A GIS Model for Site Selection of Industrial Zones in Sri Lanka

(A Case Study of Kesbewa Divisional Secretariat Division in Colombo District)

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Abstract— Site selection of industrial zones in Sri Lanka has become a critical issue and a sensitive decision making process that may create a range of socioeconomic and environmental problems over time. Hence, several site selection criteria and appropriate methods for establishing industries have to be concerned by the decision makers and authorities before locating industrial zones in particular regions. Though, at present the enormous data volume and complex criteria regarding this field are available, the suitable site selection process is still problematic. Therefore, this paper assumes that, in some extent, such failures can be overcome by applying Geographic Information System (GIS) and Multi-criteria Decision Making Techniques into the site selection process of industrial zones.

In this study, a GIS based model is proposed to screen most suitable locations for establishing Industrial Zones in Kesbewa Divisional Secretariat Division of Colombo District, Sri Lanka. In methodology, initially seven set of site selection criteria were identified through a literature survey and consultation of expertise. Land use, Water, Soil type, Wildlife, Archeological sites, Roads and Power lines were the selection criteria relevant to this study area. Next, attribute values of the criteria were entered into a multi-criteria decision making scheme by using GIS model. Consequently, a suitability map was created by the weighted overlay method of the model so that it could easily identify the suitable sites that have met the entire requirements. The final step of the methodology of this model was to reunion the selected sites with two compulsory sub criteria; minimum land extent of 25 acres and applicability of 100m buffer zone (green belt) ordained by the authorities. In order to identify the status of available sites, a suitability scale was created with the categories of Excellent, Very good, Good, Fair and Not suitable.

The result flags that there is no any block of land under the 'excellent' category that can be associated with suitable site selection model for establishing an industrial zone in the study area but two block of lands were identified under the 'very good' category. Finally, only one site was able to select by matching with the two compulsory sub criteria for establishing an Industrial Zone in Kesbewa DSD but with some restrictions. This GIS analysis and output model can be used to speed up the site selection procedure of industrial zones in Sri Lanka but it need to be further developed by using variety of socio-economic and environmental criteria in order to get more accurate outcome.

Index Terms— GIS Application, Industrial Zones, Multi-criteria Analysis, Site selection

1 INTRODUCTION

ECONOMIC Development is fundamentally a process of structural transformation from traditional agriculture to modern agriculture, industries and services. Especially after the industrial revolution, industrial development has become a base of the economy in each country. Industrialization began in 19th century around the central Europe and was gradually spread towards Asia and other regions of the world. Rapid development of the industrial field caused to rapid distribution of the industries as well. But Most of the investors face high transaction costs because of a lack of infrastructure and weak institutions on the one hand and, people and environment are influenced in various fields by the Industrial pollution on the other. In that phase, the industrial zone began to be constructed with the aim of creating a space where industry could be removed from population centers, with all the facilities and infrastructure has been given.

The principles of liberalization, globalization and privatization and the relative changes at the global economy have been very important for the industrial zones development. Most of the countries use this tool for development of industrial field with minimizing its negative impacts on people and the environment. This has been very important as a better environmental management tool which can be used for sustainable development of the industrial sector. The best location for the industrial zone is the key factor of the accomplishment of its main objectives which are the requirement of all facilities and the minimum of social and environmental negative impacts.

As several reports indicate industrial zones are the second foremost factor that caused to increase the Toxic Pollution Problems in world wide. Thus it is very important to plan and select suitable sites for minimizing its negative impacts on people and environment. Unfortunately, in many low and middle-income countries, industrial zones have little attention to be paid on the environmental and social impacts because their industries often located in very populated areas.

Most high-income countries have strict regulations and codes for their industrial zones, but in some low- and middle-income countries, little is done to protect surrounding communities from the waste and byproduct of these concentrated industries. South Asia and Africa, for example, have large-scale problems with lead contamination of groundwater systems by untreated effluent. The Blacksmith inventory has documented twenty-nine sites in these regions, and twelve in Southeast Asia, where industrial zones are releasing large amounts of lead contamination into the surrounding environment – which often means into an adjacent residential neighborhood. The above inventory estimates that these sites

alone impact close to 3 million people.

