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Identification of suitable landfill site based on GIS in Leh, Ladakh Region

Sajad Nabi Dar · Muzafar Ahmad Wani · Shamim Ahmad Shah · Safiya Skinder

Abstract Solid waste management is emerging as a big environmental issue in the world. This has direct link with consumption and generation. The problem is more serious in urban and tourist towns where its management is done through traditional and obsolete methods. Leh town of Ladakh being a tourist town has witnessed a huge influx in tourist arrivals, which at times outnumber the local population. As a result huge amount of waste is generated in a short span of time, intensifying environmental pollution and also providing breeding ground for flies, rodents and stray dogs, which repel the aesthetic appeal of the destination. This study was carried out with the aim to ameliorate this menace by identifying optimal locations for a landfill site. The suitability of the locations were evaluated in relation to socio-economic variables employing buffering, erase and weighted overlay analysis techniques in GIS environment. The criteria were assigned weights and ranks to arrive at decision making process. The methodology successfully isolated all sensitive land uses i.e. airport, built up, plantation, agriculture, etc. by defining a desired buffer around them. Finally, seven potential sites were identified that can be considered for landfill. All of these sites have good road connectivity. Three of them have a relatively large size but being located on alluvial tracts are moderately suitable. In terms of slope and geology, only two sites can be considered. The methodology used in this study can not only be helpful in locating the appropriate sites for waste disposal but also other critical facilities in Leh town and can also be replicated in other towns in order to ensure sustainable environmental management.

Keywords Suitability · GIS · Landfill · Integrate · Solid waste · Criteria

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Introduction

Municipal solid waste management is regarded as one of the major problems for city planners, administrators and researchers, especially in developing countries (Mwanthi et al. 1997; Doan 1998; Mato 1999; Obirih-Opareh and Post 2002). Safe and reliable disposal of solid wastes is an important component of integrated waste management. However due to paucity of resources, the common method of waste disposal is

Fig. 1 Framework for spatial multi criteria analysis (developed on the simons decision-making model; Simon 1976)
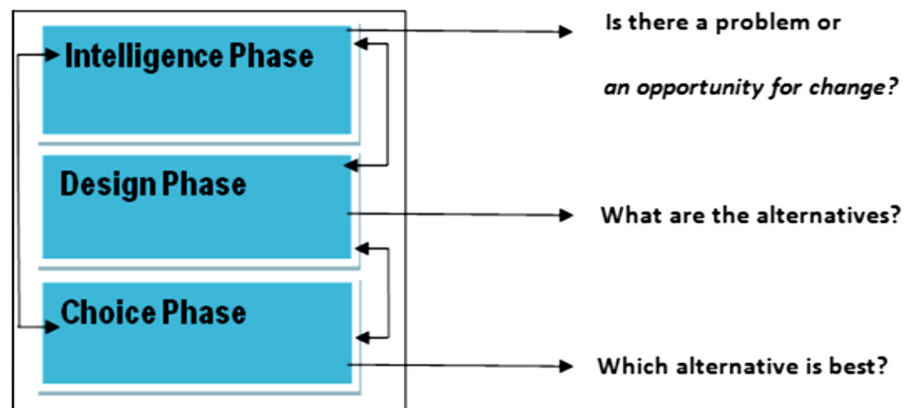
open dumping (Angels and Brú 1990; Rushbrook et al. 1999). The most common problems associated with it include; disease transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses (Basagaoglu et al. 1997; Oteng-Ababio 2011). The task of site selection for a municipal landfill or transfer station in most of the cases is a tedious task (Joyce 1990; Erkut and Moran 1991; Yitzhak and Aharon 1993; Siddiqui et al. 1996) and legislative regulations and public opposition can make landfill selection even more difficult (Furuseth and Mark 1988; Siddiqui et al. 1996). Landfill facility siting is also ecologically significant as it has a large impact on the surrounding environment (Bodhankar and Chatterjee 1994). For example, landfills have been known to contaminate drinking water wells, ground-water aquifers and nearby streams via ground leaching which could ultimately contaminate water, wetlands or fish habitat (Nagar and Mizra 2002). The problem is further compounded by shortage of land for waste disposal in urban areas (Markandya and Pearce 1991; Babyrani and Bhoyar 2003). Therefore, it is essential to dispose of the solid waste at a proper location without creating hazards to public health (Yilmaz and Atmaca 2006). The successful siting of a landfill aims at overcoming significant environmental, social, economic, political, geologic, hydrological obstacles, choosing the most suitable options available (Lane and McDonald 1993). Most spatial decisions are based on multi-criteria (Malczewski 1999) and therefore, to identify appropriate placement for a landfill site, a diverse range of criteria from the social, economic, political and ecological realms must be integrated and analyzed in a GIS environment (Kao and Lin 1996; Dikshit et al. 2000; Gbanie et al. 2013). The ultimate

aim of GIS is to support spatial decision making which has been structured into three major phases: intelligence, design and choice, based on Simons model of decision making (Simon 1976) as shown in Fig. 1. The major objective of this research paper is to identify suitable landfill sites for proper waste disposal of Leh town. The identification of an optimal site will help to ameliorate the menace of improper solid waste disposal. Therefore, in order to achieve this specific objective an attempt has been made to combine a set of diverse criteria to develop a sound base for decision making.

Significance of the study

The Ladakh region is one of the popular tourist destinations of South Asia (Shah 2013) and also one of the most fragile ecological zones of the Trans Himalayan region, vital to the sustainability of the Indian sub-continent (IPCC 2001). This region contributes large amount of perennial water supply to the Indus river system which is the main source of drinking water, irrigation, and hydropower generation, conserving biodiversity, and spectacular landscapes for tourism development (DST 2010). Besides that, from ecological point of view, it is the only breeding grounds for a rare bird species like black necked crane, outside China. Since Ladakh is primarily a tourist destination, the major environmental challenge for tourist destination development is related to improper waste disposal (Arbulu et al. 2013). The high mass consumption patterns make the destination dirty (Jain and Kuniyal 1994; WTO 2002), also discouraging future tourism development (Alegre and Cladera 2006). To tackle the waste menace, the urban local

bodies invest around 35–50% of their budget on it; hence there is an urgent need to increase efficiency for better service delivery and optimization (MoEF 2016).

