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Evaluation of Ecological Vulnerability in Chelgard Mountainous Landscape

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ABSTRACT: Although complexity and vulnerability assessment of mountain landscapes is increasingly taken into consideration, less attention is paid to ecophronesis-based solutions so as to reduce the fragile ecosystem vulnerability. The main propose of this study is to provide an insight of mountain complex landscape vulnerability and propose ecophronesis-based solutions in strategic planning framework for reduction of vulnerability. The study has been carried out by following five steps in Chelgard Mountain landscapes (center of Iran): First, it determines the evaluation framework on basis of rapid literature review. Second, the vulnerability is assessed, using Analytic Hierarchy Process (AHP), in accordance with experts' opinion. In the third step, the results provide a zoning map of vulnerability. Afterwards, the study suggests a strategic plan to manage the area environmentally and, finally, the solutions are proposed, based on ecophronesis, in order to not only solve the plight but also reduce the vulnerability. Results from the vulnerability assessment indicate that anthropogenic stressors intensify the vulnerability. While local ecological wisdom is shaped over time in the area, its application faces challenges as a result of rapid and immense socio-economic changes. It seems that sustainability of mountain ecosystem needs to regenerate social structures on basis of socio-ecological capital. Main characteristics of these adopted social structures include their balance with the ecosystem and adoption with new lifestyles.

Keywords: Ecological Vulnerability, Vulnerability assessment, mountainous landscape, Ecological wisdom, Iran.

INTRODUCTION

Mountainous landscapes are extremely sensitive and vulnerable to natural and human stressors, which can indeed cause severe degradation (Beroya-Eitner, 2016; Macchi, 2010; Tse-ring, ET, 2010). In hot and dry regions, the exotic and secluded nature of mountainous landscapes turns them into a hub of economic activities, especially in tourism and hospitality sector. Increased human presence as well as growth of tourism and competitive activities in mountain landscapes has a variety of negative impacts on their ecosystem (Fang, et al., 2009; Godde, 2000). Thus, before promoting any development activity in mountainous landscapes, it is necessary to identify the adverse factors, evaluate the possible vulnerabilities, appropriate site selection, and make sure that the activity matches the capacity of the environment. Following this guideline, it is possible to exploit a mountainous landscape without undermining its' sustainability. Deep understanding of the vulnerability concept and vulnerability assessment regards as the

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first prerequisite for effective management and sustainable development of mountain landscape (Fang et al., 2009; Metzger, et al., 2006).

Vulnerability is associated with concepts like risk, sensitivity, susceptibility, flexibility, compatibility, stability, and adaptive capacity, all of which give the idea of an ecosystem's fragility (Beroya-Eitner, 2016). While, vulnerability is defined differently (Berrouet, et al., 2018; Darabi, et al., 2018; De Lange, et al., 2010; Füssel, 2007; Kok et al., 2016), it generally refers to the ability of an ecosystem to adapt its responses to stressors within certain temporal and spatial domains (Beroya-Eitner, 2016). The interactions between environment and socioeconomic systems influence the sensitivity of the landscape. On this basis, an indicators of these interactions can be regarded as basic tools to understand key processes that affect vulnerability and identify the response strategies, accordingly (Kok et al., 2016; Shukla, et al., 2016). Vulnerability assessments of mountainous landscapes require a set of specific indicators. Normally, the indicators are classified into three major groups of ecological sensitivity, flexibility, and socio-ecological pressure, which constitute the basis of this study as well.

Ecological sensitivity is a measure of ecological instability or resistance to change (Hong et al., 2016; Thiault et al., 2018). In mountainous areas, ecological sensitivity is mainly expressed by physical factors such as slope angle and aspect along with elevation. Ecological adaptability represents the ecosystem's ability to adapt itself with disturbances and to cope with the consequences of changes (Kok et al., 2016). Overall, these translate into the system's ability to resist interference while maintaining its structure and performance. In this discussion, the term "adaptability" refers to the development of genetic and behavioral characteristics in the organisms of an ecosystem, enabling them to cope with environmental changes and survive in new conditions (Fang et al., 2009; Hong et al., 2016). Self-regulation and reconstruction abilities of an ecosystem depend on its component characteristic. In view of what is mentioned above, indicators can be grouped into three sub classes: vital, structural, and performance indicators. Structural indicators are the ones, related to species composition, system structure, inter-species relations, and also vegetation and moisture. Performance indicators are those that involve supply, regulation, protection, and ecosystem's culture. And finally, vital indicators pertain to system's production capacity and represent soil fertility (Apul, 2010).

