Optimal Locations of Municipal Solid Waste-to-Value-Added Conversion Facilities Using GIS Analysis: A Case Study in Mymensingh Division, Bangladesh

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Abstract
The goal of the current study was to use a GIS analysis of the Mymensingh division to place municipal solid waste to energy conversion facilities in the optimal location. A geographic information system (GIS) is used to identify appropriate locations and weed out unsuitable ones that produce a land suitability map (LSM). The relative preferences of environmental, social, and economic aspects are assessed using a multicriteria decision analysis (MCDA) based on an analytical hierarchy process (AHP). Overall, this study measures the MSW potential, examines geographic locations for the dispersed MSW feedstock, chooses the most suitable locations for W2VA facilities throughout the Mymensingh division in Bangladesh, and prioritizes these locations. Furthermore, the GIS-MCDA model provided might benefit local governments' waste management efforts, if necessary, adjustments were made to consider more pertinent exclusion and preference criteria, as well as their interactions concerning tradeoffs.

Keywords: Analytic Hierarchy Process, Geographic Information System, Land Suitability Map, Multi-Criteria Decision Analysis, Municipal Solid Waste

1. Introduction

Population expansion causes an increase in commercial, residential, and infrastructure development, adversely affecting the environment. Among the most difficult environmental issues facing local government in growing economies is managing urban solid waste. Municipal Solid Waste (MSW) is a broad term for all types of solid waste, including domestic garbage, non-hazardous waste from businesses and institutions, and municipal and construction debris. The main sources of MSW include homes, businesses, hospitals, clinics, fresh markets, malls, restaurants/canteens, and slaughterhouses [1]. About 90% of the total MSW streams are from household solid waste (HSW), of which 80%-92% are organic solid waste (OSW) [2]. Tourist attractions, recreation areas, and institutions are some of the smaller sources of MSW and they indirectly pose serious environmental and public health risks [3]. Human waste such as night soil, cremation ash, septic system sludge, and wastewater treatment plant sludge are handled by several countries' solid waste management systems.

In Bangladesh's cities, solid waste is produced at a rate of about 25,000 tons/day or 170 kg/capita annually. One-fourth of all urban garbage in the nation is generated in the metropolis of Dhaka. By 2025, the overall amount of urban solid garbage is expected to increase to 47,000 tons/day because of population expansion and rising per capita waste production. Urban solid trash generation averaged 0.4 kg/capita/day in 1995, but by 2025, this number is anticipated to rise to 0.60 kg/person/day. Statistics on the effectiveness of waste collection in various urban regions range from 37% to 77%, with an average of 55%. A significant percentage of the waste is not being collected, which is an unsatisfactory condition overall. Uncollected waste contains an organic component that adversely affects the local ecology by contaminating the land. Moreover, large amounts of solid waste clog the drainage system after each rainfall, causing waterlogging. Furthermore, a substantial amount of solid waste pollutes water bodies like rivers, lakes, etc. The waste management system that is currently practiced in Bangladesh is depicted in Figure 1.

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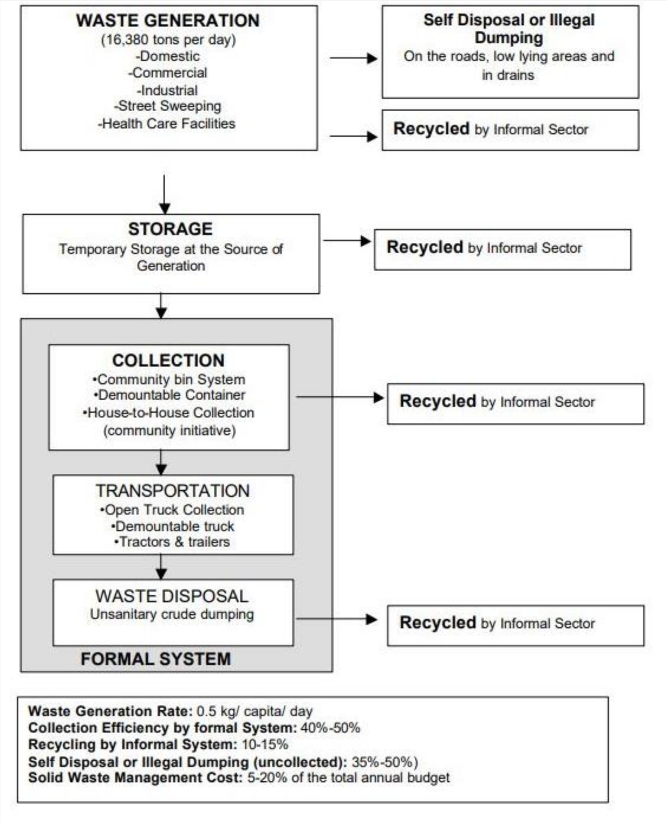

Figure 1: Solid waste management process in Bangladesh [3]

One is the "Formal System," where solid waste management (SWM) is the responsibility of city corporations and municipalities. The "formal system" is based on the conventional waste collection, transportation, and disposal procedure utilized by local governments. Recycling is not a notion in this system. Finally, the "Informal System," which is exemplified by the sizable informal labor force participating in the solid waste recycling trade chain, is based on primary solid trash collection by Community Based Organizations (CBOs) and Non-governmental Organizations (NGOs). For the country's solid waste management system to be effective, cooperation across all three systems is required. Currently, Mymensingh produces around 150 tons of waste each day, of which the municipal authority collects 130–140 tons, or about 90% of the total, while 10–20 tons of waste are left in different city streets and drains [4]. According to predictions made by Local Government Engineering Department (LGED) (2017), this waste creation will double to 280 tons/day and 0.40 kg/capita/day [5].