The profound anthropogenic pressure has slowly begun to impact the Ladakh region negatively; manifested in the form of glacial recession, scarcity of water resources, water pollution and cloud bursts (Deen 2009). However, the most threatening and disenable pollution in the region is related with improper solid waste disposal (Alexander 2005). The solid waste management becomes very problematic during summer, because of mass tourism. The shipment of packed food items and liquids to cater the needs of tourists, local people and army personnel results in generation of large amounts of garbage in the form of plastic bottles, papers, wrappers and plastic cans. Since, the town is not equipped with proper infrastructure, machinery and manpower, the problem becomes convoluted enormously in absence of landfill and sewerage treatment system (Gondhalekara et al. 2013). As such, solid waste of both municipal origin and biomedical origin is being disposed in the common dump site without any treatment (LEDG 2008). In year 2011, the number of tourist flow increased to 179,491 which was more than population of Leh district i.e. 147,104 (Census 2011) and still the tourist numbers are continuously mounting. Thus, there is every possibility that environs and socio-economic quality of life will get severely affected on account of improper environmental planning. Besides, from academic point of view, none of the study has been carried out regarding the solid waste disposal in Trans Himalayan towns of India.

Therefore, the present study is a pioneering attempt to locate suitable areas for landfills using geospatial techniques to manage the solid waste in a sustainable manner. The methodology and results of the research are intended to help environmental scientists, tourism department, local municipality, Ladakh Autonomous Hill Development Council, environmental protection agencies, and NGOs for preparing comprehensive strategies for sustainable development in the Trans-Himalayas.
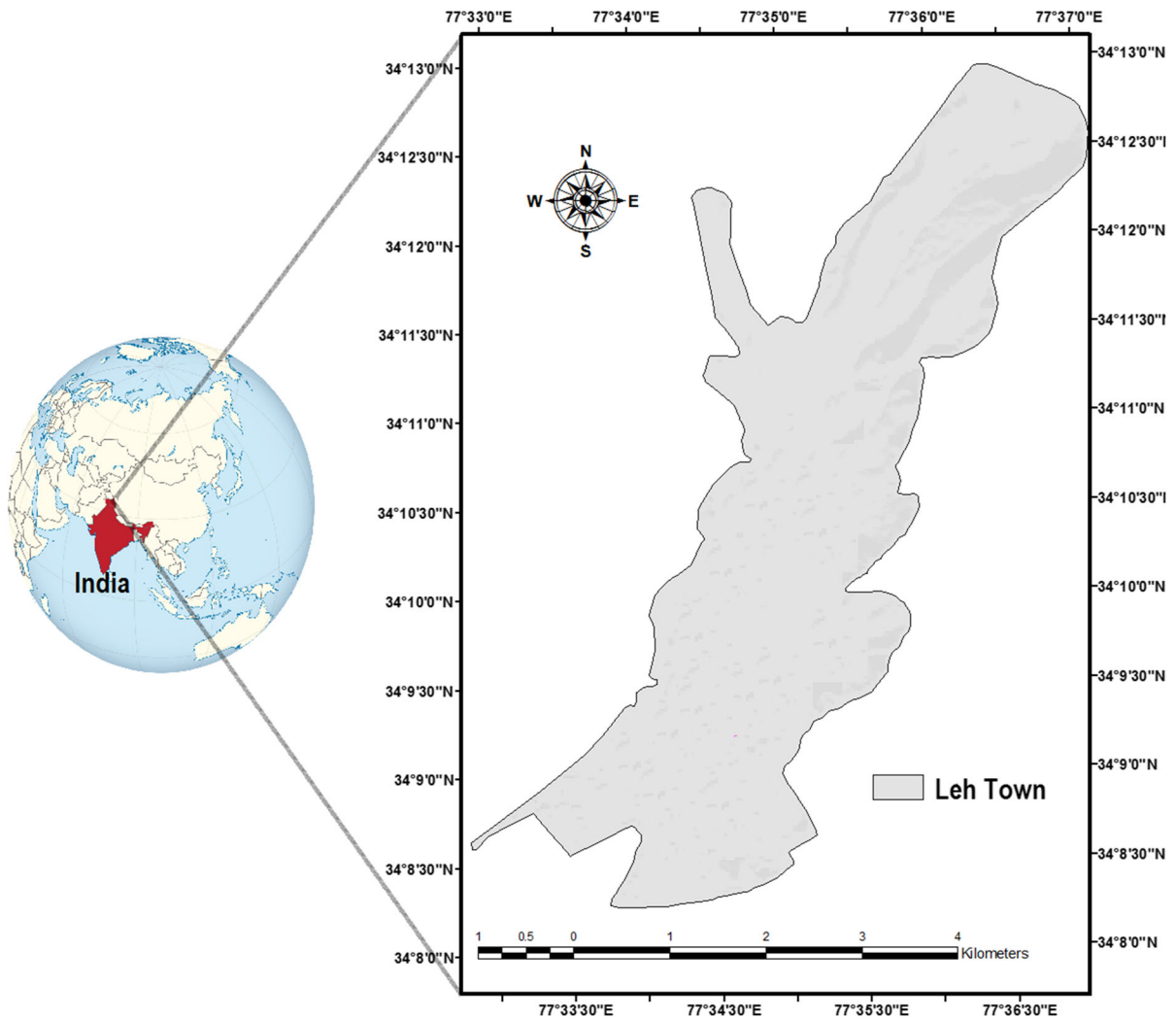
Study area

Leh town is the district headquarter of Leh district of Ladakh division of Jammu and Kashmir, located in north of the Greater Himalayan Range called Trans-Himalayas (Fig. 2). The town is located at an altitude of 3500 meters ASL (LAHDC 2010). The total population of Leh town as per 2011 census is 30,800 comprising of 4377 households (Table 1). Moreover the population of the town swells many folds with inflow of tourists and migrant works during summer (Alexander 2005). Table 1 also shows that annual solid waste generation from all sources is about 4716.62 metric tons, with a per capita waste generation of 0.41 kilograms/day. The region is basically a cold desert (Hussian 2000; Shah 2013) therefore, even basic economic activity like agriculture has not flourished properly (Sagwal 1991). However, over the years, tourism has been gaining grounds and opening new vistas for Ladakh (Alexander 2005). Tourism industry is predominantly concentrated in Leh town. The region is also a source of some of the subcontinent's major rivers like the Indus river system. Therefore, environmental management in this region is of vital significance for the sustainable development of the Indian subcontinent.