Socio-ecological pressure concerns external disturbances and all factors that affect the ecosystem's stability. In this study they included land use, access, facilities, population, and tourist density (Beroya-Eitner, 2016; Guoba, et al., 2010). Finally, it is worth mentioning that while the traditional approach to vulnerability assessment tries to identify the affected areas, newer approaches are more focused on reasons behind the vulnerability, while acknowledging that vulnerability is not always an observable phenomenon.

In terms of approach, the literature on ecological vulnerability assessment can be categorized into three groups. In the first, the focus is on risk assessment to understand the system's response to threats (Papadopoulos, 2016; Ribeiro, et al., 2016; Zabeo et al., 2011). The second one not only considers the issue of ecology and natural threats but also the socioeconomic issues that may affect the research subject (Berrouet et al., 2018; Liu, et al., 2016; Maikhuri et al., 2017; Pandey, et al., 2011; Sowman and Raemaekers, 2018). Finally, the third approach utilizes theoretical frameworks like ecosystem services or resilience in an attempt to make an integrated evaluation within these theoretical structures (Beier, et al., 2008; Metzger et al., 2006; Metzger and Schröter, 2006; Schröter et al., 2005). There is also another emerging approach that applies ecological wisdom in vulnerability assessment, the weak signals of which are identifiable. An example of this approach is the study of urban design principles for flood resilience, based on ecological wisdom learned from floods in the Vietnamese Mekong Delta (Liao and Nguyen, 2016). Another instance can be found in the study of environmental solutions, in accordance with some reverence for nature, as derived from ecological wisdom in Beijing, China (Zhang, et al., 2016). This approach tries to break the dichotomy between nature and humans and instead introduces an integrated system where analyses focus on wisdom rather than knowledge (Patten, 2016; Wang et al., 2016; Xiang, 2016).

The studies, using the first approach, include the research by De Lange et al. (2010), wherein they developed an ecological vulnerability assessment framework emphasizing the risks that can threaten an ecosystem. This framework, which is based on three aspects of environmental conditions, system recovery capability, and exposure to risk, attempts to provide an overall picture of the risk and exposure (De Lange et al., 2010). Barnett et al. (2008) examined the vulnerability assessment indicators as well as four key aspects of evaluation, ultimately underscoring the importance of taking heed of the risk of assets during the evaluation (Barnett, et al., 2008). In another study, the vulnerability indicators were used to identify the environmental risk in South Wales in order to determine the risk of asset and infrastructure vulnerability, thereby improving the adaptive capacity of the community (Denner, et al., 2015).

In the second group of studies, Adger (2006) investigated the vulnerability to environmental changes. Here, environmental and social factors were taken into consideration as key study variables, thanks to their decisive role in adaptability and vulnerability discussion. Another study assessed the ecological vulnerability of Kenyan Coast, with intertwined social and ecological dimensions considered as the basis of evaluation. The results of this study indicated that the intensity of vulnerability was correlated with the social conditions (Meneses, 2002). Abson (2012) used an integrated socio-ecological vulnerability framework to assess the vulnerability of rural communities in south Africa (Orams, 2002). Another study developed a vulnerability assessment framework in which it was assumed that ecological and social systems were intertwined and provided a vulnerability reduction process (Berrouet et al., 2018).

The notable studies, using the third approach, include the one by Metszger (2006), which assessed the vulnerability of ecosystem services due to land use conversions (Miral, et al., 2013). Another study assessed the vulnerability of ecosystem services, based on possible socioeconomic changes caused by global trends (Metzger and Schröter, 2006). Furthermore, analysis of ecological and ecosystem resilience and their relation to vulnerability made another valid framework for ecosystem management (Molloy, et al., 1999), e.g., in a study in Cambodia, a vulnerability and resilience assessment was conducted to evaluate public knowledge about the effects of climate change (Moore and Brooks, 1996).

