
بسم الله الرحمن الرحيم

IQRA National University

Faculty of Engineering

Department of Civil Engineering

LANDFILL SITE SELECTION BY USING GIS OF PESHAWAR CITY/PAKISTAN

Prepared by

Habib Ullah

ID = 7716

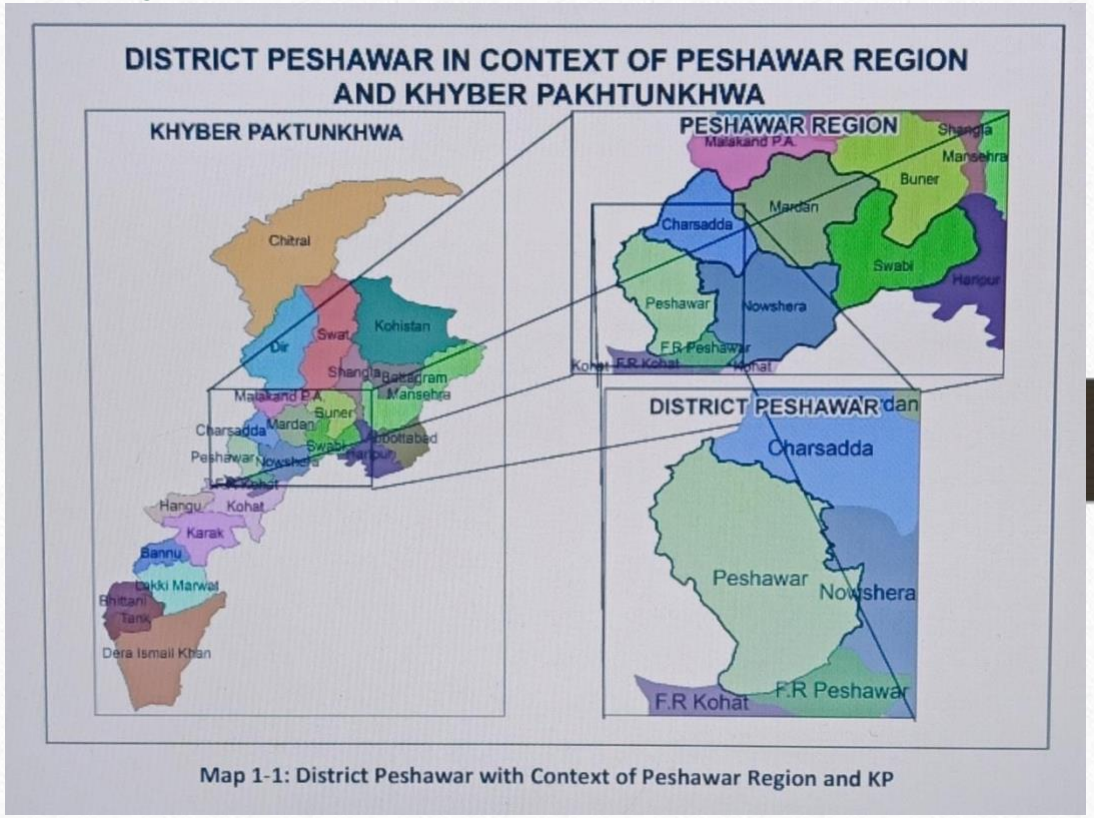
Semester = 8th

Section = "C"

Peshawar city

Peshawar is a city in the north of

Pakistan. Latitudes and longitude (34.0151° N, 71.5249° E"). The study area has a surface area of 215 km2. The population of Peshawar City is 1.97 million number of people.



Map 1-1: District Peshawar with Context of Peshawar Region and KP

Statement of the Problem

As a consequence of population growth and development activities, high amounts of household and municipal solid wastes are generated. The population of a Peshawar city is growing due to both natural increase and through immigration of people from rural areas to city.

The current waste disposal system of the city is open dump system and the site is filled out, causing many dangerous problems to the agricultural lands quality residents, and also to health.

