

Land use planning using Geographical Information System (GIS) techniques (Case study: Kalaleh & Darana watershed, North of Iran)

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ABSTRACT

Having information about natural conditions, resources, limitations and problems of watersheds, planning based on problems severity, potentials and priorities to decrease economic and human losses, increase in efficiency of resources based on capabilities and finally defining the best alternatives according to health and sustainability of ecosystems in a watershed are main objectives of land use planning. Resources allocation process is vital task especially for resources with limitations. One of these resources all over the world is land to use for different purposes. Since land use planning process use combination of different spatial information sources, applying effective tools with analysis capability is necessary. One of these tools is Geographic Information System (GIS), which is used widely in land use planning in national and global scales. In this study, land use planning has been developed in north-western part of Iran using conditional functions in GIS in order to decrease erosion and for optimum use of resources. In the designed model, several information layers such as slope, aspect, DEM, soil texture, drainage, soil hydrologic groups, rainfall, infiltration, plant cover and erodibility were considered. The results showed that 12% of total area is suitable for forest, 25.7% suits for agricultural-rangeland land uses. The results also indicate that 18% of area under agriculture use is not suitable for this class of land use.

INTRODUCTION

Watersheds are characterized by their high degree of cultural and ecological diversity and are considered as basic unit for sustainable development. The main goal of sustainable development is improving public welfare and preserving the environment for next generations. Resources allocation especially about natural resources which are limited is very sensitive process. One of such limited resources which is clearly marked in all around the world is land for various utilities. Land use planning is a process based on socio-economic needs and spatial analysis of elements such as topographic shapes, vegetation characteristics, soil and water resources. Since the land use planning process is based on analysis of combined spatial resources, use of effective tools for spatial analysis can be helpful. One of these tools is geographic information systems (GIS) which are widely used in land use planning process at national and global levels. One of the most useful applications of GIS for planning and management is land use suitability mapping and analysis (McHarg, 1969; Hopkins, 1977; Brail and Klosterman, 2001; Collins et al., 2001). The GIS-based land use suitability analysis has been applied in a wide variety of situations including ecological approaches to determine land suitability/habitant for animal and plant species (Pereira and Duckstein, 1993; Store and Kangas, 2001), geological favorability (Bonham-Carter, 1994), suitability of land for agricultural activities (Cambell et al., 1992; Kalogirou, 2002), landscape evaluation and planning (Miller et al., 1998), environmental impact assessment (Moreno and Seigel, 1988), selecting the best site for public and

private sector facilities (Eastman et al., 1993; Church, 2002), and regional planning (Janssen and Rietveld, 1990). Main objective of this study is land use planning using conditional functions in GIS to achieve optimum use of resources in Kalaleh watershed located in Northwest of Iran.

METHODS

Kalaleh watershed with 31 km² area located in Northwest of Iran. Figures 1 and 2 show location of this watershed in Iran and its 3D status. There are different types of land uses and land covers with different coverage including dryland farming (3.4 km²), garden (0.64 km²), shrubs (2.1 km²) and forest (5.7 km²) in the Kalaleh watershed. In this study the GIS functions were used for land use planning. For this reason some features that have the main role in landuse were used. They are including topographic, meteorological and climatic, geologic, hydrologic, scio-economic, pedologic, vegetation and erosivity features. These features were modeled in GIS by multi criteria analysis. The main steps in GIS for environment ecological assessment are as follows: 1- identify land use goals; 2- identify the factors necessary to achieve the desired goal; 3- prioritization based on objective factors; and 4- ecological assessment based on results. Figure 3 shows the GIS modeling approach in this study.