MSW frequently ends up in Mymensingh's lowland regions with no safety precautions or operating limitations. As a result, one of Mymensingh's most pressing environmental concerns is MSW management. It includes the creation, storage, collection, transportation, and processing of solid waste [7]. The MSW management system in Mymensingh City, however, only includes these four tasks: trash creation, collection, transportation, and disposal [6].

Yet, despite ongoing government efforts, sustainable MSW management in Bangladesh remains a challenge. The existing scientific literature on the management of MSW in Bangladesh reflects this. Citizens of Bangladesh are extremely concerned about the lack of a system for managing urban waste that is beneficial to the environment. Together with urbanization, higher living conditions and increasing economic activity boosted the nation's waste production per person. Bangladesh, the eighth-most populated nation in the world with 1,015 people per square kilometer of land, is struggling to manage its urban trash. However, no detailed study has been performed for the sustainable management of MSW. Due to the lack of sufficient facilities to process and dispose of the more significant amount of MSW generated daily in the Mymensingh division, MSW management is currently experiencing an unsustainable phase that pollutes the environment. The major objectives of this study include:

- Integrate Analytic Hierarchy Process (AHP) into the GIS system to create a suitability map of the study area.
- Identification of the optimal locations of waste-to-value-added facilities conversion facilities for Mymensingh Division, Bangladesh using a range of social, economic, and environmental factors.

2. Materials and Methods

MSW availability is measured, potential point source locations for W2VA conversion facilities are analyzed for suitability, and the facilities under consideration have their spatial layouts optimized. The main considerations in building up any W2VA conversion establishment in this sort of study are measuring the availability of feedstock and choosing the most suitable location for a facility by assuring compliance with environmental, social, and economic aspects. Figure 2 illustrates the conceptual model's flow chart as well as the multiple analyses carried out for this study. To identify possible areas for waste conversion facilities, an integrated GIS-AHP method was employed. A two-step suitability study map was constructed to identify the most suitable sites for possible conversion facilities. Areas considered inappropriate due to social, economic, and environmental restrictions were filtered out of the research region in the first stage, known as an exclusion analysis. The relative preferences of the various regions of the research area based on multi-criteria decision factors were then discovered using a preference analysis that considered nine preference variables. The suitability analysis map was generated by combining the exclusion and preference analysis maps. The following sections provide a full description of the research methodology.

2.1 Exclusion Analysis

Unsuitable locations were filtered out using an exclusion analysis based on social, environmental, economic, hydrographic, and geomorphological factors. The environmental limitations in this study were predicated on regions where the construction of W2VA facilities was restricted. The goal of limitations is to ensure that new construction complies with current environmental and conservation standards while avoiding interference with existing infrastructure. Each restriction was surrounded by a buffer zone, or safety area, whose size matched the minimum site development distance from the chosen geographic entities. The buffer distances in this study were chosen based on the study area's circumstances as well as recommendations from earlier publications. The raster map for each constraint element measures 30 m x 30 m. The image data might be transformed into a binary image by reclassifying cells with values of "0" for the exclusion zone and "1" for places outside of it. The final binary constraint map was created by merging relevant data layers that could be explained by equation 1.

$$C_{E,i} = \prod_{m=1}^{n} C_{i,m}$$

Equation 1

Where $C_{E,i}$ represents the Boolean value (0, 1) assigned to the i^{th} cell in the resultant exclusion map; $C_{i,m}$ is the Boolean cell value (0, 1) of the i^{th} cell value in the m^{th} constrained grid layer; and n shows the number of constraints considered for the analysis. Like binary function, a value of ‘‘0’’ in the final raster file indicates the cell was unsuitable for plant build whereas a value ‘‘1’’ represents probable locations for building energy facilities.

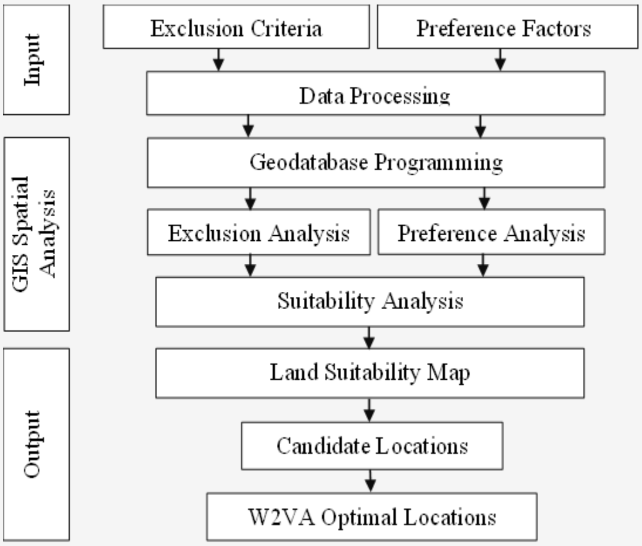

Figure 2: Flow chart for the conceptual model and multiple analyses

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2.2 Preference Analysis

To determine relative preference for specific research area regions, preference analysis was utilized. Nine criteria based on social, environmental, economic, and technological concerns were taken into consideration in this study. Around each factor, many buffer rings were created. Each buffer ring received a grade, with the most desired location receiving a score of 10 and the least preferred receiving a score of 1.