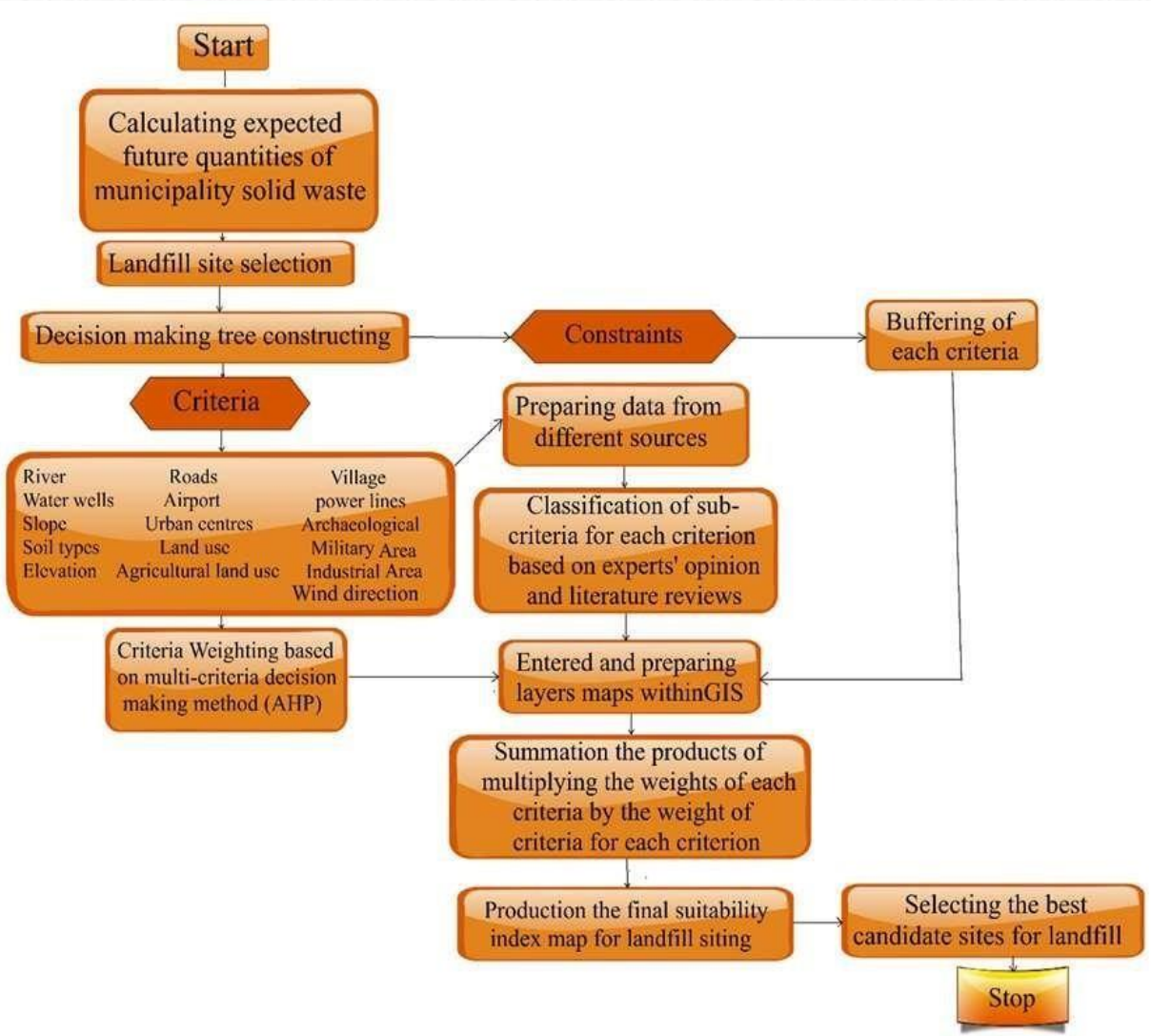
Scope of the Study

Presently, there are no landfill site in Peshawar City that follows the scientific and environmental criteria which are usually applied in the selection of landfill sites. There are irregular waste disposal sites or dumping sites which are distributed throughout the cities of the Governorate. These sites caused many environmental problems in those areas. The main aim of this research is to select the best landfill sites in Peshawar city that conform to international and environmental criteria. To achieve this goal important criterion that can affect the environment were considered. Then, GIS technique and

multicriteria decision-making method (AHP) were used to define the best suitable sites.

Methodology

To evaluate study area for selection of a suitable landfill site, the analytical hierarchy process (AHP) together with GIS with its special analysis tools, were used to prepare maps layered according to sixteen criteria. Analytical hierarchy process (AHP) is a widely used approach for obtaining preferences or weights of importance regarding to the criteria and alternatives for a variety of research fields. The main advantages of this method are the possibility to use qualitative and quantitative criteria. The AHP is simple and fast understandable methods for people who are not



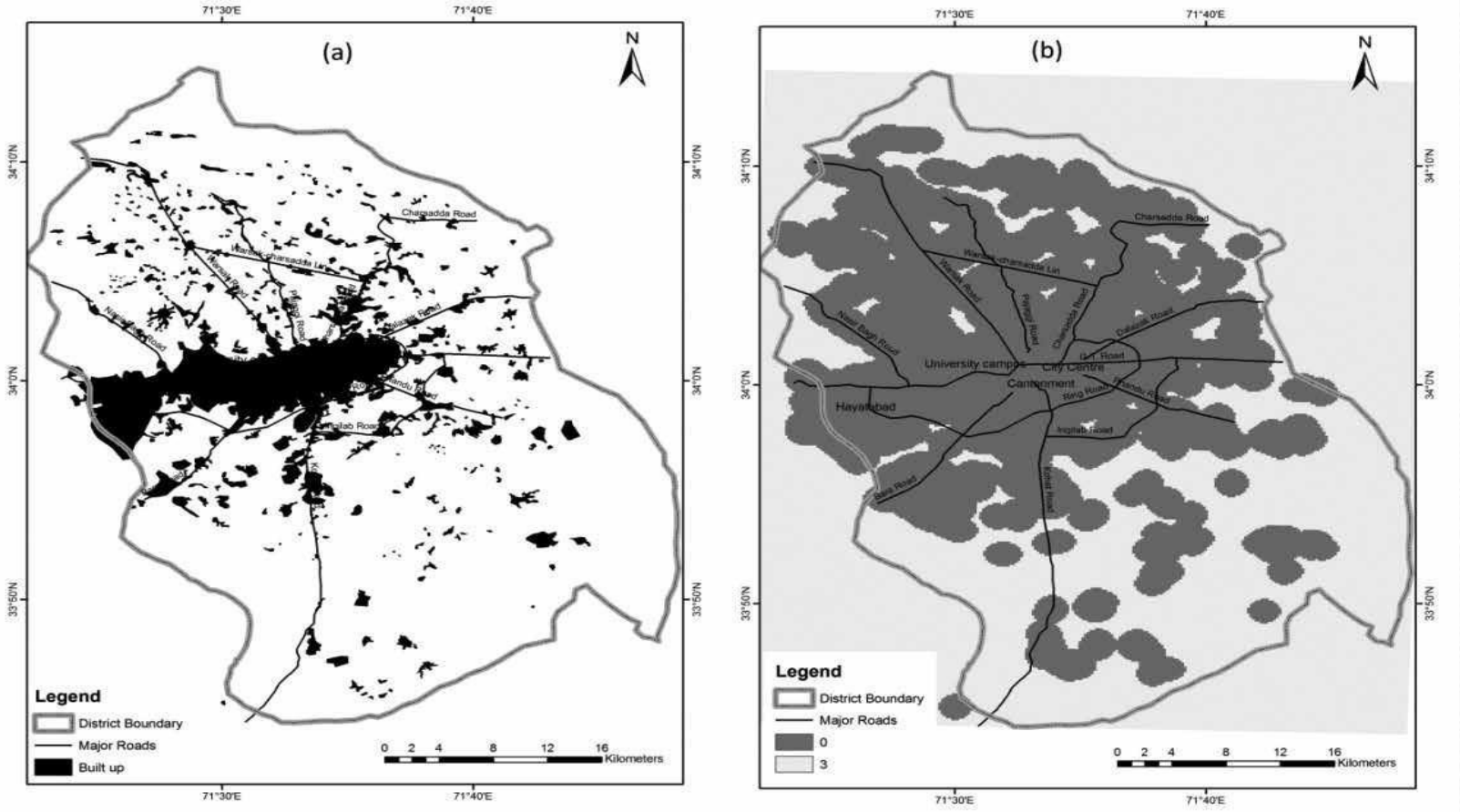
familiar with the multi-criteria decision support methods.