The present study aims at assessing the vulnerability of Chelgard Mountain landscapes, located in Chaharmahal-Bakhtiari Province, Iran, which are exposed to natural stressors as well as human interference in form of ski resort, tourism, and other economic activities. Initially, the literature has been reviewed to identify a set of suitable indicators for vulnerability assessment. Once the factors threatening the mountainous landscapes are identified, the study area is zoned in terms of vulnerability as defined by socio-ecological approach. Finally, the paper provides a number of management solutions, derived from ecological wisdom to reduce vulnerability. Figure 1 illustrates the conceptual model of this study. The study assumes that vulnerability is a result of natural and human factors; therefore, vulnerability is carried out on base of socio-ecological system approach. The vulnerability reduction is the main goal of the study which is achievable through integration of vulnerability assessment, strategic planning, and presentation of solutions, based on ecophronesis as an integrated system (Figure 1).

MATERIALS AND METHODS

The study took place in Koohrang County, located in the west of Shahre Kord, the capital of Chaharmahal-Bakhtiari Province in central Iran. It is situated in the hearth of the Zagros Mountains at a latitude of 32°17′ to 32°25′ and longitude of 48°25′to 49°58′, with about 36,651 inhabitants (Figure 2) (Statistical Center of Iran, 2012). Having a mean height of 2350 meters above sea level, Koohrang is one of the most elevated and most mountainous counties of the province, enjoying a humid and temperate climate with very cold winters and semi-steppe-astragalus vegetation. Geologically, Koohrang is located in the thrust zone of Zagros Mountains, also known as high Zagros. The economy of the area significantly depends on agriculture and animal husbandry and positioned in high mountains in the path of favorable Mediterranean winds, the region enjoys significant precipitation and is the source of three major Iranian rivers, namely Karun, Zayanderud, and Dez. Gifted with bountiful water springs and lush mountainsides and valleys, the area is a natural tourist attraction, which hosts a large number of visitors in all seasons of the year.

