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Research Article

Spatial-Systematic Analysis Approach for Conservation Purposes

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Abstract

Increasing human population growth leads to the increase in resource consumption and biodiversity degradation. The current threats to the biodiversity and widlife extinction emphasis on the protected areas role in the conservation plans. In this research we used systematic conservation planning map overlay method and analytical approach for zonation of Havashanq non-hunting area in GIS. For this purpose, 15 criteria were identified and entered in GIS and then were catagorized for modelling phase. The zonation mode was developed on McHarg and Makhdum models (the Iranian model to determine land capabilities). These models use all criteria and elements affecting environmental planning and management process in an area. Additionally, in these models, they were changed on the existing data. Owing to lack of socio–economic data, the area zoning had 7 zones, including strict nature reserve zone, protected area zone, intensive use zone, extensive use zone, recovery zone, special use zone and multiple use zones. The results showed that the strict zone 31 %, protected area 38.8%, intensive use zone 1.9%, extensive use zone 14%, recovery zone 8.3 %, special use zone 4.8 % and multiple use zone 1.2 %, compose area extent.

Keywords: System Analysis, Conservation, Geographical Information system (GIS), Non-hunting area, Havashanaq, Ardabil province.

Introduction

Increased destruction of nature in recent years has inevitably affected human society and forced human beings to reconsider a solution as well as protect some areas of wild life for the future (Dudley et al. 2005). Integration and determination of modern protected areas in terms of national parks have started since the mid-nineteenth century in different countries (Phillips 2003). The evolution of the concept of protected areas can be classified in three different models: classical model, modern model, and emerging model (Ervin et al. 2010). The current emerging model fits Greifswald approach for landscape ecology and is based on three principals: ecology, economics, and ethics or social matters (Ott 2002). According to this model, the main reason for establishment of

protected areas is the strategy for maintaining life supporting systems (Ervin et al. 2010).
According to the Convention on Biological Diversity (1992), the protected area is described as a geographical region determined and set in order to achieve specific conservation objectives. In this context, the total area of protected areas on global, national and regional scales is the key indicators of spatial protection. Goal No. 11 of the Convention on Biological Diversity (2010) indicates that by 2020, at least 17 % of internal waters and inland areas as well as 10 % of coastal and marine areas should be connected properly, especially the areas of particular importance for biodiversity and ecosystem service should be connected to each other through an effective relation as conservation management.

Protected areas are considered the main points to evaluate management objectives and classify different areas. These areas represent the most valuable and diverse samples of natural habitats in their protection that formed as a basis for environmental activities. In fact, protected areas considered as the results from land use planning that can achieve the predicted goals by the IUCN classification if they are planned by environmental planning and zoning during the environmental assessment process (Najminezhad et al. 2005).

Zonation is a tool to plan and manage protected areas and provides the possibility that each region in each class meets its own multi-purposes without any conflict with others so that its protective goals are met properly. The zonation of a spatial strategy is performed in a protected area (Murzakhanov 2012). In recent years, many efforts have been made on the PA networks planning methods (Margules and Pressey 2000), but much less studies have been conducted concerning the zonation of protected areas. However, many techniques used to select the PA are applicable in the zonation and can be also determined (Murzakhanov 2012).
In this regard, various studies in the world have focused on zonation of the protected areas. For example, in Italy, land use planning process is conducted by the ultimate environmental threshold (UET) method to discover the UET of tourism via GIS technology in order to analyze the results and data storage process as well as results presentation in desert areas (Senes and Toccolini 1998). Based on the evaluation of the zonation plan of the Kalamalka Lake and considering the current applications and potentials of the area as well as ecosystems in the lake, the entire lake was finally introduced as tourism and recreational zones (Carmichael and Wilkin 2006). In this regard, Hjorts et al. (2006) studied application of multi-criteria decision-making in management of protected areas and buffer zones in the Royal Chitwan National Park in Nepal. Their study aimed at developing a comprehensive model of land use to manage buffer zones and protected areas in developing countries. Naughton (2007), in another study, performed a common land use planning, including zonation for conservation and development in the protected areas to achieve a useful issue on balanced conservation and development on landscape scale.
Using GIS technology and satellite imagery, this study was conducted in Bolivia, the Philippines and Peru. In this context and in Talampaya National Park in Argentina, using a modification in zonation of forest protected areas, as provided by Bos, a quantitative method was introduced for zonation of the area and evaluation of its ecological applications in theoretical zonation contexts so that it could improve zonation of protected areas in developing countries with minimal cost, time and energy (Sabatini et al. 2007). According to the survey conducted by Geneletti and Duren (2008), protective zonation of protected areas was presented as a combination of multi-criteria evaluation to manage the parks having scientific and practical value. This method has four stages. At first, the park is divided into multi–subunits, at the next stage; three multi-criteria evaluations occur for land utility mapping in zones A, B and C and at the third stage, each unit is included at the level of protection through the multifunctional land

allocation method. Finally, a sensitivity analysis is conducted to test the zonation plan.