Figure 2. Flowchart of model for landfill sitting

Decision-Making Tree for Landfill siting

Figure 3. 2: Tree diagram of the decision process developed for selection of suitable landfill site

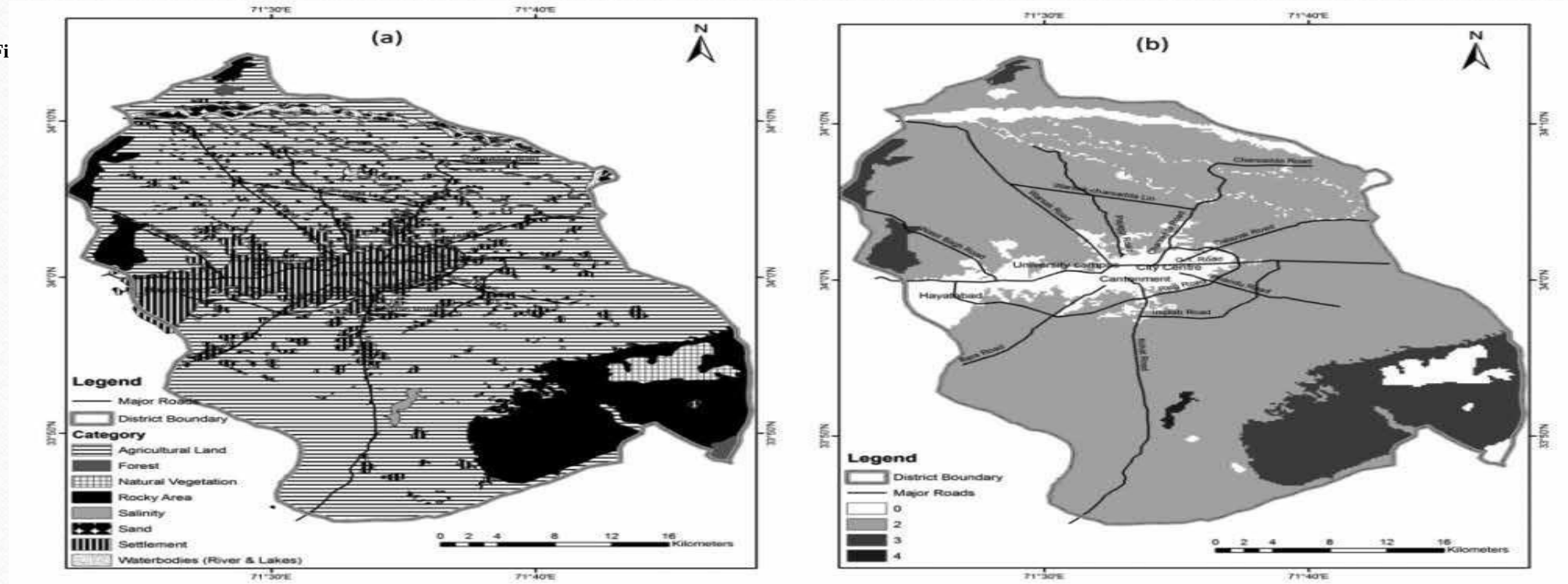
Sub-Criteria Weights



Sub-Criteria Weights

Fig. 1..(a) Built up 2010 after SPOT Image 2.5 m, 2010; **(b)** Weighted built up

