ASSESSMENT AND OPTIMAL ALLOCATION FOR MUNICIPAL SOLID WASTE COLLCTION BINS USING GEOGRAPHIC INFORMATION SYSTEM AND MULTI-CRITERIA ANALYSIS FOR SHILLONG MUNICIPAL BOARD

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for the award of the Degree of

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In

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She has completed the dissertation in the North Eastern Space Application Centre (NESAC) Umiam, Shillong with effect from 07.01.2019 to 15.04.2019.

I wish her all the success in future life.

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DECLARATION BY AUTHOR

This is to declare that this report entitled "Assessment and optimal allocation for Municipal solid waste collection bins using geographic information system and Multi-criteria for “Shillong Municipal Board" has been written by me. No part of the report is plagiarized from other sources. All information included from other sources have been duly acknowledged. I confirm that if any part of the report is found to be plagiarized, I shall take full responsibility for it.

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ABSTRACT

In India, the management of solid waste is an integral part of Sanitation in which Municipality and Municipal Corporation play significant role. MSWM ensures the proper and legit disposal of Municipal solid waste. It is the systematic combination of various activities such as collection, transportation and proper disposal of solid waste. Improper and poor management of solid waste leads to degradation of pollution level, rendering a hard to live in environmental conditions. With time, the need of proper disposal of solid waste management has been increasing, and thus the applicability. Before 2000, there was no mandatory provision or any authority regarding it, but Municipal Solid Waste (Management and Handling) Rules 2000 makes it obligatory and compulsory for an area's administrative authority to undertake and undergo all the responsibilities of MSWM. In Shillong, about 12% burn the waste generated and very less door to door collection is done due to physical aspects and less amount of municipal equipment. Awareness about segregation of waste into organic and non-bio degradable waste is 64 percent and a significant number do the segregation. In this study, Remote Sensing data CARTOSAT-2S and survey data are used to integrate and create a model to estimate amount of waste generated from a house and find the number of dustbins required in each ward. It is all done by using Multi-Criteria Analysis. Based on the models developed and estimation of number of waste bins, an attempt was made to facilitate maximum coverage and optimize the number of bins.

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INTRODUCTION

1.1 Solid waste management:

Solid Waste Management (SWM) is a function of combination of various activities such as collection, transportation and disposal of solid waste. It also includes processing and treatment of the solid waste before disposing. The purpose of SWM is to create uncontaminated environment for people without disturbing natural resources and a proper SWM helps safe disposal, reduction of final waste and increase re- use and recycling. On the other hand, a poor management system, on the contrary, leads to a filthy environment affecting the well- being of the people residing therein.

1.2 Project Aim:

The project aims to improve the environmental condition of Shillong urban area by augmenting Municipal solid waste collection system. This involves finding out the adequate number and position of Municipal waste collection bins within the city adopting GIS techniques and Multicriteria analysis. The optimal positions and number of collector bins are to be assessed based on Population density, road network, Urban Land use and quantum of waste generated.

1.3 Context:

The entire quantity of generated MSW in the city is planned to deliver to the dumping site station. The Shillong Municipal Corporation collects solid waste only along the main roads weekly and most of the valleys and unreachable areas remain unserved. Consequently, the people tend to dispose the MSW into nearby drains. Also due to the insufficient number of collection bins, the MSW collected is dumped in nearby streams or thrown down the slopes. This has not only created highly unhygienic conditions in the city and has led to choking of drains and streams but also poses serious threat to contamination of surface water and ground water. Also manual handling and crude dumping of the wastes in the dumping sites poses serious threat to environment and lives. This reveals that, a proper collection service of MSW is necessary at the city level.

1.4 Objectives:

- To study the physiography of Shillong Municipal Board to find suitable location for dumping site.
- To give an appropriate idea of keeping city clean through managing solid waste by placing bins at most suitable locations.
- To identify the factors that influence municipal solid waste management in Shillong Municipal Board.
- To appraise the role of the various agencies involved in municipal solid waste management.
- To explore innovative approaches for municipal solid waste management for Shillong according to their physiography and financial condition.

REVIEW OF LITERATURE

2.1 Ramakrishnaiah, et al, This work deals with the study of current solid waste management strategies and the use of geographical information system (GIS) as a tool for planning waste management. Waste collection and transport constitutes a large fraction of the total municipal solid waste management costs. A GIS optimal routing model based on the parameters such as, population, waste generation capacity, road network and the types of road, storage containers and collection vehicles had been developed for efficient collection path for transporting solid waste to the disposal site. The proposed model can be used as a decision support tool by the municipal authorities for efficient management of the daily operations for moving solid wastes, load balancing within vehicles, managing fuel consumption and generating work schedules for the workers and vehicles.

2.2 Agarwal, et al, The purpose is to provide some suggestions and recommendations to improve the waste management practices in Indian towns. Existing reports related to waste management and recommendations of planners/NGOs/consultants/government accountability agencies/key industry experts/ for improving the system are studied. It offers deep knowledge about the various waste management initiatives in India and find out the scope for improvement in the management of waste for the welfare of the society. The paper attempts to understand the important role played by the formal sector engaged in waste management in our country.

2.3 Xhafa et al, Use of GIS in urban planning helps and guides planners for an orderly development of settlements and infrastructure facilities within and outside urban areas. Continued growth of population in urban centres generate need for expansion of urban space. Use of GIS in this field is a different approach regarding space, its development, gap analysis, site suitability and various processes occurring in it. The case study addresses the application of GIS in the planning and design of urban infrastructure in urban development in Egypt. It concludes that GIS can be an important tool in planning process. (M.J.G. Brussel et.al)

2.4 Sierra et.al, The aim of the study was to review the current state of multi-criteria infrastructure assessment studies that include social aspects. The review includes an analysis of the social criteria, participation and assessment methods. The results identify mobility and access, safety and local development among the most frequent criteria. AHP and simple additive weighing methods are most frequently used in study.

2.5 A.Parry, et al, The case study on Jammu and Srinagar dispatch the alarming population growth rates in last thirty years, thus result in various problems like pollution, uneven provision of urban amenities etc. The land suitability assessment for provision of new urban amenities is a Key determinant in any urban and suburban planning and decision making process. The suitability analysis was done through AHP (analytical hierarchical process)model using a set of criteria involving geo-physical and socioeconomic variables like slope, land use/land cover and existing amenity status.

2.6. Oddershede, et al, Paper presents a decision model based upon community preferences to prioritize activities that support the development of a rural area in Chile. Determining the best activities to carry out is difficult in a multi-attribute decision-making situation.The Analytical Hierarchy Process(AHP), developed by Thomas L. Saaty, allows the arranging of factors in a hierarchical structure and prioritizing them to make trade-offs between decision criteria and alternatives to find the best policies or actions to achieve the desired growth in the area.

2.7 V. Sengtianthr, et al, In this study the map created by geographic information system (GIS) was proposed to generate GIS database of solid waste with data entry of the details - spatial and attributes - bins, routes, quantity of dry waste etc. The analysis techniques were composed of database generation and map visualization. Map overlay techniques were used to study the general sources of solid waste and waste distribution boundaries. There is a lack of a data sharing and also a lack of database generation using geographic information system. Therefore, good methods of waste management and appropriate technology are needed to improve this trend

STUDY AREA

3.1 About Shillong:

Shillong is situated at 25°34´12.00´´N latitude and 91°52´48.00´´E longitude which is 100 km from Guwahati and it is accessed by road along NH 40. Shillong, is the capital of Meghalaya which is also called "Scotland of East" because of full of natural beauty. The mean elevation of the city is 1496 m from the mean sea level (MSL), with the highest point is Shillong Peak at 1,966 m, the city stretches for about 6 km on an elevated tract. City was planned by the British as a hill resort, has undergone substantial change-both in character and form. Shillong has its own charm, different from other hill stations, and presents a natural scenic beauty with waterfalls, brooks, pine groves and garden.

Shillong city lies on the Shillong plateau which is the only major uplifted part in the North-East India. "Scotland of East" lies in the middle of the plateau and it is surrounded by three main hills in Khasi tradition: Lum Sohpetbneng, Lum Diengiei and Lum Shillong. The city is located on a hilly terrain in Seismic Zone V. Shillong experiences a tropical monsoon climate, with an annual rainfall of about 3385 millimetre (mm). The city is vulnerable to an annual recurrence of rain- induced landslides, resulting in heavy losses and damages. Shillong is a linear city, developed along a ridge. The city growth indicates an increasing densification along the ridgeline. The spread onto other directions has been constrained by steep slopes and vulnerability to landslides, forest cover, and inadequate access.

3.2 Terrain:

The city is located over high hills with rugged terrain conditions. Its altitude varies from about 1,200 meters to 1,966 meters. The mean elevation of the city is 1,496 m above the sea level.

3.3 Climate:

The climate of the city is of tropical monsoon type. The average annual rainfall is 3385 mm and the temperature varies from 5.6°C in winter to about 24.95°C in summer. The

driest month is December, with 8mm of rainfall. Most of the precipitation falls in June, averaging 851 mm. Summer and autumn skies are frequently over-clouded owing to the thick mists. Average number of rainy days is 179.