Then, using the respective weightages, all nine preference factor maps were merged using the weighted overlay technique to produce a single preference analysis map. Because the nine preference parameters are not equally essential, the relative weightage of each was determined using the AHP. This approach uses a relative score on a range of 1 to 9 to do a pairwise comparison. The value of the cells on the final preference analysis map were calculated using equation 2.

$$C_{P,i} = \sum_{j=1}^{m} W_j C_{i,j} \quad ,0 \le W_j \le 1$$

Equation 2

Where $C_{P,i}$ represents the grading value of i^{th} cell of the resultant preference map, $C_{i,j}$ mentions the grading value of i^{th} cell for j^{th} preference factor, m represents the number of preference factors considered for this study, and W_j is the relative weightage to the j^{th} preference factor.

2.3 Suitability Analysis

To determine the optimal locations to build energy facilities, a suitability study was done. The final exclusion analysis map and final preference analysis map were integrated to generate the land suitability map. Every map cell has a value that represents its suitability index. To compute the suitability index, equation 3 was utilized.

$$SI_j = C_{E,i} \cdot C_{P,i}$$

Equation 3

Where SI_j represents the suitability index for the i^{th} cell in the final land suitability map; $C_{E,i}$ defines the Boolean value (0,1) assigned to the i^{th} cell of the final exclusion analysis map; $C_{P,i}$ represents the ith cell value of the final preference analysis map. The land suitability map's cell values range from 0 to 10, with 0 denoting an unsuitable site and 10 denoting the best place to put a renewable energy production facility. Using a reclassification tool, grading values were applied to create buffer zones, as indicated in Table 1. The buffer distances are referenced from previous studies, as listed in Table 2.

3. Case Study: Mymensingh Division

3.1 Study Area characteristics

The Mymensingh Division is one of Bangladesh's eight administrative regions. It consists of four districts-Mymensingh, Jamalpur, Sherpur, and Netrakona (Figure 3). Currently, there are 35 sub-districts in the Mymensingh division. As of the 2022 census, it has a population of 12,225,498 and a land area of 10,485 square kilometers (4,048 sq.mi). The population growth rate of the Mymensingh division is 1.34% and the population density (per square kilometer) is 1,273. The population More than 8,000 business entities, four medical colleges, and four universities are present. Additionally, this division has been home to the construction of around 7,650 educational facilities, including colleges, cadet colleges, primary schools, polytechnic institutions, high schools, madrasas, and teacher training institutes.

Table 1: Grading values for preference factors

Preference level	Grading values	Road & rail network (km)	Substation & transmission lines (km)	Urban areas (km)	Transfer stations (km)	Slope (degree)	Landcover (type)	Waterbodies (km)
Very suitable	9-10	0.05-0.1	0.5-1	> 2	< 30	< 10	Exposed land, low land, grassland	0.1-0.5
Suitable	7-8	0.1-0.5	1-2.5	5-6	30-70	10-15	Developed land	0.5-1
Almost suitable	5-6	0.5- 1.5	2.5-4	4-5	70-110	-	Agricultural land	1-1.5
Unsuitable	3-4	1.5-3	4-5	2-4	110-150	-	Boreal forest, mixed forest	1.5-2
Very unsuitable	1-2	> 3	> 5	1-2	150-190	-	Rock/rubble	> 2
Not suitable at all	0	< 0.05	< 0.5	< 1	> 190	>15	Rivers, lakes, waterbodies	< 0.1

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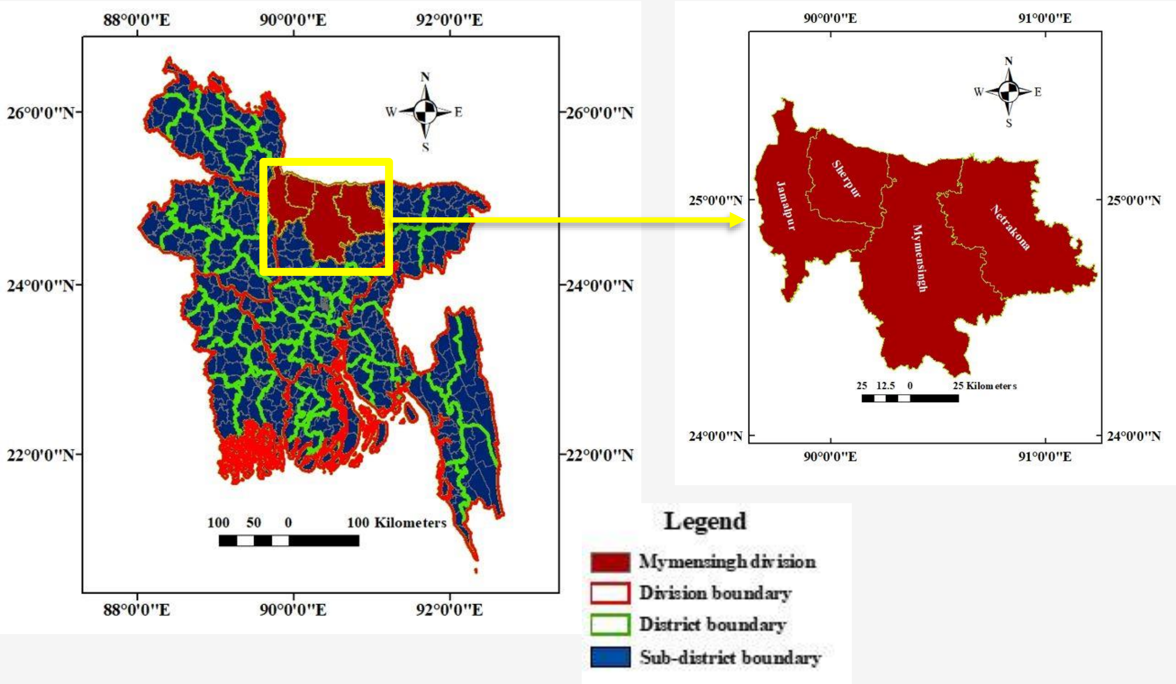

