LAND USE SUITABILITY ANALYSIS USING GIS TECHNIQUE IN THE ERZURUM WATERSHED, TURKEY

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ABSTRACT

Efficient and sustainable use of natural resources such as land is one of the most important subject for economic growth and management especially large watershed areas like the Erzurum watershed. Rapid population and migration call for new areas for future generations. For this purpose, it is extremely important subject to arrange land use plans to transfer the next generations. Watersheds consist of essential natural resources, their planning requires careful consideration. Land use suitability analysis is the process of deciding the suitability of a watershed area for a certain type of use and the level of suitability. There is a growing need to develop methods for analyzing natural resource suitability that are both legally efficient and accurate. Suitability analysis with Geographic Information System (GIS) based techniques are essential for decision-making process. GIS is one of the important tool for evaluating the land use planning. A GIS allows access to a lot of information quickly and efficiently. Suitability analysis of watershed with GIS facilitates land-use planners to correlate multiple data layers. The aim of the present study was to evaluate the land use changes in Erzurum watershed by using GIS for ecological planning aspects. An important goal of land suitability analysis in watershed gives ecological inventory of the watershed and identify opportunities for future land conservation and development. In this paper, the risk areas were determined from an ecological point of view. It has been established a risk map for each factor identified in the assessment. According to the ecological risk assessment for the given area, 38,797 ha (or 15%) were high-risk areas and 257,285 ha (or 85%) were identified as intermediate risk areas. While making the ecological risk assessment on available fields located in wetlands, it was determined that ecological risk value of these areas is high. According to the results obtained in areas where the natural tissue is damages within the scope of ecological planning, it was determined that these areas should be re-evaluated and protected.

Keywords: Ecological Planning, Ecological Risk Analysis, Erzurum Watershed, GIS, Land Use Suitability Analysis, Watershed Planning

1. Introduction

The expansion of urban land areas was cause the decrease of urban wetlands. Along with this expansion of urban land was the decrease of urban wetlands. The wetlands of the world provide more ecosystem services every area than any other habitat type (Li *et al*. 2014, Dodds *et al*., 2008). Urban wetlands, a complex social–economic–natural ecosystem, are known to provide many valuable ecological benefits to urban ecosystems. As a complex social–economic–natural ecosystem, urban wetland is an integral part of the developed landscape. Wetlands have recreational, historical, scientific, and cultural values (Jia *et al*. 2011, Ehrenfeld, 2000). Based on different scientific and policy objectives, various ecological functions of wetlands have been studied and evaluated, including hydrology, groundwater recharge; flood control, and recreation for nearby residents, water purification; floods detention; microclimate regulation; biodiversity maintenance; scenic creation, cultural heritage (Min *et al*., 2010, Trepel, 2010, Hefting *et al*., 2013), water quality (Trebitz *et al*., 2007; Verhoeven *et al*., 2006), vegetation composition (Hebb *et al*., 2013) and animal population dynamics (Fracz and Chow-Fraser, 2013; Seilheimer and

Chow-Fraser, 2006). However, the wetland ecosystem services are undervalued and widely threatened (Turpie *et al*., 2010). Wetland loss in Turkey has been more significant than in most parts of the world, and ecosystems in fertile lowlands have been most severely impacted by agricultural development. Recently, ecological risk assessment (ERA) has applied several tools for modeling. Practical application of wetland ecological risk assessment will result in a better understanding of how physical, chemical and biological stressors impinge on wetlands and will provide a framework for prudent wetland management (Malekmohammadi and Blouchi, 2014, Chen *et al*. 2013). According to Altan (1991) and Yücel (1997), ERA is one of the commonly used method about analyze and evaluation of the relation between land use types on echological planning. Interaction between land use types in a specific area constitutes the basis of the ecological risk analysis. To improve the implementation for ERA to ecosystems, studies by using Geographic Information Systems (GIS) and the science of ecology as a tool are underway. (Malekmohammadi and Blouchi, 2014; Solomon and Sibley, 2002). There is generally a need for detailed technical guidance, specification and/or codes for urban wetlands planning (Wang *et al*., 2010). In the present paper, the Erzurum central region was selected as a case study on urban wetlands planning methodology with an urban planning perspective.

2. Materials and methods

2.1. Material

The city of Erzurum is at an average elevation of 1850 m. Erzurum is one of the cities located in the eastern part of Turkey (location of 39,90° N to 41,27° E; Fig. 1), situated on a plateau surrounded by mountains to the east, north and south. The height of this plateau is 1950 m above see level. It lies in a northeast–northwest direction, on an area 20 km long and 5 km wide. According to the census conducted by Turkish State Statistics Institution, the population of the city is 361,235 (Anonymus, 2002). From the data obtained between 1988 and 2003, the mean daily temperature is 5.2 °C, the max. and min. temperature is 35.6 °C and -37.2 °C, respectively.

