal
Mahatgau
Legend
Restricted
Less Suitable
Moderately Suitable
Suitable
0 0.5 1 2 3
Kilometers
© OpenStreetMap
27°42'0"N
27°40'0"N
27°38'0"N
27°36'0"N
85°28'0"E
85°30'0"E
85°32'0"E
85°34'0"E


NO POVERTY
CLEAN WATER AND SANITATION
ZERO HUNGER
QUALITY EDUCATION
GENDER EQUALITY
GOOD HEALTH AND WELL-BEING

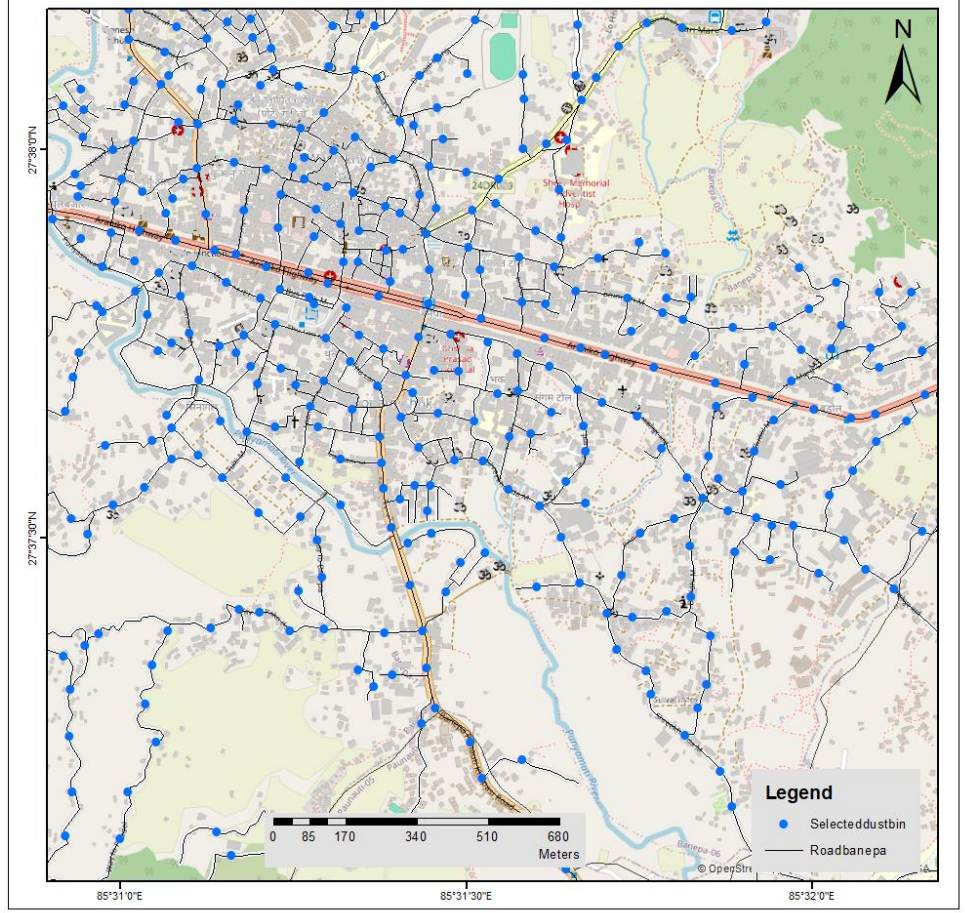
DUSTBIN ALLOCATION

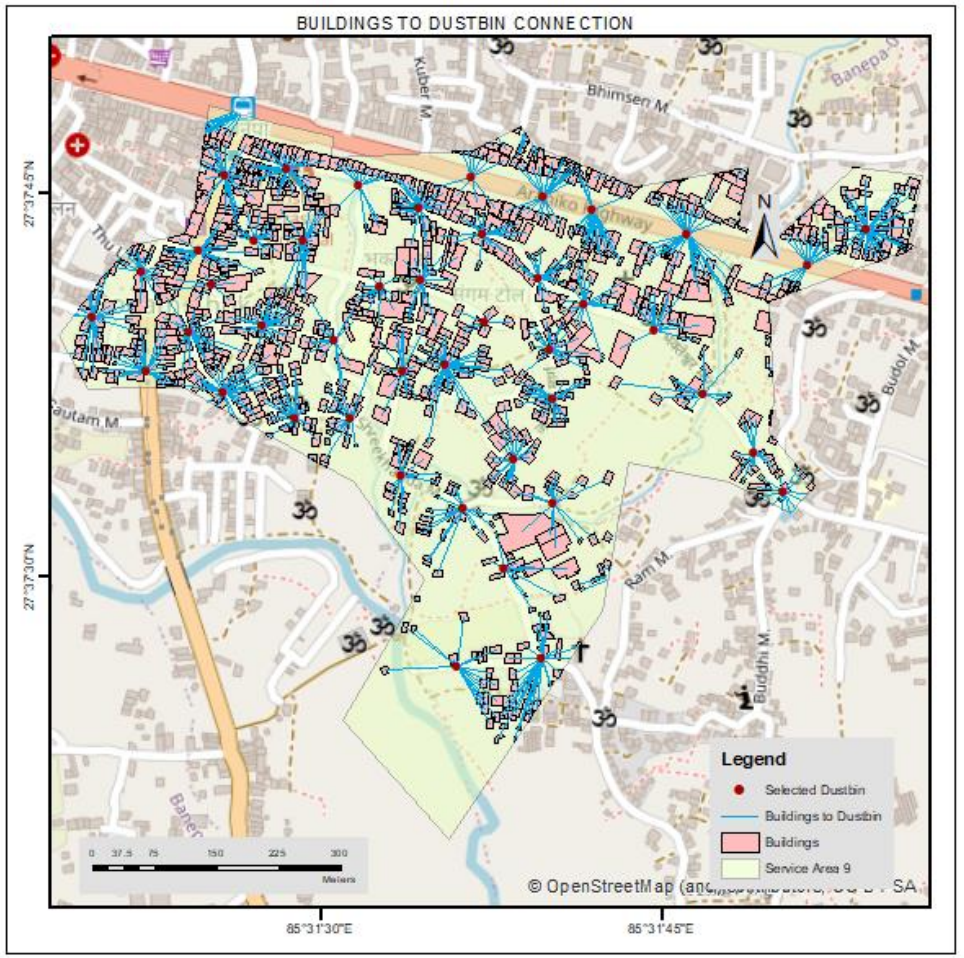
- Concept: Building within 50m of the road would walk no longer than 50 + 15m to dump waste
- 1436 bins of varying capacities (5-1800 litre)
- 1377 bins within 65m walking distance from buildings
- Successively fewer bins in subsequent buffer zones (50m – 250m)
- One-to-Many Relationship (Dustbin–Building Relationship)
- Calculation of the volume of waste accumulated in each bin

