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In the name of God

Whenever a tradition of the Holy Prophet is related to you, scrutinize it, do not be satisfied with mere verbatim repetition of the same because there are many people who repeat the words containing knowledge but only few ponder over them and try to fully grasp the meaning they convey.

(Imam Ali)

This book discusses some of the methods that can be used to reduce and prevent environmental problems. In particular, it explores aspects of environmental impact assessment, land use planning, pollution and climate change, environmental education, environmental law and policy, environmental engineering, and environmental design. As such, the volume will be useful to anyone interested in solutions to today's turbulent environmental situation.

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CHAPTER ONE:

ENVIRONMENTAL IMPACT ASSESSMENT

ECOLOGICAL STABILITY AND ENVIRONMENTAL VULNERABILITY ASSESSMENT OF THE AHVAZ-SHIRAZ RAILWAY

JAHANBAKHSH BALIST,* SAEED KARIMI, HAMID REZA JAFARI

Abstract

In this study, and along with the assessment of the environmental impacts of the Ahvaz-Shiraz railway, the ecological stability and environmental vulnerability of the proposed alternative for this project was evaluated. Firstly, the region's ecological stability was assessed by triple formulas. Then, to assess vulnerability, the physical, biological, and socio-economic criteria were selected, provided and standardized and then for criteria prioritizing, the fuzzy analytical hierarchy process was applied. At the next stage, these layers were combined, and a vulnerability map of the region was created, dividing it into five classes. The results showed that 10.58 per cent of the area is very highly vulnerable, and 23.8 per cent is highly vulnerable. Finally, the route intersections with the five vulnerability classes were surveyed and the results showed that 4151 metres of the total path length (56,345 metres) crossed 7.36 per cent of land with very high vulnerability, and 14,189 metres of the total course length was cut with 25.18 crosses of great vulnerability.

Keywords: Ecological stability, environmental vulnerability, railway, geographic information system, decision-making technique.

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Introduction

Railways are systems which, after emerging in urban areas, grew rapidly and now railways compete with airlines in terms of distances travelled. The high daily passenger density in airports, increases in road traffic and growing awareness of security has given a new role to railways, which have numerous advantages over road and air travel. It seems the only transportation system in a position to consistently meet these environmental and safety concerns.

The vulnerability concept was first proposed regarding groundwater pollution awareness in late-1960s France (Vrba and Zaporozec, 1994). Vulnerability is defined differently for environmental tensions. However, it usually relates to a particular hazard or a set of hazards and shows the considerable differences between the biophysical/natural and the socio-economic dimensions. At a glance, vulnerability is defined as a resources' potential for the accepted effect of harmful impacts due to natural hazards (NOAA, 1999). The second dimension is defined as individuals, groups or society status, and their capacity or potential to: 1) Suffer emotional or physical injuries, and 2) Predict, cope, resist and build resilience to natural hazards or unexpected changes in their life or existence (Adger and Kelly, 1999).

Landscape ecological stability is the potential of a landscape as an ecological system to endure any disturbance pressure and reproduce essential characteristics to foreign interference (Michal 1994). This is likely to be reflected in minimum changes under distress or by a natural return to its prior status or its main development route. Ecological stability of a landscape has the potential to be preserved by modifying the interior processes without the need to change its structure. In Environmental Impact Assessment, exotic disturbance is evaluated as a development investment and human-made interference that can maintain the ecological stability of a landscape, a proposed tool in EIA to minimize the final state of the process (Pavlickova and Vyskupova, 2015).

Ecological vulnerability is taken from Clement's ecological ecotone concept defined at the Seventh Academic Conference on Environmental Problems in 1989 (Wang, 1989). Then, mostly studies on ecological ecotones were considered. Now, 3S technologies are used extensively in ecological vulnerability studies (Kamaljit et al., 2007), and a vulnerability evaluation system that encompasses landscape theory is applied (Mortberg, Balford and Knol, 2007).

