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Tourism carrying capacity assessment for Phong Nha - Ke Bang and Dong Hoi, Quang Binh Province

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Abstract. Recently, tourism activities in Quang Binh Province have been growing rapidly, especially since the Phong Nha - Ke Bang National Park was certified as the World Natural Heritage in 2004. Among the tourist sites of Quang Binh, Phong Nha and Dong Hoi tourism centers are the two places which attract the largest numbers of visitors. The rapid but unplanned tourism activities have been creating various social and environmental concerns. If appropriate planning measures are not derived from the consideration of the carrying capacities of these sites, tourism centers will be overloaded, tourism quality will be degraded and therefore the benefit obtained from tourism activities will be reduced. This paper presents the tentative establishment of a method to calculate the environmental carrying capacities of three basic components: ecological, economic and social. As the results, the carrying capacities of several tourism activities are quantitatively evaluated for Phong Nha tourism center. The resulting carrying capacities for Phong Nha cave sightseeing, ecotourism forest hiking and cable car ridding are 43893, 1450 and 33000 visits per day respectively. With respect to the Dong Hoi tourism center, the carrying capacities of local beaches are 71000 visits per day. These estimates can be used as the preliminary benchmarks for later tourism planning of the two tourism centers: Phong Nha - Ke Bang and Dong Hoi.

Keywords: Tourism; Carrying capacity; Limiting factor; National park; Beach.

1. Introduction

Tourism, as well as some other economic sectors, is a profitable economic sector in Vietnam. The tourism activities are related to different exploited natural resources such as mineral resources, geotop, cultural site,... The rapid but unplanned exploitation and utilization of these resources create a risk of loosing their recovery capacities, destroying the basic functionalities of ecosystem within tourism areas. Various tourism-related factors can be identified to have impact on these resources, among which the number of tourists would be the most important one. The concept of carrying capacity of a tourism site was stemmed from this perception. This concept is important in the tourism planning which aims to sustainable tourism development. In 1994, the World Tourism Organization (WTO) proposed a definition of tourism carrying capacity as follow: *"The maximum number of people that may visit a tourist destination at the same time, without causing destruction of the physical, economic, socio-cultural environment and*

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an unacceptable decrease in the quality of visitors' satisfaction".

Luc Hens [1] defined the tourism carrying capacity as "*The maximum number of people that use tourism site without unacceptable effect on environmental resources while meeting the demand of tourists*".

Based on our perception of sustainable tourism development, objectives of the project QGTD-03-04, the local characteristics, and several concepts of carrying capacity in literature, our concept proposed to be applied to Quang Binh as follow: "*Tourism carrying capacity is the highest bearing capacity of a natural, environmental and socio-economic system within which the maximum number of tourists has no influence on sustainable development of the entire system and tourists' satisfaction are remained during the peak tourism period*".

According to this definition, the tourism carrying capacity includes three components: ecological carrying capacity, social carrying capacity and economic carrying capacity.

Ecological carrying capacity is the number of tourists who can undertake activities in a tourism site without causing the degradation below the allowable limit of natural environment. In order to calculate the ecological carrying capacity, safety limits of ecosystems are often used through indicators of natural environment, biological diversity, environmental pollution,...

Social carrying capacity includes two aspects: 1) Acceptance level of local community which is reflected by the maximum number of tourists which does not make local residents unpleasant; and 2) acceptance level of tourists which is expressed by their satisfaction to tourism sites and the number of returnees.

Economical carrying capacity is acceptable level of tourism activities without doing any harm to key local economic activities. It means that tourism activities must not make conflict to other economic sectors and a decrease in the income of the local people.

2. General formulae

To calculate carrying capacity of some tourism activities in Quang Binh Province, the formulae of Cifuentes [2] and Ceballos – Lascurain [3] are used with some adjustments. Tourism carrying capacity is divided into the following levels:

2.1. Physical carrying capacity (PCC)

Definition: PCC is the maximum number of tourists that can physically fit into or onto a specific area, over particular time:

$$PCC = A \times D \times Rf \,, \qquad (1)$$

where: A : available area for use (m^2);

D : tourist density (tourists / m^2);

Rf : Rotation factor (number of visits per day).

A is determined by particular conditions of the considered area. In natural area, this parameter can be determined by natural boundary such as mountain range, river, stream,... or safety demand. In conservation area, where tourism is developed, the available area can be estimated from the length of track in that area or the total area where tourists can do camping.