DUSTBINS LOCATION



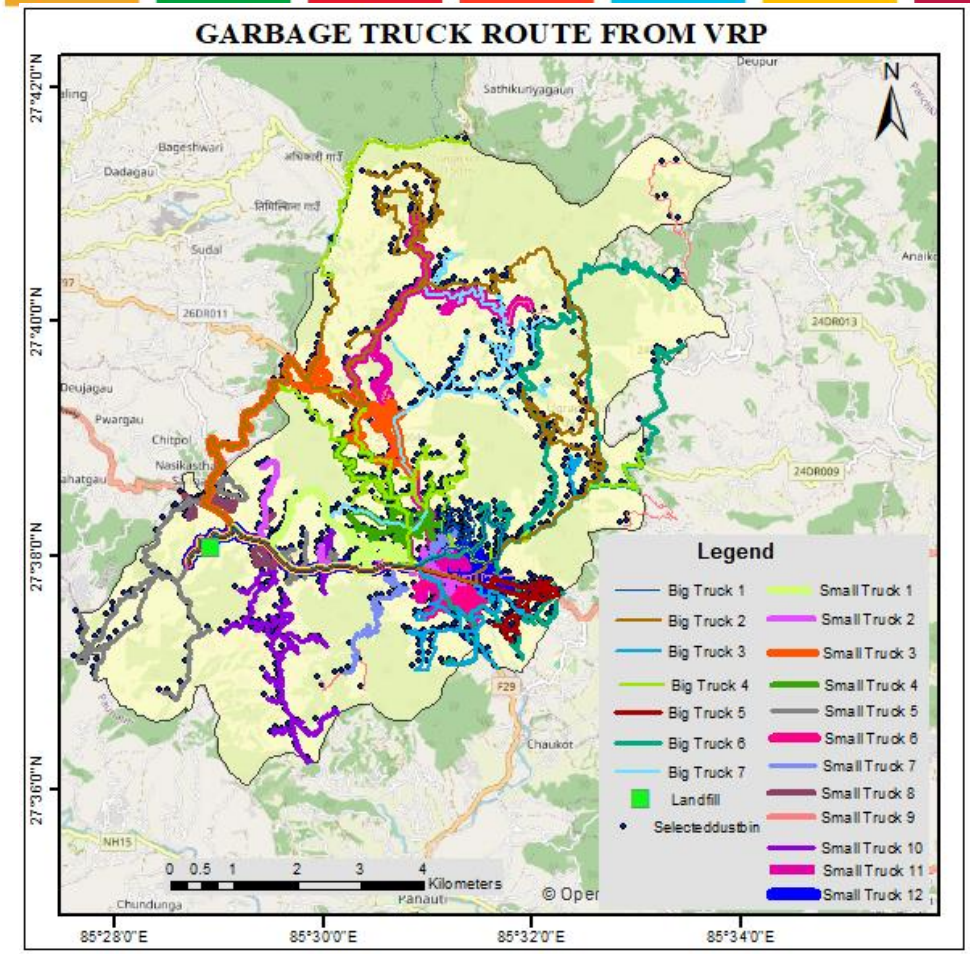
DUSTBINS LOCATION

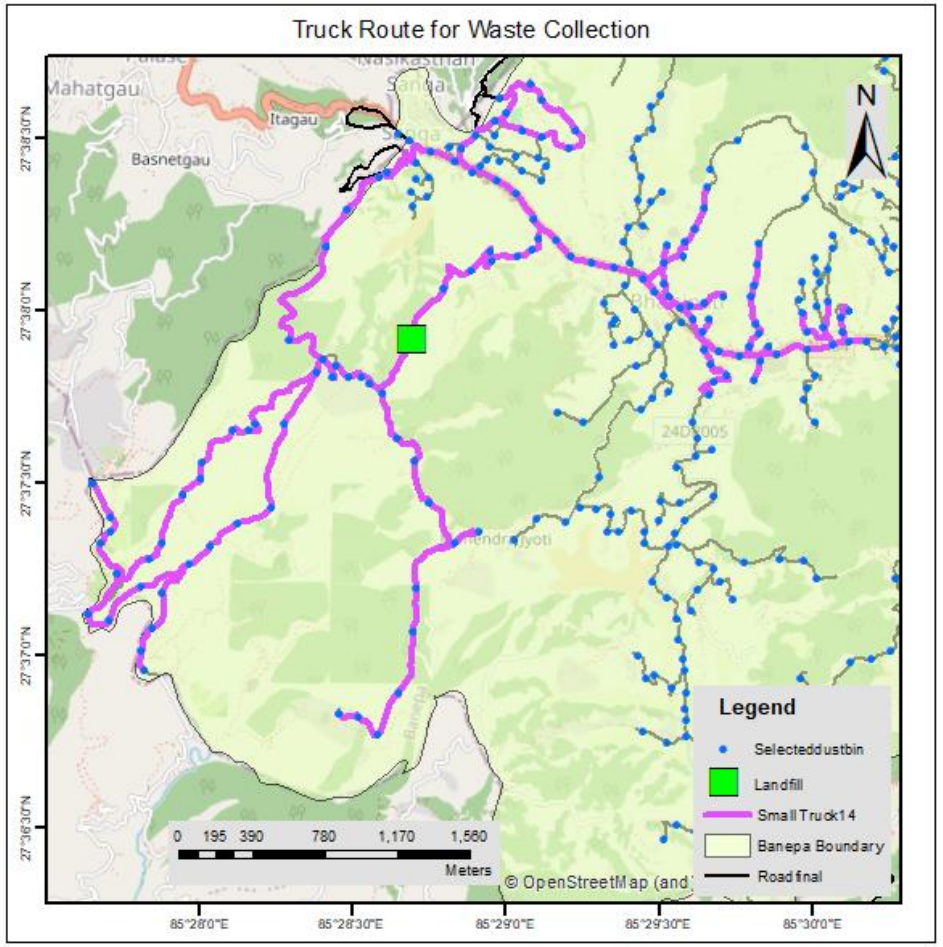



BUILDINGS TO DUSTBIN CONNECTION
Legend
Selected Dustbin
Buildings to Dustbin
Buildings
Service Area 9
© OpenStreetMap
27°37'45"N
27°37'30"N
85°31'30"E
85°31'45"E

Vehicle Routing Problem Analysis (VRP)

- 19 Routes:
- 12 trucks routes: 5-ton carrying capacity truck
- 7 trucks routes: 7-ton carrying capacity truck