Zonation of the area performed using the systematic analysis model that developed on McHarg and Iranian model in the GIS environment. This study was conducted with the purpose of zoning different parts of the area and achieving the optimal model for protection of its natural, cultural, and historical resources. In this research, the combination of spatial modeling obtained from zonation paradigm is surveyed on protected area management and planning aims and also systematic model that are a step-by-step legal model based on hierarchical principles in zones determination.

Material and methods

Study Area

Havashanq is a village near the study area with beautiful natural (mountains and rivers) and historical scenes. The study area of Havashanq is located at 267601-285149 meters east and 4175222 to 4194342 meters north coordinates. This area is in the southeastern part of Ardabil Province in Iran and between Kosar and Khalkhal cities. As figure 1 shows and according to the recent survey, it is suggested that Havashanq non-hunting area is 19,723 ha from this area, 10,127 ha is in the central part of the surrounding cities of Kosar and 9596 ha is located in the central part of the surrounding cities of Khalkhal.

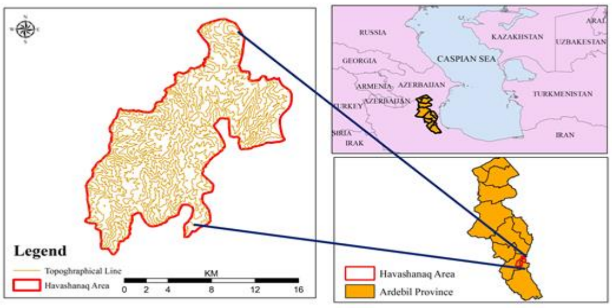

Figure 1. Location of the study area in Ardabil, Iran.

Geographical location and mountainous ecosystems of Havashanq have been influenced by the Caspian and Mediterranean climate. In addition, locating between the tropical and humid region of Gilan Province, the Talysh Mountains and the Givi River as well as the Neor Lake in the northern part of the region, has caused climate and biological diversity. This leads to the unique biodiversity of the area in which due to natural conditions, numerous natural caves, and wildlife, this area has become a suitable habitat for a variety of animals and other plant species. Height of the study area ranges from 1588 to 2700 meters and its slope varies between 0 and 4.81 degrees. Most of this area is pasture and dominant erosion is on the hillside parts. Morphologically, there are three tips in this area, which are mountains, hills and plateaus, and upper terraces. Astragalus is the dominant species in many parts of the region, and in some parts, thinning forests can be observed and the main canopy of the region is between 25% and 50 %.

Modeling approach

As figure 2 shows, three stages were developed in order to run the zonation process in Havashanq non-hunting area. The first stage shows the model input maps in three physical, chemical, and socio-economic sections of the study area. Secondly, GIS and using this system in the process of the zonation modeling are described. At the third stage, the main zonation model and the working mechanism are investigated.

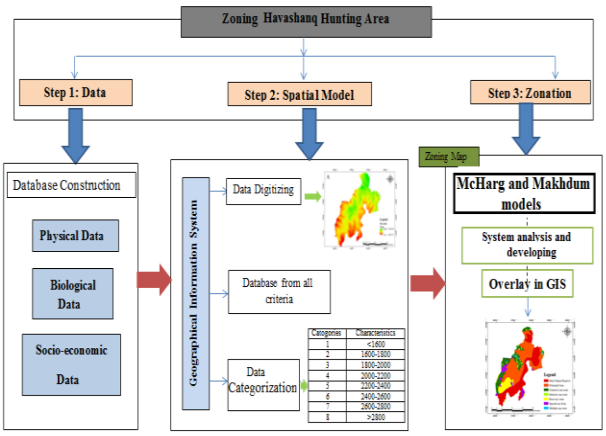

Figure 2. Research steps diagram

1. Initial data

The basic input data for zonation of Havashanq are in three groups of data: physical, biological, and socio-economic as described as following:

a. Physical data

This group of data, including data on elevation, slope, direction, geology, soil, degree of erosion, positions of the rivers and spring points. Some of physical Data such as elevation, slope and aspect extracted from digital elevation. Also, geological and soil data digitized from 1:100000 map of the region. Moreover, degree of erosion, rivers and springs points were obtained from Department of Environment of Ardabil Province.