Focus on the environment in planning is often mentioned under a different title and thus not considered; however the approach must be taken that these concepts are closely related to assess vulnerability. As effect models (Lyle, 1985, Steinitz, 1990), resources sensitivity (Lyle, 1985, Kozlowski, 1986), threat sensitivity (Kozlowski, 1986), development restrictions (Patri and Ingmire, 1972, Kozlowski, 1986), and growth thresholds (Kozlowski, 1986). The vulnerability in landscape planning is defined as effect vulnerability, and describes the planned activities' adverse impact potential on natural and human-made environment values (Steinitz, 1967). So, the vulnerability level depends on tension characteristics (human interferences) and the environment.

Several studies have been conducted around the globe in relation to vulnerability. Some are mentioned below.

Safari and Akhtar (2013) conducted a study on landslide hazards along the Sanandaj-Marivan Road by fuzzy memberships and a frequency model. In this study, they created spatial layers in a GIS environment and then zoned the landslide vulnerability of the region using a fuzzy logic model.

Gorge and Buker (2003) presented a methodology for the assessment of the vulnerability of infrastructure facilitates. They did this on a regional scale. Miniti, Iasio and Alexander et al. (2011) conducted a study called "Vulnerability to Earthquakes and Floods of the Healthcare System in Florence, Italy."

Klodio and Horest (2007) performed a study called "Beaches natural hazards spatial vulnerability assessment in Paray of Brazil." Pavlickova and Vyskupova (2015) presented a methodology for cumulative environmental impact assessment based on landscape vulnerability. This method was used to predict the aggregate environmental impact based on landscape vulnerability evaluation.

In this study, the ecological stability and environmental vulnerability of the Ahvaz-Shiraz railway was evaluated using decision-making tools combined with a geographic information system. Ecological sustainability was calculated using triple formulas; first, to evaluate vulnerability, ten criteria were identified, the spatial layers attributed to them were created, standardized and, evaluated. Then each of these layers were weighted by the fuzzy analytical hierarchy process. Finally, to achieve the region vulnerability map, the layers were overlaid. The final map is classified into five classes from very low to very high vulnerability.

Materials and methods

This study was conducted on the Ahvaz-Shiraz railway located within Mamasani County that is in its preliminary stages. This rail project starts from Ahvaz and turns to Farashband city, Fars, Iran (Figure 1). Along with the assessment of the environmental impact of the project, the project vulnerability is evaluated as a part of it.

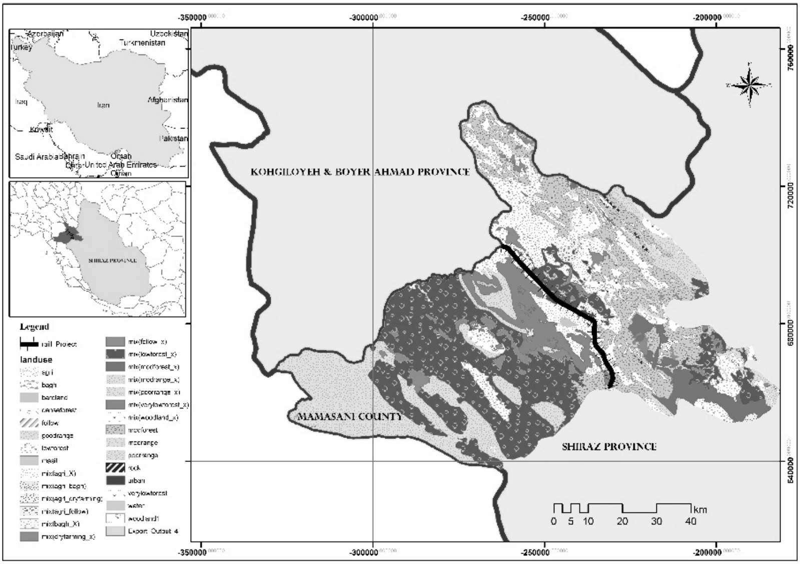

Fig. 1. The studied region

Methods

In this study, first the ecological stability of the area was calculated using triple formulas, which are described in the following text, and then the environmental vulnerability was analysed by fuzzy logic.