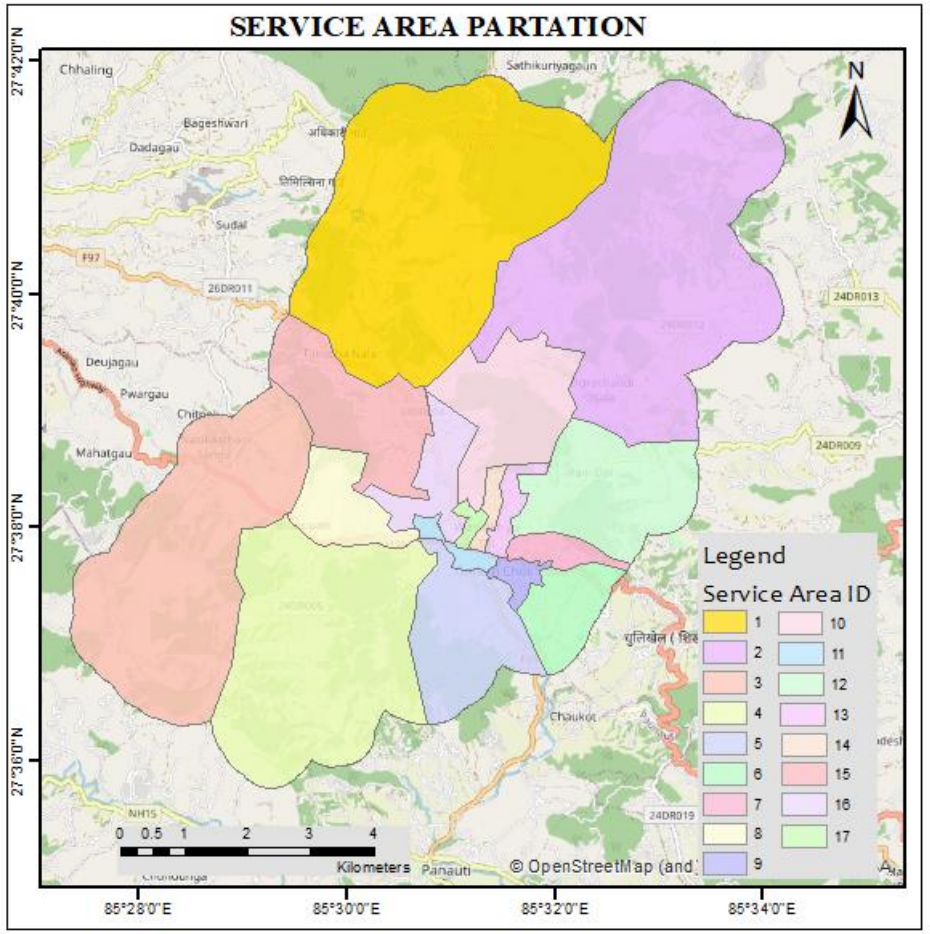

GARBAGE TRUCK ROUTE FROM VRP
Legend
Big Truck 1
Big Truck 2
Big Truck 3
Big Truck 4
Big Truck 5
Big Truck 6
Big Truck 7
Landfill
Selecteddustbin
Small Truck 1
Small Truck 2
Small Truck 3
Small Truck 4
Small Truck 5
Small Truck 6
Small Truck 7
Small Truck 8
Small Truck 9
Small Truck 10
Small Truck 11
Small Truck 12
Kilometers
N
85°28'0"E
85°30'0"E
85°32'0"E
85°34'0"E
27°42'0"N
27°40'0"N
27°38'0"N
27°36'0"N


Truck Route for Waste Collection
Legend
Selecteddustbin
Landfill
Small Truck14
Banepa Boundary
Road final
Meters
N
85°28'0"E
85°28'30"E
85°29'0"E
85°29'30"E
85°30'0"E
27°38'30"N
27°38'0"N
27°37'30"N
27°37'0"N
27°36'30"N