If we consider the Sri Lankan experiences regarding the locations of the industrial zones, often they have been located based on political rather than other environmental, economic or social criteria. According to the article "Accelerated Industrial zone Programme" of Ministry of Industry & Commerce, 80% of industrial zones of the country are located in western province of Sri Lanka. It is the highest populated province of the country. Thus it is very necessary to have a proper plan for locating industrial zones in such a province with considering all relevant fields.

In 1994 Sri Lanka government has got very important decision based on industrial zones to protect the social and physical environment from the industrial pollution. According to that the Ministry of Transport, Environment and Women's Affairs, the Cabinet in 1994 approved a decision that all high and medium polluting industries should be located in designated industrial zones. But this decision was not practice. Thus it is very important, that establishing the industrial zones in division wise to locate the distributed high and medium polluting industries in one place where minimum effect to the people and the environment. It will be helped for the practicing that important policy and as well as these industrial zones should be located in most suitable places of the divisions and it is very essential to optimize their objectives.

Site selection with minimum impacts is very difficult to achieve considering criteria one by one, because of the big list of criteria including very important spatial factors. But still in Sri Lanka this process is conducted as politicians need. Because of that so many considerable problems often have been occurred. In this study have mentioned what are the criteria that we must consider before establishing industrial zones in Sri Lanka. That is the one of major significance of this study. The GIS based model has been developed in this research can be used for every where to get a very accurate dictions for site selection process. It is very important especially for the sustainable development of industrial field.

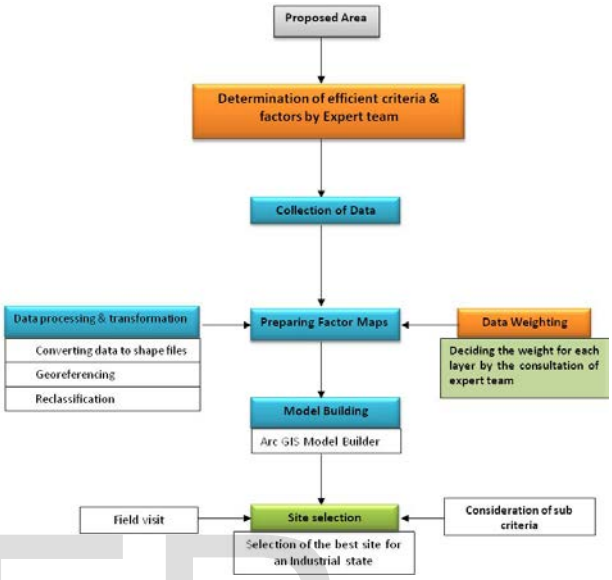
2 Study Area

Kesbewa Divisional Secretariat Division was the target area for this study. It is located in Colombo District of Western Province of Sri Lanka, bordering to Bologoda Lake, and between Latitude 6°44′ to 6°51' North and Longitude 79°54' to 79°58' East. Total land area of the division consists 61.91 square kilometers and there are 243,842 populations in the division. The population density referred as 3939 (per square kilometer) (Census data 2012). This is the 3rd highest populated DS in Colombo district.

3 Methodology

Five steps were followed in the methodology which used to select the suitable sites of industrial zones as seen in Figure 1. The first step was the selection of study area. The second step involved the selection of criteria and factors, and subsequently Data Collection according to developed criteria and factors in study area for preparation of factor maps. Data weighting was decided by the experts considering layer importance. In the fifth step development of the GIS model was done using ArcMap 10.1 software and final step was incorporation of the all factor maps through the GIS based model that the final suitability map could be created.

Figure 1– Flow chart of the Methodology followed



3.1 Determination of efficient criteria and factors

The suitable site selection for an Industrial zone involves many geospatial data layers and related attributes. Since the site selection process is highly depended on several criteria and factors, one of the main tasks of the research methodology was the determination of such criteria and factors. In order to fulfill those requirement two methods were applied. a). some of general criteria applied by other researchers were identified through literature survey and b). Some specific criteria and factors determined by consultation of Sri Lankan expert team from the field of social, economic and environmental sectors.

The criteria list which wants to consider for site selection was depended on the selected area. Thus main criteria list which need to considere on area basis is given below.