Identification of the problem

The daily generated solid waste from different sources of the town is dumped in the nearby dump site which has piled up in heaps as depicted in Fig. 3. This dumping site has been selected randomly without taking any environmental and socio-economic factors into consideration. The open dumping has been linked to many harmful health effects, including skin and eye infections, respiratory problems, vector-borne diseases such as diarrhea, dysentery, typhoid, hepatitis, cholera, malaria and exposure to heavy-metal poisoning (UNEP 2011). The town has only one dumpsite which is shown in Fig. 3. It has been in use over a decade. As per the MoEF norms, the dump site is highly lethal, not only in terms of crude dumping method but also from an environmental and socio economic perspective. The distance between airport and existing dump site (locally called Bamgard) is only 2 km (Fig. 3), which is a clear indication that the dump site is very lethal. Moreover, as per the Solid Waste Management and Handling Rules (2000), the distance between airbase/airport and dump site should be minimum 10 km. The reasons being that dump sites attract birds, increasing the chances of Bird Aircraft Strike Hazard and more often a fire in dump site produces a lot of smoke which becomes dangerous for

Fig. 2 Location map of study area

Table 1 Magnitude of solid waste generation in Leh Town. *Source*: Wani (2017) Unpublished Ph.D. Thesis, Department of Geography and Regional Development, University of Kashmir

Number of households	4377
Total population	30,870
Per capita waste generation	0.41 kg/day
Annual waste generation	4716.62 metric tons

aircraft landing and take-off (Sodhi 2002; Gard et al. 2007).

There are three types of waste collection points in Leh town as shown in Table 2 and Fig. 4. The Leh town has 15 dumper bins which can be directly transported on a vehicle such as a dumper placer equipped with a hoisting mechanism. Such bins are located at places where huge quantities of solid waste are generated, viz. near hotels, shopping complexes and main market. They can hold two metric tons of solid waste. The other types are small plastic dustbins and their number is only 7 which are located along the main road in Skazagling, Sanker, Shakynos, etc. These small bins can hold up to 200 kilograms of solid waste. The third category is constituted by illegal open dumping which attracts stray animals and dogs. They create a lot of nuisance during peak tourist season.

Fig. 3 Dump site and surrounding environment, Leh Town. *Source*: Field survey 2017

Table 2 Solid waste collection points in Leh Town. *Source*: Field survey 2018

Collection point type	Number
Dumper bin/garbage bin	15
Small dust bin	7
Open dump	40
Total	62

Data base and methodology

The study is undertaken to understand the solid waste disposal system in Trans Himalayan cold desert urban center, in order to explore the alternatives and opportunities to achieve higher level of environmental sustainability. The data has been collected using a variety of methods to gain a better understanding of the situation, issues, challenges, perspectives, priorities, opportunities and alternatives. The present study is based on both primary and secondary data. The base map of Leh town was developed from the ward map supplied by Leh municipality. The ward map was geo-referenced with survey of India topo-sheet of year 1971, bearing number 52 F/12 in Esri's ArcGIS 9.2.1 software. These base maps were updated with Carto-Sat-1 data (2015) of 2 m spatial resolution to generate thematic layers like road and drainage. Geology map was developed form the data of geological survey of India of 1969 of scale 1:2,250,000. Carto DEM of 30

meters spatial resolution was used for deriving different thematic map layers like slope and elevation. IRS LISS-III P6 (August 2016) data was used for generating existing land use of the study area. Lineaments were also identified from the IRS LISS III L6 (August 2016) and Carto-DEM (2013). Besides that GPS survey was carried out to determine the spatial location of dust bins, collection points, and dumping sites. The criterion for landfill suitability is based on Municipal Solid Waste Management and Handling Rules (2000, 2016) and other cutting edge research works as mentioned in Table 3. Various spatial analysis techniques of ArcGIS 9.3 software like buffering, erase, merge have been used as shown in Fig. 5, to develop the constraint or binary maps to distinguish between lands that are suitable for landfill siting and those lands that are restricted. Besides that weighted overlay analysis has been used to locate optimal areas for landfill to enhance the environmental sustainability of the region.

