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SUITABLE SITES FOR URBAN SOLID WASTE DISPOSAL USING GIS APPROACH IN KHULNA CITY, BANGLADESH

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Abstract: Urban solid waste management is considered as one of the most immediate and serious environmental problems confronting municipal authorities in developing countries like Bangladesh. The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses. In the major cities in Bangladesh, per capita production of solid waste is 0.5kg/day but only 0.2 kg of waste per capita is carried to the final disposal. In Khulna city the municipal work force disposes hardly one third of daily waste about 400 ton/day. The location of disposal (secondary) sites of Khulna City Corporation (KCC) represents the unconsciousness about the environmental and public health hazards arising from disposing of waste in improper location. A suitable disposal site must have environmental safety criteria's and attributes that will enable the wastes to be isolated so that there is no unacceptable risk to people or the environment. Criteria for site selection include natural physical characteristics as well as socioeconomic, ecological and land-use factors. Different tools and techniques are being developed for solid waste disposal site selection in developed countries. The Geographical Information System (GIS) can provide an opportunity to integrate field parameters with population and other relevant data or other associated features, which will help in selection of suitable disposal sites.

Keywords: GIS, Decision Support System (DSS), Expert Support System ESS, KCC, Solid Waste, Multi-Criteria Analysis

Introduction

Urban solid waste management is considered as one of the most immediate and serious environmental problems confronting municipal authorities in developing countries like Bangladesh. It is now a major global concern that is increasing day by day. The rapid growth of population and urbanization decreases the non-renewable resources and disposal of effluent and toxic waste indiscriminately are some of the major environmental issues posing threats to the existence of human being. The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses [1]. General awareness of our environmental problems has led to the development of pollution control technologies, more rigorous legislation, strategies on waste handling and disposal to minimize the environmental impact associated with solid wastes. Waste disposing is an important part of waste management system, which requires much attention to avoid environmental pollution. In context of Bangladesh waste disposal and management is in bad shape in urban area, since urban inhabitants generate huge amount of municipal solid waste daily and population density is high. Only major cities have

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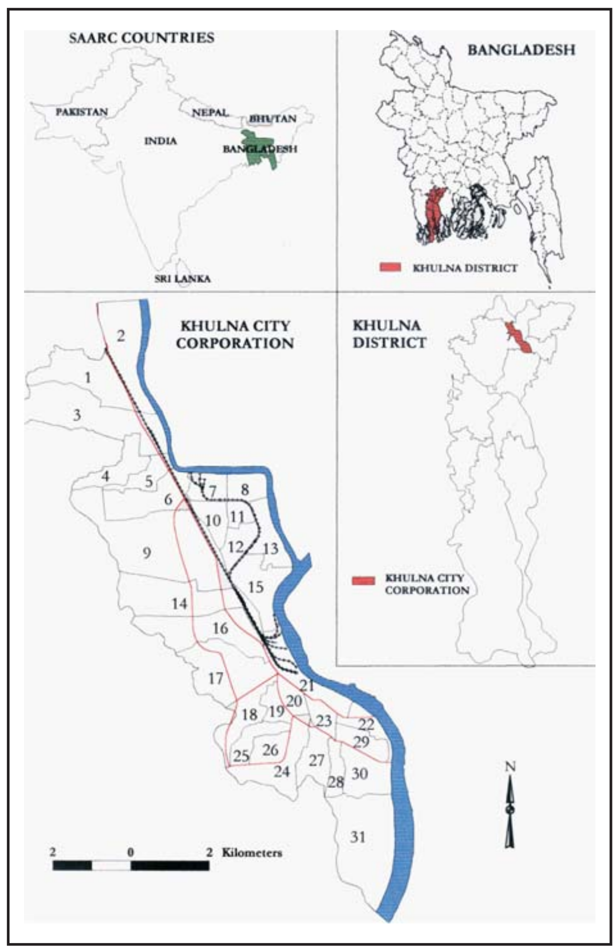
some sort of garbage disposal system. In the major cities in Bangladesh, per capita production of solid waste 0.5 kg /day but only 0.2 kg of waste per capita is carried to the final disposal [2] and rest is disposed off locally. This view of the major cities of any country obviously exhibits the poor waste management situation of that country.