b. Biological data

Due to the vast variety of habitats of plants and animals, biological data play the most important role in determining and zoning the protected areas. Data in this group include information on vegetation, vegetation density, land use, distribution of the brown bear and Lynx. Information on vegetation and land use density was extracted from satellite images. Furthermore, data on distribution of the umbrella species, including Brown Bear and Lynx were obtained from studies in the Department of Environment of Ardabil Province.

c. Socio-economic data

In the study area, there isn’t any village points and industrial place, but only roads and Service place has existed which are extracted from Ardabil govern GIS Department.

2- Spatial models

Using spatial models and techniques can create functions and outputs that are of interest to decision-makers in public and private organizations (Fischer and Unwin 1996). A model is summarized and simplified through representation of the reality (Odum 1975, Jeffers 1978, Duerr et al. 1979). Using the models for environmental activities causes connection and synergy among the separated physical, biological and socio-economic systems. The models can also predict and simulate the future in terms of time and space.

At this stage, the maps are on a scale of 1: 25,000. In this respect, physical resources (including climate, water resources, geological formations, geology and soil) and biological resources (including type and density of vegetation, distribution and habitat of wildlife) are digitized and entered into the GIS environment, and relevant database in the GIS environment is formed. Then, with respect to the existing facilities and roads, the socio-economic resources of the region are classified and entered into the GIS software. Finally, in order to conduct systematic analysis and preparation of the final plan (stage III), all layers are classified to integrate and analyze the data.

3. Spatial-systematic zonation

Identifying physical and ecological resources as well as socio-economic factors for zonation of Havashanq non-hunting areas led to resource maps (on scale of 1:25000), and the systematic approach was used in the GIS environment to collect amplitude variation (Makhdum 2005). In this method, the natural landscape of different parts of the region appeared on the map as homogeneous units by integrating homogeneous classes and matching borders of sustainable ecological resources according to MacHarg method (Makhzouni and Pangeti 1999). In the next step, after creating the table of features for ecological resources, zonation is performed using the properties of the above-mentioned units as well as definition of the zones (IUCN 2001).

Since the socio-economic and ecological conditions differ in different regions, then the systematic analysis model and its equations were modified according to the conditions in the region. Therefore, the capabilities of Arc GIS software were used. In this regard, the mentioned models were uploaded into the system as some mathematical functions and the final result was extracted as the zonation map of the study area. The result of this process is a mosaics of homogeneous zones in which depending on the type and number of the zones in the study area, represents the position of the study area in one of the six classes offered by the International Union for Conservation of Nature (IUCN 2001).

Results

Fifteen criteria (in accordance with methodology mentioned in section 1) were used for zonation of the Havashanaq non-hunting area. As figures 3, 4 and 5 show, these factors are divided into three classes of physical, biological and socio-economic factors.

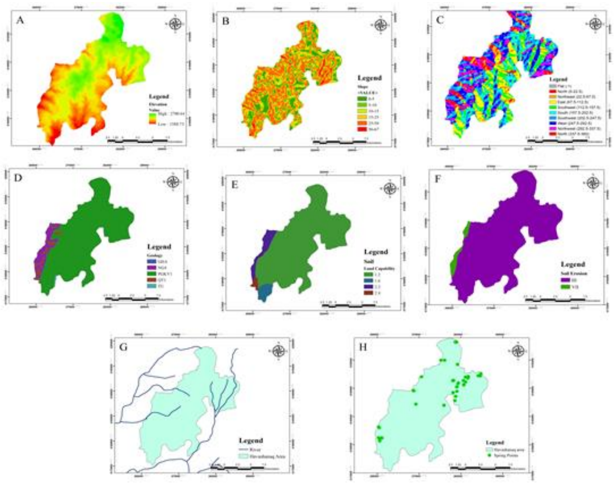

Figure 3. The physical data maps (A: Elevation, B: Slope, C: Aspect, D: Geology, E: Soil Type, F: Erosion, G: River, H: Spring Point)