Results and discussion

Distance from road network

There are many suggested buffer zone distances between the road network and landfill site, with a primary focus on avoiding visual impact and other nuisances. According to Cantwell (1999), all roads including primary, secondary and regional roads
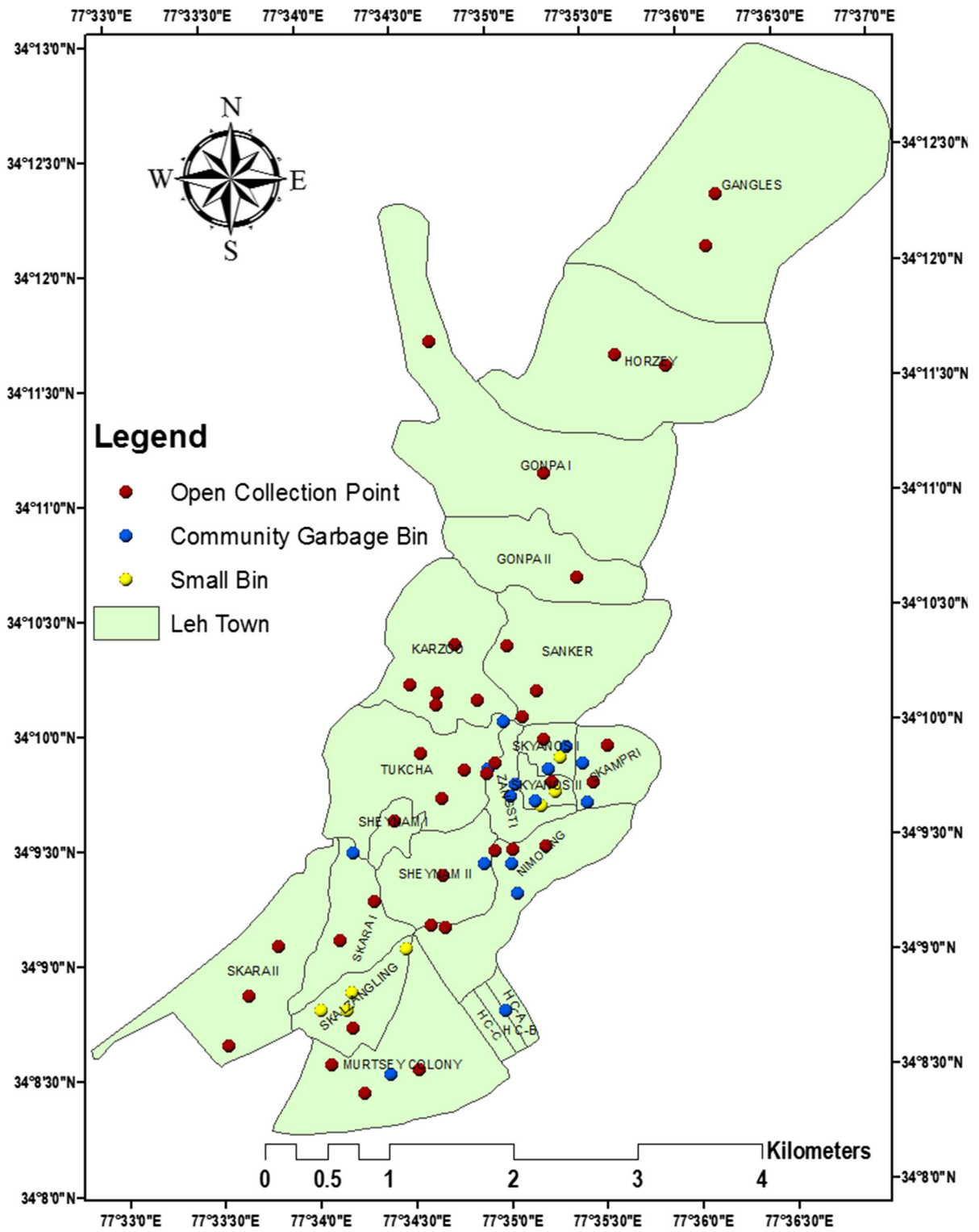
Fig. 4 Distribution of collection points in Leh Town

Table 3 Criterion for selection of suitable landfill site for municipal waste dumping in Leh Town. *Source*: Wani (2017) Unpublished Ph.D. Thesis, Department of Geography and Regional Development, University of Kashmir

S. no.	Criteria/layer	Preferred distance/attributes	References
1	River/water body	500 m	MoEF (2000, 2016)
2	Road network	500 m	MoEF (2000, 2016)
3	Airbase/airport	20 km	MoEF (2000, 2016)
4	Buildup	1 km	Suman (2012)
5	Agriculture	500 m	Suman (2012)
6	Plantation	500 m	MoEF (2000, 2016)
7	Snow/glacier	2 km	MoEF (2000, 2016)
8	Lineament	500 m	Thirukumaran (2011)
9	Rural Settlement	3 km	Unkapis (2004)
10	Geology	Porosity should be minimum	Mutlutu (2007) and Oyediran and Adeyemi (2011)
11	Slope	Land should have gentle slope	Saaty and Vargas (1991) and Akbari et al. (2008)

should be avoided and have a buffer of at least 30 meters on each side. However, as per the Municipal Solid Wastes Management and Handling Rules (2000, 2016), at least 500 m buffer should be created around the high ways, since the town is primarily tourist town. Therefore, to avoid the aesthetic pollution on account of improper waste disposal a 500 m buffer has been created around all types of roads as shown in part 1 of Fig. 6. However, on the other hand, the landfill site should not be placed too far away from existing road networks which would increase the cost of landfill by constructing new road connectivity (Lin and Kao 1999).

Built up area

The built-up areas particularly in urban centers, apart from residential areas, are occupied by official buildings, commercial institutions like schools, hotels, market areas, hospitals and other facilities. Landfill site provides congenital environment for disease vectors like rodents, flies, mosquitoes, or other animals and insects capable of transmitting disease to humans (Dasgpta 2014). EPA (2003) recommends at least 500 meters from an urban residential or commercial area. Therefore, for the sustainable development of the urban center, at least 1 km buffer has been developed around built up areas to prevent them from the lethal impacts as shown in part 2 of Fig. 6. The other researchers like (Mahamid and Thawaba

2010; Suman 2012) have also used such type of constraint mapping while searching for the suitable land for waste dumping.

Distance from plantation area

Vegetation is extremely sparse in Ladakh except along the course of streams and irrigated places. The average annual rainfall is less than 20 cm, and short growing season has resulted into xerophytic vegetation (Hussian 2000). Generally in entire Ladakh there is a deficiency of oxygen, which causes High Altitude Pulmonary Edema, Breathlessness, Chest pain, etc. (Thinles 2010). However, plantation including social forestry, apple and apricot orchards has been developed over the areas where irrigation is possible. Plantation cover plays an important role in ecological balance of the region and also provides fire wood to locals. Therefore, an effort has been made to develop a 500 m buffer distance around plantation areas from the landfill site in order to protect them from destruction and damage as shown in part 3 of Fig. 6.