Ecological stability evaluation

Landscape stability represents the region's current situation in relation to the main features and functions preservation despite exotic disturbance. Ecological stability evaluation helps us to improve the vulnerability assessment of the entire area against external impacts (Pavlickova and Vyskupova, 2015). Three formulas were proposed. Ecological stability should be finalized by mutual comparison of the three equations' results to validate them.

The first method was developed by Law in 1984. In this method, A is the area in hectares of regions with ecological values of 5 (forest, water resources); B is the area in acres for regions with ecological values of 4 (greenways); C is the area of regions with ecological values of 3 (grasslands and pasture); D is the area of regions with ecological values of 2 (agriculture); and E the area of regions with ecological values of 1 (residential). The numerical results showed the landscape situation by degraded class (<0.1), disrupted (<1), moderate (1), landscape with the dominant natural element (1<*<10) and very natural landscape (10<) (Pavlickova and Vyskupova, 2015).

Equation 1. $$CES_1 = (1.5*A) + B + (0.5*C) / (0.2*D) + (0.8*E)$$

The second formula was developed by Michael (1982) and modified by Rehackova and Pauditsova (2007), where P_i is the landscape structure element area, S_i is ecological importance degree of this element, n is the total number of the elements in the model and p is the total area. The ecological importance is related to the structure element origin, its scarcity, and its environmental stability preservation. These data can be taken from baseline studies. Each landscape structure elements ecological importance particular degree is adjusted based on the scale below. Zero (insignificant), 1 (very low), 2 (low), 3 (average), 4 (high), 5 (very high). The value obtained from the second formula is divided by the below domain: landscape with very low stability (1<*<1.5), landscape with low stability (1.5<*<2.5), landscape with medium stability (2.5<*<3.5), landscape with high stability (3.5<*<4.5), landscape with very high stability (4.5<*<5) (Pavlickova and Vyskupova, 2015).

Equation 2. $$CES_2 = \sum_{i=1}^{n} P_i * S_i / p$$

The third formula was proposed by Mikols (1986) and is based on comparison of the total areas of landscape elements with relative stability, S and those that are unstable, L, in hectares. The first group includes forests, rivers, natural waters, and grasslands. Agricultural or residential are are usually considered unstable (Pavlickova and Vyskupova, 2015).

Equation 3. $$CES_3 = S/L$$

These numerical values can describe landscape as either a region with the most disrupted natural structures where basic ecological functions are interrupted by technical intervention (*<0.1), an area which consumes more than average with considerable disruption to the natural structure (0.2<*<0.3), a region used extremely for heavy agriculture with weak autoregulatory mechanism (0.3<*<1), a usually moderate area that has relatively permanent goals with a preserved natural structure (*>1) (Pavlickova and Vyskupova, 2015).

Fuzzy analytical hierarchy process

The analytical hierarchy process first presented by Saati is a multi-criteria decision-making tool that is applied widely. The traditional Analytic Hierarchy Process (AHP) is unable to express the decision maker's beliefs exact value to give a comparison of different alternatives (Moradzadeh et al., 2011). To resolve this problem, we use the fuzzy analytical hierarchy process as criteria coefficients, first developed by Chang (1996).

Fuzzy logic model

Fuzzy logic has developed a form of Boolean logic. In the fuzzy logic model, the membership value of an element in a set is defined by a value between [0, 1].

Fuzzy membership function

A method of criteria weighting is fuzzy logic membership in the ArcGIS software. In this approach, to fuzzify criteria, the fuzzy membership presented in Table 1 is used. This membership application was conducted by considering two parameters: the spread and midpoint. Membership selection to fuzzifying down by reviewing the identity, importance, and relationship of any criterion with a goal (Safari et al., 2012).