Figure 3: Study area

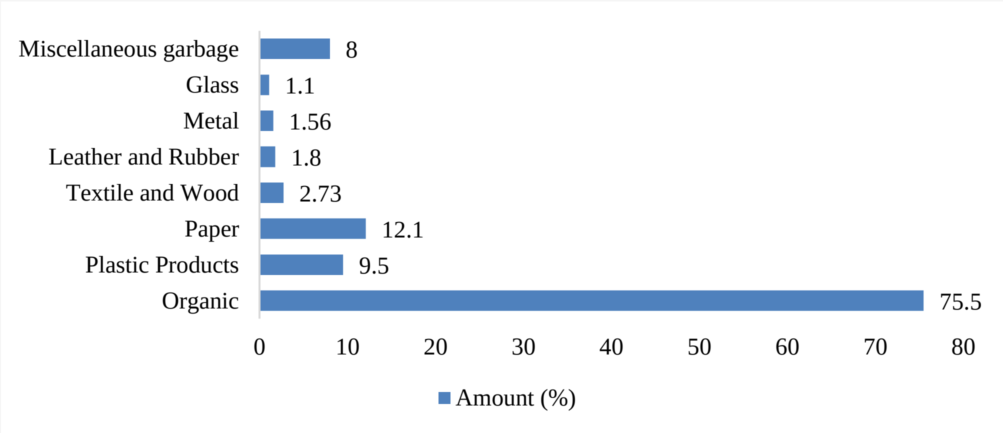

Figure 4: Composition of solid waste generated in Mymensingh division

The main causes of Mymensingh's rising rate of solid waste creation are urbanization and industrialization, which are coupled with population expansion. The composition, features, and macronutrient concentrations of municipal solid waste (MSW) were assessed through extensive field and laboratory research carried out at the Mymensingh division. Figure 4 shows the composition of solid waste generated in the Mymensingh division. Food/organic waste makes up a significant amount of waste ending up at the landfill at 75.5% of total waste generated followed by plastic waste at 9.5% and paper at 12.1%. Only a small percentage of Mymensingh's garbage gets collected by the low-cost, door-to-door collection system established by community-based organizations (CBOs) and non-governmental organizations (NGOs) in the late 1990s. A significant section of the community does not have the opportunity to utilize garbage collection services.

3.2 Landfills

Waste materials are discarded in a landfill site, also known as a tip, dump, rubbish dump, waste dump, or dumping ground. Lithium-based waste disposal is now the most used method [9].

Large tracts of land or sites that have been expressly constructed and made available for the disposal of all solid waste from municipalities are known as landfills. 52.6 % of waste is landfilled in USA, 59.1% in Brazil, 94.5% in Malaysia, 79% in China [10], and 42% in Bangladesh [11]. Around 37% of solid waste ends up in landfills globally [9].

3.3 Exclusion Criteria

A waste conversion plant should not be located too close to wetlands, airports, water bodies, industrial zones, or environmentally sensitive places for environmental reasons. For social and safety reasons, it shouldn't be situated too close to parks, power plants, transmission lines, gas pipelines, or other urban or rural areas. The following parameters and accompanying distances were taken into consideration for the constraint analysis in this study.

3.4 Preference Parameters

The preference analysis took into consideration the nine criteria listed in Table 3.

3.4.1 Waste availability and distance from landfills

The location of a waste-to-energy conversion facility is greatly affected by transportation costs as well as environmental issues (such as odor and nuisance). Therefore, the locations of current landfills play a crucial role in planning of waste conversion plants. waste conversion facilities should be located as near as feasible to waste collecting locations. However, transfer stations with more waste capacity need to be prioritized over those with less waste availability. As seen in Figure 5(a), many buffer rings were created in this study, and grading values were given to each buffer for each landfill with varying distances. Land near landfills should be given consideration since reducing transportation costs is a top priority. Maps showing grading values according to the distance from current landfills are displayed in Table 4.

