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ORIGINAL ARTICLE

Estimation of Tourism Carrying Capacity of Fandoqloo Forest in Ardebil Province, Iran

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ABSTRACT
Technique of tourism tolerance capacity or tourism carrying capacity is an applied and quantitative technique in sustainable tourism. Carrying capacity estimates physical, actual and effective capacities in a tourist spot and manages them based on sustainability and management indexes and acceptable limits of changes in the indexes. In this paper, tourism carrying capacity of Fandoqloo Forest of Ardebil Provincewhich is located in the northwestern of Iran was determined through quantitative estimation of land carrying capacity by a systematic assessment. Results of the study showed that, each tourist spot has its specific priorities and carrying capacity of each region differs according to the environmental conditions. Hence, it needs sustainable programming and management adapted with tourism carrying standards and endurance ability.
Keywords*: Tourism development, Carrying capacity, Sustainable management, Ardebil Province, Iran.*

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INTRODUCTION

In the process of land programming and management, understanding of land consistency and ability for different applications, and using quantitative methods for estimating the amounts of use of available resources in certain carryings of the land in temporal units of programming have key roles in the land planning and management. Thinking of civil system which has been created in the concept of sustainable development especially in metropolitan field, role and operation of resorts and especially natural resources within urban and extra-urban and their environmental operations have made the environment of human society significant [1].

It is obvious that, recreational resources are founded often based on natural features and capabilities in each area or at least e considered as a major factor to determine a place as recreational. Obviously, in such circumstances, maintaining the dynamism and the quantity and quality of this category of natural resources is necessary to utilize them consistently and providing acceptable level of a recreational experience for visitors [2]. Since resources are often limited in nature and needs of human civilization to the use of resources resulted from some factors such as economic and industrial development and population growth is steadily increasing, therefore, every day there is more pressure on natural resources to meet these needs . Thus, optimal balance between the creational capability of a resource as one of the important functions of environmental resources and the amount of using them by the visitors is a much important task and forms the basis of systematic programming of urban resorts to prevent creation of ecological disturbance in these areas as well as making it possible to have steady and optimal utilizing of them [3].

Effective adjustment and completing the actual strategy in avoiding the pressure of tourism on the environment are often done based on carrying capacity. Use of carrying capacity index in programming of recreational regions began in the second half of 1990s. This term means the number of using periods of a recreational area without permanent decline in physical and biological capacity to support recreation area and obvious damage to the recreational quality[4]. Global Tourism Organization defines the carrying capacity as following: a certain level of use by visitors in an area who can accumulate in a certain time and place [7].

Firstly, it is emphasized that, carrying capacity is a complicated concept and shows the relationship between visitor and environmental conditions. It means that, increase of the number of visitors causes occurrence of more damaging environmental impacts such as soil compaction, reduced soil surface and vegetation density. Gradually, social aspects of carrying capacity such as experience and quality of visiting were considered. For instance, we can mention to the initial understanding of carrying capacity in creational areas which can be estimated by ecological view and based on resources degradation, but it was found very soon that, human values must be considered in this view seriously. This theory was based on this matter that, by increasing of visitors in a region, not only the quality of natural resources is affected, but also recreational quality of visit of the region will reduced due to social and psychological effects of population density, collisions and the resulting stress [8, 10, 11]. Considering that, the classification of carrying capacity is considered as the basis of estimation methodology of carrying capacity, therefore, based on the above definition and Hunter's classification, the types carrying capacity are included:

-Social carrying capacity: Tolerance level of the host population in an area being developed for accepting the presence and treatment of new members or degree of readiness to accept congestion and overcrowding of new users.

- Economic carrying capacity: The ability to attract and accepting new development activities without handling or disturbing the local optimal land uses and activities.

In addition, two other classes which have not been mentioned in Hunter's classification are as below:

- Ecological carrying capacity: It considers structure, function, role and ecological processes in the estimations.