Multi-criteria evaluation by weighted linear combination

The weighted linear combination end is selected as the best alternative (the best pixel or place) based on their rate by several main criteria. There are several methods to multi-criteria evaluation; the largest ones encompass weighted linear combination, value/suitability function, analytical hierarchy process, ideal point method and compromise (Tomlin, 1990; Berry, 1993; Malczewski, 2000) (alavipour et al, 2016).

The weighted linear combination is a widely used conventional practice in multi-criteria evaluation which is called the simple sum weighting and numbering method. This approach is based on the common weight concept. An nnalyst or decision maker might weigh the studied criteria based on relative importance, directly. Then, by multiplying the relative weight by the criteria's value, the final value is obtained for each option. After specifying the alternatives final value, the one with the highest value would be the most suitable for the intended propose. In this way, the rule of decision-making, the value of each option A_i is calculated using the Equation 4.

Equation 4. $$A_i = \sum_j W_j X_{ij}$$

In Equation 1, the i'th alternative in relation with j'th attribute and W_i is the standard weight so that the sum weights is 1 ($\sum W_j$=1). The weights showed the relative criterion's importance and preferable alternative selected by maximum value definition A_i (i=1, 2, 3…, m).

Results and discussion

Ecological stability

At this point, the results of stability evaluation are shown in the form of maps and tables. The stability of this region was evaluated according to the formula and the results of all three equations revealed that the area is stable. These results will help to accurately assess the vulnerability of the area.

Table.1. The landscape ecological stability result

Landscape element		CES1	CES2	CES3
Water and forest	Area (hectare)	450700	450700	450700
	Ecological value	5	5	5
	Stability index	A	S	A
Greenways	Area (hectare)	221	221	221
	Ecological value	4	4	4
	Stability index	B	S	B
Pasture	Area (hectare)	141890	141890	141890
	Ecological value	3	3	3
	Stability index	C	S	C
Agriculture	Area (hectare)	63940	63940	63940
	Ecological value	2	2	2
	Stability index	D	L	D
Urban	Area (hectare)	1340	1340	1340
	Ecological value	1	1	1
	Stability index	E	L	E
Stability		49.98	4.036	8.3

According to the Low formula, stability is equal to 49.98, which is in the >10 class and means it is a natural landscape. The region's landscape is very stable based on the results of the Low method.

According to the second formula, the landscape's stability is equal to 4.036 which is the fourth class and means high stability.

According to the third formula, the landscape stability was placed in a fifth class that means very high stability.

The results of the three equations indicate that based on the assessed parameters, the region's landscape is very stable. This result shows that any development project should be evaluated with caution. The regional situation is such that any project can have irreparable effects on sustainability and landscape status. Preventive and precautionary measures when building projects and corrective actions in the exploitation phase of the project should be considered seriously. The results of this stage are used to help to perform a more detailed vulnerability assessment. So, that projects located in the classes with high ecological value should be avoided as much as possible.

Vulnerability assessment

Allocation of weights to the indicators of vulnerability should place at a later stage. The fuzzy AHP was used to assign weights to the vulnerability factors. The results are shown in Table 2.

Table 2. The evaluation criteria and their weights

criteria	Criteria weight	Sub-criteria	Sub-criteria weight	Final weight
Rock formation	0.154	erosion	0.122	0.018
		geology	0.558	0.085
		Dis to fault	0.320	0.049
population	0.168	Pop density	0.168	0.168
Water resources	0.170	river	0.170	0.170
climate	0.098	climate	0.098	0.098
landform	0.120	slope	0.667	0.080
		elevation	0.333	0.039
land-use	0.140	Land-use	0.140	0.140
flora	0.150	Plant cover	0.150	0.150
	1			1

The criteria used in vulnerability assessment were created and standardized in the ArcGIS environment. The fuzzy logic was used to standardize spatial data layers. The attributes for spatial layers and their standardization are presented in Table 3.