Solid wastes management is carried out by the City Corporation for which conservancy fee also charged on to the urban inhabitants. But waste management system of Khulna City Corporation (KCC) of Bangladesh is not satisfactory. As a part of such improper management system selection of solid waste disposal (secondary) sites for this city does not consider the environmental factors. The location of disposal (secondary) sites of this city represents the unconsciousness about the environmental and public health hazards arising from disposing of waste in improper location [2]. Because selection of disposal sites is not located considering residential area, clinic/hospital, educational institution, drainage network, socio cultural and religious institution. A suitable disposal site must have environmental safety criteriaís and attributes that will enable the wastes to be isolated so that there is no unacceptable risk to people or the environment while it is operating. Criteria for site selection include natural physical characteristics as well as socioeconomic, ecological and land-use factors. Preferable selection of suitable sites for waste disposal has been normally carried by traditional approaches i.e. throwing it at all types of vacant land in or around the city [3]. The Geographical Information System (GIS) can provide an opportunity to integrate field parameters with population and other relevant data or other associated features, which help in selection of sites. Site selection procedures can benefit from the appropriate use of GIS. The use of GIS in selection process will reduce the time and enhance the accuracy.

Materials and Methods

Study area

Bangladesh is located in Southeast Asia. Khulna is one of the 6^{th} divisional cities of Bangladesh, which is located in south west of Bangladesh between 22∞ 49í North latitude and 89∞ 34í East longitudes and its elevation is 2.13 meters above mean sea level [4]. City Corporation area of Khulna is 44.78 sq. km with population around 1.3 million. The Bhairab River and Fultala Thana bound Khulna on the North, by the Rupsha River on the East and South and on the west by Dumuria Thana. The location of Khulna city in context of the South Asian Regional Countries (SAARC), Bangladesh and Khulna district is shown in Map 1.



Map 1. Study area map

The prime objectives are given below:

(i) To investigate the solid waste disposal system in the study area;
(ii) To identify the environmental problems generated due to the indiscriminate solid waste disposal in the study area; and
(iii) To provide some suitable solid waste disposal sites using GIS techniques in study area.

Methodology is a logical as well as systematic part of the study to guide scientific investigation. A method involves a process or technique in which various stages or steps of collecting data or information are explained. The methodology of this study covers some sequential steps. Detailed methodology is also graphically presented in Figs. 1 and 2. Common benefits of GIS include its ability to: (i) capture, store, and manage spatially referenced data, (ii) perform analysis of spatially referenced input data, (iii) perform sensitivity and optimization analysis easily, and (iv) communicate model results [5,6]. Spatial feature extraction or classification is one of the GIS capabilities for searching suitable sites .The ultimate aim of Geographical Information system is to support spatial decision making. Spatial decision-making process has been structured into three major phases: Intelligence, Design and Choice as shown in Fig. 1.

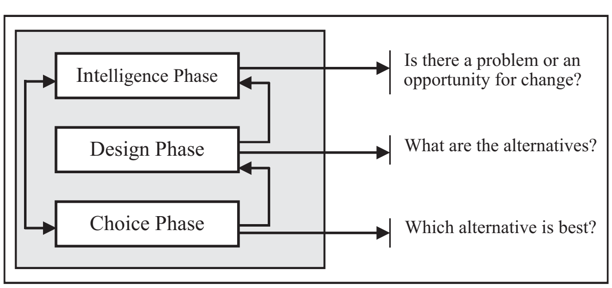


Fig. 1. Three phase of decision making process [7].