Physical Criteria - Surface water, Ground water, Soil type, Slope, Wind, Natural hazards, Erodable area, Flood
Ecological Criteria - Forest, Wildlife, Wetlands, Coastal area
Social Criteria - Home garden, Agricultural areas, Public places, Archeological sites
Infrastructure - Road access, Water access, Width of the Roads, Waste water discharge, Electricity, Highway, Airports, Seaports, Solide waste management
Other Criteria - Ownership of the Land, Distance to urban centers, Location of other national projects, Availability of man power.

Accodingly, Data availability and considering the situation of the study area, seven criteria were selected for this study.

Those are **Land use, Water, Soil type, Wildlife, Archeological sites, Road, Power lines.** Then seven factor maps were prepared based on above criteria.

3.2 Layer weighting

Weighting of data layers was done with consultation of the experts. Figure 2 is representing the metrix which used for layer weighting.

Figure 2 – Metrix of the layer weighting

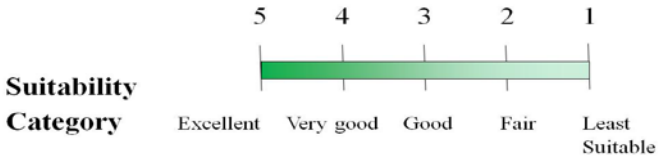
Attributes		Waste water discharge	Water intake	Power Supply	Road Access	Loss of life and fatal injur	Acute health hazards	Chronic health hazards	Human Interferences	Loss of habitats	Loss of fauna	Loss of flora	Environmental Pollution	Sum	Average	Percentage (Weight of the layer)
		12	11	10	9	8	7	6	5	4	3	2	1	78		%
Plantation	Land use						7	6	5				1	19	17	15
Home garden							7	6	5				1	19		
Important public Area							7	6	5				1	19		
Industry Area				10	9								1	20		
Open land							7		5				1	13		
Other cultivation								6	5				1	12		
Paddy								6	5				1	12		
Scrub									5	4	3	2	1	15		
Wetland		12							5	4	3	2	1	27		
Water		12	11										1	24	24	20
Wildlife						8			5	4	3	2	1	23	23	20
Soil								6	5				1	12	12	10
Archilogical sites							7		5					12	12	10
Road				10	9									19	19	16
Power line				10										10	10	9
Toatal														256	117	100

Twelve factors were considered which involved with industrial pollution and the required infrastructures for industrial zone. Figure 2 represents the method of deciding the layer weights.

3.3 Suitability scale

The attributes of the each factor maps were reclassified with the suitability scale. Figure 03 shows the suitability scale that used for this study.

Figure 3- Suitability scale

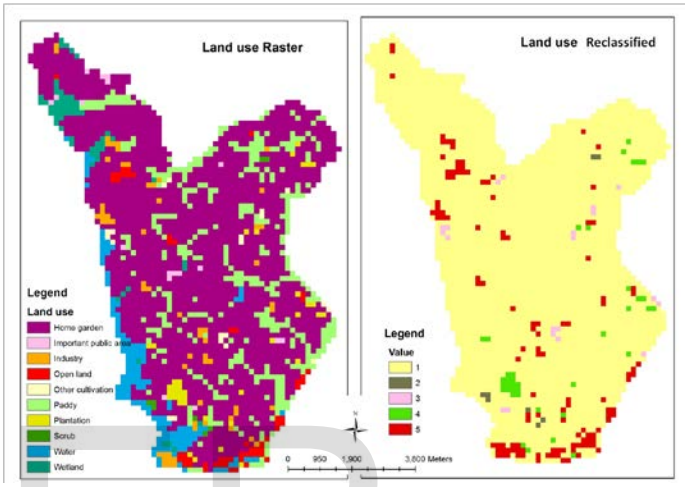


The value 5 was given for the areas where the considered factor is presented in most favorable manner for the Site selection while value 4, 3, 2 and 1 was given for the next suitability levels. Accordingly, the above selected spatial factors were assigned suitable values from 1 to 5 based on their attributes. Suitable values for each classes of the layer were selected by the experts. Figure 4 shows the given suitable values for each classes of the Landuse layer and Figure 5 shows the Landuse raster map and reclassified map according to the given valuse of classes.

Figure 4- Landuse Categories and Assigned Values

Category	Class	Value Assigned
Home garden	1	1
Paddy	7	1
Plantation	10	4
Open land	4	5
Important public area	6	1
Industry area	9	5
Water	3	1
Wetland	2	1
Scrub	5	2
Other cultivation	8	3

Figure 5- Landuse Categories and Assigned Values



4 Analysis, Results & Discussion

The study focuses the following three steps in analysis.