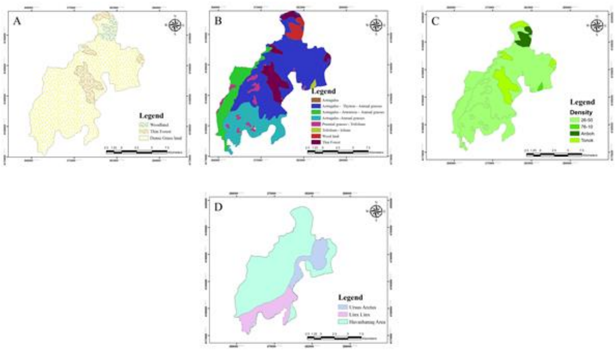

Figure 4. The biological data maps (A: Land Use, B: Plant Cover, C: Vegetation density, D: Umbrella wild area extent)

After identifying the resources and uploading them into the GIS as well as classifying them, the systematic analysis model was finally created for zonation of Havashanaq non-hunting area based on the characteristics of the study area.

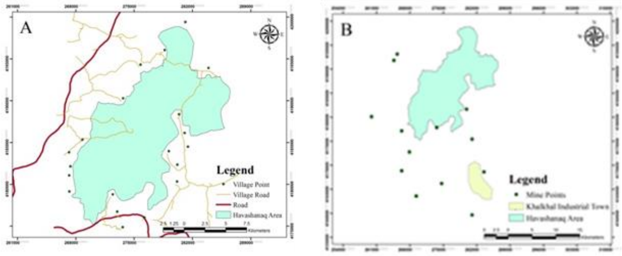

Figure 5. The socio-economic data maps (A: Roads and village in area, B: Mine and industrial town map)

Since the model is based on systematic analysis, then in order to find and study different zones, all fifteen criteria should be classified according to the conditions and the features of each criterion. This classification is necessary to make the final model, since specific features of each criterion should be considered in each zone and study area that would be possible through classification of the criteria.

It can also be argued that since human settlements in the area are not available, then socio-economic conditions can be removed from the ecological capacity model. Therefore, the zonation was performed only in zones 1, 2, 3, 4, 7 and 11. Finally, based on the geographic conditions in this area and according to the International Union for Conservation of Nature classification, the zonation model for the study area was prepared as follows (Systematic Approach):

Zone (1): PL1 (2, 3, 7) or LL2 (1) or UA3(1) or ER4 (2) or DP5 (3)

Zone (2): SL6 (6) or LL (1) or UA (1) or PL (2,3) or DP(2,3)

Zone (3): SL (1, 2, 3, 4, 5) and SO7 (1, 2, 3, 4) and DP (1, 4)

Table 1. The related classification for all the criteria

			Layer's classification								
	Criteria	Sub-criteria	1	2	3	4	5	6	7	8	9
Physical	Physiographic variables	Slope	0-5	10-15	15-25	25-50	>50	-	-	-	-
		Aspect	P	N	NE	E	SE	S	SW	W	NW
		Elevation	<1600	1600-1800	1800-2000	2000-2200	2200-2400	2400-2600	2600-2800	>2800	-
	Land features	Erosion	3	7	-	-	-	-	-	-	-
		Soil (land capability)	2.6	2.2	1.6	1.2	-	-	-	-	-
		Geology	GHA	NG4	PGKV1	QT1	TU	-	-	-	-
	Water resources	Access to Rivers	Exist	Not	-	-	-	-	-	-	-
		Access to Springs	Exist	Not	-	-	-	-	-	--	-
Biological	Vegetation	Plant cover	*Astragalus*	*Astragalus - Thymus*	*Astragalus – Artemisia*	*Astragalus –Annual grasses*	*Prennial grasses – Trifolium*	*Trifolium – lolium*	Woodlands	Thin Forest	-
		Density	26-50	76-100	Dense	Thin	-	-	-	-	-
	Wildlife	Umbrella wildlife	Exist	Not	-	-	-	-	-	--	-
	Land use	Land use	Woodland	Thin Forests	Dense Grasslands						
Socio-economic	Structures	Roads	Yes	No	-	-	-	-	-	--	-
		Villages	Yes	No	-	-	-	-	-	--	-

Zone (4): SL (1, 2) and AS8 (2,3,4,5,7,8,9) and SO (3,4) and GE9 (1,2,3) or RV10 (1) and SP11(1) or AC12 (1) and LUS13 (1,2) and DP(1,4) not ER (2)