Under different steps of multi-criteria evaluation a particular set has been chosen for the concern study. For generating the criteria deductive approach has realized as suitable. For determining the scores of criteria indirect qualitative determination approach is considered as suitable for the study. Decision support system, together with many other tools such as expert system and computer models, are designed to help decision makers to select an optimal option among a broad set of alternatives. In order to comprehend the final part of the study- to select some most appropriate sites for wastes disposal from a set of alternatives, it is necessary to recall briefly the definition belonging to the decision with multiple objective [8]. Multi-criteria Evaluation (MCE) is a decision support technique where a decision is a choice between alternatives (such as alternative actions, land allocations, etc.). The basis for a decision is known as a criterion. In MCE, an attempt is made to combine a set of criteria to achieve a single composite basis, a score function, for a decision according to a specific objective [9]. Expert classification shell has now been incorporated in the GIS software and this expert classifier has been used to locate suitable sites for solid waste disposal in this study. The framework for multicriteria decision analysis has been treated as an expert classifier. The framework for spatial multicriteria decision analysis flow chart is given in Fig 2.

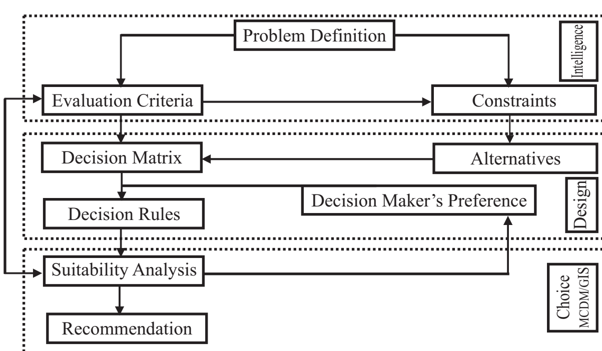


Fig. 2. Framework for spatial multi criteria decision analysis [7].

The generation of criteria bears close resemblance to the generation of objectives. There are two approaches *deductive* and *inductive* for generating the criteria [9].

In *deductive* approach some general criteria are developed and each main criterion must then be specified in terms of one or more evaluation criteria. The *inductive* approach starts with an inventory of all features of the choice-possibilities [10]. In addition, these features are grouped and eventually aggregated in such a way that a set of evaluation criteria arises. Though there are numerous criteria used for evaluation, the ones used here represent local factors. These are classified as environmental, economic, social and technical operational. The corresponding indicators are:

- *Environmental criteria:* Environmental consisting of surface water, groundwater quality, land cover and ecological character, disposal site management and public health, safety and nuisance

- *Economic Criteria:* Economic land use and social value consisting of the distance from human settlements), industry and proximity to protected places, and impacts on housing and/or other development.

- *Technical-operational criteria:* Technical-operational consisting of the altitude, the design of the site, i.e. hydrological evaluation, and grading of the surfaces/protection of the slopes, access roads, and the distance from the main source of waste consumption. The rating of the above indicators are done according to the performance of the criteria as follows:

    ñ Very suitable,

    ñ Moderately suitable, and

    ñ Less suitable.

The methodology proposed uses multicriteria ranking techniques to combine the available, site data into final overall sites. At the first level, the user of the assessment system must specify parameters and balancing factors. These weight parameters are established based on the degree of importance the user feels each indicator possesses relative to indicators of the same group.

Results

Land elevation and soil characteristics: The area comprises a flat land land with two natural ground slopes. One of the natural ground slopes is found from northwest to southwest, which follows the general flow direction of the Bhairab River (upper reach) and Rupsha River (Lower Reach). Another natural ground slope follows the northwest to southwest direction from the Bhairab and Rupsha riverbank towards Dumuria. As a result, the elevated land lies along the bank of river and low lands are present in the south-western part of the study area. The general ground elevation of Khulna City Corporation (KCC) and its adjoining area varies from 2.64 m in Dumuria to 4.07 m in Terakheda above AMSL (Average Mean Sea Level). Most of the KCC areas are above 3.32 m from AMSL [11]. The spatial distribution of the different elevated classes and the area under different elevated land classes is shown in Table 1.