Table 2: Buffer zone areas for different exclusion criteria

Criteria	Buffer distance [m]
Rivers and other water bodies	300 [6] and [7]
Remote and urban locations	1,000 [6] and [7]
Airports and helipad	8,000 [6] and [8]
Coal Field	1,000 [6] and [9]
Industrial areas	1,000 [6, 9]
Gas and Oil field	1,000 [6] and [8]
Environmentally conservation areas (ECAs)	1,000 [6] and [8]
Natural gas and Oil pipelines	100 [6]
Park and outdoor activities	500 [6] and [8]
Roads	50 [7] and [10]
Power plants and substations	100 [6] and [11]
Electricity transmission lines	100 [11]
Land surface*	[6] and [8]
Rail Track	50 [11]
Coastline Ferry stations	1,000 [12]
Forestry	1,000 [6] and [8]
Aquifers	1,000 [6]

Remark: *Land having slopes larger than 15% is removed

Table 3: Preference factors

Sectors	Preference factors
Economic factors	Waste availability and distance from existing landfills Distance from substations Distance from transmission lines
Socio-economic factor	Distance from roads Distance from railways Land slope
Environmental factor	Distance from waterbodies

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Table 4: Value assigned based on distance from landfills

Distance from landfills (kilometers)	Grading value	Distance from landfills (kilometers)	Grading value
0-10	10	90-110	5
10-30	9	110-130	4
30-50	8	130-150	3
50-70	7	150-170	2
70-90	6	170-190	1

3.4.2 Distance from roads

In this analysis, the existing road network is used in locating waste-to-energy conversion facilities. Considering socio-economic aspects regarding odor and pollution, a restricted buffer zone of 50 meters was incorporated. A facility location beyond the buffer zone area close to the road network buffer zone area is preferable to minimize transportation costs. Grading values were applied to several buffer rings that were constructed around the roadways in a manner that increased the closer the rings were to the roads. In their studies, Sultana et al., [8] made use of the various buffer ring extents and the road grade values. Table 1 lists the different places' grading values according to how far away from roadways they are, and Figure 5(b) displays the resulting map.

3.4.3 Distance from transmission lines and substations

Current transmission lines are the greatest option since transmission prices decrease as facilities get nearer to substations. The preferred areas' distance from substations and power lines are graded according to the values shown in Table 1. To stick to national laws and customs, a 500-meter buffer zone was restricted. The grading values that are allocated to different locations according to their distance from substations are displayed in Figure 5(c).

3.4.4 Distance from Railway

Rail networks were used to determine optimal W2VA facility sites while incorporating a restricted buffer zone of 50 meters. For a facility to adhere to government regulations, it must be situated outside of this restricted area. Buffer rings were created around rail tracks based on the distance. Table 1 shows the grading value for each buffer ring on a scale from 0 to 10. Grading values increase as the distance from rail tracks decreases. Figure 5(d) presents the resultant maps for rail networks with assigned grading values.

3.4.5 Water availability

In this study, water bodies denote rivers, lakes, and other surface water sources. Surface water pollution must be taken into consideration and maintained by national standards, laws, and practices. Multiple buffer zones surrounding all types of water bodies were created using rivers and water grid data. The limited buffer zone's grading values are displayed in Figure 5(e), where the places with the lowest suitability were 100 meters and those with the highest suitability were 500 meters and beyond. Table 1 displays the grading values allocated for different zones according to their respective water generates.

3.4.6 Distance from urban areas

To minimize any unexpected consequences, waste conversion plants must be located a reasonable distance from residential areas. However, proximity to the point of waste generation will end up in cheaper transportation costs, which will have a substantial impact on the plant's sustainability. Therefore, the cost of transportation is not a direct priority but an indirect priority, considering the proximity to residential areas [13]. Urban areas were surrounded by many buffer rings, each of which was given a grading value that increased with the buffer rings' distance from urban areas. The lowest distance received the maximum grading of 10, while the greatest distance received the lowest grade of 0. Table 1 includes these grading values and the related distances. The grading values assigned to different places according to their distance from urban areas are shown in Figure 5(f).

3.4.7 Slope

Since leveling slopes incurs costs, it is crucial to locate the WTE facility in an area with a minimum slope. Sultana and Khan's research eliminated regions from their study areas that had slopes greater than 15% [8]. Areas in this study that had slopes higher than 15% were screened out of the study region by assigning a value of "0." Therefore, the value of "1" was given to locations with slopes less than 15%. The suitability of land areas according to land slopes is depicted in Figure 5(g).

