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Solid Waste Dumping Site Suitability Analysis for Pachmarhi Town of Madhya Pradesh using Remote Sensing and Geographical Information System

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Solid waste dumping is a serious problem in the urban areas and it is more serious if the area is situated in forest and ecologically sensitive areas such as Pachmarhi. The main objective of this study was to identify the potential areas suitable for solid waste dumping sites for Pachmarhi town and its surroundings. The main data used for this study were Liss-III Images with a spatial resolution of 23.5 m; digital elevation model (DEM) with 30m spatial resolution, and ground control point (GCP) collected by ground point survey (GPS) and topographical map of the study area. Multi criteria analysis methods along with the remote sensing techniques and geographic information system (GIS) were used to derive the results. Arc map was used to finalise the areas levelled as high, moderate, less suitable, and unsuitable regions of the study area. The results indicate that most of the area comes under unsuitable and only 4.04 % is suitable. The selected areas fall on north to east of the town where slope gradient is low, surface water bodies absent and forest degraded.

Key words: Remote sensing, Geographic Information System (GIS), Dumping site, Multi Criteria analysis, solid waste, AHP, weight overlay.

Introduction

Solid waste disposal is a global problem in the world. Increasing urbanisation and industrialisation, rapid economic growth and rise in living standards accelerate solid waste generation in the world⁴. Solid waste disposal is an important part of waste management system, which requires lots of attention to avoid environmental

and health issues. However, most solid waste disposal sites are found on the outskirts of the urban areas near water bodies, highways, crop field, settlement etc. These disposal sites are good ground for the incubation and proliferation of flies, mosquitoes, rodents and so many other disease causing pests. They transfer diseases that affect human health badly¹. Inappropriate disposal of solid waste can contaminate the natural resources of the area and can spread several communicable diseases. Therefore selection of solid waste disposal should be done very wisely and in a scientific manner. The main issue of solid waste management site is that it should be far from human habitation, natural resources and should not harm the environment of the area. Solid waste should be disposed to a place which is properly designed, constructed and safe enough.

In Pachmarhi, most of the solid wastes are collected manually and transported to temporary transfer stations, which are not planned and approved and no standard transfer stations present in the city. GIS and remote sensing data can play an important role in site selection of solid waste dumping site, and can minimize the environmental risk and human health problems by analysing many factors.

Study Area :

The Pachmarhi lies in between latitude $22^{\circ} 11'$ to $22^{\circ} 56'$ N and $77^{\circ} 47'$ to $78^{\circ} 52'$ E longitude and comes in Hoshangabad districts of Madhya Pradesh. The study area covers an area of about 153 sq. km. in south-eastern part of Pachmarhi town falling in survey of India topographical map sheet no. 57J07 on 1:50,000 scales which lies between $22^{\circ}30'0.802''$ N latitude and $78^{\circ}14'58.445''$ E longitudes.

Methodology :

The land cover of the town was analysed from the LISS-III image. The land use/cover is the natural and human landscapes, which may be exposed to the threats imposed of landfill adjacency. By reviewing the related literature, it was found that most appropriate land for waste disposal are either barren or scrubs. This type of land category is occupied by 5.69% of the total area. On the basis of land use criteria this type of land is shown in yellow colour in Fig 1.

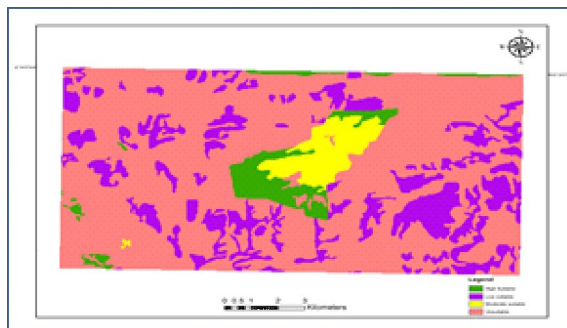


Fig 1. Reclassified Distance from Landuse land cover

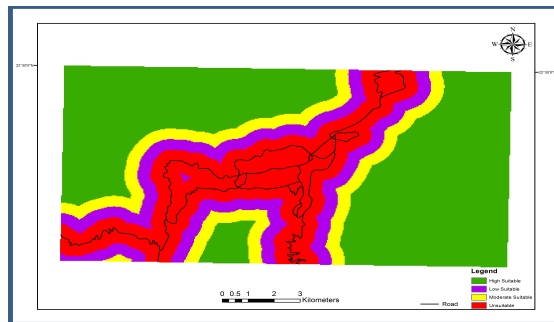


Fig 2. Reclassified Distance from Road

1. Solid waste dumping site must be located at suitable distance from roads network in order to facilitate transportation and consequently to reduce relative costs. The study preferred a buffer of 2000 m distance from main roads by referring to different sources.
2. Distance from river and other water body got more preferences for solid waste dumping site suitability. Hence, to maintain the environmental health of water sources 2000 m buffered distance ringed through straight line calculation. Accordingly, four different zones were specified considering relative distance from water bodies.
3. This study considered the lower slope as more suitable than the land with higher slope. Different research

shows that areas with high slopes will have high risk of pollution and potentially not a good site for dumping. According to Sener *et al.*¹⁰ and Leao *et al.*⁷, the land with a slope less than 10% is highly suitable for solid waste dumping. The majority of the study area falls under the slope class of 0-10%, which covers 17.08% of the total study area. The class values were given based on the level of suitability from the lowest to the most suitable area used at the time of weighted overlay.