Table 1
Different elevated land classes [12].

Elevation	Area (km^2)	Percentage (%)
Upland	434	18.6
Moderately upland	1182	50.64
Moderately low land	718	30.76

The spatial distribution of the different land characteristics and the area under different land characteristics is shown in Table 2.

Table 2
Different land characteristics of KCC area [12].

Land characteristics	Area (km^2)	Percentage (%)
Ganga polol	315	4.49
Ganga katal polol	107	1.53
Mixed ganga katal	1071	19.28
Beel area with organic soil	756	10.79
Homestead	4287	61.17
River	472	6.74

Information on land cover, especially the extent and spatial distribution, is a prerequisite for the site suitability for urban development. The land cover information helps in the formulation of policies and programs for urban development. Therefore, an attempt has been made to adopt a suitable land cover classification system for use with available data. Table 3 shows different land surface cover information.

Table 3
Different land surface cover [12].

Nature	Area (km^2)	Percentage (%)
Terrestrial	6402	76.08
Beel area	756	9.07
Mixed (Terrestrial & Beel)	1178	14.13

Road network: KCC area is served by a network of pucca (metalled), semi-pucca and kutcha (unmetalled) roads. Total road milage in KCC area is about 262.68 kms of which 104.32 kms are pucca, 101.49 kms are semi-pucca and the remaining 56.81kms are kutcha. Types of roads within KCC area have been shown in Table 4.

Most of the KCC roads are in good condition except those which are kutcha and semi-pucca. The single lane pucca roads are narrow, often 3.6 metres in width, with un-surfaced kutcha shoulders and insufficient or no space for parking and pedestrian movement. Open road-side drain creates environmental problems for pedestrians.

Population distribution: The present average density of population of Khulna city stands at 17,735 persons per sq. km and the highest density wards are 10, 11, 12 and 20 where density varies between 45,152 to 53,335 persons per sq. km. Ward No. 10, 11 and 12 are the high-density wards of the city all of which are in Khalishpur planned residential area and are close to the industrial area [4]. Ward No. 20 is situated in the old part of the city and is a sponta-

Table 4
Existing road system in KCC area [13,14, 15,16].

Agency	Bitumen (km)	Concrete (km)	WBM[i] (km)	HBB[ii] (km)	FBS[iii] (km)	Kutcha (km)	Total (km)
	Pucca		Semi Pucca			Kutcha	
KCC	103.44	0.88	28.62	15.46	57.47	56.81	262.68
RHD[iv]	43.89	-	-	-	-	-	43.89
KDA[v]	20.67	-	-	-	-	-	20.67
LGED[vi]	89.50	-	58.86	65.15	30.21	612.56	766.78
Total	257.5	0.88	87.48	80.61	87.68	669.37	1180.49

N.B: WBM[i]-Water Bound Macadam; HBB[ii]-Herring Bone Bond; FBB[iii]-Flood Brick Soling, RHD[iv]- Roads and Highway Department; KDA[V]-Khulna Development Authority; LGED[vi]- Local Government Engineering Department.

neously grown area. The lowest density wards fall in the northwestern fringe where the structures are sparsely built and dominated by huge vacant and agricultural land.

Land use pattern: As mentioned earlier, because of physiographic setting, Khulna has grown along the west bank of the river Bhairab in a linear pattern. Because of the non-availability of land that could be built on the west, the westward growth of the city has been restricted, making the city a narrow strip of urbanized land, 16 km in north-south and a maximum of 4 km in east-west. The settlement area with 23.50 sq km. (51.1 per cent of the city area) dominant among the land use categories. The mixed built-up area (residential area with intense commercial activity) 14.3 per cent of the total city area, spread over the older areas (ward nos. 20, 21, 23, 26, 27, 19) of the city. It is notable that 21.2 per cent of the city corporation area is in agricultural use, which lies along the western fringe of the city. Table 5 shows the existing land use pattern in Khulna city.