- Development of GIS based model for multi-criteria analysis
- Run the model with factor maps and deriving the output
- Consideration of sub criteria
- Final site selection

4.1 Development of GIS based model

Figure 6- Flow chart of the GIS Analysis

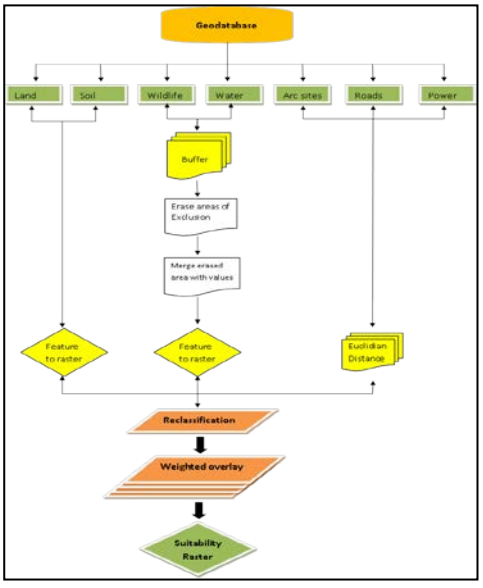
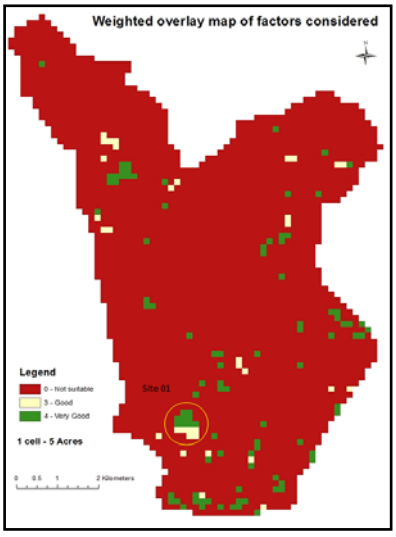


Figure 6 shows the flow chart of developed GIS based model of multi-criteria analysis for deriving the research output.

4.2 Overall land suitability

Figure 7- Suitability Map



Resulted suitability map of the weighted overlay model is representing in figure 7. As result of the model, "Very good", "Good" and "Not suitable" sites had been categoried. "Excellent"and "Fair" categories were not found in study area. According to this result, there is no any excellent suitable (5) site for industrial zone in Kesbewa DS Division.

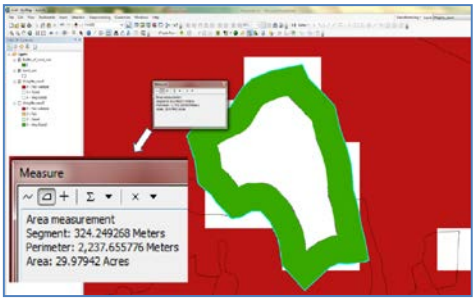
4.3 Consideration of sub criteria

There are 98 cells has been selected as good and very good for establishing industrial zone. 1 cell is representing 5 acres in ground. Since excellent sites were not selected, we have to consider the area where selected as "good" and "very good" with conditions. Based on the sub criteria, the most suitable site out of the 98 cells which can be used for establishing industrial zone was selected. This selection was done by based on sub criterions at first.

Sub criterions for industrial zone site selection

- Minimum land requirement is 25 acres
- There should be 100 meter internal buffer in the site

Figure 8- Selected land considering sub criteria



According to the sub criteria site 01 which representing at figure 07,08 was selected as suitable for establishing an industrial zone in Kesbewa Divisional secretariat Division. Even thogh the selected land is not an excellently suitable location for an industrial zone, it could be considered with some restrictions.

5 Conclusions

In general site selection process has become increasingly complex because of the plethora of environmental laws and regulations as well as the greater public awareness and involvement in the zoning and environmental issues. GIS is very vital efficient tools for solving sitting problems. Its special capability for multi criteria analysis was very useful in developing the model discussed in this research. Selection of the criteria by experts is very important to get the accurate decisions. They should be represented from economic, social and environment fields to fulfill this process. The GIS model developed in this research is very cost effective and easier than the traditional approach of identifying potential sites for industrial zones.

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