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Rapid Vulnerability Assessment of Lavizan Urban Forest Park

Darabi, H.[1*], Hamedi, R. [1], Ehsani, A. H. [1] and Kafi, M.[2]

1. Graduate Faculty of Environment, University of Tehran, P.O.Box 14155-6135, Tehran, Iran

2. Faculty of Agricultural Sciences and Engineering, University of Tehran, Tehran, Iran

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ABSTRACT: Although the vulnerability assessment of forest parks is used to determine the threats they face, a rapid and holistic framework has not been established well. The primary objective of this study is to adopt a framework for rapid assessment of forest parks vulnerability, examined in Lavizan forest park in Tehran (Iran) as the case study. The vulnerability assessment has been conducted, using the evaluation matrix on the basis of landscape and ecological values and threats. In this model, the most important values and threatening factors of the Lavizan forest park have been identified and assessed, based on the intensity of their effect as well as occurrence probability. Finally, this article proposes five strategies to reduce the vulnerability. Results from this research indicate that the most important values have been air purifcation, wildlife, flora and fauna species, environment regulation, mental health, and scientific resources and the most important threats have included reduction of habitat diversity, intensive exploitation of the resources, fire, woodcutting, and reduction of ecological connectivity. Based on these vulnerabilities, the most important strategies propose the use of affordance strategy formulation framework to preserve and enhance ecological and landscape values of the park.

Keywords: Vulnerability, Forest park, Ecological Values, landscape Values, Iran

INTRODUCTION

Forest parks are of significant importance, thanks to their diverse functions in urban areas, such as oxygen production (Nowak, et al., 2001), air quality improvement (Baumgardner, et al., 2012; Escobedo et al., 2008), and natural habitat establishment (Bruner, et al., 2001; Morrison and Chapman, 2005; Shochat, et al., 2004), along with many other functions (Chiou, et al., 2016; Hartter, et al., 2014; Lee et al., 2011; McPherson et al., 2017; Andrew, Millward and Sabir, 2010; Andrew, Millward and Sabir, 2011; Tsunetsugu et al., 2013; Tyrväinen, 1997). Nonetheless, in spite of their functions, they are exposed to various threats as a result of their location within urban spaces. Hence, the damages inflicted on urban parks have to be recognized and preservative actions should be made in order to reduce damages and vulnerabilities (Mullaney, Lucke, and Trueman, 2015; Steenberg, et al., 2017). Vulnerability means being exposed to the accidents, tensions, and hardships, the tackling of which becomes a function of flexibility and sensitivity (Millennium Ecosystem assessment, 2005). In fact, vulnerability is the result of inflexibility, which in turn entails fragility, leading to system collapse (Wells, 2012).

[*]Corresponding Author, Email: darabi@ut.ac.ir

Vulnerability includes diverse dimensions. Based on the literature review, it is possible to divide researches into two different categories: the first class includes the studies considering forest parks as a system and studied the vulnerability accordingly (Steenberg, et al., 2016; Steenberg et al., 2017), and the second involves studies, emphasizing a particular subject such as climate change, invasive species, or so forth, in order to evaluate the vulnerability (Berland and Elliott, 2014; Laćan and McBride, 2008; Ordóñez and Duinker, 2015; Ventura and Lana, 2014).

In the first category, Steenberg et al. (2016) provided a theoretical framework, based on three areas, viz., exposure, sensitivity, and flexibility. In this framework, the magnitude, sequence, time, and range of exposure are investigated at vulnerability level; while, in sensitivity level, the focus is on parks' function and structure and in flexibility level, the relation among the outcomes and compatibility are the main areas (Steenberg et al., 2016). In another research, the structure and functions of forest park ecosystem were investigated in Toronto, based on temporal and spatial change indices. Based on the proposed indices, the structure and function of park was predicted along with its vulnerability for 45 years (Steenberg et al., 2017).