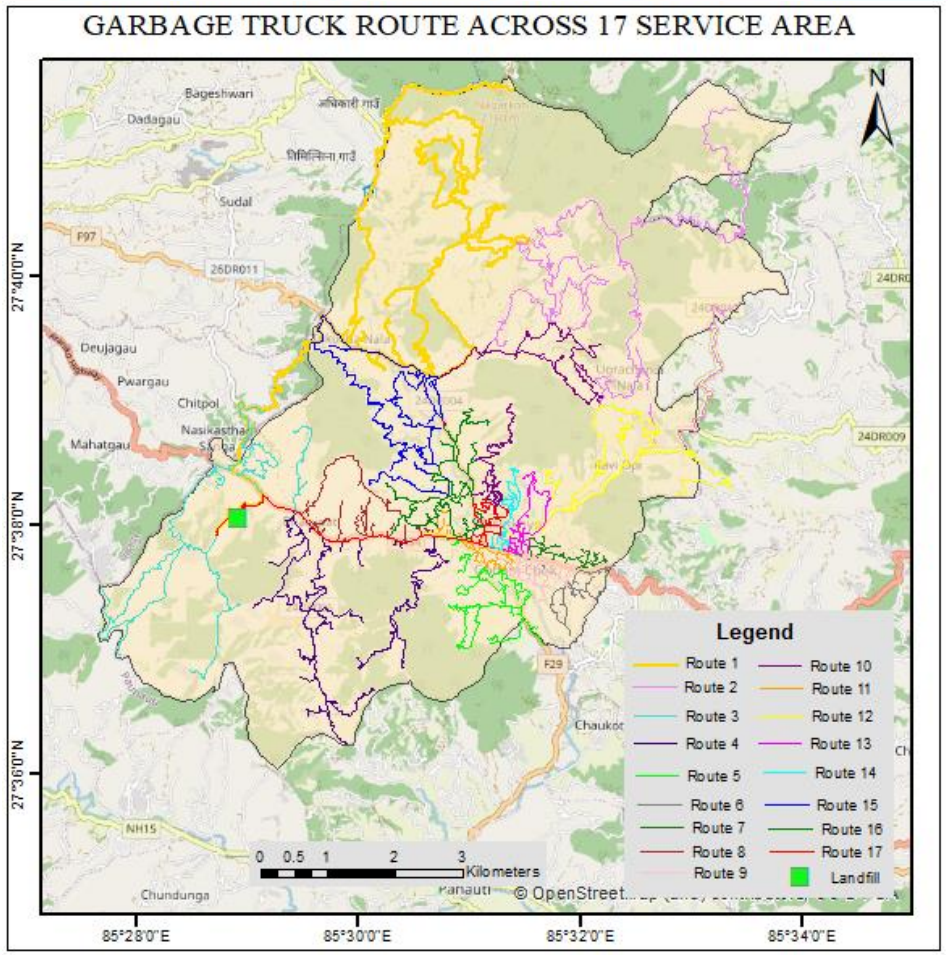

NO POVERTY
ZERO HUNGER
GENDER EQUALITY
GOOD HEALTH AND WELL-BEING

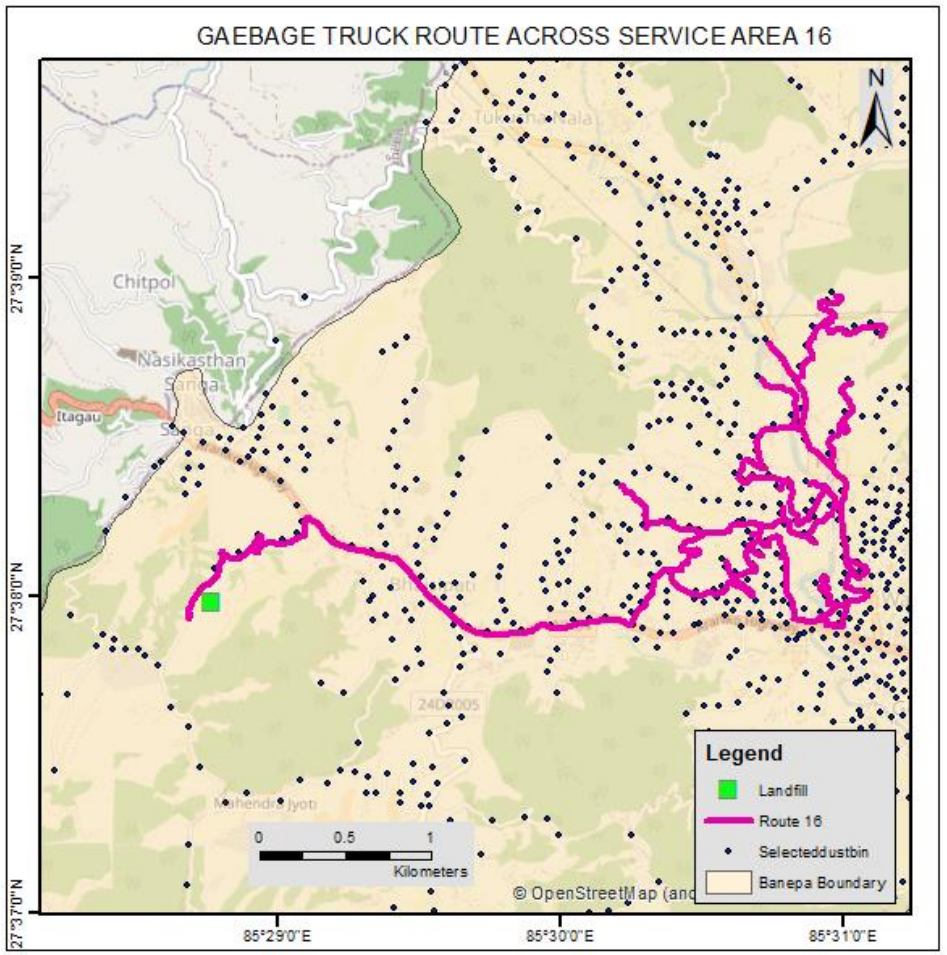
Service Area Partition and Travelling Salesman Problem(TSP)

- Service area partition
- 17 service areas based on the volume of waste accumulated and the carrying capacity of a garbage truck
- Travelling Salesman Problem
- Garbage truck routes for each service area
- Comparison between the VRP and TSP
- TSP yielded better results


SERVICE AREA PARTATION
Chhaling
Sathikuriyagaun
Bageshwari
Dadagau
Sudal
26DR011
24DR013
24DR009
24DR019
Deujagau
Pwargau
Mahatgau
Chaukot
Panauti
N
Legend
Service Area ID
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
0 0.5 1 2 3 4
Kilometers
© OpenStreetMap (and
27°42'0"N
27°40'0"N
27°38'0"N
27°36'0"N
85°28'0"E
85°30'0"E
85°32'0"E
85°34'0"E