- Environmental carrying capacity: Which ultimately provides an integrated estimation of intrinsic carrying capacity considering some types of carrying capacities by an integrated approach? Sometimes also, the carrying capacity is increased and adjusted using services which are defined as extrinsic carrying capacity in such state. In tourism development planning, for carrying capacity of two main elements are considered includingmoral element that determines the quality of the experience achieved by the visitors or tourists, and biophysical element which determines natural and physical quality of the recreational area considering the manner of tourists. Accordingly, three kinds of carrying capacity have been considered including physical carrying capacity (PCC), Real carrying capacity (RCC) and Effective carrying capacity (ECC) in introduced methodology by International Union for Conservation of Nature and Natural Resources to estimate carrying capacity of natural areas for tourism purposes[12, 13].

Due to the unique climatic conditions of Ardabil Province and increasing tourists in the area, and on the other hand, rich biodiversity of sylvan region of Fandoqloo, Ardabil where has been placed as a part of the ecosystems of Arasbaran forests as biosphere in Ardabil Province; makes its utilization more obvious. Therefore, in this research, tourist carrying capacity of the region was estimated in order to sustainable utilization.

MATERIALS AND METHODS

Study area

Fandoqloo forest is located 30 km far from the southeastern of Ardabil city and 10 km far from the south of Namin city. The forest has high tourist demands particularly in holidays due to having forest-pasture morphology and capabilities of diverse development and having no alternative and similar in the province and other capabilities. Fandoqloo forest is the genetic origin of hazelnut and has an area by 207.94 km^2 and is located between longitude of eastern 48º 30' 25"to 48º 45' and latitude of northern 38 5' 30" to 38 30'. The study area is conterminous from the east with Gilan Province and from the northeastern with Republic of Azerbaijan (Figure 1) [5].

Methods:

In this research, the following methods were used to estimate carrying capacities of physical carrying capacity (PCC), Real carrying capacity (RCC) and Effective carrying capacity (ECC).

Physical carrying capacity

Physical carrying capacity includes the maximum number of visitors who can be physically present at a certain time and place [6]. This number can be calculated by Equation (1) for suitable tourism area.

1) Pcc = A * V/a * RF

Where:

A (Area) is the suitable tourism area.

V/a (Visitor/area) is the space that each visitor needs to easily be able to move and does not have interaction with other physical phenomena or people (this amount normally is a horizontal area by 1 $m^2$for an ordinary person and varies with regard to natural barriers, the region sensitivity or safety considerations, and the tour guide is responsible to adjust it).

Rf (Rotation factor) is the number of daily visits of a place which is calculated as below:
Rf= Usability Time of the place/mean time of a visit
In calculating the physical carrying capacity, following matters should be noticed:
The first matter is that, suitable area for the tourists is actually the identified areas in assessment of ecological ability for tourism as the areas which have ability class 1 and 2;
And the other matter is that, the number of visitors per m^2 considering natural characteristics of each region and safety considerations can be variable.

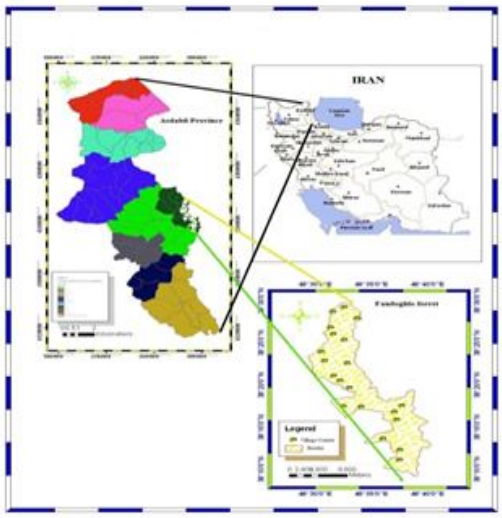

Figure 1. Geographical position of Fandoqloo Forest in Ardabil Province, Iran

Real carrying capacity

Real carrying capacity includes the maximum number of visitors who are permitted to visit a recreational place considering limiting factors resulted from specific conditions of the place and their effect on physical carrying capacity. These limiting factors are achieved considering biophysical, ecological, social and management conditions and variables [14].
RCC is calculated using the following equation:
Rcc = Pcc - cf1 - cf2 - …. cfx3)
Where:
Cf is a limiting factor that is stated as percent. Therefore, the equation can be stated as below:

4) $Rcc=Pcc * \frac{100-cf1}{100} * \frac{100-cf2}{100} * \frac{100-cf3}{100}$

It should be considered that, limiting factors of each area can be limited to the area, for instance, flood can be a limiting factor while, this threat may not be in another area. In other words, the limiting factors depend completely on the characteristics of each area. Limiting factors are stated as percent and are calculated using Equation 5:

5) $CF= M1/ M_+ * 100$

Where:
CF is the limiting factor, M_1 is the limiting amount of a variable and M_+ is the total amount of a variable.

Effective carrying capacity

Effective carrying capacity includes the maximum number of visitors which can be managed sustainably by the existing management [6]. This index is calculated by combining the real carrying capacity and the region carrying capacity and using Equation 6 [14].

6) Ecc = Rcc * Mc

Management Capacity or MC includes a set of conditions that a regional management needs it to achieve desired operations and goals. In quantitative estimation of these abilities, there are many variables that interfere including the policies, rules and regulations, infrastructural facilities, human resources requirements, financial resources, etc. Lack of these management abilities is one of the most serious problems in management of touristic regions in developing countries. MC is calculated using following equations:

7) $MC=\frac{100-Fm}{100}$

8) $Fm=\frac{Imc-Amc}{Imc} * 100$

Where: Fm is management adjustment factor, Imc is ideal management capacity and Amc is real management capacity (available).

RESULTS

In order to investigate physical carrying in the study area based on applied approach, it is needed to calculate and assess required data including suitable area for tourism, applicability duration of the location, visit duration, etc. Considering that the study area is one of the protected regions by DOE which has management plan. Suitable area for tourism was determined equal with the extent of recreation zones [5].

Table 1: Area of each concentrated and extensive classes

Area m2	Season	Outing classes	Outing types	number
756000	All seasons	2	Extensive	A
17205800	All seasons	1	Extensive	B
174000	All seasons	unsuitable	Extensive	C

Calculation of physical carrying capacity

Physical carrying capacity for talented areas of extensive outing class 1:
As it was mentioned, physical carrying capacity is calculated using following equation:
Pcc = A*v/a*Rf
Values of the components of this equation for Fandoqloo region are as below:
Area of talented areas for extensive outing class 1: A: 17205800 m^2
Number of Peron per m^2 for extensive outing class 1: v/a: 1/ 2.5
Number of visits per day: Rf = 12/6 = 2
Therefore, physical carrying capacity is as below:
Pcc = 17205800 * 2 * 1 / 2.5 = 13764640 person
The components for extensive outing class 2 are as below:
Area of talented areas for extensive outing class 2: A: 756000 m^2
Number of Peron per m^2 for extensive outing class 2: v/a: 1/ 4
Number of visits per day: Rf = 12/6 = 2
Therefore, physical carrying capacity is as below:
Pcc = 756000 * 2 * 1 / 4 = 378000 person

Calculation of real carrying capacity

Real carrying capacity for talented areas of extensive outing class 1:
In order to interfere in determination of carrying capacity by ecological constraints existing in the watershed of Fandoqloo, ecological vulnerability of the ecosystems must be determined and carrying capacity should be determined according to the vulnerability of each ecosystem. In this regard, considered ecological factors were listed and classified. In order to determine ecological vulnerability, the principal of limit or threshold values in ecology is used. According to this principal, by closing the ecological factor to its critical or threshold, the damage of considered ecosystem increases. Accordingly, the amount of vulnerability of each class of ecological factors is determined based on numbers 1 to 4 in which 1 means the minimum vulnerability and 4 means the maximum degree of vulnerability (Table 2).