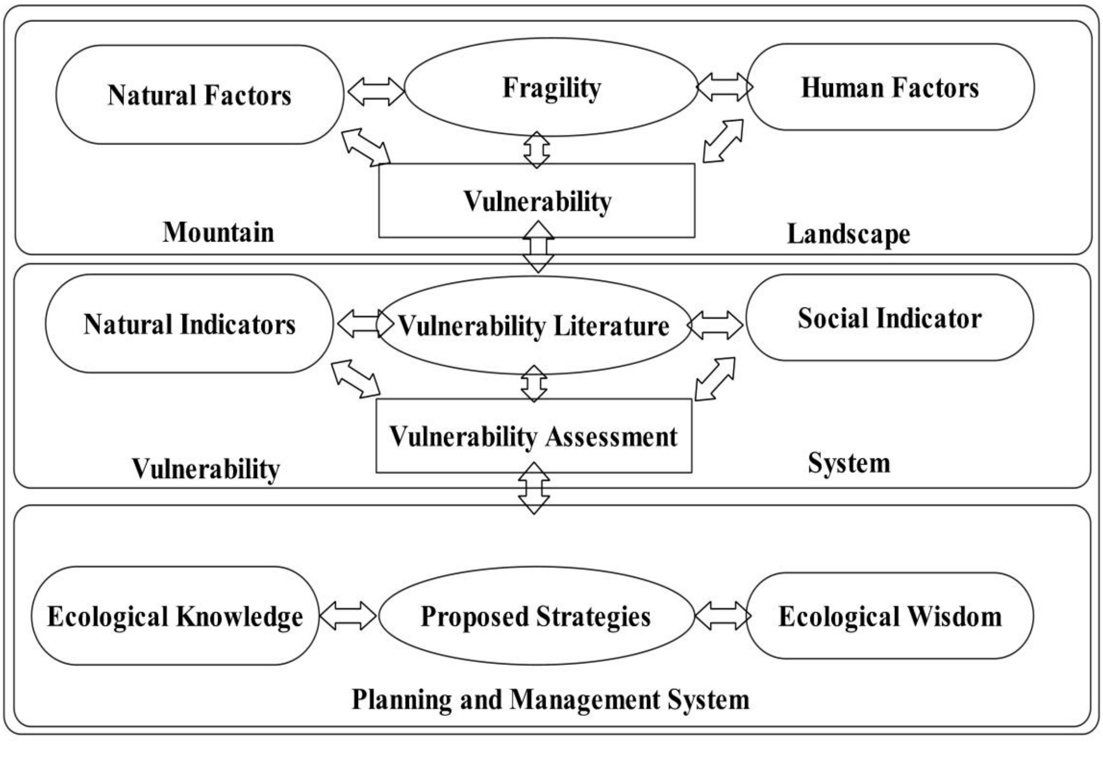

Fig. 1. Conceptual model of the research

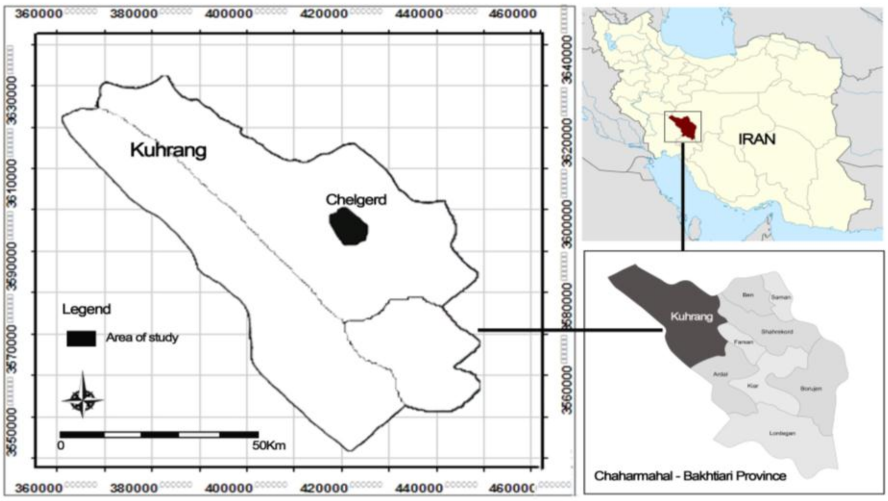

Fig. 2. Location of the study area

The research was carried out in three steps: The first one involved scoping, wherein the literature was reviewed in order to identify the indicators of ecological vulnerability assessment; the second step included system definition and evaluation; and the third concerned the analysis of outcomes, simultaneously addressing the vulnerability challenges for planning and management line, on basis of ecological wisdom approach.

Accordingly, a sum of 24 published articles, dating from 2003 to 2016, about vulnerability assessment got reviewed, leading to the preparation of a primary list of indicators, which was then reviewed to identify suitable indicators to measure vulnerability of mountainous landscape. Finally, an integrated system of ecological vulnerability indicators was developed based on the conceptual model of sensitivity, flexibility, and pressure as well as the real condition of the study area in terms of soil, habitat, climate, and vegetation.

In the second step, the ecological vulnerability indicators got evaluated, using the Analytical Hierarchy Process (AHP) and the Expert Choice Software, v. 11. The former helped weighting the chosen indicators based on the intensity of their effects (the indicators associated with more damage to the mountainous landscape received a higher weight). The information maps of the area got prepared by means of aerial photos and field surveys. Using the GIS software, the weights were applied to produce the required layer, based on identified indicators.

The software program employed the following formula so as to overlay the layers:

$$\mathrm{EVl} = \sum_{i-1}^{n} (\mathrm{wi} \times \mathrm{EVli})$$

Where EVI is an integrated ecological vulnerability; EVIi, the value of the standardized indicator I; and Wi, the weight of this indicator (Hong et al., 2016). Afterwards, the produced layers got overlaid, based on the weights that were attained from AHP process as well as the aforementioned equation. The output led to the production of vulnerability zoning.

Finally, ecological wisdom and indigenous knowledge were employed to provide managerial and planning solutions in accordance with vulnerability zoning. Using the strategic orientation, proposed by Ahern (2006), the final outputs were divided into four groups of protective, defensive, offensive, and opportunistic classes, each representing a planning approach in response to the change in the landscape (Ahern, 2006).