3.4 Geology and Seismicity:

The areas in and around Shillong city are dominated by the presence of tertiary rocks of Disang and Barail series. The Disang series consists of unfossiliferous Sand Stone, Shale, Slates and Phyllites. Due to the splintery character of the Shale, and the softness of the resulting soil, often underlain with a layer of clay, there is frequent occurrence of landslides in the city. The rocks of the Disang series make very steep angles of Dip.58.

The state of Meghalaya is mainly mountainous and underlain by several thrusts, being a part of the region where the Indian plate thrusts into the Eurasian plate. Earthquakes here are generally shadow but some intermediate focus events have also occurred. The entire state of Meghalaya lies in Zone V.

3.5 Soil:

Soil in Shillong is fertile except on extreme slopes. The soil is mainly acidic and rich i n organic carbon. The soil has high water holding capacity.

3.6 Drainage Pattern:

River Umshyrpri and River Wahumkhrah are the two rivers which flow right through the heart of the city, these two rivers have crystal clear water and beauty. Shillong is characterized by a hilly topography, the first and second order streams dominate the area. The drainage pattern is mainly sub-parallel to dendritic in nature. The streams tend to flow through the joints and faults of the area, which is reflected in almost straight stream courses. There is also presence of numerous ‘V’ shaped gullies. The major streams have also have cut deep gorges which are often narrow and have a depth of more than 600 m.

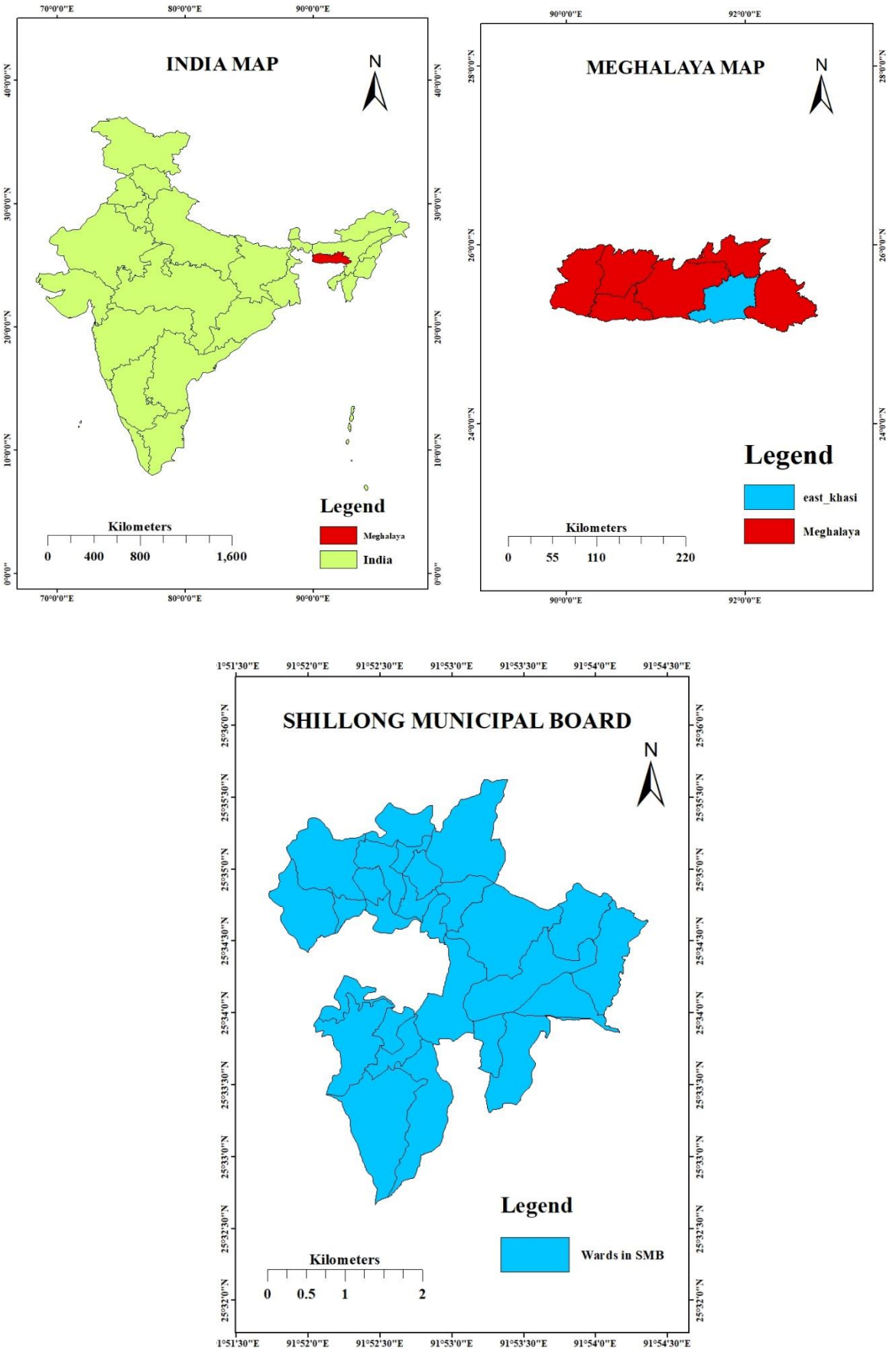


Figure 1: Study area location

3.7 Wards in Shillong:

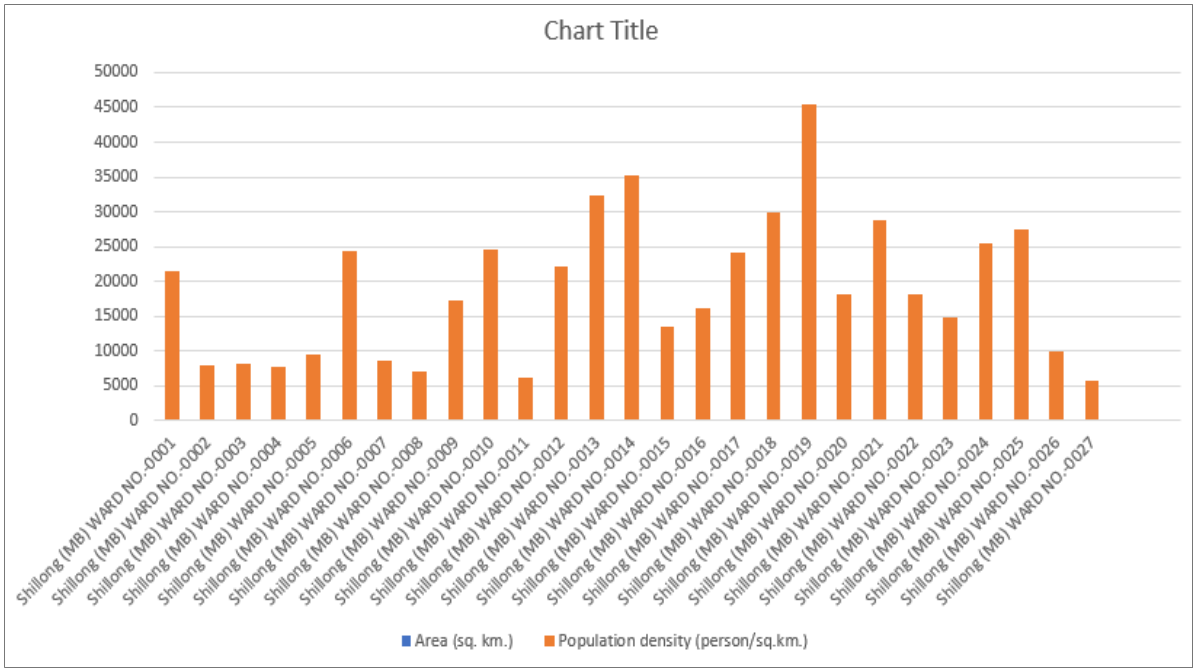
Shillong Municipal Board area comprises of 27 wards. Among them, ward no. 27 has the largest area of 0.91 sq km, followed by ward no.11having area of 0.78 sq km. Ward no. 25 has the least geographical area of 0.19 sq km. The average Household size for Shillong municipal limits is 4.6, where ward no.17 has the highest Household size (5.3) and ward no. 2 & 24 has the least value (4.2)