Table 3. Evaluation criteria and its standardization

Row	Criteria	Used fuzzy membership	Minimum	Maximum
1	Slope (percent)	Increase linear	5	25
2	Geology	Increase linear	2	4
3	Erosion	Increase linear	1	5
4	Dis to fault (m)	Decrease linear	1000	10000

5	Land-use	Increase linear	3	7
6	Plant cover	Increase linear	1	5
7	Pop density	Increase linear	1	200
8	Climate	Increase linear	1	4
9	Dis to river	Decrease linear	500	5000
10	Elevation (m)	Increase linear	200	1600

Vulnerability of each layer is determined with respect to its nature and internal weighting. After classification and standardization of the layers, the final vulnerability layer was created by multiplying the weights obtained from FAHP in each layer and them overlaying them. It is showed in Figure 2 below. This final layer is classified into five classes. Each class percentage is indicated in Figure 1.

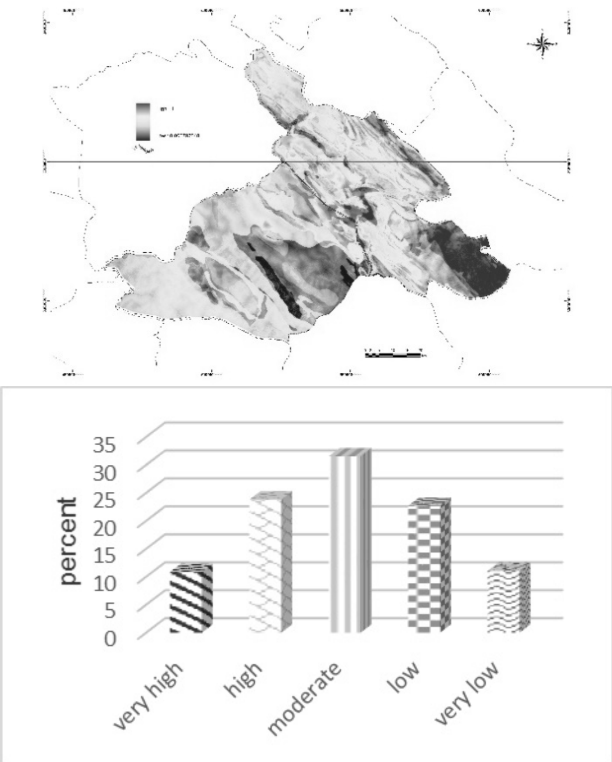

Fig. 2. Region vulnerability layer and its class percentages

The result shows that about 10.85 per cent of the region has very high vulnerability and 23.8 per cent has a high vulnerability.

Table 4. Length and passing percentage of the route in the vulnerable class

Vulnerability class	Moving duration in each class	Passing percentage in each class
Very low	10726	19.03
Low	10349	18.36
Moderate	16930	30.047
High	14189	25.18
Very high	4151	7.36
total	56345	100

According to the result, 4151 metres (7.36 per cent) of the total route length (56345 m) were very highly vulnerable, and 14,189 metres (25.18 per cent) were highly vulnerable.

Conclusion

The Ahvaz-Shiraz railway was evaluated within the Mamasani county boundary, Fars, Iran. The in project, which is 56 km in length, the stability of the whole region was evaluated by a triple formula and the results indicated a favourable situation of the area. In this regard, the environmental vulnerability of the project was assessed and investigated with various criteria in GIS and fuzzy AHP decision-making techniques.

Criteria selection, interaction and the tangible result is possible by selecting the appropriate model. In this study, the model was chosen through determining the criteria, weighting, standardization and producing spatial layers with decision-making techniques to consider the different effects of the criteria in the evaluation. Ten criteria were selected, standardized, re-classed and weighted and then allocated particular weight to each by the fuzzy analytical hierarchy process and expert opinion. This weight as multiplied in spatial layers and then overlayed to create the final vulnerability map.