Table 2. Coding of ecological vulnerability

Vulnerability code	Vulnerability content
1	Low vulnerability
2	Moderate vulnerability
3	High vulnerability
4	Very high vulnerability

Ecological factors that have been considered include: soil erosion, elevation, vegetative cover, frost days, rainy and snowy days and intense sunshine hours.
Ecological factors classes and the amount of vulnerability of each class have been listed in Table (3).

Table 3. Coding of vulnerability of ecological parameters

Class number	Elevation classes	s	Vegetative cover density	s	Soil erodibility	s
1	800 - 1000	1	60–40	1	Moderate	1
2	1000 - 1400	2	80–60	4	high	2
3	1400 – 1800	3			intense	3
4	1800 - 2000	4			Very intense	4

At the next stage, the weight of each parameter was calculated relative to the other parameters based on pairwise comparison method [16]. In this method, firstly paired comparison matrix was formed and each parameter was compared with another parameter as pairwise and its relative weight was calculated in Expert Choice software. Then, by combining the relative weights, the final weight of each parameter was calculated. Accordingly, the weight of ecological factors was achieved as Table 4.
Then, ecological factors weight of each class was calculated based on following equation:
9) Hi = Wi * Si
Where:
H is ecological vulnerability of each class, W is the weight of each class, S is vulnerability code of each class.

Table 4. Weighting of ecological parameters

Ecological factor	Weight
Elevation	0.309
Vegetative cover density	0.132
Soil erodibility	0.264

In order to calculate the limitation caused by conditions of each class of ecological parameter the following equation was used:
10) Cf1 = Hi * Ai / ∑ Ai * 100
Where: Hi is ecological vulnerability class 1, Ai is the area having various kinds of vulnerability, ∑Ai is total area of talented area for extensive outing use (class 1 or 2). Based on the mentioned method, percentage of ecological vulnerability class 1 has been calculated in the watershed of Fandoqloo region for desired ecological factors (Tables 5, 6, 7).

Table 5. Determination of ecological limitation percentage caused by elevation classes

elevation classes	S	W	Hi	Ai	Hi*Ai/∑Ai *100
800 - 1000	1	0.309	0.309	3600	**0.06**
1000 - 1400	2	0.309	0.618	848800	**28.2**
1400 – 1800	3	0.309	0.927	916600	**45.8**
1800 – 2000	4	0.309	1.236	85700	**5.71**
total				1854700	**79.77**

Table 6. Determination of ecological limitation percentage caused by soil erodibility

Erodibility	S	W	Hi	Ai	Hi*Ai/∑Ai *100
Moderate	1	0.246	0.246	606400	**7.98**
high	2	0.246	0.492	45800	**1.2**
intense	3	0.246	0.738	990000	**39.1**
Very intense	4	0.246	0.984	225100	**11.8**
total				1867300	**60.08**

Table 7. Determination of ecological limitation percentage caused by vegetative cover density

Vegetative cover density	S	W	Hi	Ai	Hi*Ai/∑Ai *100
40 - 60	1	0.132	0.132	**124830**	**4.8**
60 – 80	4	0.132	0.528	**215550**	**33.4**
total				**340380**	**38.24**

Rainy and snowy days, frost days, strong sunshine hours and agricultural lands are some other limitations affecting the visit time thatshall be deducted from the physical carrying capacity.
Based on average climate data of the years 1999 – 2009 of Ebibeigloo station, the number of rainy and snowy days are 97 and 35 days respectively therefore, total snowy or rainy hours is:
(97+35) * 12 = 1584