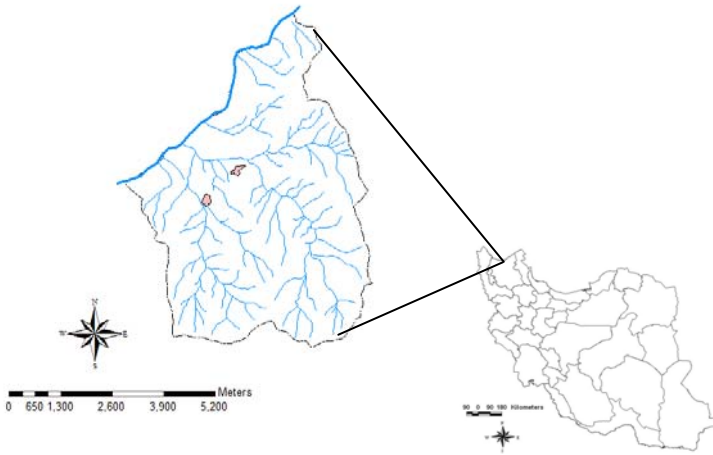


Figure 1: location of study area in Iran



Figure 2: 3D model from the study area

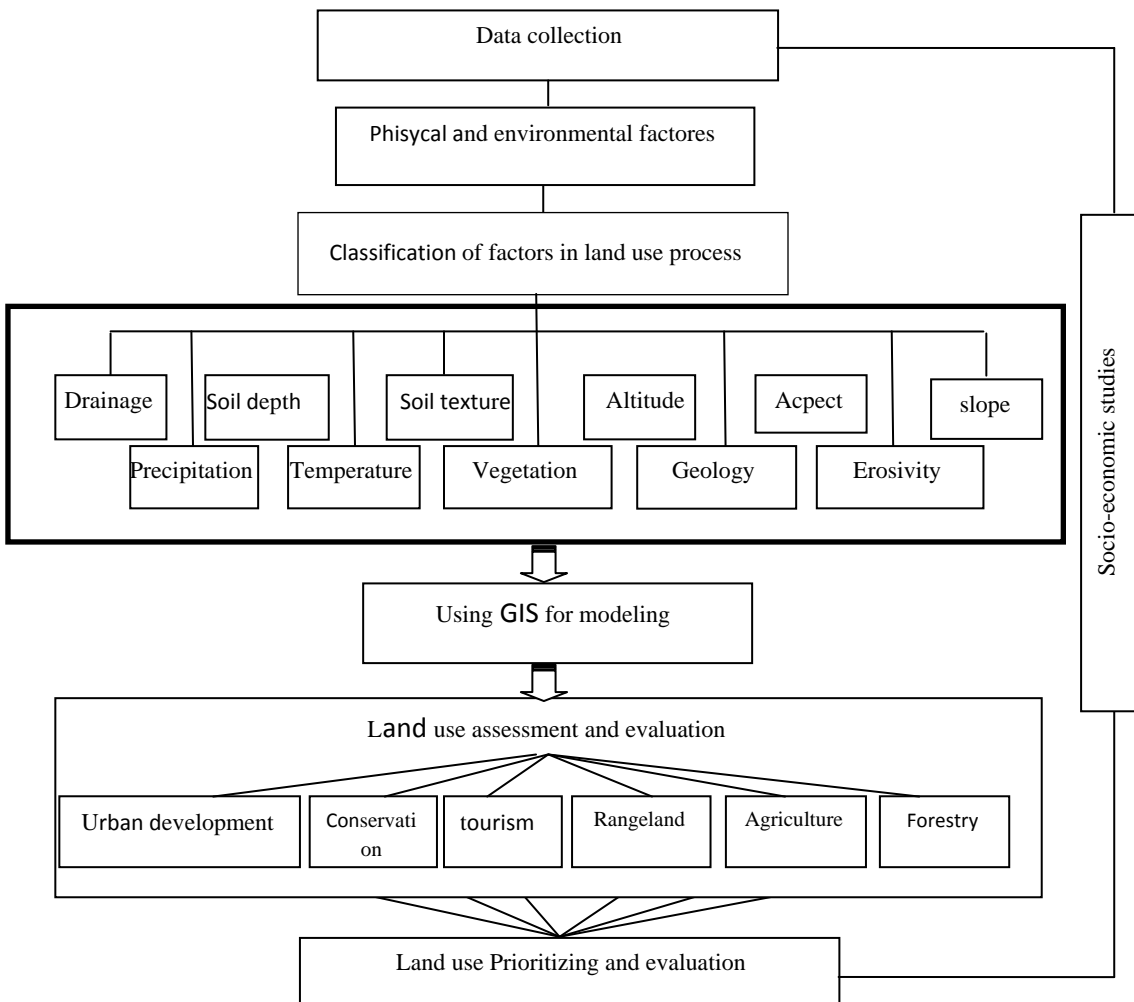


Figure 3: Steps of research method

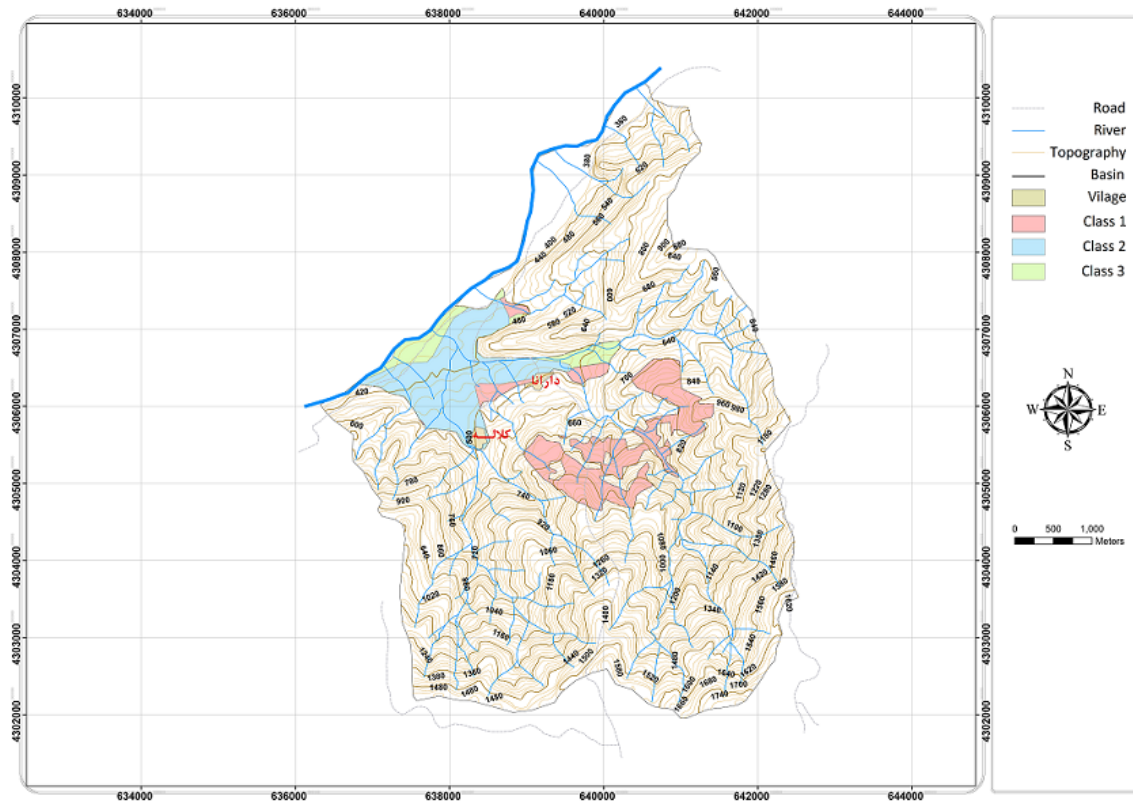


Figure 4: Forestry suitability

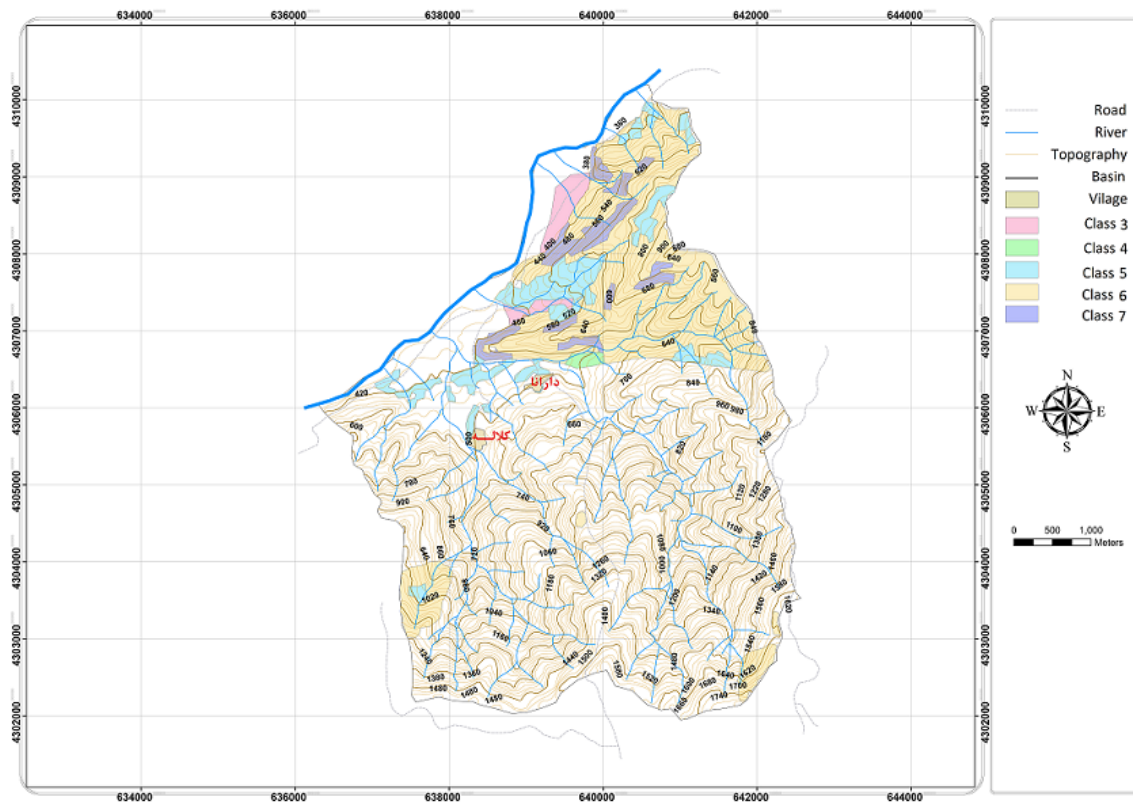


Figure 5: Agricultural and Rangeland suitability

In this study the ArcGIS software was applied. At first step data of study area was collected, which are including topography layer, land use, soil, geology, hydrologic groups, temperature and precipitation. Topographic features of watershed such as slope, aspect and altitude were created using spatial analyst and 3D analyst module with Model Builder toolbox in ArcGIS software. Next step is defining land unit layer by Arithmetic overlay function. Land unit polygons contain environment, pedologic, geologic and topographic features of watershed. Then the models defined in Tables 1 and 2 for forestry and agricultural-rangeland suitability were applied in GIS environment. The results of land use allocation in GIS presented in Figures 4 and 5. Outcomes of the models which were used in GIS, were checked using main layers and field works.

RESULT

For this case study 2 types of land use suitability were found which is explained in this section. It should be mentioned that there is not type of tourism land use in this watershed.