RESULTS AND DISCUSSION

The rapid literature review included 24 articles about ecological vulnerability, published between 2003 and 2016. By examining these articles, the related indicators and the frequency of use for each indicator was identified in the literature (Table 1). The most frequently used indicators turned out to be the height, temperature, rainfall, and population.

Table 1. Frequency of vulnerability indicators in related literature

Main Category	indicators	Frequency percent	Main Category	indicators	Frequency percent
Topography	Aspect	2.20	Flore	Endangered species	0.55
	Elevation	6.59		Fragmentation	0.55
	Slope	7.14		Degradation	0.55
Geology	Geological condition	0.55		Number of species	0.55
	Geological pattern	0.55		Extinctions	0.55
	Glacial	0.55		Isolation	0.55
Climate	Temperature	6.6	Social	Tourism	0.55
	Wet period	0.55		Population rate	6.04
	Dry period	2.74		Growth of population	1.09
	Hot period	0.55		Human activity	0.55
	Cold period	0.55		Female activity rate	0.55
	Humidity index	1.64		Age structure	0.55
	Precipitation	7.69		Literacy index	0.55
	Wind	1.09	Land use	Agriculture	4.94
Hydrology	Depth to water table	0.55		Pasture	0.55
	Aquifer media	0.55		Built-up area	0.55
	Hydraulic conductivity	0.55		Mining area	0.55
	Surface runoff depth	0.55		LUCC (Land use/Land cover)	3.3
	Water area proportion	0.55		Land area	0.55
	Flood-waterlogging area proportion	0.55	Distance	From road	1.09
	NDWI (normalized difference water index)	1.09		From market	0.55
	Distances from hydrological network	0.55		From residential	0.55
	Water conservation	0.55	Disaster	Earthquakes	1.64
	Renewable water	0.55		Volcanoes	0.55
Soil	Drainage	1.09		Tsunamis	0.55
	Soil type	2.74		Flooding	0.55
	Soil texture	2.74		Fire risk	1.64
	Soil erosion	2.19		Desertification	0.55
	Soil fertility	1.64			
	Soil pollution	2.19			
Vegetation	Vegetation type	1.64			
	Vegetation cover	3.3			
	Diversity	1.64			
	Forest canopy/type	1.64			
	NDVI (normalized difference vegetation index)	1.09			
	Endemic	0.55			
	Introduced	0.55			

(Beroya-Eitner, 2016; De Lange et al., 2010; Eakin and Luers, 2006; Hong et al., 2016; Ippolito, et al., 2010; Kurniawan, et al., 2016; Li, et al., 2006; Li et al., 2009; Nandy, et al., 2015; Nguyen, et al., 2016; Papathoma-Köhle, et al., 2011; Qiao, et al., 2013; Sahoo, et al., 2016; Schroter, et al., 2004; Skondras et al., 2011; Guoba et al., 2010; Guobao et al., 2015; Villa and McLEOD, 2002; Xu et al., 2016; Yang, et al., 2015; Ying et al., 2007; Zhang, et al., 2012)

Afterwards, the site-specific index framework should be constructed. Thus, the list of indicators was presented to the experts. The site-specific indicators were selected, based on mountainous features of the study area. These indicators are depicted in Table 2. Following the Delphi method procedure, the obtained indicators and sub-indicators were shared with a panel of environmental experts, asked to rank them in terms of their impact on vulnerability, while taking the mountainous and touristic nature of the region into consideration (the indicators with greater impacts received higher ranks). Finally, the ranked indicators were weighted using the AHP method in the Expert Choice software. In the analytic hierarchy process, each indicator's weight was calculated through pairwise comparison of its ranking in different categories (Table 2).

For each indicator, the information layer of the study area was extracted from the existing maps of the region, and got updated with the help of aerial photos or through field inspections. The output of this process was a series of data layers, namely the maps of vegetation, geology, soil, roads, topography, slope and aspect, hydrology, erosion, land use, and facilities (Figure 3).