In the second category, vulnerability assessment focuses on a particular subject. For example, three cities of Halifax, London, and Saskatoon, Canada, were studied based on the vulnerability of forest parks to climate changes (Ordóñez and Duinker 2015). This research managed to identify the sensitive elements to the climate change, recognize the role of effective elements, and finally present the suitable strategies to reduce vulnerability. Lacan and McBride (2008) studied the interaction between tree species and vulnerability to insects and diseases in city forests. Berland and Eliot (2014) also studied the link between urban forests diversity and vulnerability to invasive beetles. The main topics in this category involve climate change (Lee et al., 2011), fire (Amalina, Prasetyo, and Rushayati, 2016), vulnerability to wind (Moore and Quine, 2000), trees' mortality (Allen, Breshears, and McDowell, 2015), and invasive species (Berland and Elliott, 2014; Holmes, et al., 2009; Puric-Mladenovic, Bradley, and Strobl, 2012)

A review of literature indicates that while the vulnerability in forest parks has been investigated, the framework capable of evaluating the vulnerability rapidly and providing strategies for better management has been considered less. Hence, the present research attempts to provide a rapid vulnerability assessment framework in order to evaluate vulnerability of urban forest parks quickly. The suggested framework is based on rapid evaluation method of wetlands, first proposed by Stratford et al. (2011). It is adopted on basis of landscape services and ecological values to assess forest parks' vulnerabilities. To do so, two dimensions of landscape and ecological values have been integrated and investigated in forest park. In next step, the threating and vulnerable factors have been determined. Finally, the strategies for reduction the vulnerability are suggested through investigating the relations between the threats and values.

MATERIALS AND METHODS

The studied site is Lavizan Forest Park, located in District 4 of Tehran municipality in northern part of the city. In term of geographical coordinates, it is located in longitude of 51˚ 29' to the 51˚ 34' 15'', equivalent to 544000 to 551500 UTM, and the latitude of 35˚ 44' 20'' to 35˚ 46' 45'', equivalent to 3956500 to 3969500 UTM. The lowest elevation of the park is 1390 meters and the highest, 1590 meters from the sea level. In terms of roughness, the park is highly rough with the majority of its lands being of hill physiographic types. Positioned in a strategic location, it plays the role of

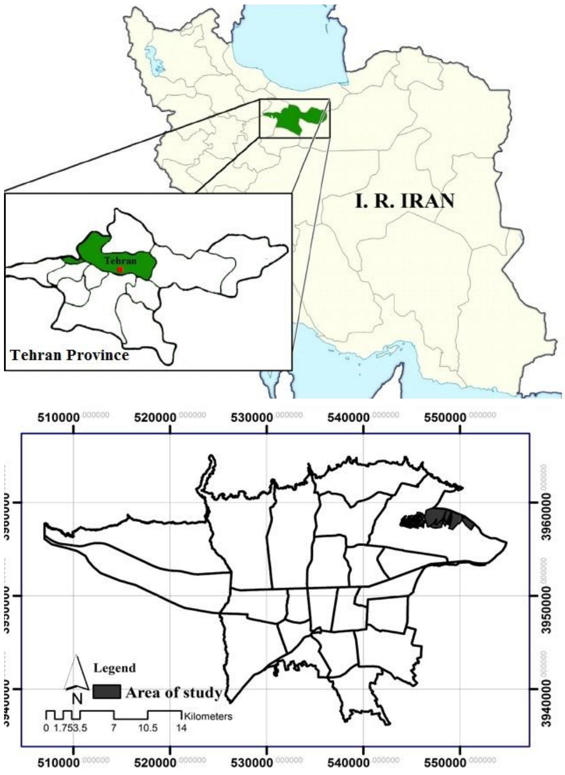

Fig. 1. Lavizan forest park location

preserving the green belt as well as a determinant role of Tehran urban district, which adjusts the structural form and acts as breathing lungs for Tehran air (Figure 1).