Fi



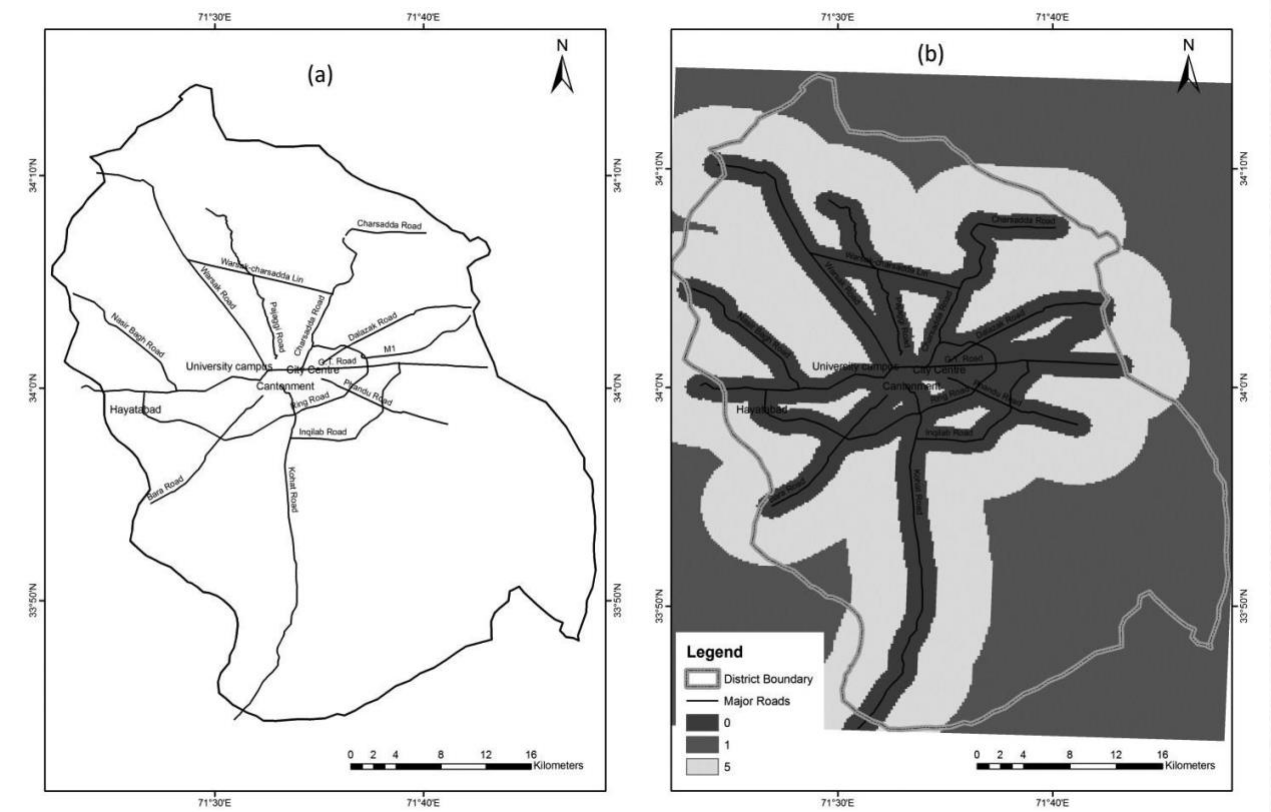
Sub-Criteria Weights

Fig. 2. (a) General Land use Pattern after SPOT Image 2.5 m, 20100; **(b)** Weighted Land use.

Sub-Criteria Weights

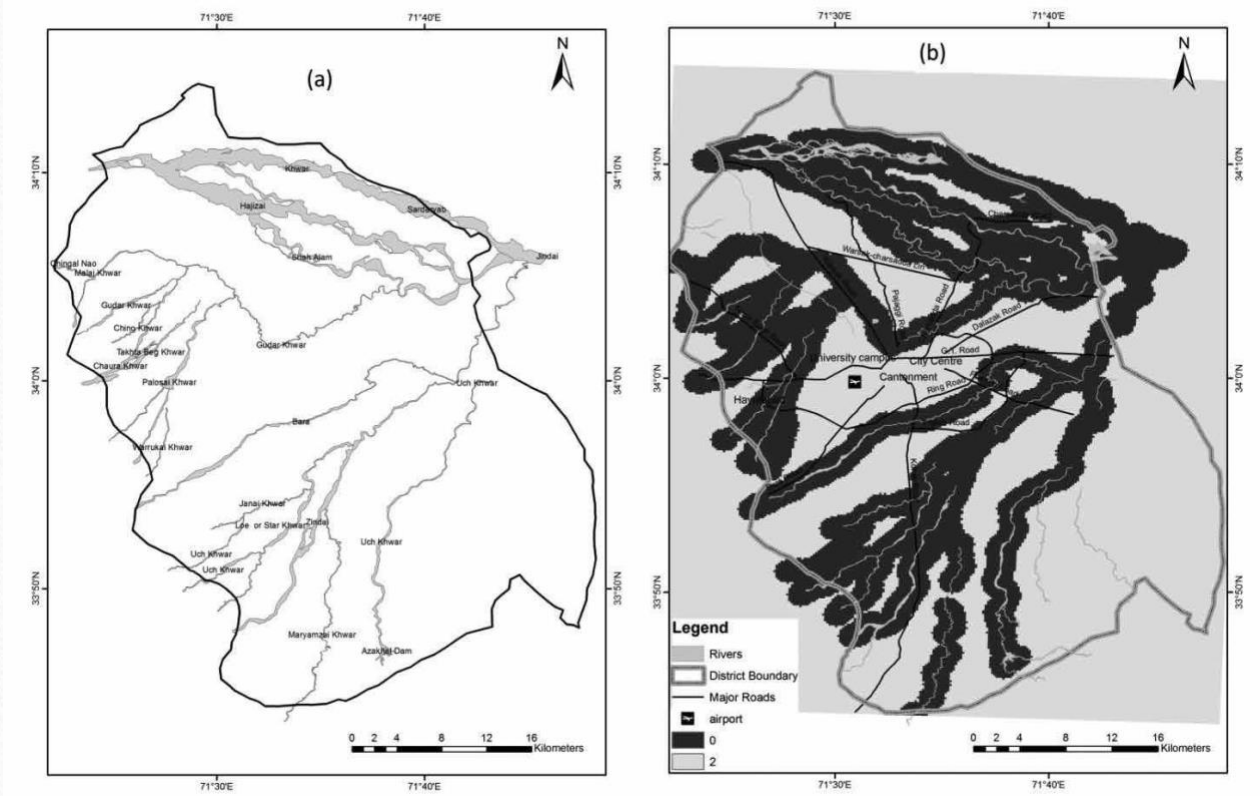
Sub-Criteria Weights

Fig. 3. Land values Sites **(**Source: Field Survey, 2010).