NO POVERTY
CLEAN WATER AND SANITATION
ZERO HUNGER
QUALITY EDUCATION
GENDER EQUALITY
GOOD HEALTH AND WELL-BEING

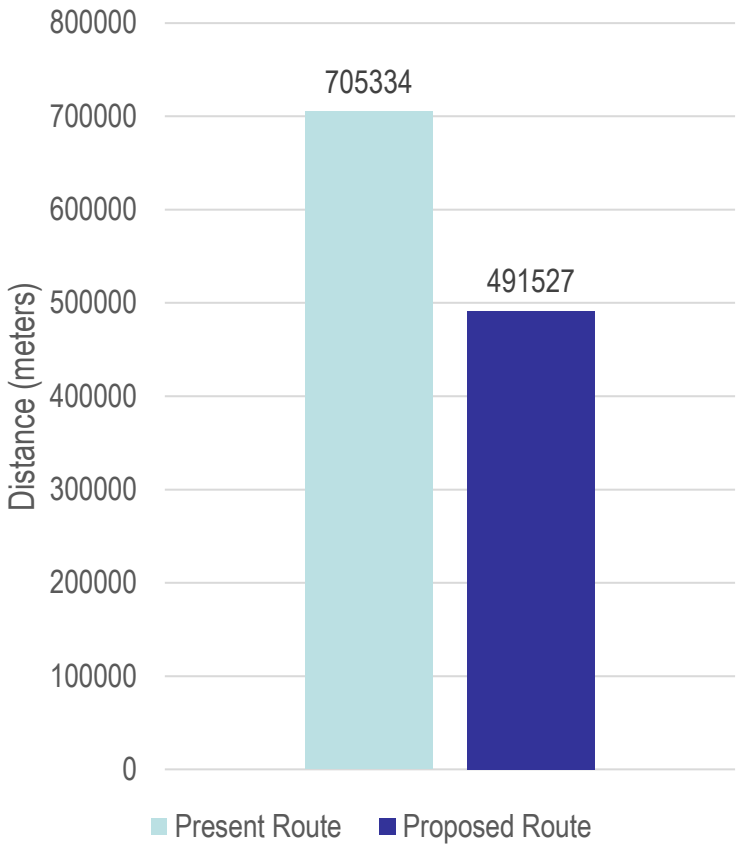

GARBAGE TRUCK ROUTE ACROSS 17 SERVICE AREA
N
Bageshwari
Dadagau
Sudal
Deujagau
Pwargau
Chitpol
Nasikastha
Mahatgau
Chundunga
Legend
Route 1
Route 2
Route 3
Route 4
Route 5
Route 6
Route 7
Route 8
Route 9
Route 10
Route 11
Route 12
Route 13
Route 14
Route 15
Route 16
Route 17
Landfill
0 0.5 1 2 3
Kilometers
© OpenStreet
27°40'0"N
27°38'0"N
27°36'0"N
85°28'0"E
85°30'0"E
85°32'0"E
85°34'0"E


GAEBAGE TRUCK ROUTE ACROSS SERVICE AREA 16
N
Chitpol
Nasikasthan
Itagau
Legend
Landfill
Route 16
Selecteddustbin
Banepa Boundary
0 0.5 1
Kilometers
© OpenStreetMap (and
27°39'0"N
27°38'0"N
27°37'0"N
85°29'0"E
85°30'0"E
85°31'0"E