The research conducted vulnerability assessment, using evaluation matrix in accordance with the method, proposed by Stratford et al. (2011) which emphasized on ecosystem services, applying them in wetland assessment. Well-justified to evaluate the vulnerability of forest parks, constructed on ecological values and landscape services instead of ecosystem services, the method evaluates vulnerability, using the most important ecological values as well as landscape services or threats of Lavizan Forest Park. The identified factors were ranked based on the following phase and then, using the evaluation matrix, these values were assessed based on the intensity of their effect and the probability of the threatening factors' occurrence. Therefore, the region's vulnerable factors were identified and finally the solution to reduce the vulnerability was proposed. Based on Ffigure 2, the methodology of this research included five sections:

1. Assessment of the forest park's values
2. Assessment of the forest park's threatening factors
3. Investigating the relation between values and threatening factors in the forest park
4. Assessment of forest park's vulnerability
5. Proposing management solutions to tackle these threating factors (Stratford C.J. et al. 2011).

Forest parks have different values, among which the landscape and ecological values were chosen to be investigated and assessed in this research. The ecological values included habitat diversity, air purification, vegetation species, biodiversity, hydrologic functions, organic functions of the soil, air moderation, etc. (Table 1) Each aforementioned value got scored based on the function and value indices, in which the score H meant high value; M, medium value;

and L, low value. Integrating the score of these two indices and using the matrix in Figure 3, the ecological value score could be determined. The landscape values were based on landscape services, such as providing services and adjusting cultural and social services (Fagerholm, Käyhkö, Ndumbaro, and Khamis, 2012; Gulickx, Verburg, Stoorvogel, Kok, and Veldkamp, 2013; Paracchini et al., 2014; Ungaro, Zasada, and Piorr, 2014). In investigating the provision services, the material, energy, and nutrition provision can be considered in the area. The regulation services included the physical and biological regulation services, while the cultural and social ones comprised different aspects such as physical and mental health, constant and variable enjoyment of landscape, scientific and tutoring resources, spiritual experiences, and social interactions (Vallés-Planells, Galiana, and Van Eetvelde, 2014). These values were scored like ecological ones, with Table 4 demonstrating the matrix, obtained from the integration of these indices

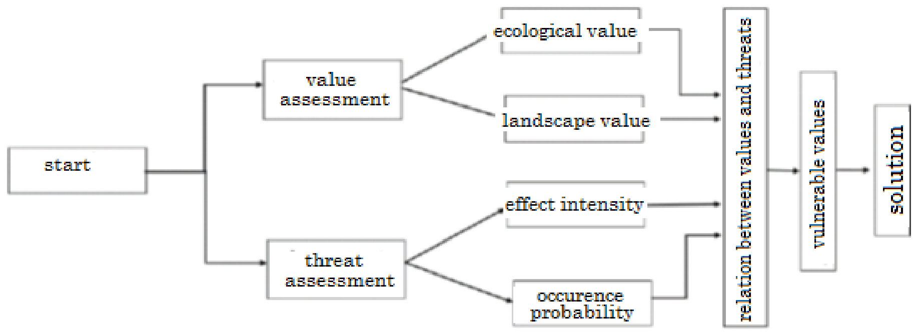

Fig. 2. Vulnerability assessment process (Stratford C J et al. 2011)

Table 1. Ecological values of Lavizan Forest Park and indices, used to evaluate their vulnerability

Indices Landscape values	Indices Ecological values	Function	Value
Provision Services Regulatory Services Cultural and Social Services	Habitat diversity Air purification Vegetation species Animal and wildlife species Hydrologic functions Soil organic functions Air moderation Other values	High score (H): high functionality Medium score (M): Medium functionality Low score (L): low functionality	High score (H): high value Medium score (M): Medium value Low score (L): low value

(Stratford, Acreman, and Rees, 2011; Vallés-Planells et al., 2014)