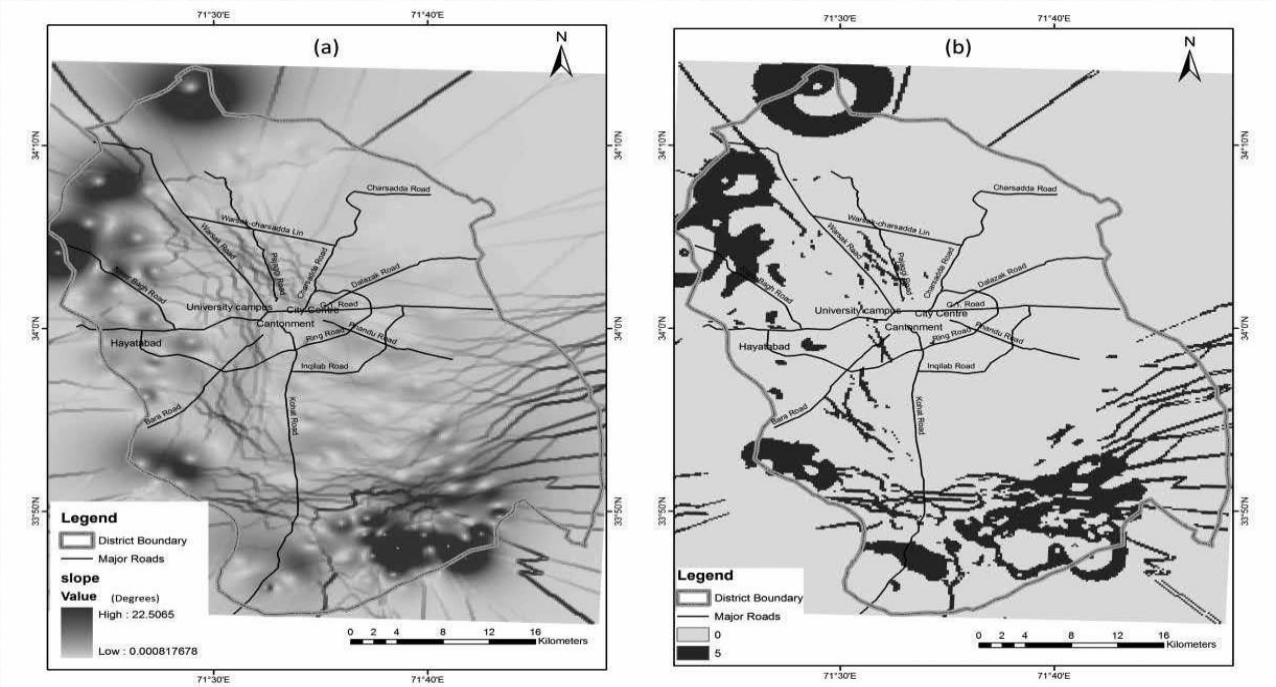
Sub-Criteria Weights

Fig. 5. (a) Major roads after SPOT image, 2010; **(b)** Weighted road network



Sub-Criteria Weights

Fig. 6. (a) Major rivers (Source: Survey of Pakistan), **(b)** Weighted major rivers.



Final Selection of Site

All above data was prerequisite for the final selection of the site. Data about land use, land values, transport network, rivers and water bodies, slopes, airport and water table was used as separate layers for final analysis. Theses layers were combined using raster calculator to get the final combined weighted map .