Table 1: Details of wards in SMB area

Name	No of Household	Population Total	Area (sq. km.)	Household size
Shillong (MB) WARD NO.-01	2714	11537	0.535883	4.3
Shillong (MB) WARD NO.-02	781	3266	0.412804	4.2
Shillong (MB) WARD NO.-03	1240	5437	0.667484	4.4
Shillong (MB) WARD NO.-04	589	2753	0.357236	4.6
Shillong (MB) WARD NO.005	1115	4908	0.518194	4.4
Shillong (MB) WARD NO.-06	1053	4888	0.2006	4.6
Shillong (MB) WARD NO.-07	1108	4891	0.568137	4.4
Shillong (MB) WARD NO.-08	1301	6009	0.85302	4.6
Shillong (MB) WARD NO.-09	420	2145	0.123928	5.1
Shillong (MB) WARD NO.-10	1212	5766	0.235252	4.8
Shillong (MB) WARD NO.-11	978	4863	0.784704	4.9
Shillong (MB) WARD NO.-12	608	2797	0.125803	4.6
Shillong (MB) WARD NO.-13	1213	5337	0.16537	4.4
Shillong (MB) WARD NO.-14	691	3032	0.085847	4.4
Shillong (MB) WARD NO.-15	752	3838	0.283824	5.1
Shillong (MB) WARD NO.-16	783	4067	0.250857	5.2
Shillong (MB) WARD NO.-17	621	3270	0.136148	5.3
Shillong (MB) WARD NO.-18	764	3875	0.129709	5.1
Shillong (MB) WARD NO.-19	967	4556	0.100429	4.8
Shillong (MB) WARD NO.-20	2118	10613	0.587682	5.0
Shillong (MB) WARD NO.-21	2865	14009	0.485223	4.9
Shillong (MB) WARD NO.-22	675	2973	0.163551	4.4
Shillong (MB) WARD NO.-23	1865	8161	0.549108	4.4
Shillong (MB) WARD NO.-24	842	3568	0.139703	4.2
Shillong (MB) WARD NO.-25	1206	5218	0.1906	4.3
Shillong (MB) WARD NO.-26	1372	6319	0.631204	4.6
Shillong (MB) WARD NO.-27	1172	5133	0.910528	4.4

Source: Census of India 2011

The average population density for Shillong municipal area is 14961, where ward no 1 9 has the highest population density of 45635 persons per square km and ward no 27 forming the least dense ward with a value of 5637. The graph below depicts the popula tion density of each municipal wards of Shillong.



Source: Census of India, 2011

Figure 2: Population Density of municipal wards in Shillong (2011)

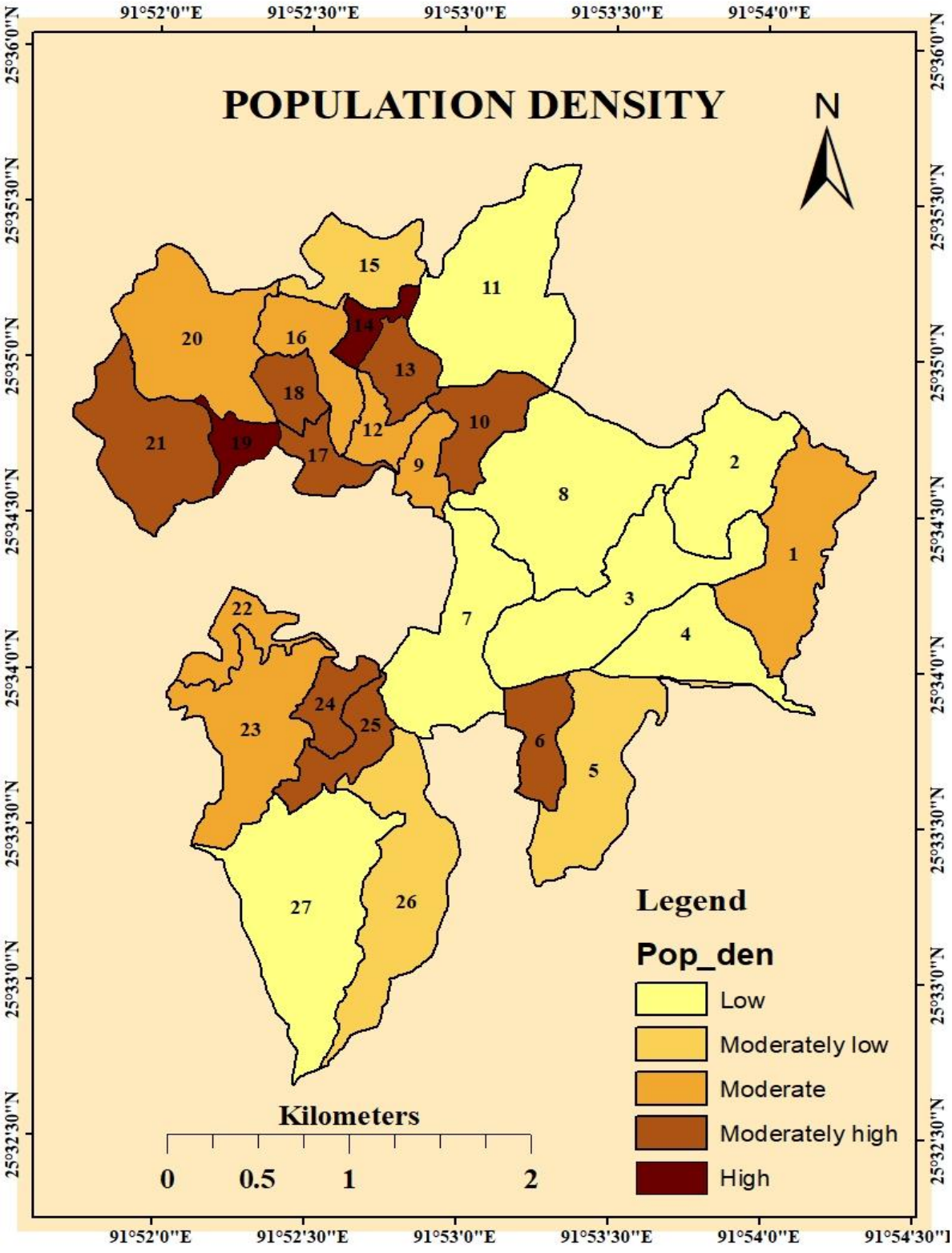


Figure 3: Population density of Municipal wards

3.8 Solid waste management (SWM) scenario in Shillong:

The daily waste generated in Shillong, is about 120 mtpd. The major sources of waste are from the residential, commercial, hotels and restaurants, sources accounting for 91% of waste generated. Biomedical wastes of the order of 1% is generated the hospitals of Shillong. The details of the same are given in Table 2.

Table 2: Categorization of waste generated in SMB

S. NO.	Waste generating sources	Proportion of waste (%)
1	Residential	65
2	Commercial	18
3	Hotels and Restaurants	8
4	Hospital waste	1
5	Industrial solid waste	3
6	Construction and Demolition	2
7	Other waste	5

Source: SMB, 2006 (DPR)

The primary collection is carried out by the SMB through street sweeping and from storage bins. At present, only 35-40% (i.e. about 120 mtpd) of the waste generated is collected according to ***Meghalaya State Pollution Control Board*** report. No house-to-house waste collection or source segregation of waste is followed. The exisiting waste collection is a manual/multi-handling 1 system. The MSW collected is a mixture, and contains a part from residential and commercial wastes, also biomedical, hazardous and construction wastes. The solid waste from the slum areas and from the slopes down the hills are generally dumped in nearly drains and stream or thrown down the slopes. Waste collected throughout the city is transported to the disposal site through refuse vehicles.

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DATASETS & METHODOLOGY

4.1 Datasets used:

The data used for this study are both primary and secondary data sources. The primary data used are field survey and reconnaissance which is collected from the field. The secondary data used are Shillong Municipal Boundary, and high resolution Cartosat-2S satellite imagery. The details of data and its sources are discussed below in the table**:** 3.

Table 3: Data used and sources

S.NO.	DATA	YEAR	SOURCES
1	Cartosat-2S PAN @ 0.65m Spatial resolution	2017	Indian earth observation, NRSC (ISRO)
2	SMB Boundary	2016	Department of Urban Affairs, Shillong
3	Ward Boundary	2016	Shillong Municipal Board

4.2 Software used:

ArcGIS: It is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. Here, in this study, it is used for digitization, multi-criteria analysis, preparing maps, and site suitability of bins.