Distance from agriculture area

Agriculture is the backbone of the Ladakhi economy as it engages about 58.48% work force (Risbud et al. 2012). Besides that, animal rearing is also an important segment of Ladakhi economy. The main crops grown in Ladakh are gram, barley, wheat and
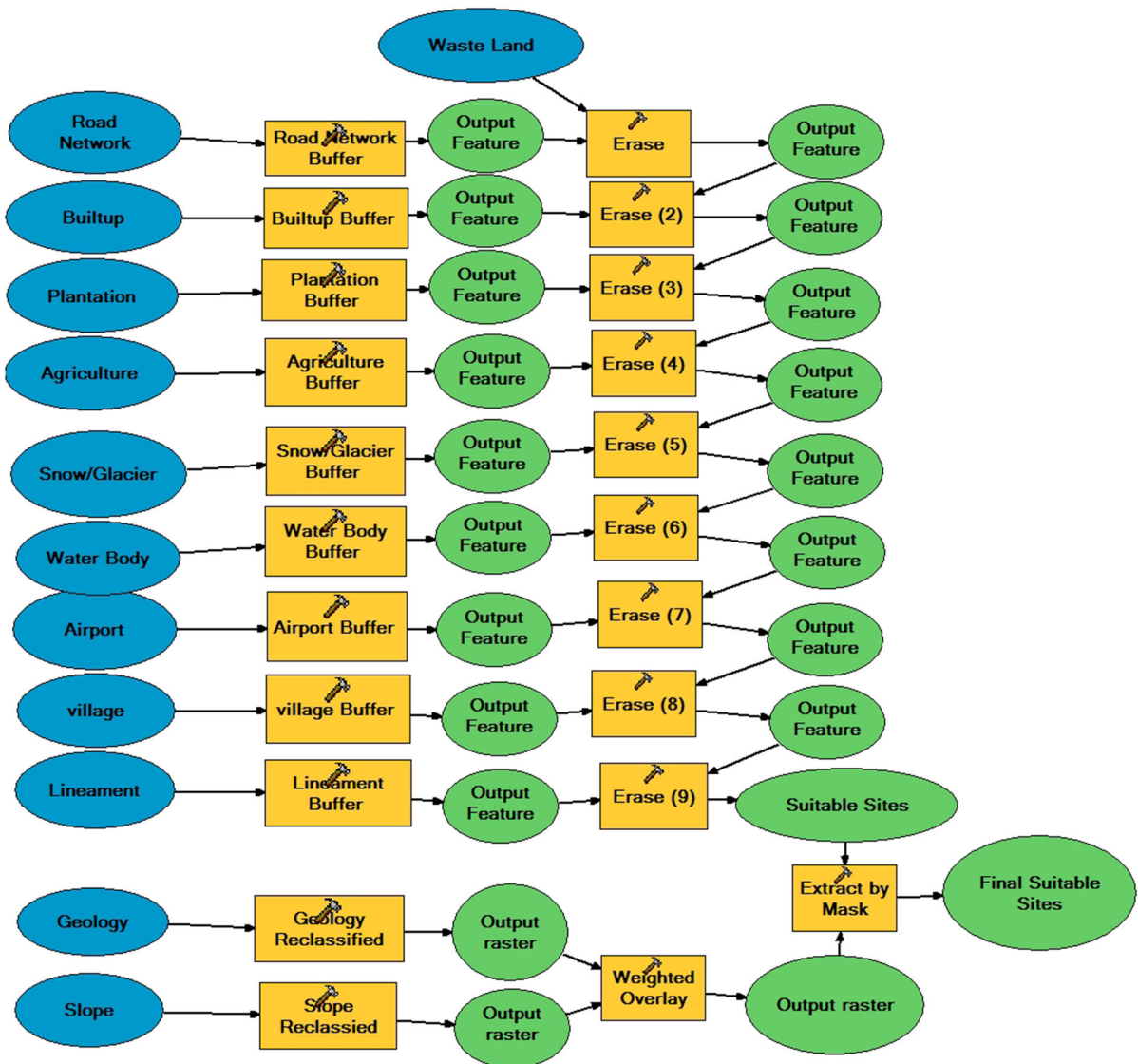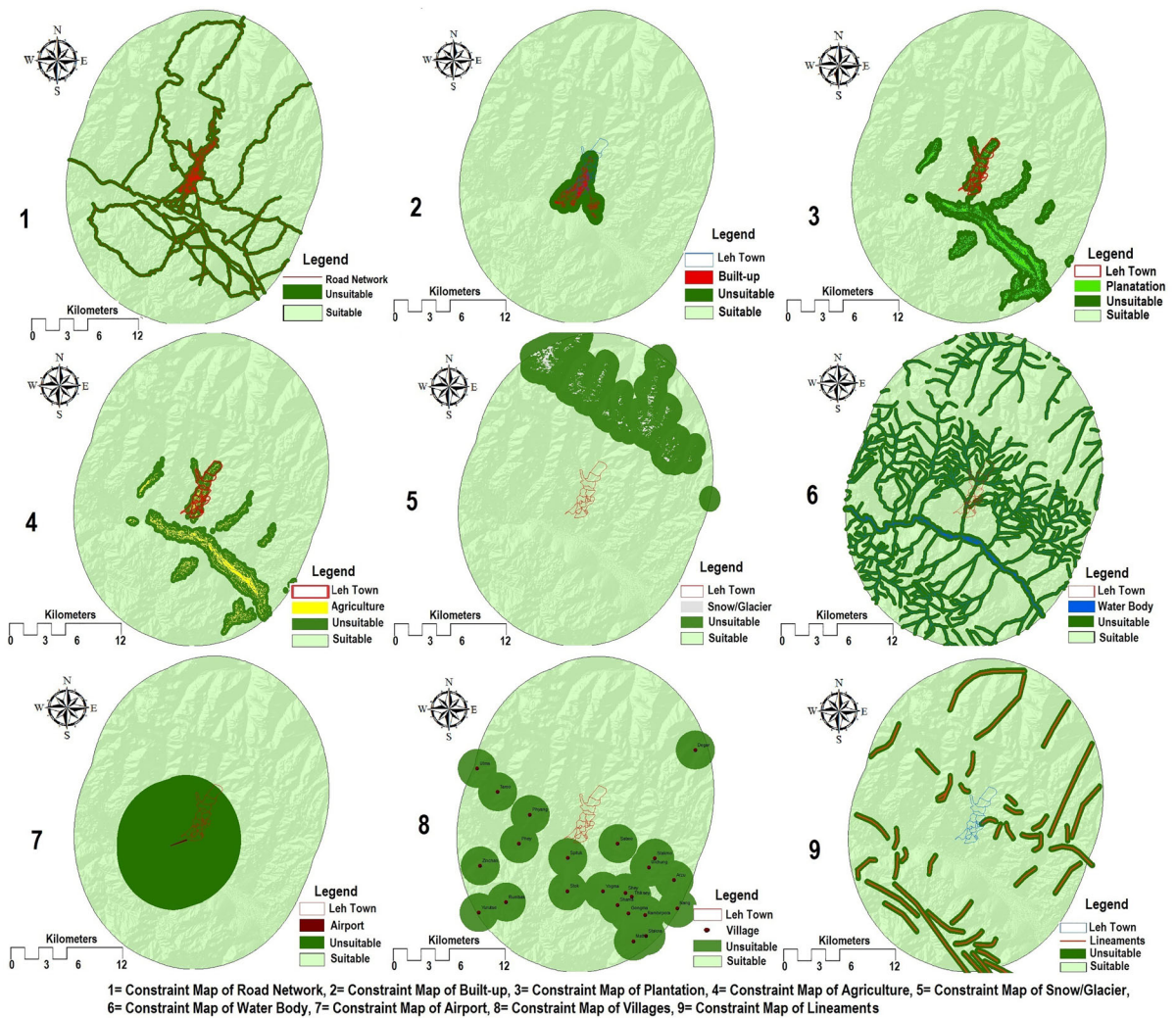
Fig. 5 Procedure for identifying suitable landfill site for solid waste disposal in Leh