Sub-Criteria Weights

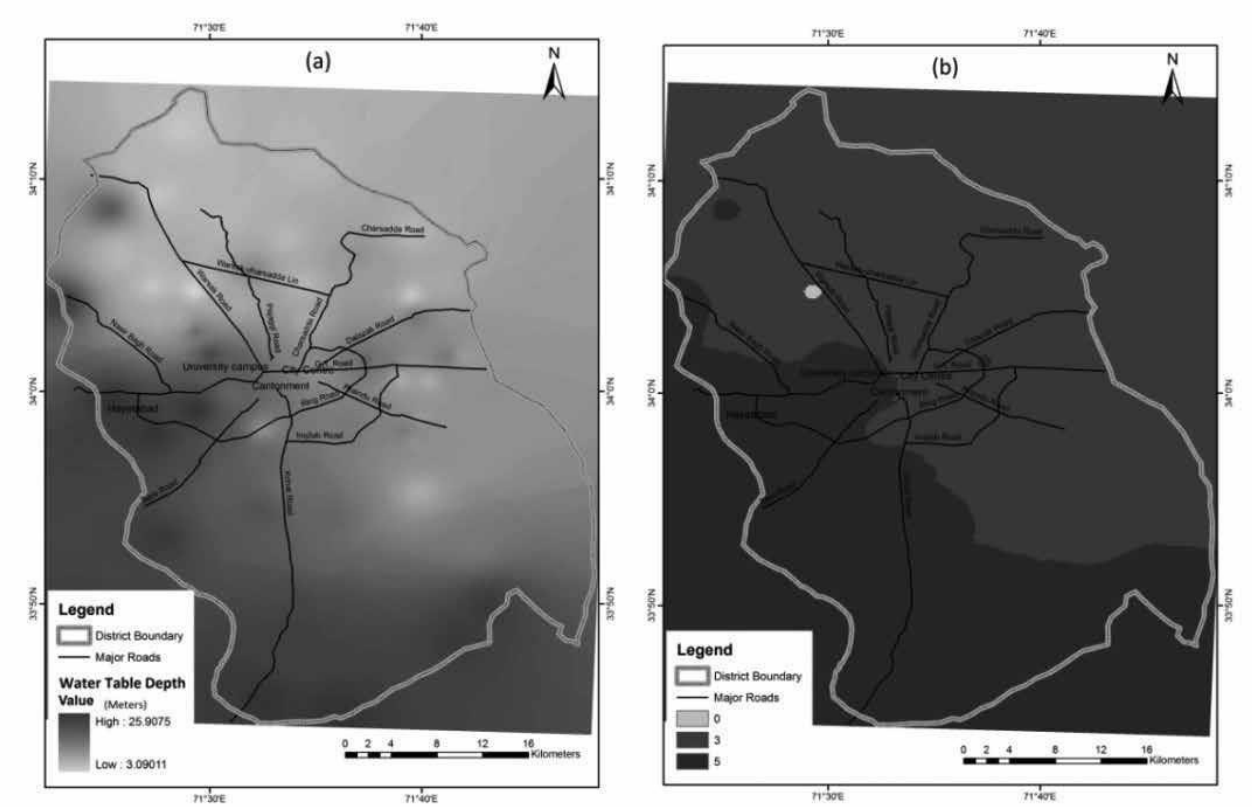


Fig. 8. (a) Water table depth (Source: GoKP); **(b)** Weighted water table

Sub-Criteria Weights

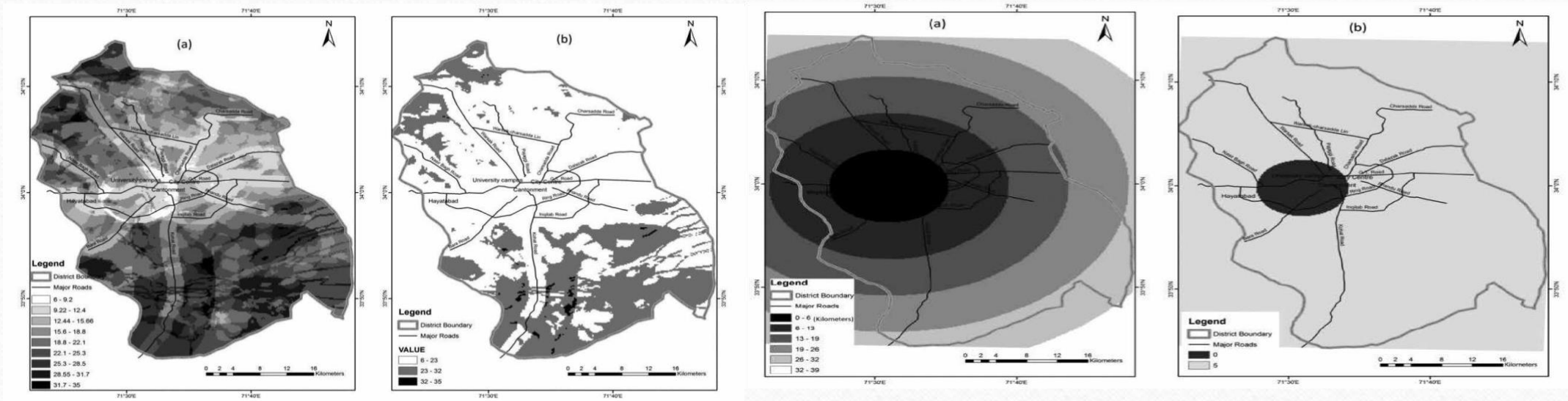
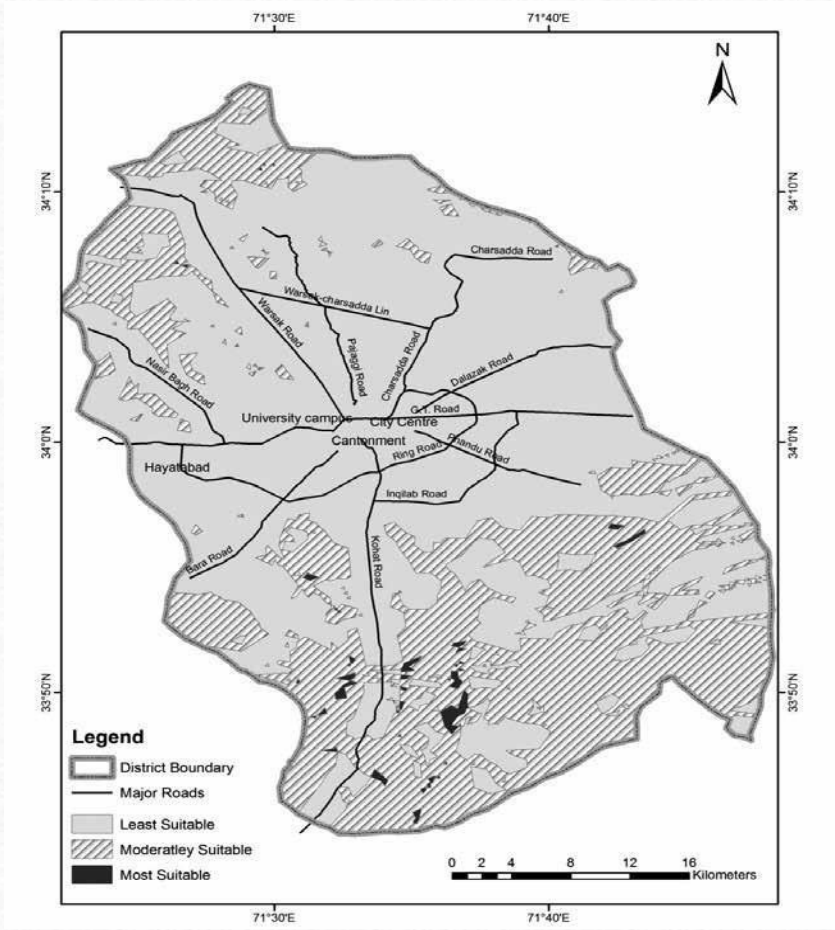


Fig. 9. (a) Airport distances; **(b)** Weighted airport.

Fig. 10. (a) Combined weighted map; **(b)** Reclassified weighted map.

Sub-Criteria Weights

Sub-Criteria Weights



Sub-Criteria Weights

Fig. 11. Final suitability map..

(Fig. 10a). New layer was built in which each was processed to fit in the selection criteria. This layer served as a base on which depend the selection of suitable site for solid waste disposal. In this layer each data set was reclassified to fit in the layer according to criteria.

Weights were reclassified into three classes for the optimal sites (Fig. 10b). The optimal sites according to the above criteria are shown in the final map (Fig. 11). The whole city district was divided into three categories. Areas having highest weights were designated as most suitable while areas having lowest weights were lest suitable for the landfill. Most suitable sites were mostly located in southern part of the city. In the north the slope is very gentle and water table is also very high that is why it was not selected although some other conditions were suitable. The selected sites were located within 5000 meters from the major roads. They were also outside the buffer of 1000 meters from the built up area so as there is no adverse consequences from the land fill sites. Slope was also very reasonable, neither too steep nor too gentle as is evident from the slope map. The sites are also located outside the buffer zone of 1000 meters from the existing rivers as well as the canals. The land use at all these sites was rain fed agriculture. The sites identified as most suitable have sufficient area to cope for at least twenty years. Sites declared as most suitable cover an area of 36 ha in different sizes ranging from smallest 1.2 ha to 12 ha largest fragment. As it is evident from the land use map that most

Sub-Criteria Weights

widespread land use in Peshawar was agriculture and it was very difficult to avoid agricultural land. Because the barren and range land in Peshawar city district were located in unsuitable location in terms of slopes, accessibility and stability of slopes.