Total frost days in the station is 136 days and in each of these days, there are 5 hours of inclement weather in the region for the visitors so, there will be totally 680 hours of inclement weather resulted from frost.
In the warm months of the year, the hours in which there are unfavorable conditions for the visitors due to intense solar radiation, should be calculated.
If these conditions are existent for four months including May, June, July and August therefore, number of hours with intense sunshine is calculated as below:
31*4 = 124 days
124 * 4 = 496 days
Average degree of cloudiness for the four months is 30% and its value is deducted from total hours of intense sunshine.
496 * 0.3 = 148.8 hrs
Total number of intense sunshine hours.
496 – 148.8 = 347.2 hrs
In order to calculate limitation percentage caused by each climatic element, the following equation has been used:
$M1 / M_{+} * 100$
Total hours having climatic limitation:
1584+ 680 + 347.2 = 2611.2
Total CF = 2611.2 / 4380 * 100 = 59/6
The ratio of agricultural lands and wastelands area to the total area of touristic location is considered as spatial limiting factor affecting physical carrying capacity.
Agricultural lands area= 5414000 m^2
Percentage of areas without the use of tourism:
Cf = m/M * 100
Where: Cf is the limiting factor, m is limiting value of a variable M is total value of a variable.
Therefore, calculation of spatial limitation factor is as below:
Cf = 54140/186780 * 100 = 28/98 m^2

So, real carrying capacity for suitable areas of extensive outing class 1 is calculated as below:
RCC = PCC * 100-CF1/100 * 100 – CF2 / 100 * 100 – CF3 / 100
$RCC = 13764640 * \frac{100 - 70/77}{100} * \frac{100 - 60.08}{100} * \frac{100 - 39.24}{100} * \frac{100 - 59.6}{100} * \frac{100 - 28.98}{100}$ = 13764640 * 0.2023 * 0.3992 * 0.6076 * 0.404 * 0.7102 = 193789.8 persons

Calculation of real carrying capacity for talented areas of extensive outing class 2:
In order to calculate real carrying capacity for these areas, firstly the percentage of each ecological limitation was calculated which has stages for calculation similar to conducted calculations for class 1. Achieved estimations are as below:
PCC = 378000
Therefore, real carrying capacity is as following:
RCC = 378000 * 0.2023 * 0.3992 * 0.6076 * 0.404 * 0.7102 = 5322

Calculation of effective carrying capacity

Since, there was no accurate estimation of management abilities in the study area (Fandoqloo sylvan zone), calculation of effective carrying capacity was done considering that, these abilities can be created in the future and interfered in effective carrying capacity with regard to the available facilities including fundamental accessories and facilities, healthcare and social security services.

CONCLUSION

Priorities of sustainability indexes are different in different aspects and places considering tourism purposes, it means that, every touristic place has its own characteristics and features. Each touristic place has its specific priorities; so, we can attempt to make sustainability models of tourism activities as much as possible through quantitative techniques and more desired modeling consistent with the realities of tourism activities in each specific place.
From investigating the current status of tourism activities in Fandoqloo region, it was found that, the current status of tourism activities is in a lower level compared with its carrying capacity, hence, this result also can be proposed as a problem, so that, due to lack of sustainability standards in the current situation of tourism activities in Fandoqloo region (for instance: lack of expert human force, erosion issue, quality of servicing to the tourists and its effect on the tourists experience, etc), tourism can move toward

instability as well as it can develop in advance programming strategies for its future sustainability that provides an opportunity to progress tourism activities adapted to the standards of tourism carrying capacity via sustainable management of its acceptable variations ranges.
A point that should be considered is the subject of tourism macro strategies at regional, national and international levels. In other words, carrying capacity technique mostly follows the tourism at the micro level and estimates and analyzes the situation of tourism activities via sustainability models and almost without analysis at the macro level, and does not consider effective elements at the macro level in current and future status of a touristic place while, relationships of political, economic, security and cultural factors between various regions of a country and between countries at international level are fundamental factors in tourism which draws its vectorsat the macro level. Accordingly, carrying capacity is a dynamic and evolving concept, and quantities resulted from a unit approach may be different in two different societies or in a society in two different time intervals dependent on socioeconomic conditions, rules, management goals and generally, public understanding level of the societies about preservation of ecosystems and natural resources.

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