vegetables. Since the area is actually a cold desert and agriculture is very limited because of harsh topography and climate, therefore an effort has been made to prevent agricultural land by developing a 500 meters buffer distance between agriculture land and landfill site as shown in part 4 of Fig. 6. Such a buffer distance has also been used by Suman (2012) while delineating suitable landfill site for Nawadweep municipality in west Bengal.

Distance from snow/glacier

It is estimated that melt-water from glaciers and snowpack sustains approximately one-sixth of the world's population. Glacier-dependent cities over the years have become victim of severe anthropogenic pressure (Eriksson et al. 2009). Leh town relies on streams originating from the snow melt of the Khardungla glacier (Norphel 2009) and the demand for the water has been increasing as a result of rapid urbanization, tourism development and population growth (Deen 2009). About 90% of the farmers in Ladakh depend on

1= Constraint Map of Road Network, 2= Constraint Map of Built-up, 3= Constraint Map of Plantation, 4= Constraint Map of Agriculture, 5= Constraint Map of Snow/Glacier, 6= Constraint Map of Water Body, 7= Constraint Map of Airport, 8= Constraint Map of Villages, 9= Constraint Map of Lineaments

Fig. 6 Constraint map of selected variables

snow melt and glacial waters for drinking, agriculture, domestication of animals and construction purposes (Avard 2013). Owing to the importance of glacier and snow fields in the region, about 2 km buffer has been developed to avoid the chances of landfill in their vicinity with an expectation to prevent these sensitive areas as shown in part 5 of Fig. 6. It has been observed that landfills release enormous quantity of CH_4 into the atmosphere which promotes global warming.

Distance from surface water streams

According to the Municipal Solid Wastes Management and Handling Rules (2000, 2016), water bodies should be prevented from impacts of waste pollution.

Since, 90% of farmers in Ladakh depend on stream water for agriculture. Therefore dump site in the vicinity of water source can potentially damage water quality and produce lethal effects on the environment and ecology. Therefore, landfill sites should not be placed near any surface water; as such 500 m buffer zone has been created around water bodies to ensure the proper protection of water bodies as depicted in part 6 of Fig. 6.

Distance from air base/airport

Landfills can attract birds seeking food or nesting sites, therefore, landfills that are located near an airport may pose a risk of collisions between birds and aircraft.

Looking at this problem, the Municipal Solid Wastes Management and Handling Rules (2000, 2016) made it mandatory that the distance between landfill site and airbase/airport should be 20 km; the reason is that dump site attracts birds, there by increases the chances of Bird Aircraft Strike Hazard. Besides that more often fire in dump site produce a lot smoke which becomes a danger for air service (Sodhi 2002; Gard et al. 2007). Ladakh has 310 different bird species both resident and migratory (Pfister 2004). Some even them are rare bird species like black necked crane the state bird of Jammu Kashmir state found only in Ladakh outside china. Number of air flights is also increasing because of the booming tourist industry in the region. Additionally, Leh airbases are very important from the strategic point of view, therefore for safety purposes about 20 km buffer zones have been developed around airport/airbase present in the town as shown in part 7 of Fig. 6.

Distance from the village

Landfills should not be placed too close to rural settlements because it enhances conflicts relating to the *Not in My Back Yard* (NIMBY) syndrome (Alfy et al. 2010). Landfill located close to the rural settlement gives birth to the problems like diseases, noise complaints, odour complaints, decreased property values and mischief due to scavenging animals. In Srinagar city there have been reports of violent protests by local villagers residing around the existing dumpsite (Achan) for its closure, whose life has been put at risk (Shah and Wani 2014). Therefore, for the safeguard of the villages located in periphery of the town, about 3 Kilometer buffer have been developed around them to avoid the impacts landfill as shown in part 8 of Fig. 6.

Distance from lineaments

A lineament is a linear or slightly curved feature in a landscape which is a manifestation of the underlying geological structure such as a fault and presence of ground water reserves (Gemitzi et al. 2007) Therefore, areas with high lineament density may have important groundwater prospects even in hilly regions which actually have meager groundwater prospects (Thirukumaran 2011). Lineaments are geologically very important as they provide the pathways for

groundwater movement (Sankar 2002). Therefore, a landfill situated in such area can trigger ground water contamination through leachate percolation (Lee 2003; Sener et al. 2005). Therefore, for the safe guard of ground water reserves, landfill site should be kept about 500 m away from lineaments to avoid environmental damages.

Output of restriction criteria using buffering and erase techniques

Some areas have been identified which can be used for developing landfill sites for solid waste disposal in Leh as shown in Fig. 7. However some portion is either too steep or geologically sensitive, by virtue of which can't be considered for landfill sites. Therefore in order to locate the potential sites for landfill weighted overlay analysis was employed for the suitability analysis.