Table 5
Existing land use pattern of Khulna city [17].

Land Use	Area in sq km	Percentage
Settlement area	23.50	51.1
Agricultural land area	9.77	21.2
Mixed built up area	6.58	14.3
Industrial area	3.07	6.7
Commercial area	0.48	1.1
Education area	0.35	0.8
Railway property area	0.32	0.7
Shipyard area	0.32	0.7
Government institutions area	0.13	0.3
Low land	0.13	0.3
Graveyard area	0.07	0.1
Others area	1.28	2.8
Total	46.00	100.0

Religious institutions: Mosques, temples and churches, belonging to the Muslims, the Hindus and the Christians respectively, are the most important religious institutions in the city. The overwhelming majority (90.7 per cent) of the city dwellers belong to the Muslim community. Obviously, there are more mosques in the city than temples. Table 6 shows the amount of different religious institution in KCC area.

Table 6
Different religious institution in KCC area [17].

Name of Religious Institution	Amount
Mosque	105
Hindu temple	11
Church	9

Health facilities: Alike most other cities in Bangladesh, the health facilities are provided by the government (through Directorate of Health), local government (i.e. the City Corporation), NGOs, and private commercial undertakings. Table 7 shows the amount of different health facilities.

Commercial establishments: There are two categories of markets in the city ñ wholesale and retail. Wholesale markets are further classified into grocery, vegetables and fish markets etc. Boro Bazar, by the river of Bhairab-Rupsha, in the central part of the city, is the largest and only grocery wholesale market. Retail markets of varying sizes are scattered all over the city. According to KCC sources, there are 21 markets in the city under its jurisdiction.

Other Sociocultural institutions: Community centers and community clubs are developed to help local people stage their various socio-cultural functions. These are also rented out to people for arranging marriage ceremony and other social gatherings. Khulna City Corporation has developed 5 community centers all over the city.

Table 7
Health facilities in KCC area [17].

Type	Description	Number of facility by different service providers				Total
		NGO	KCC	Central Govt.	Private	
Clinic	–	3	–	3	28	34
EPI Center	Vaccination Centers include both fixed and outreach stations	17	121	–	–	138
Family Planning	Consultation center for reproductive health	10	–	11	–	21
OPD	Outpatient department	19	2	7	11	39
Maternity	–	–	–	1	2	3
Hospital	–	–	–	7	8	15

Administrative areas: The administrative offices of the government agencies, many of which are divisional offices, have been built all around the city. Furthermore, many structures in different residential areas are being used as government and non-government offices.

Discussion

Decision-making is a process and it involves a sequence of activities that starts with decision problem recognition and ends with recommendations [11]. It is argued that quality of decision-making depends on sequence in which the activities are undertaken. Any decision-making process is composed of three major phases:

- Intelligence;
- Design;
- Choice.

As such methodology of the present study of spatial decision-making process of suitable sites for solid waste disposal will be discussed according to the three-phase decision making process.

Intelligence Phase: Intelligence phase involves searching or scanning the decision environment for conditions calling for decisions. The data acquisition, storage, retrieval and management functions convert the real world situation into GIS database during this phase. This involves assumptions or views of the world underlying a particular decision problem [18]. The assumptions are concerned with the following questions, which of the real world entities should be observed, selected, filtered, classified and recorded as data items and which items are relevant to subsequent spatial decision problem? Coordination must be given to the usefulness, accuracy, reliability and flexibility of data. Once spatial decisions are identified the data can be manipulated and analyzed to obtain information about the decision problem in hand. With this view in mind various thematic maps have been prepared for their integration in Geographic Information System (GIS) base [19].

