GIS-based decision support tool for optimal spatial planning of landfill in Minsk region, Belarus

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SPATIAL DECISION SUPPORT

Geographic information systems are becoming known world-wide. This advanced technology has recently gained increased visibility particularly in developing countries. The integration of multisource georeferenced spatial data within GIS database allows a synergistic processing of a considerable amount of information, the standardization of data and the elaboration of digital maps that are the basis of decision-making (Ghribi, 2005).

As many as other developing countries, accumulation of waste in Minsk region, stemming from activities of socio-economic nature including agriculture, industrialization and consequent urban expansion, is giving rise to a series of environmental problems. Waste management, in particular optimal sites for waste disposals is one of the region's priorities.

This work adopts the integration of decision-support tools and methods to manage information from various sources and to enhance decision-making through modelling environmental change and mapping human activities, in particular those related to waste disposal management in Minsk region.

This innovative method is focused on how to integrate spatial information into GIS model at different levels ranging from regional to municipal in order to manage waste. Thus GIS technology plays an important role to support decision-makers.

It makes use of remotely sensed data (MODIS and LANDSAT) to analyze changes in vegetation indices (from 2000 to 2006) and to monitor vegetation dynamics through time series analysis (TSA) and cluster analysis (CA). The normalized difference vegetation inde x (NDVI) was used as measures of the impacts of climatic conditions and anthropogenic activities on the environment. Different operational geographic units (OGUs) were used to spatially detect the change in vegetation and to temporally simulate the trend of the change from the 2000 to 2006. The examination of vegetation dynamics in a sequence of satellite images and over a period of time was carried out. This spatiotemporal analysis helped us to better understand the overview of the state of environment and to better select the study area in which will be focused the multicriteria analysis for optimal site planning.

Decision about the optimal site for landfill on certain land areas typically involve the application of multi-criteria algorithm based on logical PAIRWISE comparison. Using GIS-based decision-making processes, the work aimed at designing suitability map depicting the sensitivity of landscape to landfill. It consisted on landscape evaluation using a decision-support tool developed for the IDRISI geographic information system software package.

The purpose of building-up a multi-criteria evaluation (MCE) typology is to enhance decision about the most suitable site for landfill in Minsk region. For doing this, an attempt was made to create a suitability map by inserting interactive effects of several contributing factors and constraints (delineated in a set of raster and vector maps) that may contribute in enhancing or decreasing the susceptibility of change for each pixel.

Weighted linear combination was used in this case study. Suitability map was derived from:

$$S = (\sum WiXi) \cdot \prod Cj$$

Where,

S: suitability

Wi: weight of factor i

Xi: criterion score of factor i

Cj: constraint j

$\sum$: Somme

$\prod$: Product

Factors were land-cover categories (raster images), extracted from a classified land-cover map obtained from a satellite image. Constraints, on the other hand, were raster images that excluded certain areas from consideration (built-up areas and water bodies) to extract both factors and constraints, an image classification was elaborated.

Factors	**Description**
Urban	Proximity to urban settlements
Roads	Proximity to main roads
Water	Proximity to water (sea, lakes and rivers)
Forest	Proximity to forests, shrubs
Bare lands	Proximity to barren lands
Agriculture	Proximity to agriculture fields and croplands
Railways	Proximity to railway line
Constraints	
Water	Water (sea, lakes and rivers)
Build-up	Build-up areas (urban, industries, roads, etc)
Protected areas	National parks, public gardens etc
Groundwater	Areas of groundwater vulnerability
Historic sites	Sites of historic importance
Archaeological sites	Sites of archaeological importance

Table 1: Contributing factors and constraints

A set of maps containing the target features (factors and constraints) from which distance was measured thanks to "Analysis/Distance Operators/DISTANCE" procedure was used for weighted linear combination procedure to produce a single suitability map

Throughout "Analysis/Decision Support/WEIGHT", weights were developed by providing a series of "PAIRWISE Comparisons" of the relative importance of factors to the suitability of pixels for areas to be evaluated as suitable for landfill. To rate each PAIRWISE comparison and to fill in the matrix cells, column and row variables are rated according to the 9-point scale (Eastman *et al.*, 1995).

In Multi-Criteria Evaluation, fuzzy set membership is used in the standardization of criteria. Fuzzy set membership is characterized by a grade that ranges from 0.0 to 1.0, indicating a continuous increase from non-membership to complete membership of a pixel in a specific category (Eastman, 2001). In the present study, Sigmoidal fuzzy set membership function provided in IDRISI GIS-based software package and 3 types of fuzzy membership curves (monotonically increasing, monotonically decreasing and symmetric) were applied.

The suitability map resulting from multi-criteria evaluation has shown different land categories for which the degree of susceptibility to host landfill varies from weakly prone to extremely prone. Suitable areas were located mainly in the surrounding areas of big cities in particular in the northern part of Minsk region, within the areas of barren lands and at a certain distance from forest and water bodies.

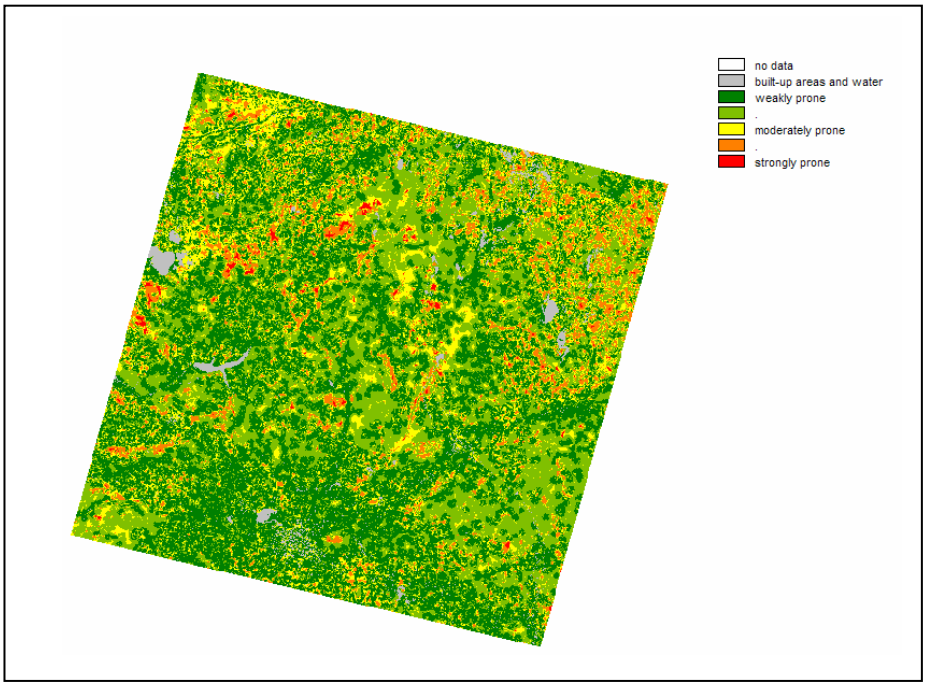

Fig. Suitability map for optimal site planning of landfill

Site selection procedures can benefit from the appropriate use of geographic information systems (GIS). Multicriteria evaluation (MCE) makes it possible to deal with qualitative multi-dimensional environmental effects, factors and constraints. Indeed decision-support tools are computer based systems that strongly sustain a single decision-maker or a group of decision-makers in evaluating

certain alternatives for a specific objective (Ghribi, 2005). Integration of GIS with MCE is a powerful tool to monitor environmental change and to support decision-making.

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