Microsoft Excel: It is a spreadsheet developed by Microsoft. It features calculation, graphing tools, pivot tables, and a macro programming language. Here, it is used for statistical generation and for analysis of results**.**

4.3 Data collection and development of geo-spatial database:

For this study, data from allied sources were collected and integrated to create geodata base for the study area. Demographic data (Number of households, Population, Hous ehold size) was acquired and derived from census of India. Road network of the area, f oot print of buildingwere digitized based on high resolution satellite imagery acquired. Population density maps were generated through integrating census of India data and g eodatabase. The work flow can be summarised in the Figure. 4

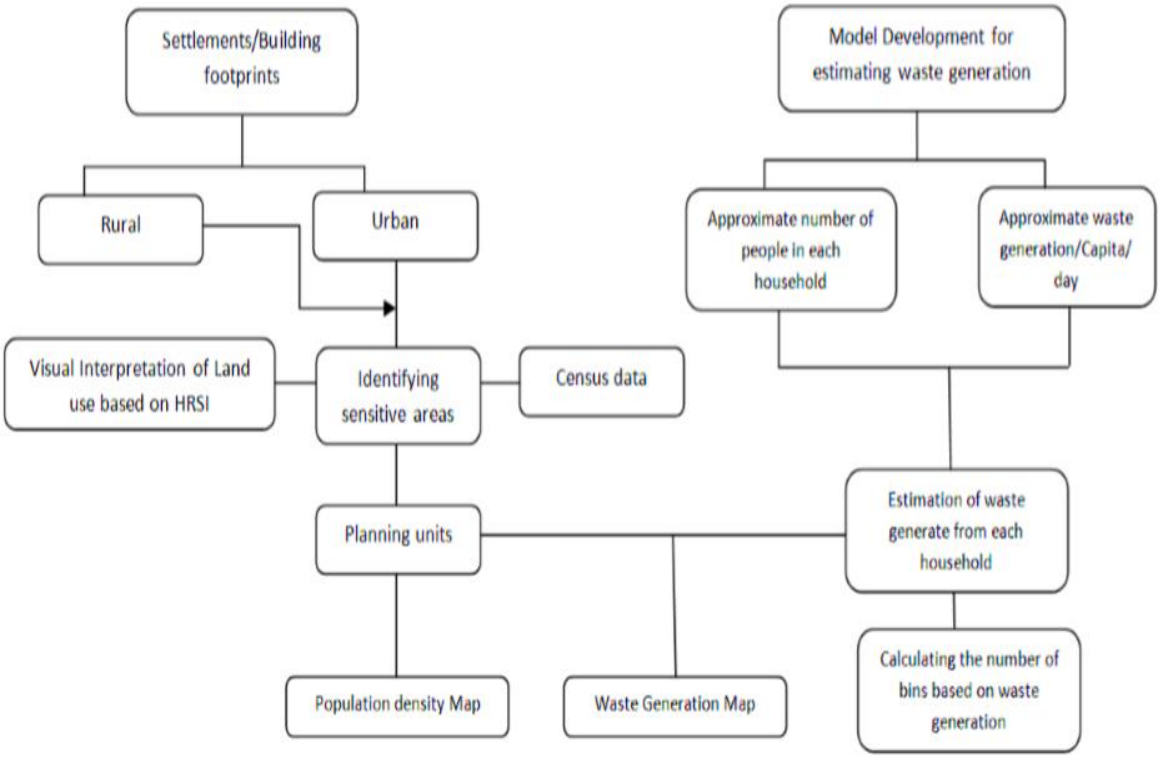


Fig.4 Work flow diagram for data collection and preparation of geospatial database

Fig.5 Digitization of Settlements

Fig.6 Digitization of Roads

4.4 Approach and Methodology:

Methodology followed in this study includes GIS based analysis to find proper locatio n for bins along the roads. The methodology is established by GIS technique in the res earch area by following three phases:

1. Data collection and Development of geo-spatial database.
2. The optimal allocation of collection bins for the proposed model based on a multi-criteria analysis.
3. Analysis of optimal proximity distance by creating buffer zone of and proposed model.

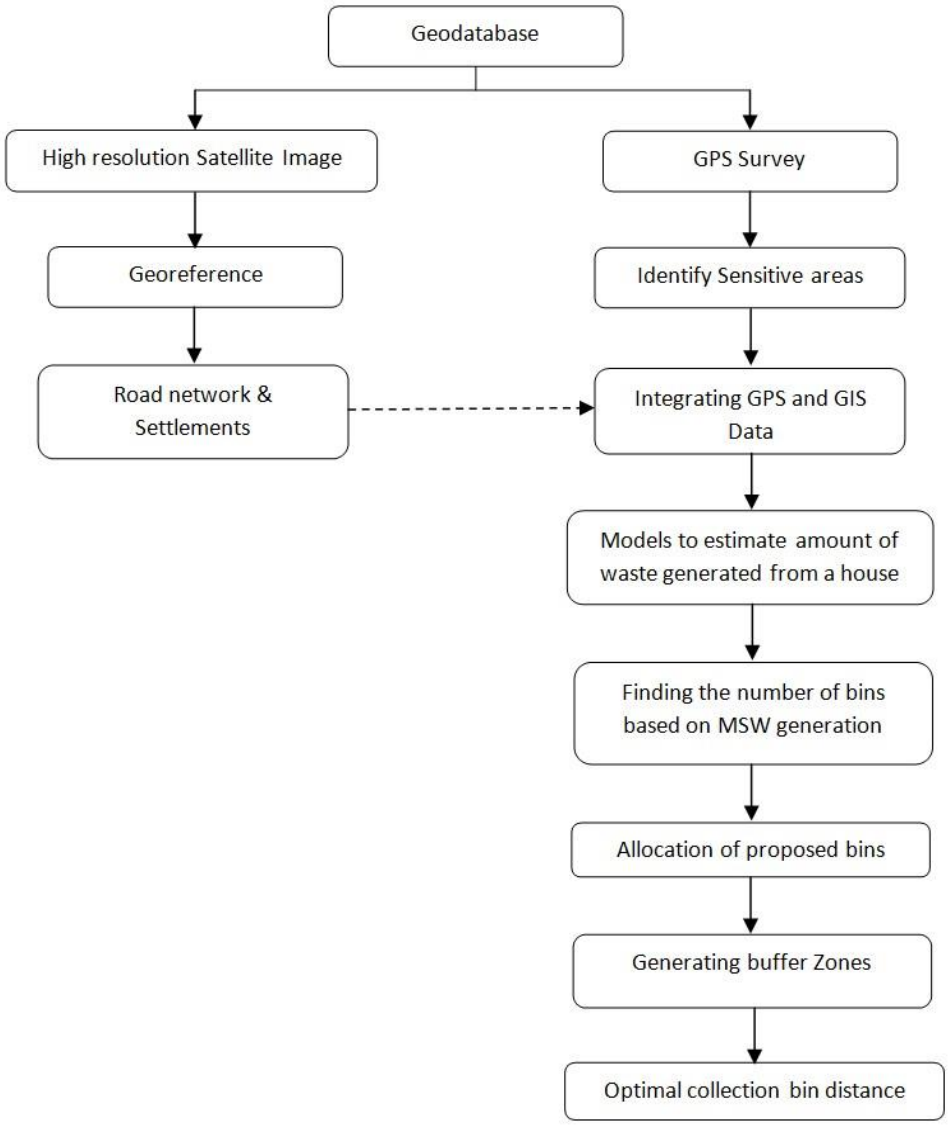


Figure 7: Methodology adopted for assessment and optimal allocation of Municipal Solid Waste Collection Bins

Generally, it could be said that amount of waste generated from a house mainly depend on the number of people in that house. Considering 0.3 kg/capita/day as a standard, waste generation from each ward was calculated based on the population data derived from census data and the following relationship was created.

Amount of waste generated (at Ward) = 0.3 * population of ward

Source: Meghalaya State Pollution Control Board

Table 4: Quantum of waste generated in municipal wards of SMB area

S.No.	Name	Waste generation (in kg)
1	Shillong (MB) WARD NO.-01	3461.1
2	Shillong (MB) WARD NO.-02	979.8
3	Shillong (MB) WARD NO.-03	1631.1
4	Shillong (MB) WARD NO.-04	825.9
5	Shillong (MB) WARD NO.-05	1472.4
6	Shillong (MB) WARD NO.-06	1466.4
7	Shillong (MB) WARD NO.-07	1467.3
8	Shillong (MB) WARD NO.-08	1802.7
9	Shillong (MB) WARD NO.-09	643.5
10	Shillong (MB) WARD NO.-10	1729.8
11	Shillong (MB) WARD NO.-11	1458.9
12	Shillong (MB) WARD NO.-12	839.1
13	Shillong (MB) WARD NO.-13	1601.1
14	Shillong (MB) WARD NO.-14	909.6
15	Shillong (MB) WARD NO.-15	1151.4
16	Shillong (MB) WARD NO.-16	1220.1
17	Shillong (MB) WARD NO.-17	981
18	Shillong (MB) WARD NO.-18	1162.5
19	Shillong (MB) WARD NO.-19	1366.8
20	Shillong (MB) WARD NO.-20	3183.9
21	Shillong (MB) WARD NO.-21	4202.7
22	Shillong (MB) WARD NO.-22	891.9
23	Shillong (MB) WARD NO.-23	2448.3
24	Shillong (MB) WARD NO.-24	1070.4
25	Shillong (MB) WARD NO.-25	1565.4
26	Shillong (MB) WARD NO.-26	1895.7
27	Shillong (MB) WARD NO.-27	1539.9