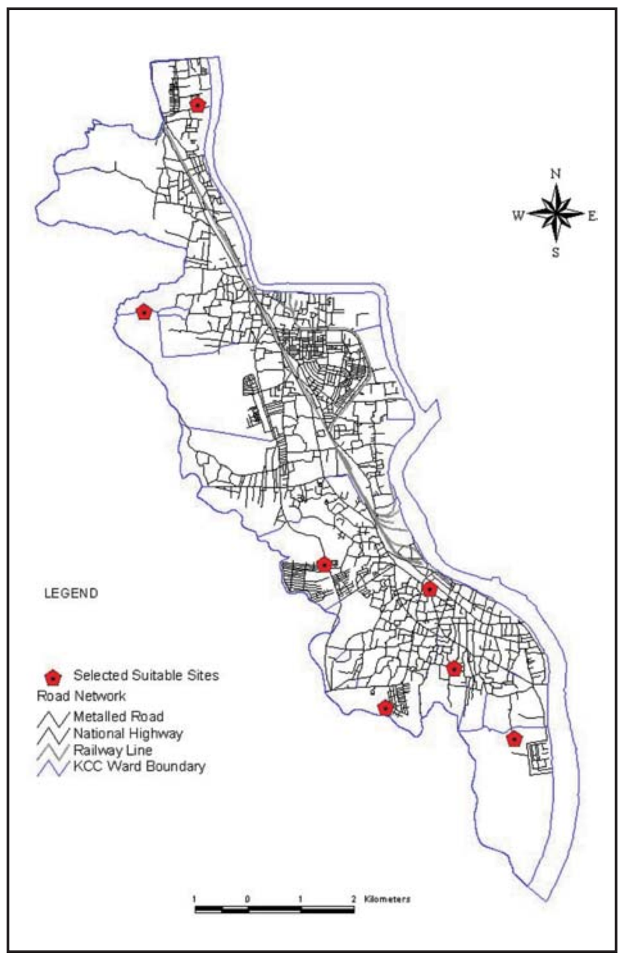
Design Phase: Design phase involves inventing and analyzing a set of possible solutions to problem identified in the intelligence phase. Here in case of site suitability analysis for urban development. What are the spatial decisions criteria or decision rules we have to consider in locating those suitable sites? So design phase represents the decision situation by structuring and formalizing the available data and information about the decision problem. Spatial decision alternatives are derived by manipulation and analysis of the data and information stored in GIS. As ultimate aim is to use Spatial Expert Support System (SESS) for the purpose of decision making, it will be better to look into available guidelines and experts opinion at this design phase which will help us in creating rule based decision trees or knowledge base in Expert Classifier shell of the software used in this present study.

Decision Rules and Knowledge Base: Decision rules for locating suitable sites for solid waste disposal has been prepared based on expert knowledge and multi criteria evaluation process. Table 8 shows the decision rules for site suitability for solid waste disposal.

In the decision process, at this phase each alternative is evaluated and analyzed in relation to others in terms of specific decision rules. The rule is used to rank the alternatives under consideration. The ranking depends upon decision makerís preference. In general, GIS does not provide a mechanism for representing choice and priority in context of evaluating conflicting criteria and objectives [20]. Under these circumstances, the ultimate success of GIS in decision making depends on how well the system can succeeded as a spatial decision support system in the decision making process.

In this study, spatial expert support system has been to support decision-making based on expert knowledge stored in the system as a knowledge base to eliminate the tedious job of evaluating different alternatives and ranking them according to the decision makersí preference. In other words the present study is aimed at to replace a decision maker by replicating an expert in the process of identifying suitable sites for solid waste disposal. Hence in true sense, choice phase does not exit when we are working on spatial support system.

There are seven suitable sites have been located by the multi criteria evaluation method and shown in Map 2. Each of these plotted points



Map 2. Suitable sites for solid waste disposal

has satisfied all the criteria adopted for highly suitable sites for solid waste disposal.

To gain the prime objectives of this research work the suitability of the sites are classified on the basis of different criteria .As for example:

- Highly Suitable
- Moderately Suitable
- Less Suitable.