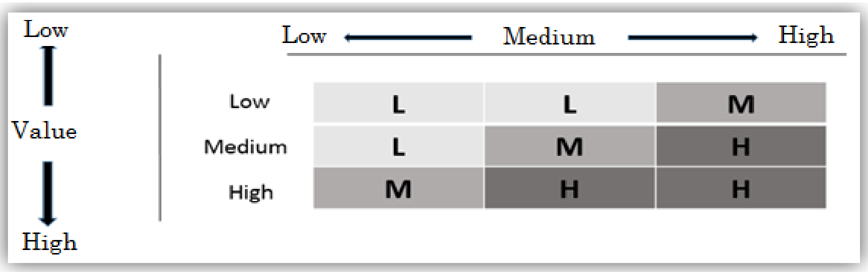

Fig. 3. Value Assessment matrix (Stratford et al., 2011)

Based on Lavizan Forest Park's values, there must be a list of threatening factors. Reduction, disruption, and biodiversity threats, such as flora and fauna, land use change, intensive exploitation, fire, pollution, and cutting trees for wood, are among the threatening factors of Lavizan Park. In this district, the most important reasons for deforestation are wood cutting, fire, infrastructures, and urban development. The present research analyzed threatening factors of Lavizan Forest Park, based on the intensity of influence and occurrence probability. The former indicates the magnitude of undesirable effects, due to forest parks' threatening and stressing factors, while the latter is the probability of these undesirable factors' occurrence along with their outcomes. For each threat, the influence intensity and occurrence probability got scored as H, M, and L, based on their nature and cause.

Figure 4 shows the matrix from this assessment in order to calculate the unit score for each threatening factor. In next step, the threatening factors' influence on each value was investigated, which was also indicated with H, M, and L, as high, medium, and low scores. In this phase, being the final level of the calculation process, the scoring spectrum was considered as H, M, L, and N, i.e., high, medium, low, and not-specified effect, respectively. Finally, by integrating these scores, the unit score (vulnerability level) was obtained for each value and threat in the final matrix (Stratford C J et al. 2011).

Value scores× threatening factors scores× interaction of values and threats scores=final score of the vulnerability assessment

Given that this method also featured a not-specified score, it was possible to assess missed and limited values and threats data. If N, L, M, and H were represented by the scores 0, 1, 2, and 3, based on the abovementioned equation, the final value would be 0 to 27, wherein 0 would be coded as N (not-specified vulnerability), 1-9 as L (low), 10-18 as M (medium), and 19-27 as H (high).

RESULTS AND DISCUSSION

Tables 2 and 3 list the results of values scoring. According to the results obtained from the table and evaluation matrix, among the ecological values, air moderation and cleaning, flora and fauna species (biodiversity), and wildlife have the highest value in this area. In addition, from the landscape values, flora and fauna nutrition, environmental regulation, mental health, and scientific resources have the highest values in Lavizan Forest Park.

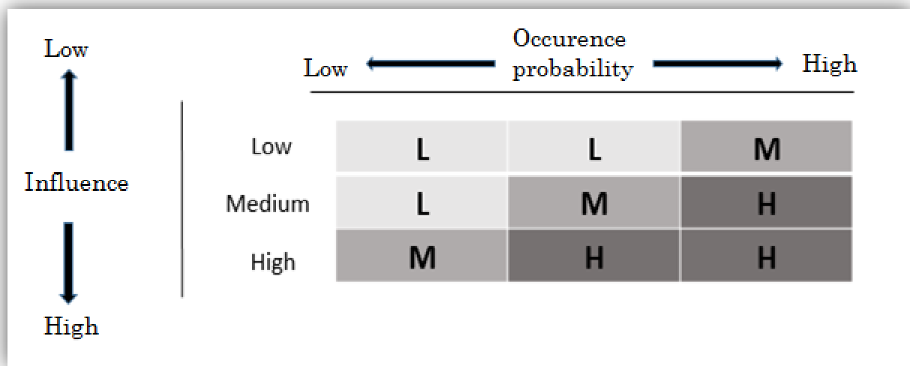

Fig. 4. Assessment and analysis matrix of the threatening factors in Lavizan Forest Park (Stratford C. J. et al. 2011)