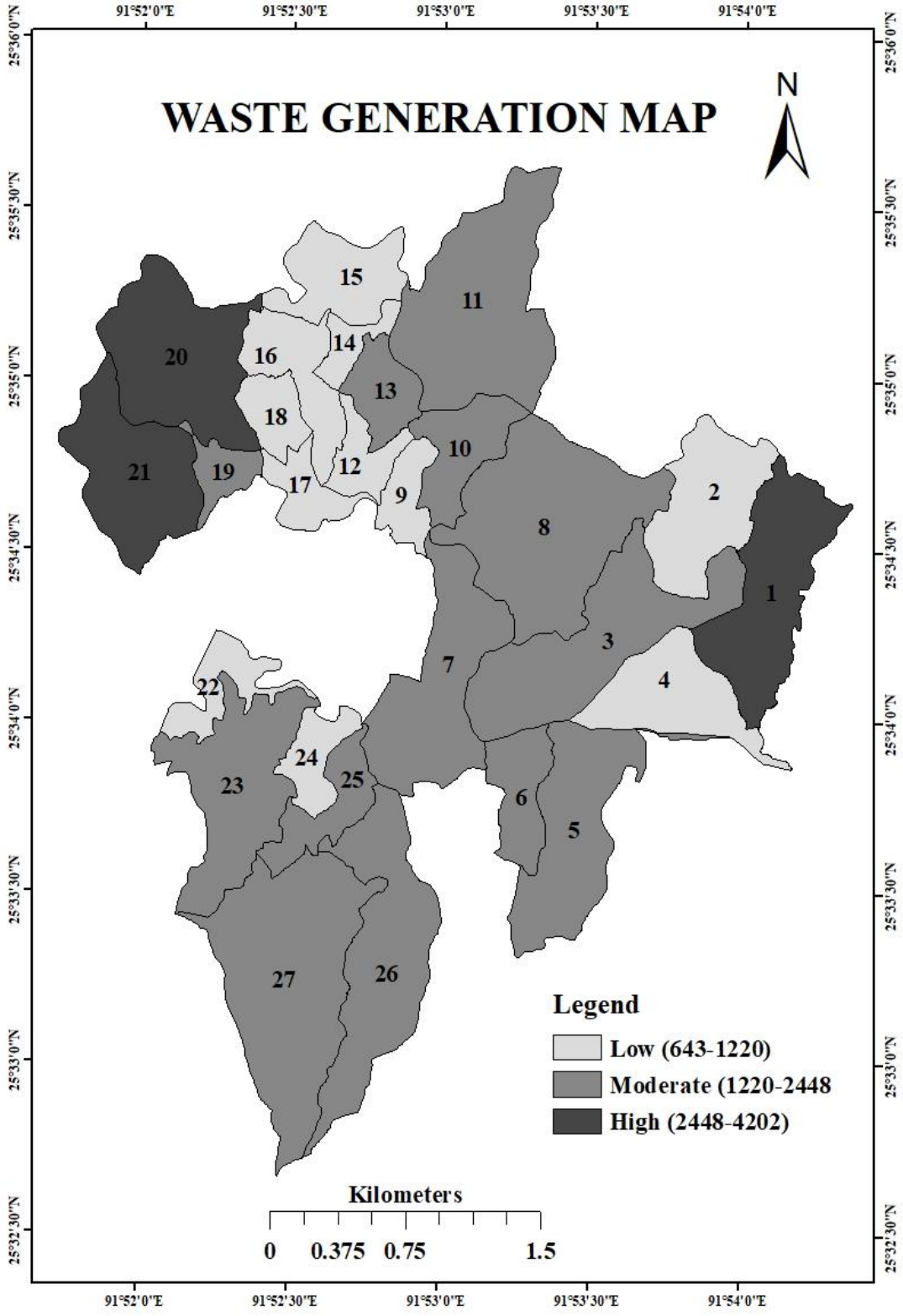


Figure 8: Waste generation in wards of SMB area

With the available data and based on waste generation from each ward, number of bins to be allocated was estimated. Conventionally municipalities generally use collection bins of two capacities i.e. 0.5 tonne and 1 tonne. But for SMB smaller garbage bins having usable load of 100-110 kg were considered with optimum capacity of 80 kg. To determine the number of bins to be allocated at each ward, the following equation was used.

No of Bins = total waste generated in kg(@ward)/ 80 kg (optimum capacity of bins)

Table 5: Number of required dustbins in Municipal wards of SMW area

S.No.	Name	Dustbins required
1	Shillong (MB) WARD NO.-01	43
2	Shillong (MB) WARD NO.-02	12
3	Shillong (MB) WARD NO.-03	20
4	Shillong (MB) WARD NO.-04	10
5	Shillong (MB) WARD NO.-05	18
6	Shillong (MB) WARD NO.-06	18
7	Shillong (MB) WARD NO.-07	18
8	Shillong (MB) WARD NO.-08	23
9	Shillong (MB) WARD NO.-09	8
10	Shillong (MB) WARD NO.-10	22
11	Shillong (MB) WARD NO.-11	18
12	Shillong (MB) WARD NO.-12	10
13	Shillong (MB) WARD NO.-13	20
14	Shillong (MB) WARD NO.-14	11
15	Shillong (MB) WARD NO.-15	14
16	Shillong (MB) WARD NO.-16	15
17	Shillong (MB) WARD NO.-17	12
18	Shillong (MB) WARD NO.-18	15
19	Shillong (MB) WARD NO.-19	17
20	Shillong (MB) WARD NO.-20	40
21	Shillong (MB) WARD NO.-21	53
22	Shillong (MB) WARD NO.-22	11
23	Shillong (MB) WARD NO.-23	31
24	Shillong (MB) WARD NO.-24	13
25	Shillong (MB) WARD NO.-25	20
26	Shillong (MB) WARD NO.-26	24
27	Shillong (MB) WARD NO.-27	19

4.4.1 Model development for optimal allocation of dustbins

The factors adopted for model development in allocating collection bins optimally are

1. Population density
2. Waste generation
3. Proximity to Road network
4. Urban land-use

Based upon the geo database created, each parameter was classified into three categories i.e. High, Medium and Low considering maxima, mean and minima respectively and was ranked with respected to the weightage allocated. Table 6 illustrates the scoring tabulation of each parameter used in the analysis.

Table 6: Multi-Criteria Analysis for Optimal Allocation of bins

S.NO.	Parameters	Categories	Rank	Weightage	Standard Score
1	Population density (person/Sq. km)	32001-46000	10	10	0.36
		9401-32000	8		
		5600-9400	6		
2	Waste Generation (in kg)	2401-4202	8	8	0.29
		1001-2400	6		
		643-1000	4		
3	Road Proximity	<0.15km	6	6	0.21
		0.15-0.30	4		
		>0.30km	2		
4	Urban Land use	Commercial	4	4	0.14
		Residential	2		
		Others	1		
				28	1

Each Planning unit was assigned a score pertaining to the parameter, rank associated and the standardized score. The formulae/equation below relates to the scoring for site-suitability for bin locations.

Site Suitability for bins location = {0.36* (Population density) + 0.29*

(Waste generation) +0.21* (Road Proximity) +0.14* (Urban landuse)

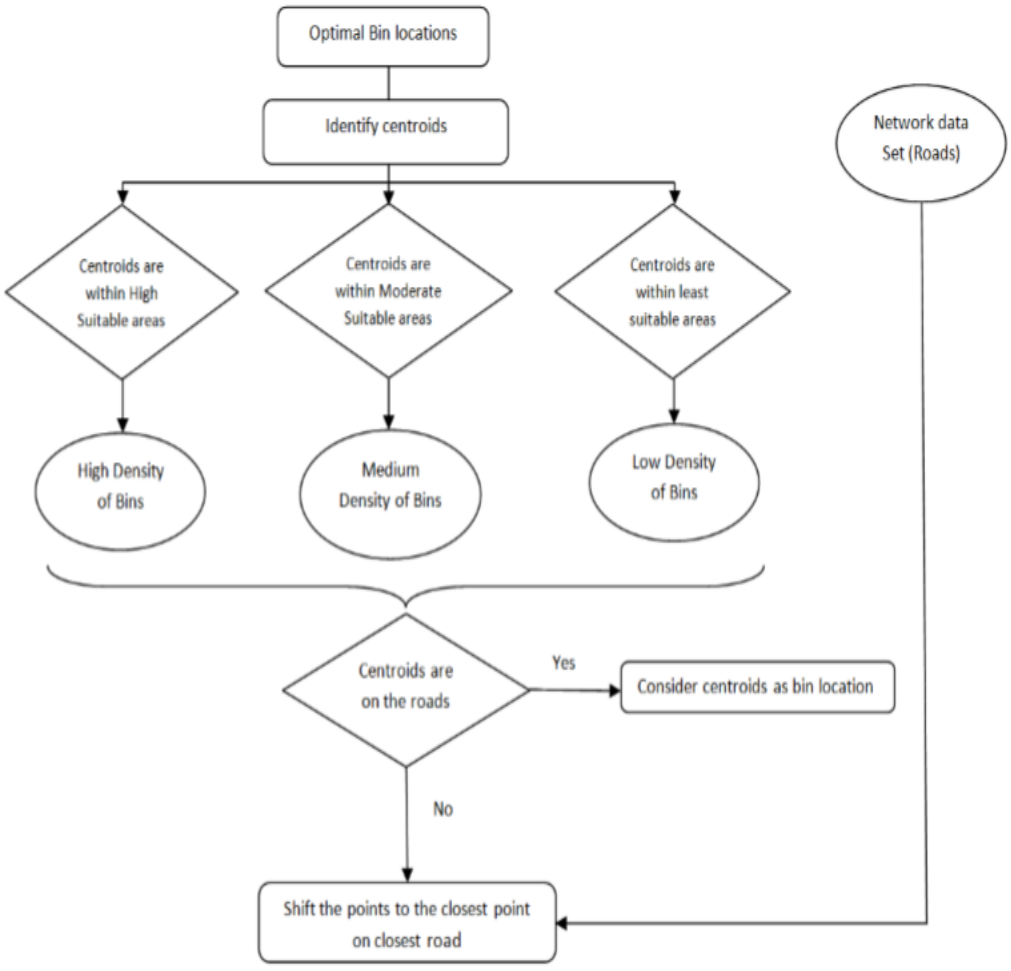


Figure 9: Work flow diagram for optimal allocation of Bins

The next step was to find out the optimal location of bins with respect to site suitability for waste collection bins. The work flow chart demonstrates the process.