The result showed that about 10.85 per cent of the total region area is very highly vulnerable and 23.8 per cent is highly vulnerable. Finally, the route passing length in different vulnerability classes was investigated that according to the results, 4151 metres, of the course equalled to 7.36 per cent of the total route length (56,345 m) has given in very high vulnerability and 14189 metres equalled to 25.18 per cent has passed in high vulnerable class. Finally, it can be concluded that the decision-making and GIS combination could have a significant role in the evaluation of the project's environment. To evaluate more accurately and reduce these effects and their management a combination of satellite images and GIS techniques can be used to make decisions.

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AN EVALUATION OF THE CAPABILITY OF REGENERATION IN THE HABITAT OF HYRCANIAN FOREST (NORTH OF IRAN) IN TERMS OF ELEVATION USING A LANDSCAPE ECOLOGICAL APPROACH (A CASE STUDY: GORAZBON AREA, KHEYROUD FOREST)

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ELHAM SHAHI[2]

Abstract

The study of natural regeneration of forests in terms of elevation is important, since most forests in Iran are located in mountainous areas. Analysis of the changes in the forest cover of natural habitats based on physiographic factors could be a criterion for controlling the stability of natural ecosystems. Accordingly, the present study aimed to investigate the association between forest regeneration patches and elevation in Gorazbon district of the Kheyroud Forest (Iran) and all the regeneration patches in this district. Three elevation classes (800–1000, 1000–1200 and 1200–1400 m asl) were located and converted in the GIS environment. We analysed landscape metrics, and FRAGSTATS software was used to quantify these metrics. In total, there were 475 regeneration patches in the landscape of Gorazbon district, most of which were located in the elevation classes of 1200–1400, 1000–1200and800–1000 m asl, respectively. Furthermore, analysis of the distance between the patches showed that patch distribution was uniform in the elevation class of 1000–800 m asl, it was random in the elevation class of 1000–1200 m asl, and it was uniform in the elevation class of 1200–1400 m asl. Other findings of the study indicated that increasing elevation augmented the number of patches per unit of the area, thereby reducing the distance between the

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patches. In other words, with increase delevation, density of the suitable mother base for regeneration soared.

Keywords: Kheyroud Forest, Regeneration Patches, Landscape metrics, Forest Habitats

Introduction

Vegetation cover of any area is one of the most important phenomena of the landscape appearance in nature and the best criterion for ecological factors in an area (Razavi, 2008). Forests are national resources of countries and their protection and proper use ensures the survival of the environment and the creation of wealth. Caspian forests are valuable natural resources with their unique characteristics. Unfortunately, forest landscapes are changing due to the permanent trend of tree mortality. Sustainability and development of forests depend on establishing natural regeneration. Consequently, the future of a natural forest depends on its current status of regeneration. In fact, what are known today as forests or forest stands are the result of evolution and previous regeneration of these forests.

The regeneration status reflects the landscape of the forest in an area. As such, any changes in the regeneration status transforms the landscape of forest stands (Dordi Tekeh, Hosseini and Tabari, 2002).

Every community has a specific pattern within its ecosystem. Clumped, regular and random distributions are a few of the types of spatial distribution of regeneration patches. These patterns indicate the stand dynamics and the establishment of young trees to compensate for the mortality of older trees (Tilman and Pacala, 1994). Therefore, it is assumed that many of the properties relating to the spatial analysis of regeneration patches reflect past stand changes and their dynamics, while some of these properties could be an indicator of the stand changes in the future. These metrics help us to predict and achieve an ideal forest by the appropriate choice of trees in forestry operations. For this purpose, knowledge and awareness of the indicators and metrics is extremely important, these include the pattern of spatial distribution in patches, shape of patches, distance of patches from each other, total area of patches relative to the forest area, and size of the patches. It is worth noting that these metrics have various meanings and interpretations in terms of the ecology and silviculture of forests. For instance, a regular spatial pattern (uniform) is indicative of substantial competition on the stand, while a clumped pattern denotes dense regeneration without subsequent severe natural thinning.