Table 2. Assessment of Lavizan Forest Park's ecological values

Ecological Value	Description	Function	Value	Assessment Matrix Score
Habitat Diversity	Vegetation and animal diverse habitats	M	M	M
Air Purification	Carbon photosynthesis, decreasing fog and greenhouse effects, absorption and keeping the dust and air particles, energy storage	M	H	H
Vegetation Species	More than 100 plant species, providing a suitable habitat for organisms, reduction of environmental pollution and local environment improvement, landscape generation	H	H	H
Animal and Wildlife Species	More than 100 animal species, wildlife diversity, biodiversity	M	H	H
Hydrologic Functions	Water flow preservation during dehydration periods, hydrological stability preservation in the region, sedimentation and erosion control, discharging and feeding underground water, nutrition transfer and cycle	L	M	L
Soil Organic Functions	Carbon fixation, plant root fixation, feeding the nutrition	M	M	M
Air Moderation	Reduction of thermal islands	M	H	H

Table 3. Assessment of Lavizan Forest Park's landscape values

Landscape Value	Description	Assessment Matrix Score	Value	Function
Nutrition	Flora and fauna foods, drinking water	H	H	M
Energy	Recyclable bio-fuel	M	H	L
Daily Activities	Life, working, movement	M	M	M
Waste Control	Compost burning, healthy disposal, recycling, waste management	M	H	L
Physical Environment Control	Sustainable planning principles of the land	L	L	L
Environmental Regulation	Environmental planning, requirements, sustainable design, environment preservation	H	H	H
Physical Health	Physical activities and walking, novel traditionalism, naturalism, security and safety, enhancement of social and cultural interactions within the neighborhood, designing desirable spaces in terms of aesthetics and architecture	L	M	L
Mental Health		H	H	M
Constant Enjoyment	Enjoying the place appearance, comfortable place for studying, visiting wildlife or cultural heritage	M	M	M
Variable Joy	Children playground, walking opportunity, climbing, gardening, hunting, and fishing	L	M	L
Legibility	Providing more signs for spatial direction, the sense of place, and where to go	M	M	M
Scientific Resources	Research resource in diverse fields such as history, geography, phytology, environment, geology, and archeology	H	H	M
Educational Resources	Opportunity to learn how stones form, vegetation, animals, traditional agricultural procedures, or past civilizations	M	H	L
Spiritual Experience	Religious places, activities related to legends or myths	L	L	L
Inspiring Source	Art, literature, music, architecture, cinema or ads inspiration	M	M	M
Social Interactions	Providing an outdoor social environment which is a social interaction opportunity	M	H	L
Local Identity	Helping the formation of social identity by means of symbols and differentiating it from others	L	M	L

Table 5 presents the results of Lavizan Forest Park's threatening factors as well as the indices for influence intensity and occurrence probability, showing that the most important threats were reduction of habitats, intensive exploitation of the vegetation resources, fire, trees cutting, and ecological disconnectivity. All these factors were effective on the values of forest park. Furthermore, threatening factors of the park, inflicted on values, got investigated too. The table also shows the results of the values and threatening factors assessment in this park as well as the results from multiplying the scores, considered for values and threatening factors in Lavizan Forest Park, and their interaction as a unit value to assess the vulnerability level.