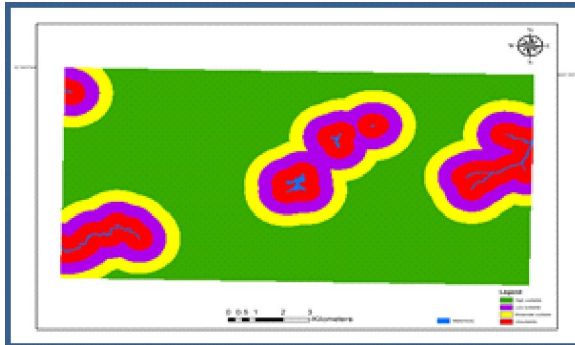


Fig 3. Reclassified Distance from River

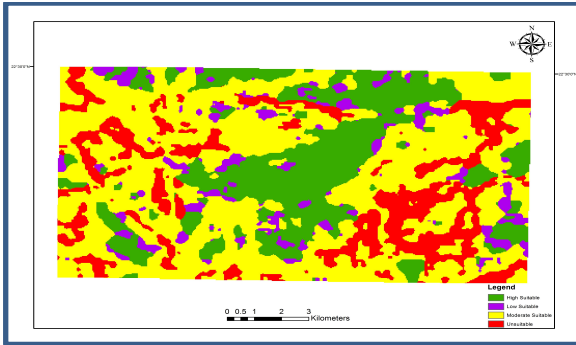


Fig 4. Reclassified Slope

4. Pachmarhi town is surrounded by many natural waterfalls, valleys, caves and temples, some of them are very important because of their historical, cultural and heritage value. These points are also very important for tourism, so the landfill cannot be located in close proximity to these sensitive areas⁵ and Babalola and Busu³.

Suitability analysis :

The site selection for solid waste disposal dumping site involves comparison of different options based on environmental, social and economic impact. Hence, based on experience and likely impact on surrounding environment, different weights were assigned to all the parameters. The larger the weight, the more important is the criterion in the overall utility. The weights were developed by providing a series of pair wise comparisons of the relative importance of factors to the suitability of pixels for the activity being evaluated. The procedure by which the weights were produced follows the logic developed by Saaty¹¹ under the Analytical Hierarchy Process (AHP). Weight rates were given based on pair wise comparison 9 point continuous scale. These pair wise comparison were then analysed to produce weights that sum to 1. The factors and their resulting weights were used as input for the multi criteria evaluation (MCE) module for weighted linear combination of overlay analysis.

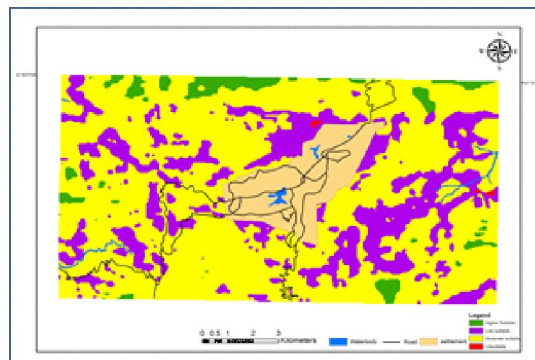


Fig 5. Final suitability Map

According to Lawal *et al.*⁸ if the consistency ratio is less than or equal to 0.1, it signifies acceptable reciprocal matrix. The consistency ratio of this study indicated that 0.07 was acceptable. In order to combine all the layers to process overlay analysis, standardization of each data set to a common scale of 1, 2, 3, 4 (value 1 = unsuitable (restricted), value 2 = less suitable, value 3 = moderately suitable, value 4 = highly suitable) was performed.

Finally, all the parameters were weighted with their respective present of influence and overlay to produce the suitability map. The factors, their values and weights are summarized in Table 1. According to the degree of importance, they have the role of selecting suitable solid waste dumping site. After the overlay analysis of the given factors the following suitable solid waste dumping site map was produced.

Results and Discussion

The final map on Fig. 4 has four colours (classes): red, violate, yellow and green. The most suitable area for solid waste dumping site is marked by green colour shaded (class 4). Out of the total area of the study site, about 4.04% (641.7 ha) fall under this category. The yellow colour represents moderate suitable area (3) and it cover an area of 0.15% (23.48 ha). The area which is shaded by violate colour covers 25.70% (4086.76 ha) representing less suitable class and the remaining 70.11% (11147.24 ha) under unsuitability class and the value is 1. The selected site areas are significantly at the optimum distance from Lake and River and from major roads. The areas were most suitable for solid waste dumping site. Similarly, Babalola and Busu³ and Al-Hanbali *et al.*² suggested that selecting the optimum site for solid waste dumping may facilitate transportation and reduce the cost of transport. Moreover, suitability, for slope analyses had shown that slope less than 10% are more suitable in order to minimize environmental impacts. The second suitable selected site is Indicted by Similar to findings of Sener *et al.*¹², the suitable area was far away from settlement and urban centre, and is covered by grass lands.

Conclusion

The findings have proved the ability of GIS and remote sensing as an actual tool for analysing the criteria for decision support. The layers Criteria taken analysis has land use, slope, water sources, and settlement, tourist areas and transport facilities as determining factor in order to find appropriate site for solid waste dumping site. The results have shown that four sites were selected as the suitable. The sites are easy to access and manage for disposal of solid wastes. These places are far away from any water sources and other variables used in the analysis. Most of them are located in north east and north west of the Pachmarhi town, bare land and grass land with 0-10% slope.

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