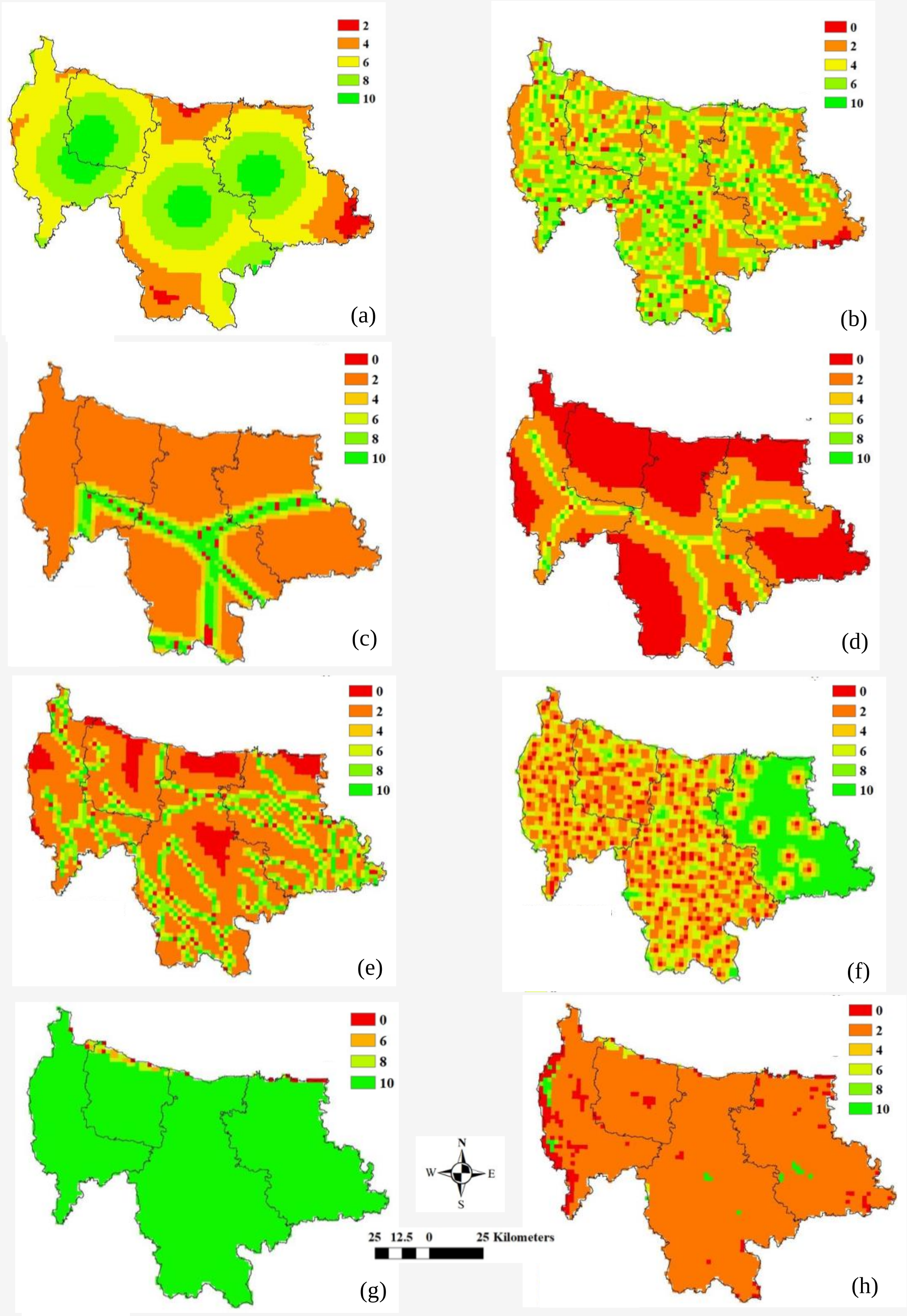

Figure 5: Grading value assigned to each factor (a) distance from landfills, (b) distance from roads, (c) distance from transmission lines and substations, (d) distance from railways (continue next page) (e) distance from waterbodies, (f) distance from urban areas, (g) slopes, (h) land cover

3.4.8 Landcover

Research by [11] was used to classify the land cover types and the grading values. Exposed lands and grasslands are preferable as those areas can go for planned development. Table 1 lists the grading values for the various land cover categories. The grading values assigned to various locations depending on land cover categories (e.g., agricultural land, forest areas, and grassland) are displayed in Figure 5(h).

3.5 Analytical Hierarchy Process (AHP)

After defining parameters for preference analysis and assigning grading values accordingly, relative weightage for nine parameters was calculated using the analytic hierarchy process (AHP). Through this method a standardized comparison scale is used to find the relative importance of the criteria. By pair comparison, each element is assigned a weight from Saaty scale [14]. The fundamental scale of relative importance is shown in Table 5. The first step is to make a hierarchal structure of the determining factors. Secondly, based on relative priority, rating of each pair criteria, is done by assigning a relative weightage between “1” (equal importance) and “9” (extremely more important). The result of the pairwise comparison on *n* criteria can be summarized in an *n* x *n* evaluation matrix A as follows:

$$A=\begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,n} \end{bmatrix} \quad a_{i,j}=1,\ a_{j,i}=1/a_{i,j},\ a_{i,j}\neq 0$$

Equation 4

Where $a_{i,j}$ is the intensity of relative importance between criteria i and criteria j and $a_{j,i}$ is the reciprocal value of $a_{i,j}$.

Then the sum of each column is calculated, and each matrix element is divided by its corresponding column sum. Finally, pairwise comparison value for each factor is divided by the average across each row to calculate the relative weightage of each factor. Table 6 depicts the pairwise comparison matrix and weights of preference factors for this case study. The final steps of the AHP are to calculate the consistency ratio (CR) and to check the consistency and credibility of the pairwise comparison. The consistency ratio (CR) is calculated using the following mathematical relation:

$$CR=\frac{CI}{RI}$$

Equation 5

Where:

RI is the random index

CI is the consistency index

The consistency index (*CI*) for the matrix is calculated using the following relation:

$$CI=\frac{\lambda_{\max}-1}{n-1}$$

Equation 6

Where λ_{max} is the maximum eigen value of the matrix and n is the order of the matrix.