Forestry suitability: this model indicates forestry land use suitability. Table 1 shows the results of model which is used for forestry suitability. This model contains 3 classes of land use suitability. In class 1 there is no limit to growth of commercial forest trees and in class 2 there are very little limits for growth of commercial forests and in class 3, limitations for growth of commercial forest trees are relatively moderate.

Table 1: Forestry allocation

class	Altitude (m)	Slope%	Soil texture	Drainage	Soil depth	Bed rock
1	0-1000	0-25	Clay	avg.	deep	limestone
2	0-1000	0-35%	Loam	avg.	deep	limestone
3	0-1400	0-45%	Loam	incomplete	avg.	limestone

Agriculture and rangeland suitability: this model indicates agriculture and rangeland land use suitability. Table 2 represents the results of the model which is used for agriculture and rangeland suitability. This model contains 5 classes of land use suitability which in class 3, land is suitable for growing agricultural products, but it is not suitable for continuous harvesting and in class 4, land is suitable for dry farming and rangeland, but in moderate suitability for fruit trees cultivation. In class 5 land is in moderate suitability for range and dry farming and in class 6 land is suitable for beekeeping and gardening in terraces on slopes and in class 7 land is not suitable for rangeland and agriculture. Tables 3 and 4 represent the area of each class in the forestry and agricultural-rangeland suitability, respectively.