Table 4. Assessment of threatening factors on Lavizan forest park values

Threatening Factors	Influence Intensity	Occurrence Probability	The Score, Obtained from Assessment Matrix
Reduction of the Habitats	H	H	H
Intensive Exploitation of Vegetation Resources	H	M	H
Water Pollution	M	M	M
Soil Pollution	M	M	M
Land Seizure	M	L	L
Construction	M	M	M
Fire	H	H	H
Trees Cutting	H	M	H
Ecological Disconnectivity	M	H	H

Table 5. Assessment of threatening factors on Lavizan Forest Park's values

Undesirable effects of threats on value	Threatening Factors								
	Ecological disconnectivity	Trees cutting	Fire	Construction	Land Seizure	Soil Pollution	Water Pollution	Intensive Exploitation of the Vegetation Resources	Reduction of the Habitats
Loss of habitats	H	M	M	L	L	H	H	H	H
Lack of air purification	H	H	H	N	N	M	L	M	M
Loss of vegetation species	H	H	H	M	M	H	H	H	H
Loss of animals and wildlife species	H	M	H	M	M	H	H	M	H
Loss of hydrologic function	M	L	N	N	N	M	H	N	N
Soil organic function loss	L	L	L	N	N	H	M	N	N
Lack of flora and fauna nutrition	M	M	M	N	N	H	H	H	H
Lack of renewable fuel energy	L	H	H	M	M	N	N	H	H
Loss of daily activities	N	N	L	N	N	N	N	N	N
Lack of waste management	N	N	H	M	M	H	H	M	N
Loss of physical environment control	M	M	H	H	H	N	N	M	M
Reduction of environmental regulation	H	H	H	H	H	H	H	H	H
Physical health loss	N	N	M	N	N	H	H	N	N
Mental health loss	N	M	M	L	L	N	M	N	L
Constant joy loss	M	M	H	H	N	L	L	M	H
Variable joy loss	L	L	M	L	N	L	M	M	H
Legibility loss	H	M	N	M	M	N	N	N	N
Loss of scientific resources	M	M	M	L	M	N	N	M	M
Loss of educational resources	M	H	M	L	M	N	N	H	H
Loss of spiritual experience	N	L	N	M	M	N	N	N	N
Loss of inspirational sources	N	L	N	M	M	N	N	N	N
Loss of social interactions	M	N	N	M	M	N	L	L	N
Local identity loss	N	H	M	M	M	N	N	N	N

Table 6. Assessment of ecological and landscape values vulnerability in Lavizan Forest Park

Values	Effects	Threatening Factors								
		Reduction of Biodiversity	Unconventional Exploitation of Plants	Soil Pollution	Land Grabbing	Water Pollution	Construction	Cutting Down the Trees	Fire	Ecological Disconnection
Habitat diversity	Habitat diversity loss	M	M	M	L	M	L	M	M	M
Air purification	Air purification loss	M	M	L	N	L	N	H	H	H
Vegetation species	Vegetation species loss	H	H	M	L	M	M	H	H	H
Animal and wildlife species	Animal and wildlife species loss	H	M	M	L	M	M	M	H	H
Hydrological function	Hydrological function loss	N	N	L	N	L	N	L	N	L
Soil organic function	Soil organic function loss	N	N	M	N	L	N	L	L	L
Nutrition	Nutrition loss	H	H	M	N	M	N	M	M	M
Energy	Energy loss	M	M	N	L	N	L	M	M	M
Daily activities	Daily activities loss	N	N	N	N	N	N	N	L	N
Waste control	Waste control loss	N	M	M	L	M	L	N	M	N
Physical environment control	Physical environment control loss	L	L	N	L	N	L	L	L	L
Environmental regulation	Environmental regulation loss	H	H	M	M	M	L	H	H	H
Physical health	Physical health loss	N	N	L	N	L	N	L	L	L
Mental health	Mental health loss	L	N	N	L	M	L	M	M	N
Constant enjoy	Constant joy loss	M	M	L	N	L	M	M	M	M
Variable joy	Variable joy loss	L	L	L	N	L	L	L	L	L
Legibility	Legibility loss	N	N	N	L	N	L	M	N	M
Scientific resources	Scientific resources loss	M	M	L	L	L	L	M	M	M
Educational resources	Educational resources loss	M	M	N	L	N	L	M	M	M
Spiritual experience	Spiritual experience loss	N	N	N	L	N	L	L	N	N
Inspiring source	Inspiring source loss	N	N	N	L	N	L	L	N	N
Social interactions	Social interactions loss	N	L	N	L	L	L	N	N	M
Local identity	Local identity loss	N	N	N	L	N	L	L	L	N