For reforestation and enrichment of forests, the ecological demands and characteristics of their habitats must be recognized (Jazireyi and Ebrahimi Rastaghi, 2003), and the role of all habitat-related factors, such as elevation, should be also examined. Using knowledge obtained about a forest and its habitats regeneration could occur with lower costs, greater success and higher efficiency.

Although some studies have been conducted regarding elevation and regeneration patches, the subject of regeneration has rarely been investigated from an ecological viewpoint. In the present study interpretation of landscape metrics is the main perspective used to elucidate elevation and the changes in various metrics of regeneration patches in forests.

In their research, Jalali et al. (2000) observed that moderate elevations were the most suitable habitat for regeneration, stating that increased elevation would enhance the status of regeneration. Moreover, Marvi Mohajer (2011) performed a study to assess the forests in Gorgan (Iran), reporting that the habitat of the Mian Band region was favourable and introduced elevation as an influential factor in the desirability or weakness of regeneration in that habitat.

On the other hand, Doost Hosseini (1976) examined the regeneration problem in different parts of the Pathom series of the Kheyroud Forest and claimed that the intensity of *Fagusorientalis* regeneration increased with higher elevation. In another study, Jalali (1980) evaluated the natural regeneration of *Fagusorientalis* in the Fagetum Forest in the north of Iran. The research was conducted in three elevation limits of 850, 1350 and 1750 m above sea level, and the results showed that the contributing factors to the lack of regeneration were more common at lower elevations.

In this regard, Mir Kazemi (1993) examined the status of natural *Fagusorientalis* regeneration in the Fagetum Forest based on the Ziyarat Forest management plan and concluded that the intensity of *Fagus orientalis* regeneration increased with higher elevation to a certain extent. Another finding of the mentioned research was that the highest rate of regeneration occurred at an elevation of 950–1150 metres above sea level (m asl). In addition, researchers have investigated the structure of the Fagetum Forest in Ramsar (north of Iran) at different elevations above sea level, observing that higher elevations were associated with increased regeneration.

Izadi (1997) conducted research regarding the natural regeneration of *Fagus orientalis* in the Fagetum Forest of the KordKooy Forest management plan in Iran and concluded that the frequency of *Fagus orientalis* regeneration was directly correlated with increased elevation. Moreover, Hojati (1999) examined the distribution pattern and age structure of natural regeneration of *Fagus orientalis* species in the Fagetum Forest of Gorazbon district, located in the Kheyroud Forest near Noshahr, Iran. According to the results, regeneration in the intact Fagetum Forest occurred in groups and patchy forms as a result of creating cavities in the forest canopy.

In another study, Etemad (2002) evaluated the seed of *Fagusorientalis* trees in the forests of Mazandaran Province (Iran) quantitatively and qualitatively, reporting that the highest rate of seed viability and regeneration occurred at an elevation of 1500 m above sea level in the Noshahr and Ramsar areas. In the Lesotekah Institute in Voronezh, Russia, Oganyan (1981) carried out a study by sampling 936 *Fagus orientalis* trees at the elevations of 900, 1500 and 1850 m above sea level. According to the findings, the elevation of 1500 m showed the highest rate of seeding and regeneration.

Various methods can be used to quantify these metrics, the methods of landscape index analysis being more important than the others in the interpretation of the spatial structure of patches at different times and scales. Quantifying the distribution pattern of patches and their spatial analysis in forest stands can clarify the dynamics and developmental mosaics of forests in future silviculture planning and forestry.

The present study aimed to address the question of whether the distribution patterns and changes of different regeneration metrics vary at different elevations, and if they do vary, to determine the type of these changes in order to obtain the distribution patterns and spatial analysis of regeneration at different elevations in the Fagetum Forest of Gorazbon district. Moreover, we attempted to quantitatively interpret the patterns and complicated structures of distribution and changes in the metrics of regeneration patches in these forests, which are shrouded with ambiguity in terms of the changes in forest ecosystems.