Regarding the altitude, the study area was at least 2260 meters and a at most 2770 meters above the sea level, with the central parts of the study area, mostly dedicated to agriculture, having a maximum slope of 22 degrees. The slope for most mountainous parts of the study area was between 22 and 46 degrees, with a small percentage of these lands having a slope of more than 46 degrees. As aforementioned, the study area was located in the thrust zone of Zagros Mountains, also known as high Zagros. Considering erosion and sedimentation factors, the area had two zones of 1) erosion sensitivity, i.e., cretaceous calcareous formations which enjoyed high resistance and low sensitivity, and 2) highly sensitive quaternary formation. The area lacks significant forest cover, its vegetation generally consisted of rangeland plants and grasses. Access to the area is provided through Shahrekord-Farsan-Chelgard road. Furthermore, the town of Chelgard and several residential, commercial, and industrial zones are also located in the study area, a large part of which is composed of agricultural lands surrounded by residential zones. The Chelgard ski resort is located in the western part of the area on the slopes of Karkonan Mountain. Having a gently-sloped, 800m-long trail in two separate segments with a lift system, Chelgard is one of the most famous ski resorts in the Zagros region. The desirable quality of snow, easy access, and convenient location in Koohgrang touristic area, along with sunny weather and peacefulness of the resort in most winter days are the reasons why this resort is a likely choice for many tourists and athletes.

Table 2. The site-specific indicators and their weights, using the AHP method

Main Indicators	Inconsistency Rate	Sub Indicators	Weight
Ecological Sensitivity	0.05	Aspect	0.026
		Elevation	0.048
		Slope	0.026
		Hydrology	0.034
		Geology	0.088
		Soil type	0.105
		Soil erosion	0.28
		Vegetation cover	0.093
Society and Economics Pressure	0.05	Land use	0.501
		Tourism utilities	0.264
		Population rate	0.132
		Access network	0.066
		Installations	0.037
Ecological Resilience	0.17	Vegetation	0.6
		Organic Soil	0.4

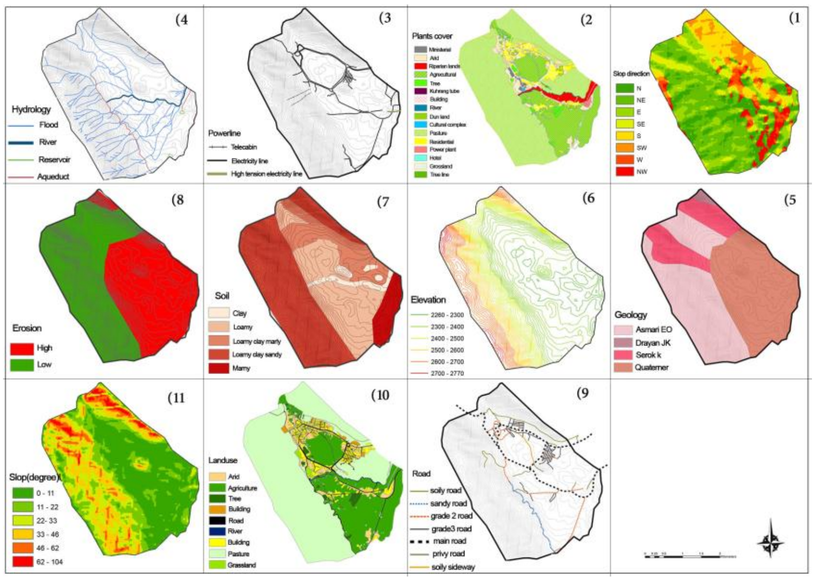

Fig. 3. The different layers of the study area

In GIS software program, the obtained maps got overlaid in accordance with the assigned weights. This was done via Weighted Overlay tool along with the formula mentioned in the previous section. The result of this process was the vulnerability map, illustrated in Figure 3, where the area is classified into four zones based on the severity of the vulnerability (very high, high, moderate, and low).

The highest vulnerability, observed in the agricultural lands located in the central parts of the area. The residential zones act as the center of population and human activities, with the areas undergoing urban development, thus being subject to high vulnerability. A moderate vulnerability was observed in rangelands and mountainsides, located at the periphery of the area. The low vulnerability zones were mostly in high altitude mountains, i.e., intact and secluded areas with very low human presence.