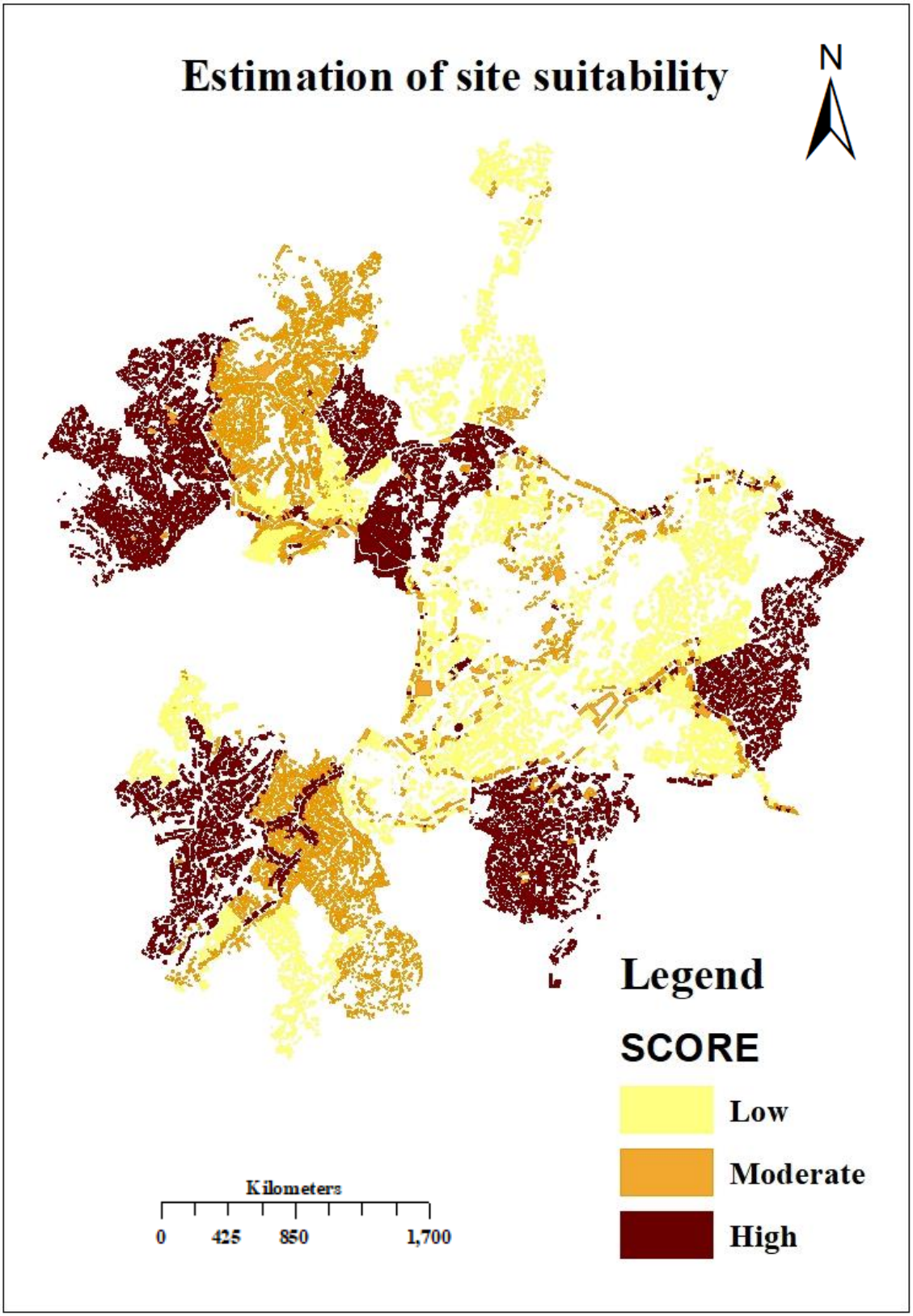
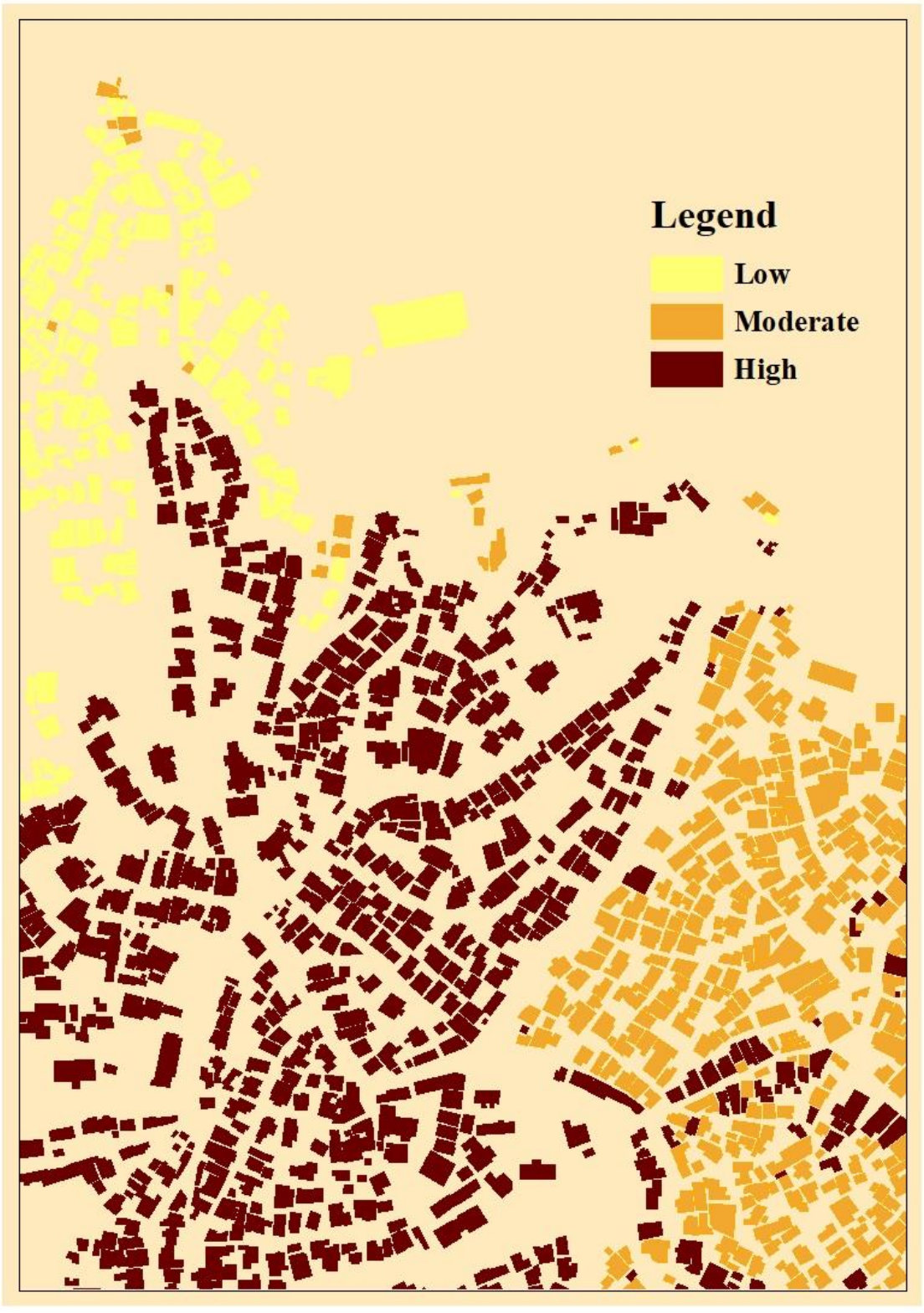


Figure 10. Estimation of site suitability for waste collection bins based on Multi-criteria analysis