The objective of the current study was to obtain information regarding the quantitative metrics of various elevations in the Fagetum habitat of the northern forests in Iran and to determine the most appropriate elevation for the comparison of the regeneration patch metrics. Furthermore, another aim of the research was achieving the proper solutions to provide and increase the regeneration of forests, to ensure the survival of the forests and to preserve the soil and water resources.

Materials and Methods

Study Area

In order for the research to be complete and realistic it was conducted in a natural forest with minimum interference. To this end, we selected an area located in the research-experimental forest of Tehran University (Kheyroud Forest) in the forests of Noshahr, Iran (Fig. 1). The area studied was 8,000 hectares, and the Kheyroud River was considered to be the main drainage of this area. This forest consists of eight parts; the entire area of Gorazbon (except for the supportive parcels) is steeply sloping, which was the study context. Forestry development is being planned for this area, but the operation according to the plan has not yet begun.

Gorazbon is the third part of the research-experimental forest of the Faculty of Natural Resources (Tehran University). With a surface area of 1000 hectares, it is located 18 km from Noshahr, between 30"32"51° to 29"35"51° longitude and 25"37'36° to 30"34'36° latitude. Gorazbon district has a dryness fraction of 28.6 and has been classified as the "humid type B cold" climate.

Geological formations in the Gorazbon district are limestone and calcareous marl belonging to the Miocene and Pliocene Eras from the third age, as well as calcareous rocks belonging to the Upper Cretaceous Era of the second age. According to the study by Marvi Mohajer (2011), four distinct plant communities are distinguishable in the Gorazbon district, including the oak-hornbeam community (Querceto-Carpinetum and B-Fagetum), hornbeam (Fageto-Carpinetum), mixed Fagetum (Fagetum-hyrcanum), and D- pure Fagetum (*Fagetumorientalis*). In addition, the most abundant tree species in the Gorazbon district include *Fagusorientalis*, *Carpinusbetulus, Acer velutinum*, *Cerasusavium*, *Acer cappadocicum, Juglansregia*, *Quercuscastaneifolia, Tiliabegonifolia, Ulmuscarpinifolia, Ulmusglabra, Diospyros lotus, Sorbustorminalis, Parrotiapersica, Fraxinus excelsior,* and *Taxusbaccata.* Some of the most prominent shrubs and woody plants in this area are black orchid, wild oatmeal, wild tomatoes, hawthorn, Liliaceae, raspberries, and matamata.

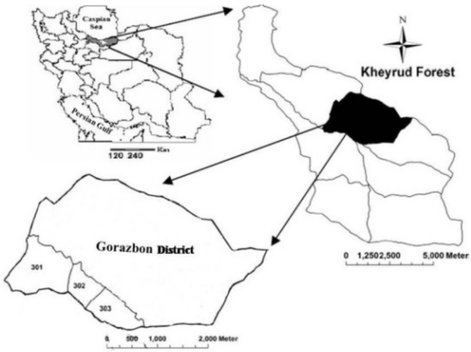

Fig. 1. Studied Area

Methodology

In order to measure the area of regeneration patches using GPS all the regeneration patches of the forest were located, and the area around the empty spaces was marked and converted to area using ArcMap software. Finally, each patch was identified as a polygon.

In order to examine the spatial structure and spatial analysis of the regeneration patch metrics, FRAGSTATS software was used to quantify the metrics. Before entering the data into the software, the data were prepared in IDRISI software to ensure the quality of raster data. At the next stage, Excel and SPSS software were used to analyse and draw the charts and related tables.

Data Analysis

FRAGSTATS software quantifies metrics at three levels: 1) any patch alone, 2) any class, and 3) whole landscape. In the present study, analysis of the metrics was performed at a whole landscape level.

Analysis of the metrics on the whole landscape level was based on calculating each index for the regeneration patches at three different elevation classes. Some of the metrics used at this level are as follows:

- Total Landscape Area (TA)
- Number of Patches (NP)
- Patch Density (PD)
- Landscape Shape Index (LSI)