In the conducted investigations, the most important ecological values of Lavizan Forest Park included air moderation and purification, vegetation, and animal and wildlife species, and the most important landscape values were food, environmental regulation, mental health, and scientific resources. In contrast, the most important threats were habitat diversity, intensive exploitation of the vegetation, trees cutting, and ecological disconnectivity, with the highest scores. These factors were highlighted by H index. It is considerable to note that important values were mostly vulnerable against threatened factors, with the reduction of habitat diversity being most intensive effect on biodiversity, flora and fauna species and nutrition, and environmental regulation. In fact, the largest damage related to vegetation structures such as biodiversity, intensive exploitation of vegetation, and loss of vegetation through fire, tree cutting, and ecological disconnectivity. The source of these threats was lack of correct vegetation management and loss of ecologic communications, threatening flora and fauna resources and, generally, the environment in this forest park (Figure 5).

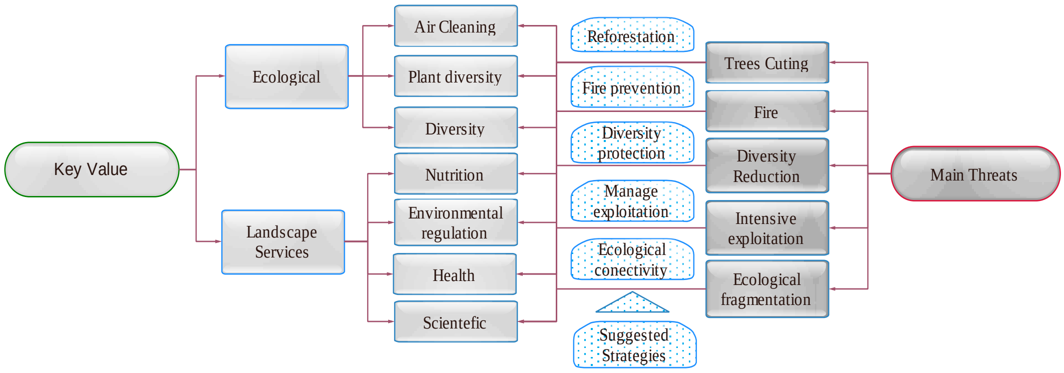

Fig. 5. Relation between threats, values, and proposed strategies

Based on the results from the assessment in Table 6, the habitat diversity and air condition are the most vulnerable elements to such threats as fire, park trees' cutting, and loss of ecological disconnectivity due to highway or excessive construction. In addition, the flora and fauna species as well as the wildlife were vulnerable to such threats as reduction of diversity and intensive exploitation of the vegetation.

Nutrition of flora and fauna is vulnerable for reducing diversity and over-exploitation of the resource. As well as the environment, regulation and control are mostly vulnerable to factors like reduction of diversity, water pollution, over exploitation of vegetation, fire, tree cutting, and ecological disconnectivity. In the current study, ecological disconnectivity was one of the main threats against the forest park, in full consistency with the findings of Darabi et al. (2013). In Litton R. Burton (2005), the integration of landscape and vegetation were identified as important values and accordingly, vegetation was a vulnerable factor, which was consistent with the present study's results.

In case of the effect and importance of vegetation and biodiversity, Clark James S (2011) identified climate-change-sensitive species along with the reason behind their vulnerability, which acted as important factors in affordance of ecological and landscape values. Finally, Based on Babaian, Bagheri, and Rafieian (2015), the water resource system was mostly vulnerable, whereas in the present research, the hydrological values were just in medium range in terms of vulnerability.