Zone (5): NO

Zone (6) :PL(1,4,5,6) or ER (1,2) or SO (3)

Zone (7) :SL (1,2,3) and AS (2,3,4,5,6,7,8,9) and EL14 (1,2,3) or AC (1,2) and SO (2,3,4) not ER (2)

Zone (8): NO

Zone (9): NO

Zone (10): NO

Zone (11): SL(1,2,3) and AS(1,2,3,4,5,6) and PL(1,2,3,4,5,6,7) and DP(1,4) and SO(1,2,3,4) or RV(1) or SP(1)

Then, the final zonation map of the study area in Havashanq was produced based on mathematical functions (spatial-systematic), the zonation models, and systematic analysis approach as well as maps of 1:25,000 scale for each of the examined criteria, (Fig. 6).

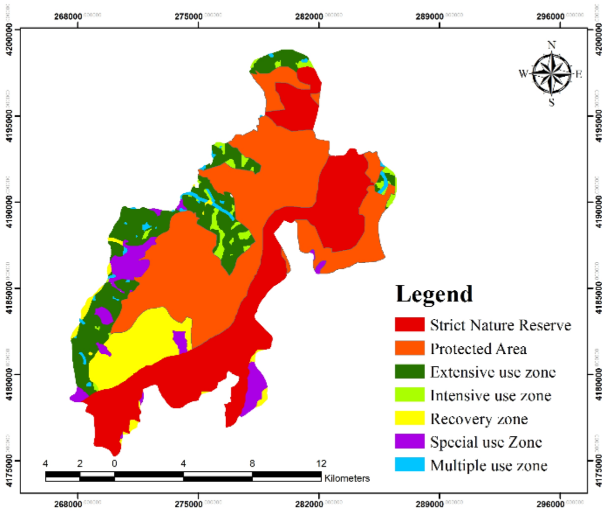

Figure 6. Zonation map of the study area in Havashanq, Ardabil province

The study results showed that habitats of rare and endangered plant species with critical regeneration habitat of Red deer (*Cervus elaphus*), Brown bear (*Ursus arctus*), Lynx (*Lynx lynx*) and Caspian snowcock (*Tetraogallus caspius*) covered 31% of the area to be allocated to the most sensitive and valuable zones of the protected areas, i.e. strict nature reserve zone. Then, it is the protective zone that is highly important after the strict nature reserve zone and includes 38.8 % of the area. In general,

higher levels of the aforementioned zones indicate the ecological value of the area.
The results showed that dry farming as well as sensitive geology formations to erosion and landslides needed to recover and occurred in the recovery zone and consisting of approximately 8.3% of the area. Due to high ecological demand for intensive recreation activities and unsuitable overlapping of the required ecological characteristics for using, only 3150 ha of the area surface can be suitable for this zone.
The most important factor in reducing this surface is slope characteristic in which only 30 % of the area is suitable for this purpose. Additionally, improper distribution and lack of roads in the area are an additional factor in the process of prioritizing the zones and only 382 ha are considered to have the appropriate capacity. On the other hand, extensive recreational activities with the least ecological demand are possible to be performed only in 14% of the region and many of the other zones possess such a capacity.

Special use zone possessed such a capacity to meet the needs of management services in the 949 ha of the area. After the zonation process and organization of the zones, the recovery zone was reduced to 1,641 ha and it may work as the pathway zone and in the revised plans, it has the capability to turn into one of the other zones provided that we have some restoration and recovery operations and in particular, reforestation with native species in empty forest space to be performed.

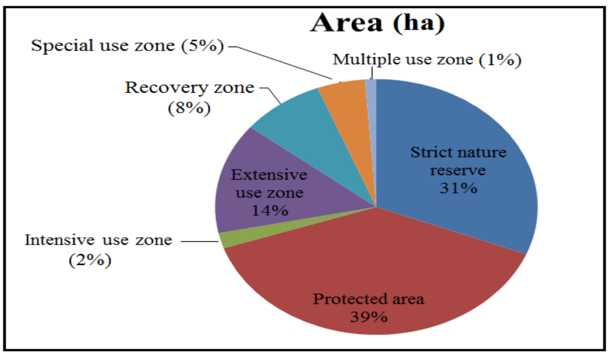

Figure 7. Extent of each zone in the study area

Agricultural lands and pastures utilized by ranchers and empty spaces left by the villagers and forest dwellers include 1.2 % of the area in the multiple use zone. Table 2 and figures 7 and 8 show the extent and distribution of the zones:

Discussion

Zonation of Havashanaq non-hunting area was implemented to specify the protective areas, make a model and classify criteria as well as perform spatial-systematic analysis on the GIS. The GIS has been used in other studies such as (Senes and Toccolini 1998, Carmichael and Wilkin 2006, Hjorts et al. 2006, Sabatini et al. 2007, Naughton 2007, Geneletti and Duren 2008) for the zonation. However, in studies conducted by Senes and Toccolini (1998) Carmichael and Wilkin (2006) only tourism models were investigated and in studies conducted with Hjorts et al. (2006) and Naughton (2007) buffer and protective zones were considered.

Additionally, Duren and Geneletti (2008) and Hjorts et al. (2006) used multi criteria decision-making methods to make the zonation process. While, in this paper, classification of the lands is based on capabilities and features of the criteria (Sabatini et al. 2007). The quantitative model (spatial-systematic approach) has been used in this paper to perform zonation, and preparation and regulation of the quantitative model for each zone have been conducted according to the characteristics of each region.

Furthermore, conditions of all 11 zones were considered in which the conditions in this study area indicated that there were only 7 zones in the region. Moreover, six categories of IUCN suggest that since more than 69% of the study area is located in safe and protective zone and its 16% is located at recreation zones, then Havashanaq non- hunting area has the capability to occur in the fourth category (wildlife habitat) of the International Union for Conservation of Nature.

Based upon high potentials of the region and increasing demands from surrounding communities to use and develop the region and also due to the unique characteristics of the area, it is possible to preserve it by implementing the proper zonation model according to the following criteria: continuous maintenance, long-term survival operations on the structure and function of the natural ecosystems; consideration of high educational and recreational value; maintenance of the integrity of ecosystems; improvement of long-term conservation in the park; enhancement of the sense of participation; multilateral contribution in environmental protection, management among the state and the society, land-owners and local residents. The study method in this paper for planning and zoning Havashanaq non-hunting area was a spatial-systematic process requiring all criteria and elements involved in managing and planning the region. This reflects the model advantage in the process of modeling and assessing the land capability.

Another advantage of this method is that one can easily change the equations and related calculations based on the environmental and socio-economic conditions in the region. This means that the model is more flexible in terms of input data. This model is run in five steps: 1) Identifying criteria, 2) Analyzing criteria and summarizing them (spatial correction), 3) Evaluating ecological and socio-economic capacity (systematic zonation), 4) Establishing land planning purposes, 5) Planning.

This process represents the establishment of land capability assessment model to perform the zonation on the land for different applications used in this study. To identify the sources, fifteen criteria were established, analyzed, and classified. Then, in order to evaluate the ecological potential and protect and for some other expected applications in the region, the model developed by MacHarg and Makhdoum (Iranian model to land capability assessment model and its zonation) was used in this study to make the zonation in the region. In this model, digitization, preparation and classification of the resources, and finally the integration of the resources (all spatial section) were performed in the GIS in order to meet land planning and conservation objectives.

Due to lack of socio-economic data such as human settlements positions and the cultural/historical spots within the study area, the model developed here only evaluates the strict nature reserve, protected area, intensive recreation, extensive recreation, recovery, special uses, and multiple use zones and other zones such as cultural/historical, inhibitory bumper, pathway, scientific and promoting zones were left without any analysis in the model and in the region. After the zonation, physical and biological conditions in the region suggest that the main causes of the formation of the zonation structure in the region are the existence of natural habitats and habitats of rare and sensitive species for umbrella species. Approximately 40% of the area are covered by high dense vegetation, and in some areas with a density of more than 50% in the canopy covering that causes the formation of a good platform to build a proper soil with optimal water infiltration and accumulation for plants. Thus, this process plays an important role in development of the soil, erosion control, ecological niche diversity, and distribution of wild animals. On the other hand, due to the existence of a suitable platform for natural and rare habitats in the study area, safe and protective areas have the largest portion in the zonation to maintain the region ecological capacity. In order to achieve an optimal efficiency on dealing with natural resources, the society and the government can play a significant role in terms of providing a safe environment for entertainments and recreational activities in the region. In this regard, equipment and ecological conditions such as the water, good slope, and special vegetation in some parts of the area caused to create a creational zone in the region.

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