Highly Suitable Site: The sites considered as suitable for disposing solid waste if it satisfy all the criteria (Table 8) as distant 100m from drainage, 200 m from any water body, 200 m from hotel, market and shopping centers etc., 500 m from bank, 200 m from socio-cultural institutions, 1 km from educational institution, health facilities and administrative offices. For gaining high suitability the sites had to also satisfy the

Table 8
Decision rules for site suitability for solid waste disposal.

Criteria	Suitability Class		
	Highly Suitable	Moderately Suitable	Less Suitable
Drainage	100 m distant	75 m distant	50 m distant
Accessibility	Good	Moderate	Low
Water body (Ponds)	200 m distant	100 m distant	50 m distant
Soil and Land Characteristics	Moderately upland non Organic soil	Upland and non Organic soil	Moderately low land and organic soil
Commercial Establishments ❑ Hotel, Market, Shopping Center, ❑ Bank	200 m distant 500m distant	300 m distant 200 m distant	500 m or more 100 m distant
Socio cultural Institution ❑ Community Center, Club	200 m distant	300 m distant	500 m distant
Educational Institution	1 km distant	500 m distant	100 m distant
Health Facilities	1 km distant	500 m distant	100 m distant
Administrative Offices	1 km distant	500 m distant	100 m distant
Land Use ❑ Settlement Area ❑ Commercial Area ❑ Agricultural Area ❑ Railway Property Area ❑ Mixed Buildup area ❑ River Area	1 km distant 1 km distant 500 m distant 200 m distant 250 m distant –	700 m distant 700 m distant 300 m distant 100 m distant (150-200) m distant –	(200-500) m distant (200-500) m distant (100-200) m distant 50 m distant 150 m distant –
Population	Low dense area	Moderate dense area	High dense area

land elevation or contour, soil type, land use criteria, specifically which are considered in selecting the sites and obviously the site plotted in low dense area.

Moderately Suitable Site: The sites considered as moderate for disposing solid waste if it satisfy all the criteria of moderately suitable column of Table 8 as distant 75m from drainage, 100m from any water body, 300 m from hotel, market and shopping centers etc., 200 m from bank, 300 m from socio-cultural institutions, 500 m from educational institution, health facilities and administrative offices. For gaining moderate suitability the sites had to also satisfy the land elevation or contour, soil type, land use criteria specifically which are considered in selecting the sites shown in Table 8 and obviously the site plotted in moderate dense area.

Less Suitable Site: The sites considered as less suitable for disposing solid waste if it satisfy all the criteria of less suitable column of Table 8 as distant 50 m from drainage, 50 m from any water body, 500 m from hotel, market and shopping centers etc., 100 m from bank, 500 m from socio-cultural institutions, 100 m from educational institution, health facilities and administrative offices. For gaining less suitability the sites had to also satisfy the land elevation or contour, soil type, land use criteria specifically which are considered in selecting the sites shown in Table 8 and obviously the site plotted in highly dense area.

Conclusion

This study used GIS integrated standard methodology for the selection of sites, which are suitable for the disposal of solid wastes. This methodology incorporates a large number of environmental and economic factors which are essential to identify the sites which have no or minimum adverse impact on environment. In fact, many other parameters are required for this study, but the most important parameters have been taken into consideration. The study illustrates the importance of GIS technology in the present days. GIS technology, as an information tool, has helped in the acquisition of recent land use information studies aimed at solving environmental problems. Information on different aspects for this study like land use, road, and slope etc., has been derived using this technique. Further integrating this data using GIS has helped in the analysis of the study, which would have otherwise been difficult to do manually using the conventional method. The involvement of such factors or criteria requires adequate database of different dimensions. So adequate attention is required for data management to ensure the perfection of the decision based on the methodology. Though GIS based methodology is highly sophisticated or developed or standard one but itís success depend on the proper and careful application of it. Thus with the use of these technologies management of municipal waste will no longer be a problem for city administrators.