Determination of Relative Importance Weights of All Criteria Using the AHP Method

In the AHP method, selection criteria can be identified and weighted, and the collected data can also be analyzed, accelerating the process of decision-making. The hierarchy is deconstructed into a pair comparison matrix. This pair-wise comparison is used to determine the relative importance of each alternative in terms of each criterion. In typical analytical hierarchy process a nine-point scale is used, where each point equates to an expression of the relative importance of two factors, e.g. "A is of the same importance as B" or "A is more important than B“. These studies use a scale with values ranging from 1 (equal importance or no difference) to 9 (absolute importance or extreme preference) as shown in table 1.

Table 1. Scale of relative importance for pairwise comparison (Saaty, 1980)

Intensity of Importance	Definition
1	Equal importance
2	Equal to moderately importance
3	Moderate importance
4	Moderate to strong importance

5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

Table 2.Pair-wise comparisons matrix for selecting a suitable landfill site, eigenvector and relative weight of criteria

Criteria	Water wells	Slope	Elevation	Rivers	Roads	Airport	Urban centers	Land use	Agricultural	Villages (m)	Military (m)	Archaeological	Industrial area	Power line	soil type	Eigen vector	Relative weight of criteria
Water wells	1	5	4	2	5	4	2	6	5	3	4	6	7	7	5	3.94	0.189
Slope	1/5	1	1/2	1/4	1	3	1/5	1/2	1	1/3	1/4	2	1/2	4	1/2	0.64	0.033
Elevation	1/4	2	1	1/3	2	1	1/3	3	2	1/2	1/3	3	1	4	1	1.02	0.050
Rivers (m)	1/2	4	3	1	6	5	1/3	3	4	2	3	5	6	6	3	2.66	0.127
Roads (m)	1/5	1	1/2	1/6	1	1	1/7	1/3	1	1/3	1/2	2	1/3	2	1/5	0.50	0.026
Airport (m)	1/4	1/3	1	1/5	1	1	1/7	1/3	1/2	1/6	1	1/2	1/3	1	3	0.50	0.031
Urban centers	1/2	5	3	3	7	7	1	5	4	2	4	5	5	7	4	3.46	0.164
Land use	1/6	2	1/3	1/3	3	3	1/5	1	1/2	1/4	1/5	1	1	3	1/3	0.65	0.035
Agricultural	1/5	1	1/2	1/4	1	2	1/4	2	1	1/3	1/3	2	2	3	1/2	0.76	0.037
Villages	1/3	3	2	1/2	3	6	1/2	4	3	1	2	4	3	6	4	2.09	0.099
Military	1/4	4	3	1/3	2	1	1/4	5	3	1/2	1	3	2	5	2	1.43	0.074

Archaeological	1/6	1/2	1/3	1/5	1/2	2	1/5	1	1/2	1/4	1/3	1	1/2	3	1/4	0.48	0.025
Industrial area	1/7	2	1	1/6	3	3	1/5	1	1/2	1/3	1/2	2	1	3	1/2	0.77	0.039
Power lines	1/7	1/4	1/4	1/6	1/2	1	1/7	1/3	1/3	1/6	1/5	1/3	1/3	1	1/4	0.29	0.015
soil type	1/5	2	1	1/3	5	1/3	1/4	3	2	1/4	1/2	4	2	4	1	1.02	0.055

12

Evaluation of Landfill Suitability Site

In order to find the suitability index value of the potential areas, A total of sixteen layers map were entered in raster in to the GIS. Then, the weighted linear combination (WLC) method was used based on the following Eq. (3.7):

$$n$$

$$A_i = \sum_{j=1}^{n} W_j X C_{ij}$$

where, Ai is the of suitability index for site area i, Wj is the relative importance weight of criterion, Cij the grade value of site area i below criterion j and n is the total number of criteria

In the GIS environment "Map Algebra" in the special analysis tool has been applied to create the final map of the landfill site suitability index. Divided the final map into five-group type depending on the suitability of the candidate landfill site selected.

Conclusion

Use of technology for real life problems have made it easy to find their proper solution without wastage of time and resources. The analysis criteria used in the identification of suitable sites for solid waste disposal in Peshawar city district indicated that using the GIS/RS technology can help local planning authorities to identify proper disposal sites. Presently solid waste is disposed at open spaces just outside the municipal boundary creating health hazards for the surrounding population. Some of the waste is thrown to larger water channels particularly the Bara River, making its water unfit for drinking purpose. GIS is now most widely used instrument to assist in the finding of suitable sites for landfill siting purposes. Using GIS for assessment of potential dumping sites will save time and resources. Usually local planning authorities have only limited resources and expertise to execute a sustainable siting procedure which causes considerable harm to the environment. This requires analysis of a great deal of

spatial information and factors that can affect the optimum selection of site. Though there is a limitation of data availability. For this study seven different thematic layers were taken for GIS analysis. Some other factors like industrial areas, geological structure and wind direction that may also affect the sitting of suitable sites but they were not included in the present study due to data limitations. After analyzing the thematic layers, most suitable waste disposal landfill sites were identified. These sites in general meet the required criteria of the suitable sites. Amongst them the local planning authorities must select the “potential landfill” sites by a careful ground preliminary survey.