Management actions and solutions to tackle high-level threats in vulnerability assessment were proposed for the factors, mostly vulnerable in the framework of affordance strategy, which relies on proper interconnectedness of potential capacities in form of demand and supply. First part of the solution concentrated on needs, which included:

First, the area of study faced fragmentation, the way many other urban forest parks did (Haaland and van den Bosch, 2015). Second, fire threatened the forest park as indicated in others studies (Flora and Thiboumery, 2006; "*Flora CB,* *Flora JL* (2004) Bonding and bridging social capital in communities with Latino In-Migrants. Cambio de Colores (Change of Colors): Latinos in Missouri: Gateway to a New Community. University of Missouri, St. Louis, USA," ; Franco and Tarrega, 2015), Third, loss of biodiversity risk was another challenge of the studied area, being a common problem in urban areas as well (Fregetto, 2004), Fourth, the intensive exploration of forest park's resources acted as a threatening factor, and finally the ecological disconectivity appeared as the most important exposure of the area.

In the supply side, two main objectives could be considered: capacity and needs. The main ability of forest park is to provide a context to establish biodiversity, which in turn requires enhancing environmental regulation in the area on one hand and improving soil fertility on the other. In addition, the richness of the plant society should be considered through reforestation, fire, and tree cutting prohibition. Planting resilient and various adoptive species could improve the richness index of the forest park, which might prove attractive for the fauna over time. The appropriate exploitation of park resources and prevention of resource overuse are prerequisites for sustainable biodiversity in the forest park, the maintenance of which requires establishment of ecological relations that could be accrued horizontally through ecological connectivity and vertically through appropriate presence of suitable flora and fauna chain in the forest park.

Based on affordance strategy, management strategies should include initiative activities to create the structural and functional changes, resulting in vulnerability reduction (Steenberg et al., 2017).

The last step is formulating the strategies on basis of demand and supply. Fundamental strategies could be mentioned, based on priority, as protection strategy which has high priority. Protecting the forest park as a natural heritage against urban development and land use change comprises the first step in urban forest park maintenance. The edging effect is the major exposure to the forest park; therefore, for this purpose strategies should determine urban impacts on forest park. The prohibition strategy is the second proposed strategy, emphasizing on preventive actions like tree cutting, fire prevention, and optimization of resources exploitation, also classified as major threat of forest park. Reinforcement strategies, which include improvement action in the context of forest park to achieve environmental regulation and provision, climax condition, and replanting in order to rich biodiversity. And restoration strategy makes the last strategy, trying to restore disrupted areas due to exposed threats. The last strategy, relying less on the threats, is opportunistic strategy, which tries to develop the forest park into the city in any possible way. The main objective of this strategy is to develop the ecological context in a variety of forms such as ecological patches, step stones, even ecological infrastructures.

Zoning the park, based on vulnerability, is a precondition to allocate the appropriate strategy. It provides suitable opportunities to lead all actions in a certain and predetermined direction. As a consequence, synergy would be used to enhance the ecology of park, based on not only urban requirements but also the necessity to respond to them and attract public participation in park improvement.

CONCLUSION

The main objective of this research was to provide a framework for rapid assessment of forest parks. As such, vulnerability was introduced and assessment models were adopted in order to provide a context for assessment of forest parks' vulnerability. The adopted framework evaluated the relation between landscape ecological values and threats, conducted in Lavizan

Forest Park. Vulnerability assessment considered required parameters to identify damages as well as their intensity due to the threatening factors and landscape values simultaneously. Finally, strategies were provided in five categories, namely protection, prohibition, reinforcement, restoration, and opportunistic strategies to minimize the vulnerability, on basis of threats and values relations.

One of the main issues with this article was that this vulnerability assessment model observed the zones uniformly, while in all zones the vulnerability was not the same. The second issue was that it did not prioritize the value and threats, not considering the importance and performance of threats accurately. Therefore, the framework could be more accurate if vulnerability assessment took the differences of zones and sub-zones into account, while considering importance and performance in a definite manner.

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