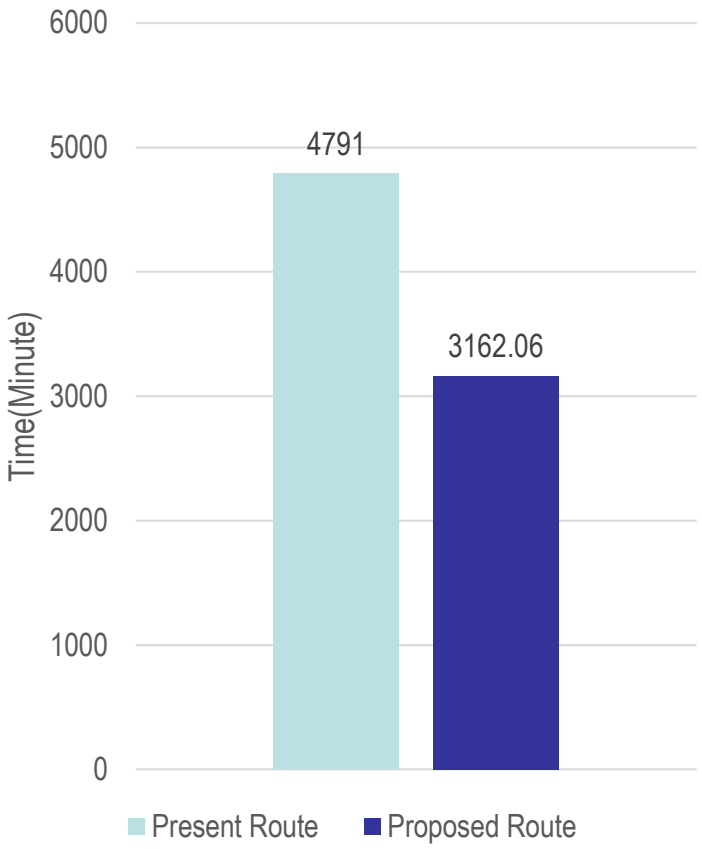
COMPARISON BETWEEN PRESENT ROUTES AND PROPOSED ROUTES

- 3-day comparison between TSP optimized routes and present route
- Present route: Banepa municipality to Transfer Station(Radhe Radhe, Bhaktapur)
- Proposed route: to Landfill Site
- Comparison result:
- Distance Reduction: approx ~ 20km (30%)
- Time Reduction: approx ~ 25hour (30%)
- Petroleum Cost Reduction: approx ~ RS 7000 (20%)

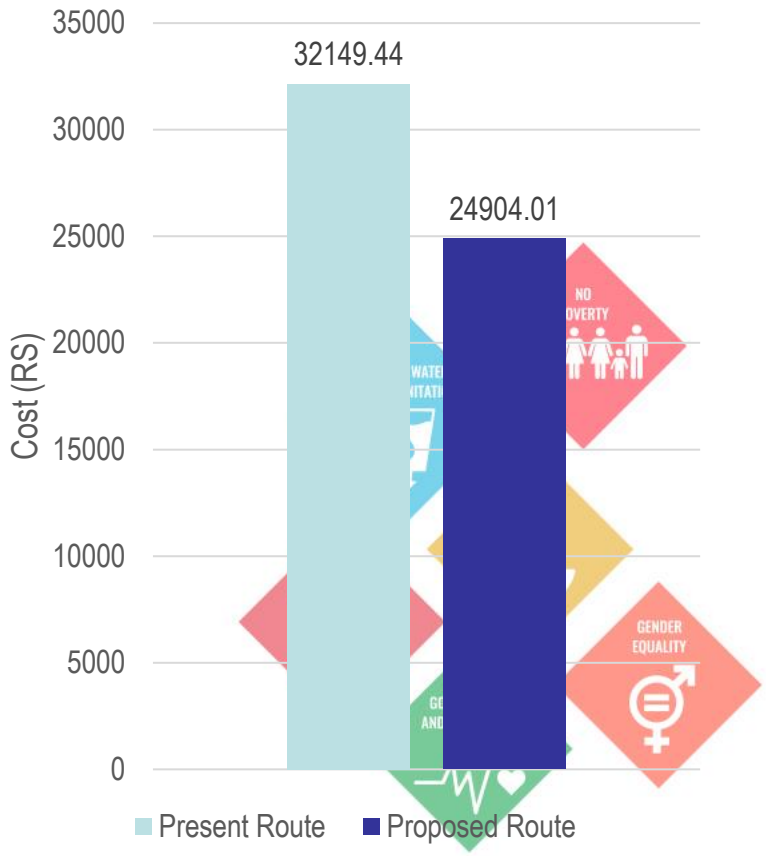
Distance Comparison



Time Comparison



Petroleum Cost Comparison



CONCLUSION

- Landfill Site Selection using AHP, Spatial distribution of capacitated waste bins, garbage truck routes optimization
- **SDG 11: Sustainable Cities and Communities**
- **SDG 13: Climate Action**

THANK YOU

ANY QUERIES?