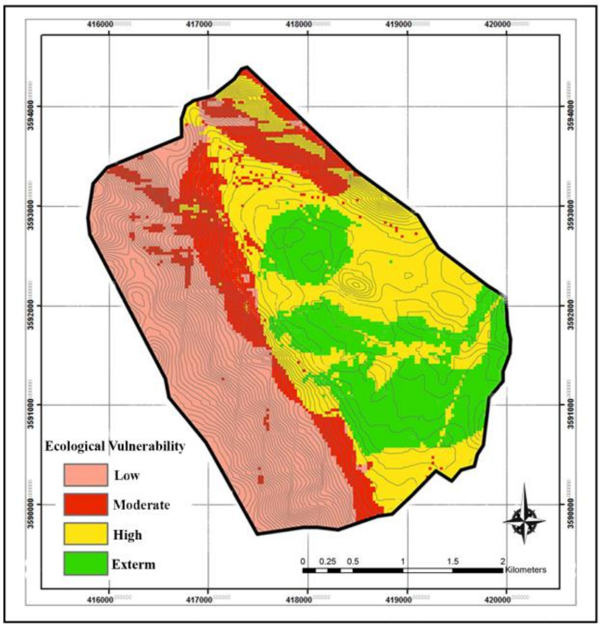

Fig. 4. The resultant map of vulnerability assessment of Koohrang area

According to the results, the agricultural zone, located in the central parts of the site, enjoyed the lion's share of vulnerability level. While the residential zones were highly vulnerable, the periphery mountainsides were less vulnerable and high-altitude mountainous regions had the lowest level of vulnerability. In the agricultural zone, vulnerability got intensified by blending agricultural and construction activities. The major challenges of this zone were the rise of agricultural land cover, land use conversion, increased soil erosion, collapse of natural waterways, reduced environmental resistance, and disruption in natural processes, caused by poor agricultural practices, misuse and over exploitation of resources, pollution, and poor management which were in line with the findings of Berrouet et al. (2018).

Considering the extremely high vulnerability of this zone, it is vital for the future of this area to enforce environmental and development laws and prohibit environment-damaging development activities more strictly. Inappropriately, this area is experiencing a rapid trend of land use conversion, to which local authorities and institutions have failed to make any serious response. The Chelgard residential zone also suffers from high vulnerability due to pollution and land use conversion, resulting from its status as the area's center of population and transportation. The vulnerability of this area is directly correlated with population density, construction activity, road building, and degradation of natural spaces, in turn leading to severe loss of environmental services and land deprivation, as mentioned by Nyguen et al. (2016).

Ecological management could be the key instrument to achieve sustainable development in mountainous landscapes. To reduce the vulnerability of this area, a strategic plan is needed (Nouri et al., 2008), which regulates human pressure on mountainous landscapes. The framework of strategic planning, presented by Ahrens (2006), proposed four strategy groups: protective, defensive, offensive, and opportunistic. This framework was adopted to meet the strong policymaking requirements.

Protective strategy means defining a desirable landscape and preventing any change that threatens this goal. In the study area, this strategy was suitable for protecting the sustainable patterns and processes of less vulnerable high-altitude mountainous regions. It also can be helpful to prevent both unregulated tourist access and overgrazing in order to preserve the existing vegetation cover; therefore, this strategy was applicable in all low vulnerability areas, restricting human activities there.

The defensive strategy means limiting the damage of an inevitable change of landscape on the nature. This strategy is suitable for medium vulnerability areas. Due to strong presence of tourists, these areas were on the verge of fragmentation which, if not properly managed, can inflict irreparable damages to the landscape in near future.

The offensive strategy involves reconstructing previously damaged elements or restoring the fragmented natural landscapes. It should be employed in the agricultural zone of the study area, where over exploitation of the land necessitated stronger efforts to restore the devastated landscape. This can be achieved by reintroducing indigenous plant species to the fragmented agricultural lands and curbing with unregulated agricultural land development.

The opportunistic strategy means acknowledging and identifying the available opportunities to add other functions to the landscape and support the ecological and cultural processes, beneficial for the region. This strategy refers to extremely vulnerable areas and ought to prevent construction activities in natural areas, limit unregulated expansion of urban and industrial spaces, and encourage ecological construction. The vulnerability of area can be reduced by adopting effective vulnerability control measures.