Table 2: agriculture and rangeland allocation

Class	Slope %	Soil texture	Drainage	Soil depth	Erosivity
3	0-8	Loam/clay	avg.	avg.	avg.
4	8-15	Clay	avg. to better	avg.	avg.
5	8-15	Clay/Loam	incomplete	low to avg.	avg. to high
6	15-30	Sandy loam	incomplete	low to avg.	avg. to high
7	>30	-	-	-	avg. to high

Table 3: area of forestry land use suitability

	Class of land use suitability	Area (km ²)
1	Whole watershed	31
2	Class 1	1.7
3	Class 2	1.7
4	Class 3	0.48

Table 4: area of agriculture and rangeland land use suitability

	Class of land use suitability	Area (km ²)
1	Whole watershed	23.27
2	Class 3	0.38
3	Class 4	0.08
4	Class 5	1.44
5	Class 6	5.36
6	Class 7	0.78

CONCLUSION

Considering the mountainous area in the watershed, a large percentage of the watershed has topographic constraints such as high slope and topography. Therefore main limitation in the watershed can be considered as topographic constraints. In management of the Kalaleh watershed, restoration of vegetation should be in priority in order to develop any plan for natural resources. Short-term plans in the watershed should focus mainly to avoid degradation of pastures and forests. Mid-term programs should concern the expansion of forests. Finally in long-term plans, main point should be improving public viewpoint in terms of natural resources conservation.

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