Figrure 11: Blow-up map showing site suitability for waste collection bins

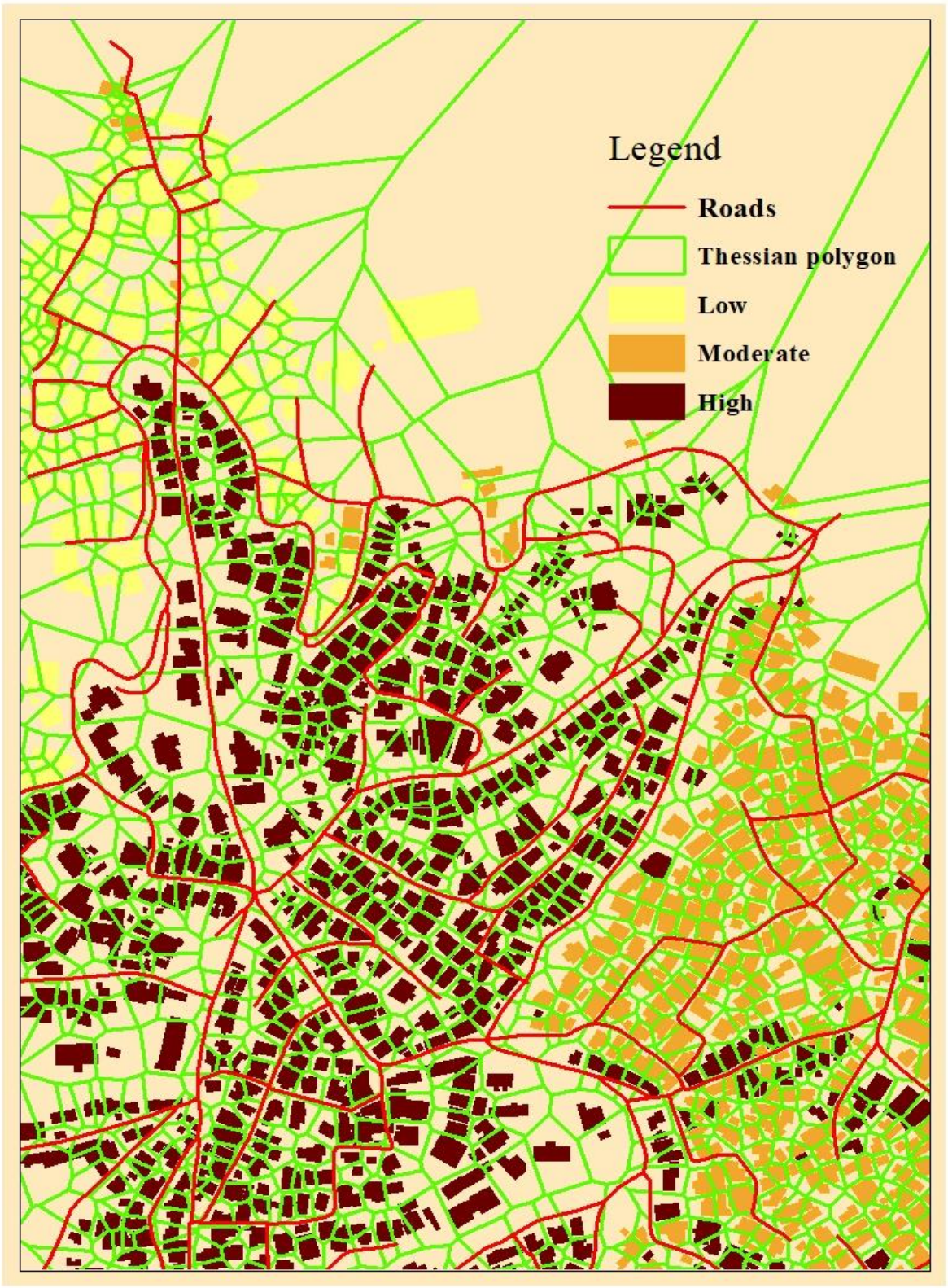


Figure 12: Identification of Centroids by intersection of roads and thessian polygon

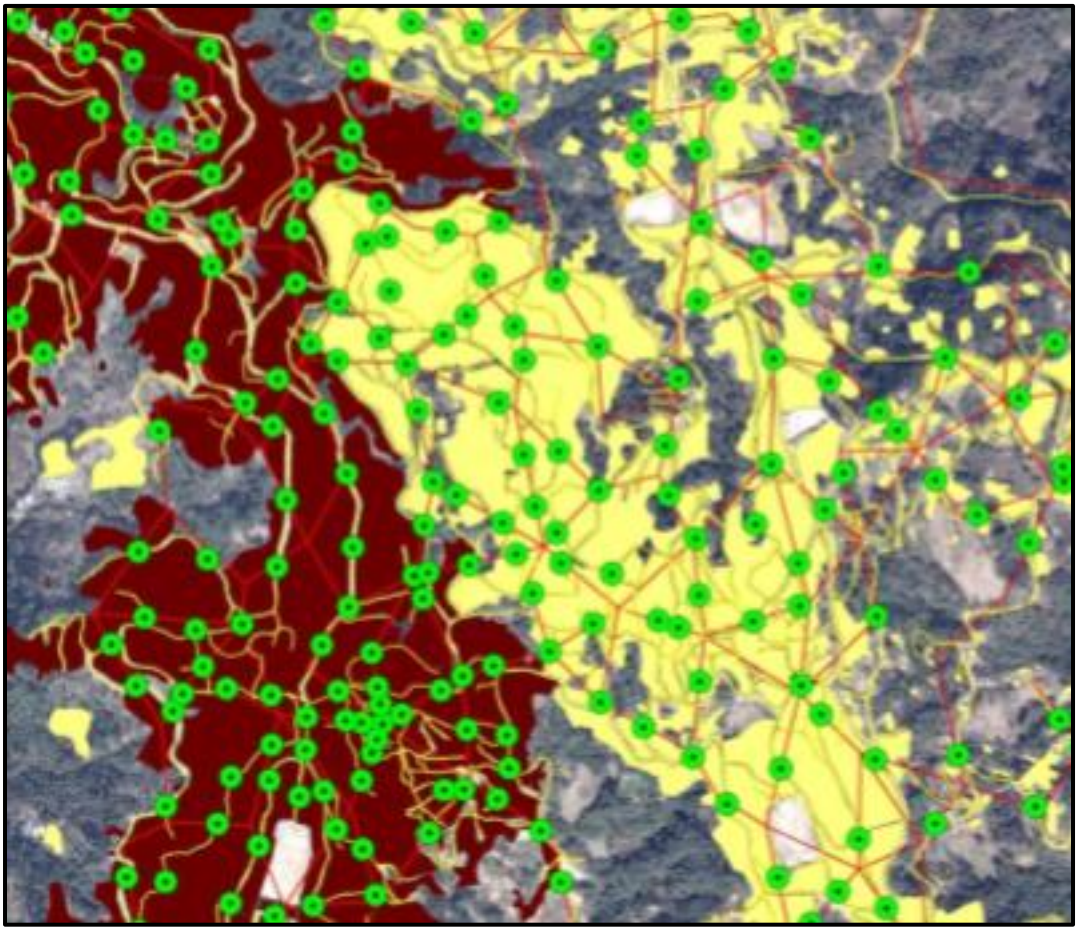


Figure 13: Identifying bins location based on centroids

4.4.2 Analysis of optimal proximity distance

In order to check the collection bin proximity distance by the residents and based on the public preferable walking distance to drop the MSW to the collection bin, a model was developed. In this model, the three different proximity distances such as 50m, 75m and 100m around proposed bins were generated and found the optimal distance. As a result, most of the urban and rural built up areas was covered by 75m distance around the collection bin with more than 75% efficiency and since the 75m buffer zone covered almost entire study area and it may be optimal primate distance by the residents in the ward. This is illustrated in the table. 7.