REFERENCES

1. Tchobanoglous. G. Solid waste management. In: *Environmental Engineering: Environmental Health and Safety for Municipal Infrastructure, Land Use and Planning, and Industry.* Wiley, New Jersey, USA, p. 177-307 (2009).
2. Shafiullah. *Hospital Solid Waste Management*. M.Sc. thesis, Department of Geography/ Urban and Regional Planning, University of Peshawar, Peshawar, Pakistan (1996).
3. Sasikumar, K., & S. G. Krishna. *Solid Waste Management*. PHI Learning Pvt. Ltd, Delhi, India (2009).
4. Batool, S.A., & M.N. Chaudhary. Municipal solid waste management in Lahore city district, Pakistan. *Waste Management* 29(6): 1971-1981 (2009).
5. Ishii, A. *Final Report for Domestic Solid Waste Management in Pakistan*. JICA Short Term Expert Publisher, Karachi, Pakistan (2002).
6. GoP(Government of Pakistan). *Statistical Year Book*. Pakistan Bureau of Statistics, Islamabad, Pakistan (2014).
7. Khan M.A., & A.Z. Samiullah. Dynamics of Urban Spatial Growth and Planning: A Case Study of Peshawar. *Journal of Engineering and Applied Sciences* 31(2): 1-16 (2012)
8. Hussain, M.M. *Solid Waste Management in Peshawar*. http://www.bioenergyconsult.com/ peshawar-swm/ (2015)
9. GoP (Government of Pakistan). *Brief on Solid Waste Management in Pakistan*. Ministry of Environment, Islamabad, Pakistan (2010).

10. Chang, N. B., G. Parvathinathan, & J.B. Breeden. Combining. GIS with fuzzy multicriteria decision-making for landfill siting in a fastgrowing urban region. *Journal of Environmental Management* 87(1): 139-153 (2008).
11. Kinobe, J.R., T. Bosona, G. Gebresenbet, C.B. Niwagaba, & B. Vinnerås. Optimization of waste collection and disposal in Kampala city. *Habitat International* 49: 126-137 (2015).
12. Paul, K., Dutta, A., & A.P. Krishna. A comprehensive study on landfill site selection for Kolkata City, India. *Journal of the Air & Waste Management Association* 64(7): 846-861 (2014).
13. Hannan, M.A., M.A. Al Mamun, A. Hussain, H. Basri, & R.A. Begum. A review on technologies and their usage in solid waste monitoring and management systems: Issues and challenges. *Waste Management* 43: 509-523 (2015).
14. Allen, A.R. Containment landfills: The myth of sustainability. *Journal of Engineering Geology* 60: 3-19 (2001).
15. Nas, B., T. Cay, F. Iscan, & A. Berktay. Selection of MSW landfill site for Konya, Turkey using GIS and multi-criteria evaluation. *Environmental Monitoring and Assessment* 160(1-4): 491-500 (2010).
16. Ministry of Environment. *Data Collection for preparation of National Study on Privatisation of Solid Waste Management in Pakistan*. Ministry of Environment,Government of Pakistan, Islamabad, Pakistan (1996).
17. Kirkwood, C.W. *Strategic Decision Making: Multiobjective Decision Analysis with Spreadsheets*. Duxbury Press, Belmont, USA (1997).
18. Malczewski, J. Propagation of errors in multicriteria location analysis: A case study. In: *Multiple Criteria Decision Making*, p. 154-155. Springer, Berlin, Germany (1997).
19. Janssen, R. *Multiobjective decision Support for Environmental Management* (Vol. 2). Springer Science & Business Media (1992).

20. Eastman, J.R. *IDRISI: A Grid Based Geographic Analysis System*, version 4.1. Graduate School of Geography, Clark University, Worcester, MA, USA (1993).
21. Siddiqui, M.Z., J.W. Everett, & B.E. Vieux.

Landfill siting using geographic information systems: a demonstration. *Journal of Environmental Engineering* 122(6): 515-523 (1996).
22. Erkut, E., & S.R. Moran. Locating obnoxious facilities in the public sector: An application of the analytic hierarchy process to municipal landfill siting decisions. *Socio-Economic Planning Sciences* 25(2): 89-102 (1991).
23. Lober, D.J. Resolving the siting impasse: modeling social and environmental locational criteria with a geographic information system. *Journal of the American Planning Association* 61(4): 482-495 (1995).
24. Ouma, Y. O., E.C. Kipkorir, & R. Tateishi. MCDAGIS integrated approach for optimized landfill site selection for growing urban regions: an application of neighborhood-proximity analysis. *Annals of GIS* 17(1): 43-62 (2011).
25. Yesilnacar, M. I., M.L. Süzen, B.S. Kaya, B. Ş., & V. Doyuran. Municipal solid waste landfill site selection for the city of ŞanliurfaTurkey: an example using MCDA integrated with GIS. *International Journal of Digital Earth* 5(2): 147-164 (2014)
26. Kontos, T.D., D.P. Komilis, & C.P. Halvadakis (2003). Siting MSW landfills on Lesvos Island with a GIS-based methodology. *Waste Management & Research* 21(3): 262-277 (2012).

27. Sarptas, H., N. Alpaslan, & D. Dolgen. GIS supported solid waste management in coastal areas. *Water Science & Technology* 51(11): 213-220 (2005).
28. Şener, B., M.L. Süzen, & V. Doyuran. Landfill site selection by using geographic information systems. *Environmental Geology* 49(3): 376-388 (2006).
29. Delgado, O. B., M. Mendoza, E.L. Granados, & D. Geneletti. Analysis of land suitability for the siting of inter-municipal landfills in the Cuitzeo Lake Basin, Mexico. *Waste Management 28*(7): 11371146 (2008).
30. Gómez-Delgado, M., & S. Tarantola. GLOBAL sensitivity analysis, GIS and multi-criteria evaluation for a sustainable planning of a hazardous waste disposal site in Spain. *International Journal of Geographical Information Science* 20(4): 449466 (2006).
31. GoP. *Topogarphical Sheets 1:50,000 Scale*. Survey of Pakistan, Rawalpindi (1984).
32. GoP (Government of Pakistan). *SPOT Image 2.5 m Resolution*. SUPARCO Regional Office, Peshawar (2010).
33. GoKP (Khyber Pakhtunkhwa). *Pak CDP Report*. Public Health Engineering Department, Peshawar (2008).

THANKS