Suitability analysis for landfill selection for Leh Town

Weighted overlay is one of the commonly used methods of suitability analysis (Saaty 1980). It is an effective method for dealing with complex decision making and aid the decision maker to set priorities and make the best decision based on multi criteria. As shown in Table 4 and Fig. 8 the two input raster's have been reclassified to a common measurement scale of 1–9 to represent the suitability. Each raster is assigned a percentage influence on the basis of their relative importance for landfill site selection. The cell values are multiplied by their percentage influence, and the results are added together to create the output raster. The problem under consideration is divided into understandable parts; each of these parts is analyzed separately and integrated in a logical manner (Saaty 1980; Malczewski 1997). It is a powerful and comprehensive methodology designed to facilitate sound decision making by using both empirical data as well as subjective judgments of the decision maker. Following formula is using to identify the potential landfill sites which are viable from slope and as well as geological point of view.

Suitability Index $= \Sigma W_i \times X_i$

where *wi* is the weight of each criterion, and *xi* is the standardized score (1–9) of each criterion.
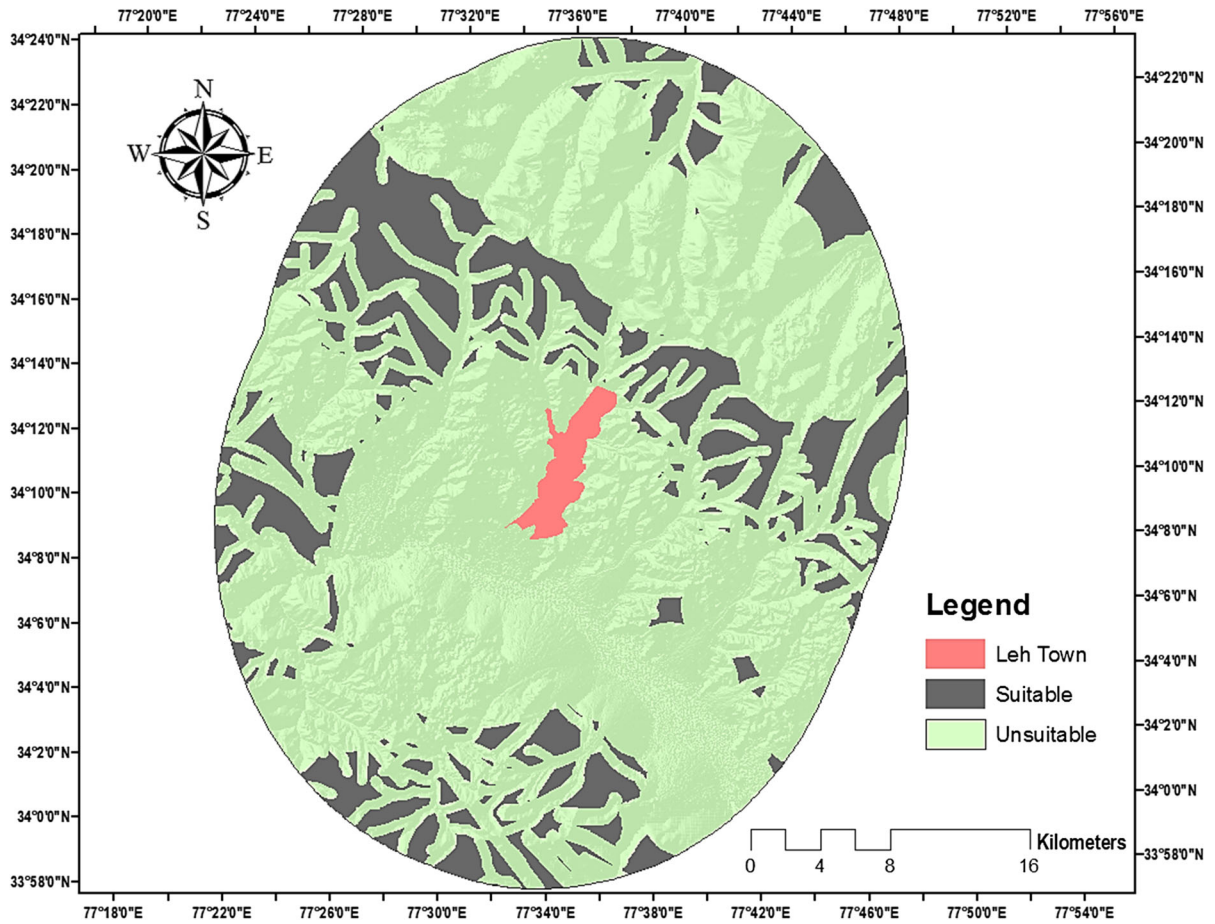
**Fig. 7** Areas identified for selecting landfill sites in Leh Town

Table 4 Rankings and weights used in landfill site selection for Leh Town. *Source*: Based on comparison scale of Saaty (1980) and Malczewski (1997)

Criteria	Sub-criteria	Suitability score	Weight-age in %
Slope (in degrees)	0–18	9	60
	18–36	7	
	36–54	5	
	54–72	3	
	72–90	1	
Geology	Eocene	7	40
	Carboniferous	5	
	Cretaceous	3	
	Alluviums	1	

Table 4 shows that the sub criterion which scores 9 is highly suitable and 1 represents very unsuitable for consideration of landfill selection. In both cases, slope has been given more emphasis than geology because the area has highly rugged topography and flat land is rarely available.