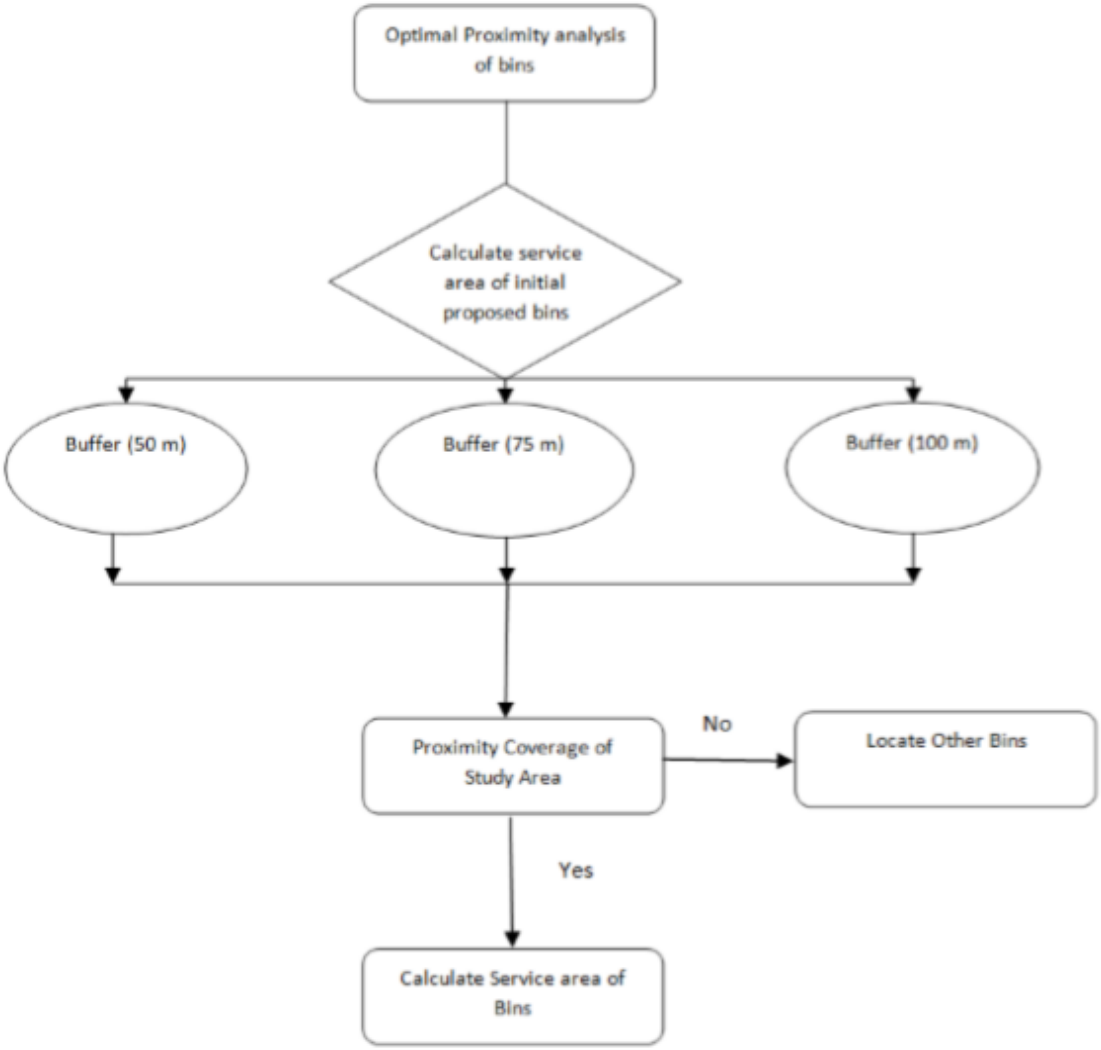


Figure. 14: Work flow diagram for optimal proximity analysis of bins

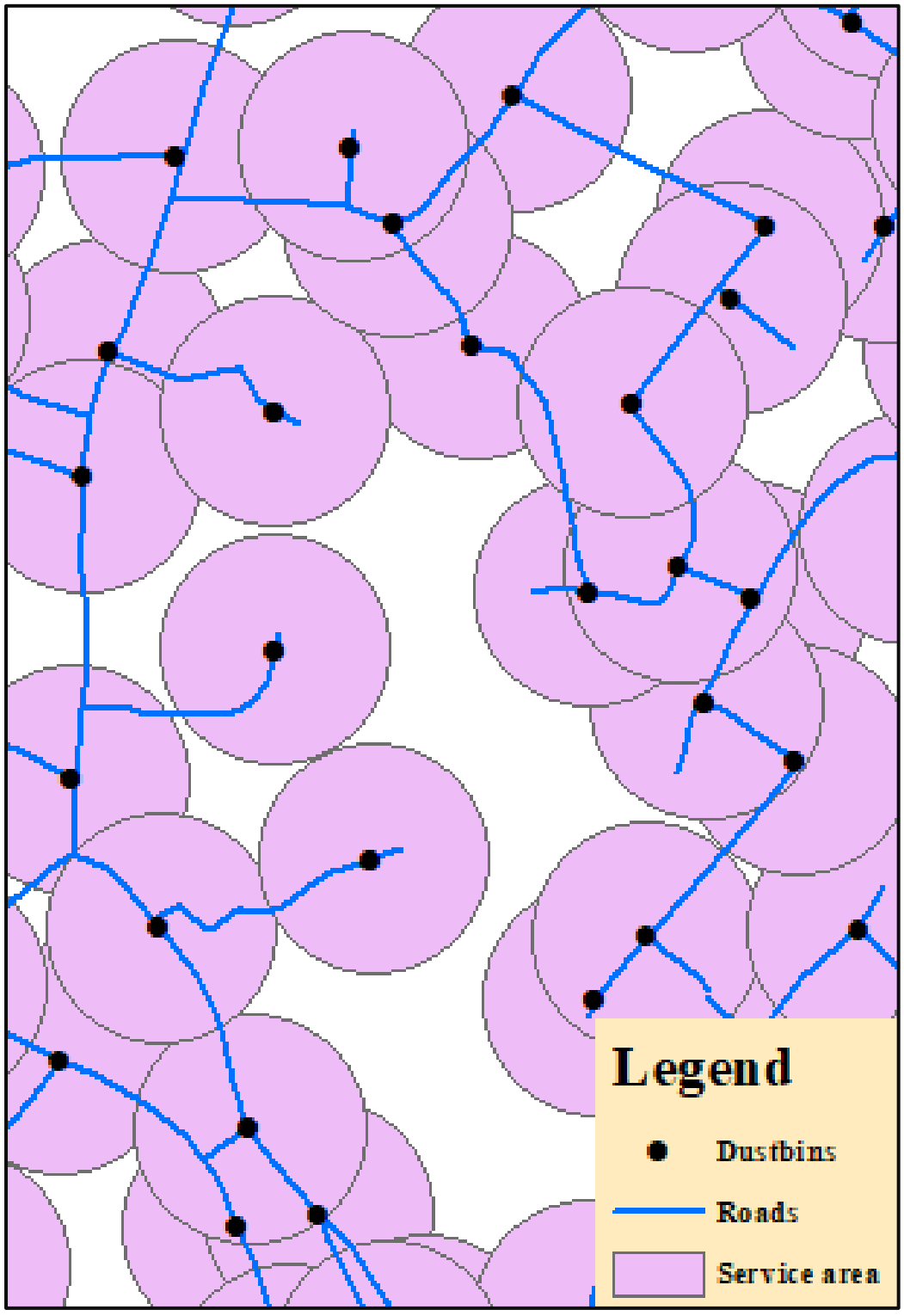


Figure 15: Estimation of service area around collection bins allocated

S.NO.	Urban and Rural builtup area (sq. km)	Buffer distance	Area Coverage (Sq. km)	Area coverage (Percentage)
1	14.86	50 m	6.5	43.6
2		75 m	11.43	76.6
3		100 m	15.31	102.7

Table 7: Buffer and coverage analysis of bins allocated

RESULTS AND CONCLUSION

Based on the models developed and estimation of number of waste bins, an attempt was made to facilitate maximum coverage and optimize the number of bins. Table. 8 shows the number of bins provided in each ward against the required number.

Table 8: No. of Bins allocated in municipal wards of SMB

S.no.	Name	Dustbins required	Dustbins to be allocated
1	Shillong (MB) WARD NO.-01	43	45
2	Shillong (MB) WARD NO.-02	12	12
3	Shillong (MB) WARD NO.-03	20	20
4	Shillong (MB) WARD NO.-04	10	10
5	Shillong (MB) WARD NO.-05	18	18
6	Shillong (MB) WARD NO.-06	18	20
7	Shillong (MB) WARD NO.-07	18	18
8	Shillong (MB) WARD NO.-08	23	23
9	Shillong (MB) WARD NO.-09	8	8
10	Shillong (MB) WARD NO.-10	22	22
11	Shillong (MB) WARD NO.-11	18	20
12	Shillong (MB) WARD NO.-12	10	10
13	Shillong (MB) WARD NO.-13	20	20
14	Shillong (MB) WARD NO.-14	11	11
15	Shillong (MB) WARD NO.-15	14	14
16	Shillong (MB) WARD NO.-16	15	15
17	Shillong (MB) WARD NO.-17	12	12
18	Shillong (MB) WARD NO.-18	15	15
19	Shillong (MB) WARD NO.-19	17	17
20	Shillong (MB) WARD NO.-20	40	40
21	Shillong (MB) WARD NO.-21	53	55
22	Shillong (MB) WARD NO.-22	11	11
23	Shillong (MB) WARD NO.-23	31	31
24	Shillong (MB) WARD NO.-24	13	15
25	Shillong (MB) WARD NO.-25	20	25
26	Shillong (MB) WARD NO.-26	24	24
27	Shillong (MB) WARD NO.-27	19	19

It is to be noted that in few wards such a ward no.1, 6,11,21,24,25, the number of collection bins allocated is more than the required number of bins. This is so overcome the terrain irregularity in Shillong which has an adverse effect on collection efficiency of waste. An increased number of bins than required would enhance coverage and hence waste collection.

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