References

1. **Jilani, T.** 2002. State of Solid Waste Management in Khulna City. Unpublished Undergraduate thesis, Environmental Science Discipline, Khulna University Khulna, pp. 25-85. Bangladesh.
2. **Farzana, F. and Kabir M.A.** 2004. Development of An Integrated GIS Based Methodology for the Selection of Solid Waste Disposal Sites for Khulna City. *Khulna University Studies*, 4:725-731.
3. **Manoliadis O. and Vatalis, K.** 2002. A two-level multicriteria DSS for Landfill Site Selection Using GIS: Case Study in Western Macedonia, Greece, *J. Geographic Information Decision Analysis,* 6:49-56.
4. **Anon.** 1999. Environmental Maps and Workbook for Khulna City, Bangladesh, Urban and Rural Planning Discipline, Khulna University, 159 pp. Bangladesh
5. **Miles, S.B., and Ho, C.L.** 1999. Applications and Issues of GIS as Tool for Civil Engineering Modeling. *J. Comp. City. Engrg*. ASCE 13:144-152.
6. **Parsons, R.L. and Frost, J.D.** 2000. Interactive

Analysis of Spatial Subsurface Data Using GIS Based Tool *J. Comp. Citv. Engrg*. ASCE, 14:215-222.

7. **Rahman, M.M. and Subudhi, A.P.** 2004. Knowledge Based Spatial Expert Support System in Identifying Suitable Sites for Urban Development in Dehradun City, India. *Plan Plus* 01:32- 41.
8. **Lombardi, M. and Bellorini, N.** 1996. *Information and Decision Support System with GIS Technology: Landfill Siting in Botkyrkaî*. M.Sc. thesis, Royal Institute of Technology. 55 pp.
9. **Sharif, M.A.** 1995. Introduction to Decision Support System and Multi-Criteria Evaluation Technique. *ITC Publication* 2:132-174.
10. **Leondes, T.C.** 2000. *Knowledge Based System: Techniques and Application*, pp. 115-205. Academic press, New York.
11. **Rahaman, M.M., Hassan, M.Q. and Islam, M.S.** 2000. *Environmental Impact Assessment on Water Quality Deterioration caused by the Decreased Ganges Outflow and Saline Water Intrusion in South Western Bangladesh*, pp. 88-95. Bangladesh.
12. **SRI.** 2006. *Soil Research Institute (SRI) Yearly Report of Khulna*, Vol. XX, pp 230-250. Bangladesh.
13. **KCC.** 2006. *Khulna City Corporation (KCC) Annual Report of Khulna*, KCC Bhaban, pp. 20-80. Bangladesh.
14. **KDA.** 2006. *Khulna Development Authority (KDA) Annual Report of Khulna*, KDA Bhaban, pp. 50-75. Bangladesh.
15. **LGED.** 2006. *Local Government Engineering Department (LGED) Annual Report of Khulna,* LGED Bhaban, pp. 22-80. Bangladesh.
16. **RHD.** 2006. *Roads and Highway Department (RHD) Annual Report of Khulna, RHD Bhaban,* pp. 61-95. Bangladesh.
17. **Field Survey.** 2006. *Field Survey, Unpublished Field Survey Report, Environmental Science Discipline.* Khulna University, Khulna 9208, pp. 15-56. Bangladesh.
18. **Saini, N.S.** 1987. *Urban and Regional Planning Information System for India/ Other ESCAP Countries*, pp. 58-65. New Delhi, India.
19. **Rahman, M.M. and Subudhi, A.P.** 2002. Site Suitability Analysis for Satellite Town of Chandigarh, India, *Plan Plus* 01:16-28.
20. **Shukla, S.K. and Srivastava, P.R.** 1992. *Waste Management and Control*. Commonwealth Publisher, pp. 66-75, New Delhi.