Table 7 shows the value of the *RI* for matrices of the order 1 to 10 using a sample size of 500 [14]. In general, consistency ratio (*CR*) is lower than 0.10 verifies that the results of comparison are acceptable [15].

Table 5: Scale of relative importance in AHP

Definition	Relative importance	Description
Equal importance	1	The two activities contribute equally based on experiment and judgement
Moderately more important	3	One activity is slightly favored over another
Strongly important	5	One activity is strongly favored over another
Very strongly important	7	Experience and judgement strongly favor one activity
Extremely important	9	The judgement favoring one activity over another is of the highest possible order of affirmation
Intermediate values	2,4,6,8	Used when compromise is needed between two adjacent judgments
Reciprocal values	If activity *i* has one of the above non-zero numbers compared to activity *j*, then *j* has the reciprocal value	

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Table 6: Pairwise comparison matrix and weights of preference factors

Preference factors	Waste	Urban	Water	Roads	Railway	Transmission	Substation	Land cover	Slope	Relative Weightage
Waste	1	3	5	7	7	8	9	9	9	0.40
Urban	0.33	1	2	3	4	4	4	5	6	0.18
Water	0.2	0.5	1	2	2	3	3	4	5	0.12
Roads	0.14	0.33	0.5	1	1	2	2	3	3	0.07
Railway	0.14	0.25	0.5	1	1	2	2	3	3	0.07
Transmission	0.13	0.25	0.33	0.5	0.5	1	1	2	2	0.05
Substation	0.11	0.25	0.33	0.5	0.5	1	1	2	2	0.04
Land cover	0.11	0.2	0.25	0.33	0.33	0.5	0.5	1	1	0.03
Slope	0.11	0.17	0.2	0.33	0.33	0.5	0.5	1	1	0.03

Table 7: Average random index (RI) at different matrix sizes [14]

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

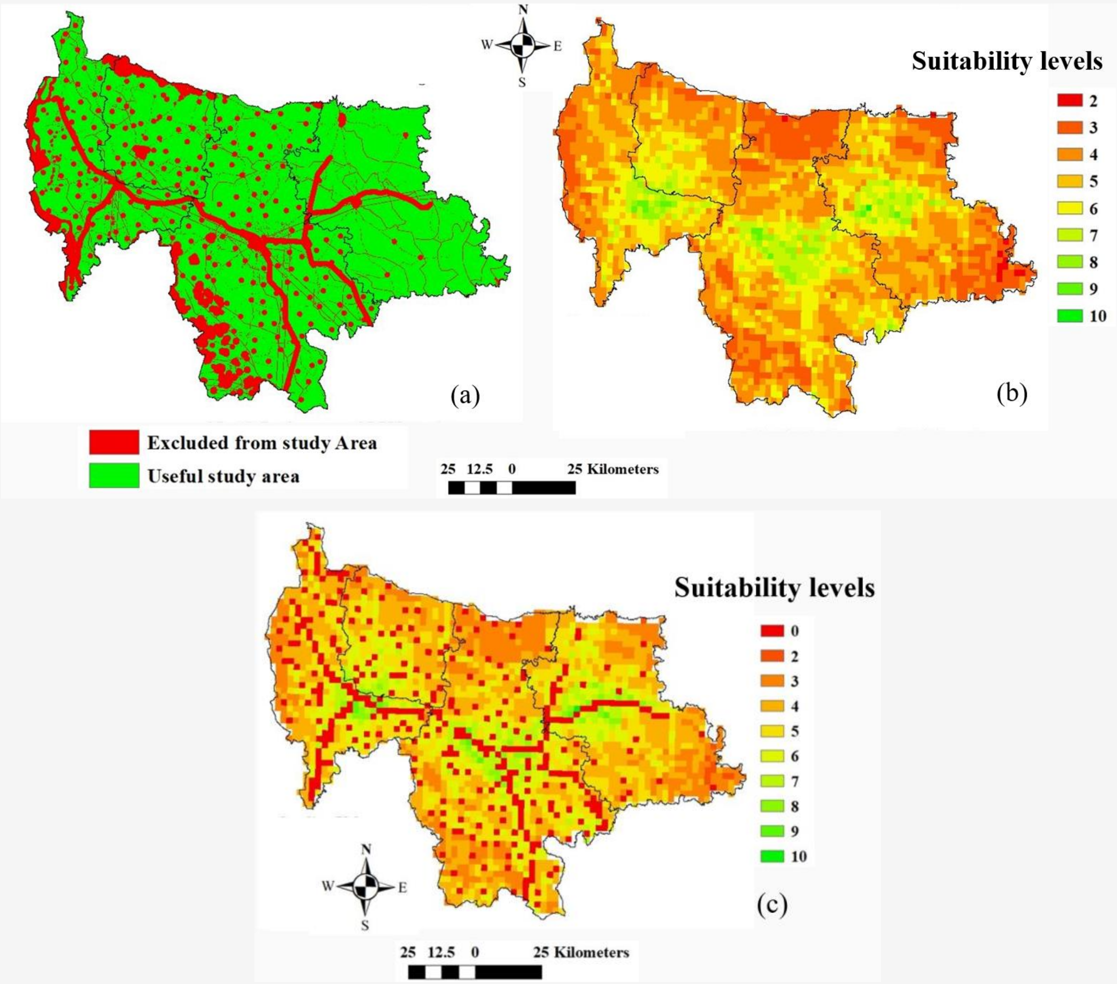

Figure 6: (a) Final exclusion analysis map, (b) Final preference analysis map (c) Final land suitability map