Slope and landfill site

The slope is one of the most fundamental factors for the construction of landfill site. The areas with steep slopes can result in extra costs for the embankment and excavation. The higher the value of the slope, the
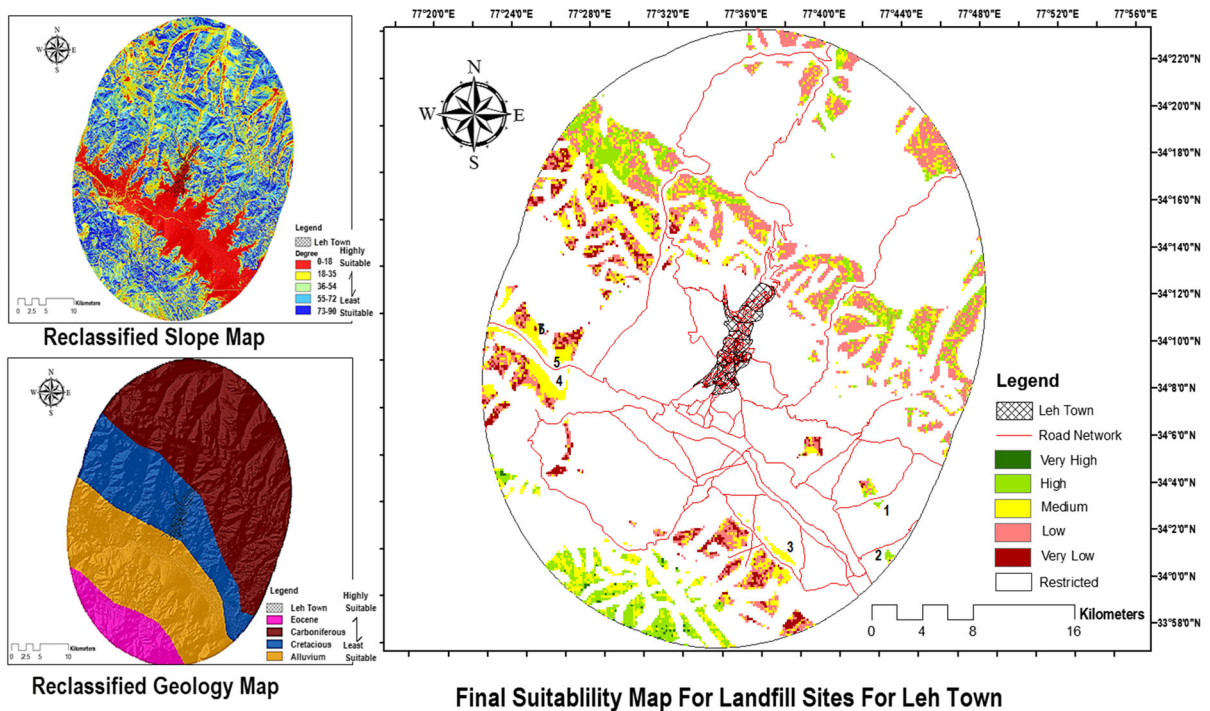
Fig. 8 Final suitability map for Landfill in Leh Town

lower is the suitability score and vice versa. High slopes can favor leachate percolation to the lower areas and can result in ground water contamination. However, areas whose slope is greater than 20% are not suitable to be selected as landfills (Saaty and Vargas 1991; Akbari et al. 2008).

Geology and landfill site

While identifying a site for landfill, primary focus should be on the protection of groundwater which is an important resource particularly in a cold desert like Ladakh. As reported by Dolma et al. (2015) the ground water of Ladakh region is at risk on account of rapid anthropogenic pressure. The porosity of rocks is significant factor which decides the water percolation (Daniel 1987). Therefore, landfills in the area with high porosity results into rapid ground and surface water contamination. Therefore, the rocks which have low porosity are highly suitable for the landfill site than the rocks which have higher porosity. Eocene rocks have least porosity (Mutlutu 2007), also the areas with granite rocks are very suitable for the location of a landfill because it has less porosity and is not chemically active (Oyediran and Adeyemi 2011).

Likewise Carboniferous rocks have a tight crystalline structure which have a low porosity and are relatively impervious to water (British Geological Survey 2004). Similarly Triassic and Jurassic rocks can be considered for the landfill site because they are hard and have less porosity which allows less percolation of water (NHT 2012). However possibility of aquifer occurrence is high in alluvial areas because they allow rapid ground water recharge through larger permeability of sediments (Jacobson and Evans 1981). Therefore, such type of areas can't be considered for landfill site.

Final suitable sites for land filling

In the choice phase, each alternative is evaluated and analyzed in relation to others in terms of suitability scores. Among the areas identified for landfill on the basis of buffering and erase techniques and through weighted overlay analysis techniques, about seven potential sites can be considered for landfill for the town as they have good road connectivity as shown in Fig. 8. The area of site 1, 2 and 3 is 8, 13 and 20 Kanals, respectively. However site 4, 5 and 6 are relatively larger in size. Keeping in view the slope and geology, only site 1 and site 2 can be recommended for

the landfill. However, site 3, 4, 5 and 6 being located on alluvial tracts are moderately suitable.

Conclusion

The socio-economic and environmental problems associated with the improper solid waste disposal sites are complex because of the quantity and diverse nature of the wastes. Therefore, solid waste should be managed by modern technologies and methods that ensure the long term sustainability of environment. In mountainous areas solid waste is haphazardly dumped in unsuitable locations which pose a lot of environmental and socio-economic threats. However, site selection for proper solid waste disposal particularly in mountainous regions is very difficult and expensive. Therefore, GIS and remote sensing techniques are proving very powerful tools for these kinds of studies due to its ability to manage large volume of spatial and non-Spatial data from diverse sources. In the present study, both spatial and non-spatial data were integrated for identifying a suitable landfill site for sustainable solid waste disposal. Landfill sites were determined through series of analysis of data layers in GIS environment. In all eleven criteria such as water body, airport, plantation, agriculture land, snowfield, built-up, villages, road network, lineament, slope and geology were evaluated in relation to set criterion for landfill suitability. The methodology used was successful in isolating all sensitive land uses i.e. airport, built up, plantation, agriculture etc. by defining a desired buffer around them. The study has successfully identified seven potential dumpsites in Leh town. The sites determined as suitable for landfill were confirmed with ground verification. The proposed sites will replace the existing unplanned waste disposal sites and protect the fragile environment of the area. The methodology used in the present study can replica for other mountainous urban areas for managing the waste in a more scientific way. The outcome of this research work shall act as an input to government and other implementing agencies for quick decision making for prioritizing actions related to solid waste management.

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