Figure 1 shows the location of the wetlands within the Erzurum watershed (39,99° N to 41,35° E, and 39,97° N to 41,27° E). Wetlands are divided into two by the Erzurum-Artvin highway. The East remain part is called Çayırtepe and the west part is called Karasu. The map made by Directorate of Nature Conservation and Natural Parks, contains total 825 km^2 from the Erzurum plain, 1,077 ha from Karasu swamp and 1,744 ha of Müdürge swamp. The total amount of wetlands in Erzurum plain with the identification of the small wetlands is assessed to 3,303.5 ha. The buffer zone around wetlands is 14,645 ha. The deepest part of the wetland is at the start point of Çayırtepe main drainage channel. Erzurum is located approximately 10 km south from the wetlands.

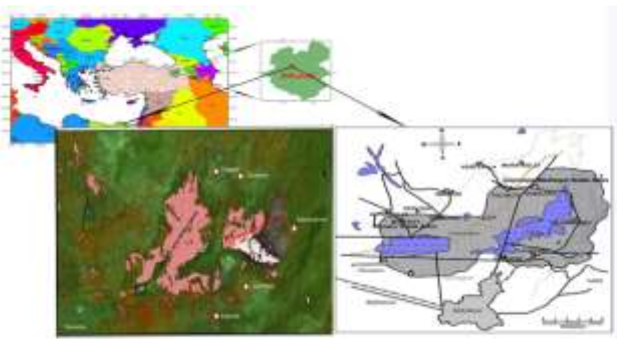


Figure 1: Illustration of the two-dimensional experimental set up.

2.2. Method

In order to detect the most suitable land-uses, priority order suggested by Mc Harg (1992), Cengiz (2003), Uzun (2003) and Ardahanlıoğlu (2014) was utilised. In this paper, ArcGIS software is used to generate map and the evaluation of the data. ArcGIS is a GIS for working with maps and geographic information. Among the numerous that ArcGIS software is used for are creating and using maps; compiling geographic data; analysing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; managing geographic information in a database etc. While preparing ecological risk charts, natural factors that may be determinant for each risk factor and their co-factors were determined. Cofactors were evaluated for their weighted effectiveness scores in the determination of the use potential. In order to detect the potential risk factor and uses, evaluation cofactors were given scores ranging from 1 to 3. In this scoring system, 3 means “high risk” 2 means “intermediate risk”, and 1 means “unsuitable”. When creating the risk maps, sub-factors are used as a base maps. Elevation, slope, aspect, are used for creating the topographic risk maps, while major soil groups, erosion, are used for land use maps (Table 1).

Table1: Cofactors chosen for the determination of potential risk factor and their suitability values

	Evaluation factor	Cofactors of evaluation factors	Area(ha)	Weighted scores of cofactors
Topographic risk map	**Elevation**	1747-2000 m	88,665.3	3
		2000-2500 m	40,258.8	2
		2500-3000 m	11,389.4	1
	Slope	%0-2	57,586.5	3
		%2-6	27,805.5	3
		%6-12	25,871.4	2
		%12-20	20,738.7	2
		%20-30	9,350.1	2
		>%30	905.4	1
	Aspect	S	18,141.3	3
		NE, E, SE, SW, W,NW	103,765.5	2
		N	1,940.7	1
Soil risk map	**Land-use ability classes**	1^{rd} class	16,350.9	3
		2^{rd} class	24,571.0	3
		3^{rd} class	11,134.0	3
		4^{th} class	13,310.4	2
		5^{th} class	0	2
		6^{th} class	15,806.7	2
		7^{th} class	29,785.0	1
		8^{th} class	120.7	1
	Erosion	1(absent or mild)	39,055.4	1
		2 (moderate)	36,636.9	2
		3 (severe)	33,964.4	2
		4 (very severe)	373.4	3
	Soil Group	A(Alluvial Soils)	23,465.5	3
		C(Saline-alkali soil)	204.6	1
		CE(Auburn Lands)	11,310.0	2
		K(Colluvial soils	30,873.6	3
		X(Basaltic soils)	45,104.4	2
Hydrology Risk Map		0-100 m	3,291.3	3
		>100 m	112,321.0	2
Land Use Capability Risk Map		C (meadow)	5,690.2	2
		F (Heathland)	109.7	3
		K Dry Farming (fallow)	23,331.8	3
		M (Pasture)	58,453.5	2
		S (Irrigated)	10,074.1	3
		Sy (Irrigated Agriculture)(inadequate)	11,125.1	3

Model Builder was developed for visualising the model that was used in this paper (Figure 2). It was used the ModelBuilder tool in ArcGIS that is an application for creating editing and managing models. Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tools as input.