Poorly managed tourism development in mountainous landscapes could create significant ecological pressure, turning into a source of environmental concern. Hence, the development of mountain tourism needs to manage and plan the way of reaching sustainable preservation as well as the manner of using mountain ecosystem. Overall, the vulnerability of the area is directly related to human presence along with the type of activity undertaken, which occurs on sensitive mountainous areas, as Sahoo et al. (2016) also acknowledged it. It seems that "*ecophronesis*" is capable of providing wise solutions to such challenges.

Ecological wisdom, called "*ecophronesis*", is the ability of upright judgment about reality and apply appropriate solutions, based on knowledge and experiences (Liao and Chan, 2016; Xiang, 2016). Schwartz and Sharpe (2010) described it as: "reasoning to provide the right way to do the right thing". Ecophronesis is rooted in ecosophy, developed by Arne Næss to reduce the duality between humans and the environment (Naess, 1989), while, Xiang (2016) defined it as: "the master skill par excellence of moral improvisation to make and act well upon, right choices in any given circumstance of ecological practice; motivated by human beings' enlightened self-interest, it is developed through reflective ecological practice" (P 55).

The ecological wisdom defines some socio ecological rules that lessen the severity of vulnerability. The main historical practice was the controlling use of common resources, mainly rangelands, on basis of social structure (Beck, 1998; Ghorbani et al., 2013), which has recently been the subject of enormous changes. As a result, land management rules have lost their functions mainly and increased the pressure on common resources. Moreover, the local community adopted some behaviors to protect the ecosystems, e.g., grazing the sheep early in rangelands at the end of spring. Since the roots of the plants are tight in the earth and plants suffer less damage from grazing in this period of year. Other sample actions are as follows:

- Construction of a strain in form of a ditch to guide the flood route,
- Proper drainage to lessen the erosion,
- Construction of a canal around marshy grounds to get extra water from the ground,
- Planting vegetation in traditional manners such as sowing plant seeds in the spring,
- Spring and autumn crop rotation,
- Separation of different types of livestock like sheep and goats and utilization of different livestock compositions,
- Determining the appropriate time for grazing and the time out of the rangeland,
- Seeding in different ways,
- Applicatoon of range classification systems and their utilization, based on this classification,
- Identification of unobtrusive areas and defining restrictions accordingly,
- Grazing limitation at flowering time, and
- Planting indigenous species.

All samples indicate that while people knew what they should do, they should only be encouraged to act appropriately (Darabi, 2010, Darabi and Saidi, 2013, Assar Khaniki et al., 2015); however, knowledge implication faced some challenges since the local community experienced rapid and major changes in social structure, thus the lessened social control. Concurrently, increase in the intensity of government intervention diminished self-reliance of local community, which worsened the situation. Therefore, application of ecophronesis needs a new and acceptable social structure for implementation. The vulnerability of areas will increase through human activities without paying any attention to environmental considerations and ecophronesis solutions. Hence, it is essential to consider the carrying capacity in conjunction with ecophronesis solutions in order to get access to sustainable development of mountainous landscape which require confident management and planning in harmony with the existing environment.

CONCLUSION

The vulnerability of mountain ecosystems increases as climate change trends intensify and human and tourism activities grow; therefore, it is a high priority in hot and dry areas to lessen the vulnerability of mountainous landscapes. The socio-ecological vulnerability assessment provides a comprehensive recognition of area circumstances, considering ecological and social stressors concurrently. The strategic planning presented diagnostic framework. Afterwards, the use of strategic framework on basis of zoning, provided from vulnerability assessment, is able to not only reduce the vulnerability but also reinforce undisrupted ecosystems. The use of ecophronesis enriches strategic planning, yet its establishment necessitates some requirements: first, a comprehensive recognition of ecological knowledge and second, a social and innovative structure for implementation by different stakeholders.

The combination of ecophronesis and vulnerability assessment provides an adoptive and innovative framework to reduce brittleness of mountainous landscapes. As such, further studies can aim at application of ecophronesis solutions in practice as well as assessment of the results from such practices.

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