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Table 8: Optimum locations for the potential conversion facilities in Mymensingh division

Site	Latitude (degree)	Longitude (degree)	Suitability Index	District
1	24.8755	89.9445	9	Jamalpur
2	24.8860	90.0247	9	Jamalpur
3	24.8139	90.3221	9	Mymensingh
4	24.7779	90.3220	9	Mymensingh
5	24.7239	90.3617	9	Mymensingh
6	24.8672	90.6591	9	Netrakona
7	24.8859	90.6797	10	Netrakona
8	24.8679	90.7780	9	Netrakona

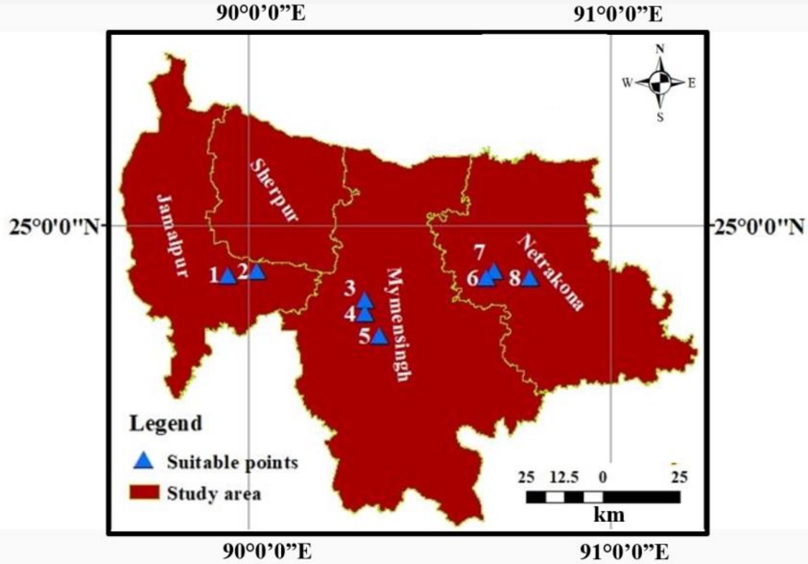

Figure 7: Optimal locations of potential conversion facilities

4. Results and Discussion

The exclusion analysis map for the Mymensingh division appears in Figure 6(a). In this study, the constraint analysis excluded 14.6% of the entire study area, decreasing it to 85.4%. Forests, ecologically vulnerable places, river bodies and industrial zones are the primary limiting elements in exclusion analysis. For each of the nine preference criteria listed in section 3, preference maps were developed, then to construct the final preference map, all the preference maps were merged using the relative weightage specified in Table 6. In the preference study, the two main criteria influencing preference are the proximity to the waste disposal place and the quantity of waste available. The final site suitability map is produced by superimposing the raster layers from the constraint and preference analysis. Figure 6(b) and Figure 6(c) show the preference and suitability analysis maps respectively. Areas with suitability indices of 10 and 9 from the suitability analysis were chosen for locating the conversion facilities. Since MSW is considered as the biomass feedstock, the suitable areas are found mostly close to the existing landfill zones. Research by [6] used an area of 10 hectares as a prerequisite to site a conversion facility. Consequently, potential sites were selected based on the centroids of polygons whose areas exceeded 10 ha. Figure 7 and Table 8 present the eight optimal potential locations for the study area. Depending on the higher population density, urbanization, forests, and rivers areas, the most suitable site with suitability index 10 (Site#7) is in Netrakona district.

5. Conclusion

The location of a new MSW conversion plant involves consideration of environmental, social, technological, and economic factors. In this study, AHP method based on Multi-dimensional Criteria Analysis (MCDA) is used to calculate relative weightage for selecting and evaluating the most suitable locations for waste-to-energy conversion facilities in Mymensingh division, Bangladesh. The evaluation of exclusion and preference criteria, as well as the relative weightage of chosen preference factors, are key aspects in the suggestions for the installation of conversion facilities as a treatment option for MSW.

To identify the optimal locations for conversion facilities, a three-step GIS spatial analysis was conducted. First, an exclusion analysis that took into consideration seventeen constraints resulted in the screening out of 14.6% of the area. Next, an AHP was applied to assess the relative weightages of nine preference factors and combine these factors into a single map. Thirdly, suitability analysis research that included the exclusion and preference studies was carried out to determine the best sites for waste conversion plants. The two most significant factors in the production of waste are population density and urbanization, and if residents of a community have a reasonable cultural understanding of waste generation and landfilling, it will be socially, environmentally, and economically feasible to invest more in this area. It is required to serve these places effectively and efficiently from several perspectives, including limiting expenses and distance travel, appropriate service time, lowering environmental pollution, and comprehensive coverage of centers, after finding the best locations for conversion facilities.

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