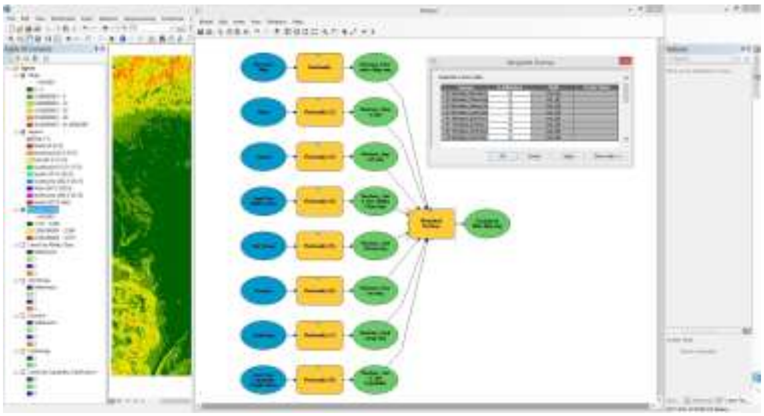
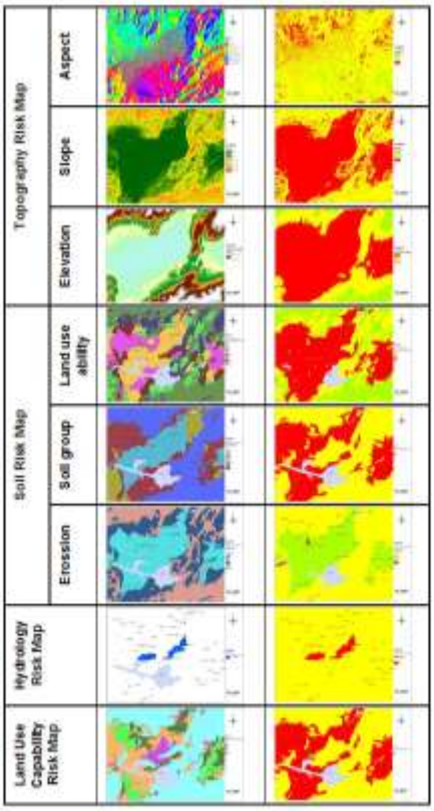
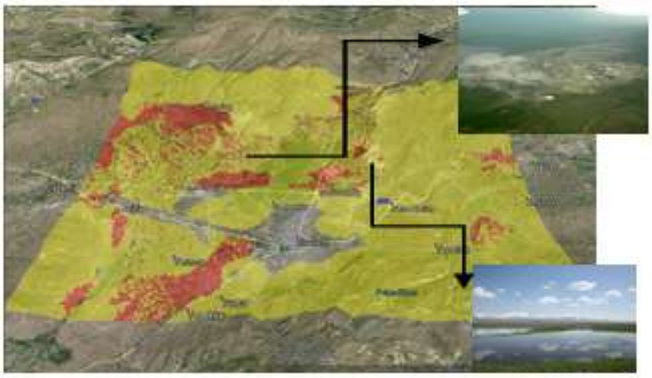


Figure 2: Ecological Risk Map ModelBuilder

3. Results



(b)



(a) **(c)**

Figure3: a) Erzurum city centre and Erzurum swamp ecological risk map, b-c) Erzurum city center and Erzurum total swamp ecological risk assessment map

While determining the potential topography risk areas, the factors, namely the elevation, slope and aspect were studied. It was assessed that areas with 1747-2000 m altitude have high risk and the area takes 88,665.3 ha. Up to 6 % slope areas (85,392 ha) and southern aspect areas (18,141.2 ha) are in the high-risk group. While determining the potential soil risk areas, the factors, namely the land-use ability, erosion and soil group were studied. 1-3 class plots (52,055.9 ha) are at high risk. Because the study area is straight and close to straight there is no risk of erosions. In the high-risk groups are the alluvial and the colluvial types of soil with 54,339.1 ha area. In this study area, the wetlands areas and 100 m around them carries high risk and it covers 3,291.3 ha area. In the current land use the agricultural areas are in particular high-risk groups (Figure 3).

4. Conclusions

According to the results of the analysis carried out for the determination of potential risk areas, 38,797ha (15%) of the study area was detected to be of "high risk", 257,285 ha (85%) were detected as "risk" (Figure 4). As shown on Figure 4, in particular plain based regions and wetlands have high risk degree. In the region, this situation should be taken into account while planning the future constructions and not to degrade the native tissue and the areas with high risk level should be brought to the status of the protection of these areas.

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