The tourist density or the area required per tourist D is the area needed for a tourist who can undertake activities comfortably.

Rotation factor is the number of permissible visits over a specified time (usually calculated by daily open hours) and expressed by:

$$Rf = \text{Open period / average time of visit} \qquad (2)$$

2.2. Effective Real Carrying Capacity (ERCC)

Definition: *ERCC* is the maximum number of tourists that is permitted by the local conditions and management capacity without influencing the tourists' demand:

$$ERCC = PCC - Cf_1 - Cf_2 - ... - -Cf_n \,, \qquad (3)$$

where: Cf_i (corrective factors or limiting factors) are factors which have negative impact on tourism activities and assessed by limiting threshold which used for identifying impact level of a factor (%):

$$ERCC = PCC \times \frac{100 - cf_1}{100} \times \frac{100 - cf_2}{100} \times ... \times \frac{100 - cf_n}{100}, \quad (4)$$

where limiting factors can be determined by:

$$Cf = \frac{M1}{Mt}, \quad (5)$$

$M1$: limiting magnitude of variable;

Mt : total magnitude of variable.

These factors are selected based on tourism activities and local conditions of the study area. In consideration of tourism activities at National Parks, the following factors should be taken into account: environmental safety, conservation, natural resources managements, tourism activities, planning and local factors such as human resources, the contribution of tourism to local economic development, social crimination,...

2.3. Limiting factors used in calculating tourism carrying capacity

Environmental indicators are used to indicate the sensitivity of environment and development. Indicators form a set of indicators (index) that help us to recognize on-going problems and propose corrective actions. In estimation of carrying capacity, only negative factors which hinder the development of tourism activities are considered. These factors are translated into quantitative or semi-quantitative values which measure the adaptability of environmental, socio-economic subsystem and tourists' demand.

Therefore, indicators selected for calculating carrying capacities have the following characteristics:

- Computable (often quantitative or semi-quantitative values).

- Easily surveyed and collected (by field research and questionnaire).

3. Carrying capacity of the main tourism centers

3.1. Phong Nha tourism center

a. Cave sightseeing

To calculate Effective Real Carrying Capacity (*ERCC*), factors that affect tourist's comfort such as the necessary distance between two people and the distance between two groups on a route should be considered. It is a limitation of the previous formulae proposed in the literature. Therefore, to improve Ceballos-Lascurain formula, the following physical parameters are included:

- Length of sightseeing route in Phong Nha cave (Wet cave): 600m.

- Length of sightseeing route in Tien Son cave (Dry cave): 450m.

- Distance from waiting house to Tien Son cave: 200m.

- Length of a boat: 5-7m.

- Distance between two boats operating in Phong Nha cave: 5m.

- Distance between two groups in Tien Son cave: 5m.

- Average distance between two people: 1m.

- Maximum number of people on one boat: 13 visitors (include tour guide).

- Average time for a tour: 3 hours (excluding the time on boat along Son River).

- Open period: 8 AM - 17 PM (9 hours).

Let x to be the maximum number of boats in Phong Nha cave. From entrance to the last visiting point, the number of boats is expressed by equation:

$$x \times 7 + (x - 1) \times 5 = 600.$$

The above equation gives: $x =$ 50 boats.

Let k to be the maximum number of groups going into Tien Son cave (one group is equivalent to one boat). The length of this cave is 450 meters, the distance from waiting house to entrance is 200 meters, and therefore the route is 650 meters in lengths:

$$k \times 13 + (k - 1) \times 5 = 650 \Rightarrow k = 36 \text{ groups.}$$

Open period is 9 hours/day; each tour is about 3 hours. Thus the number visits per day is 3 (Rf = 9/3). Therefore, the maximum number of visits per day is:

$$PCC = (x+k)\times 13\times 3 = 86\times 13\times 3$$

= 3354 visits/day (100620 visitors/ month).

Thus, the maximum number of tourists that Phong Nha cave could serve is about 3354 visitors/day.

Corrective factors:

Survey and investigation results show that the physical, biological, ecological parameters in this area are insignificant. Moreover, the sightseeing route Phong Nha - Tien Son lies outside the strict protection area of the National Park, so these parameters are not limiting factors.

+ Weather limiting factor (Cf_1):

During the year, storms often occur in September and October, and limit the number of visitors. At the same time, boats cannot get into the cave because of high water levels [4]. Almost all tourists, who were asked, do not want to visit the National Park during this time, so weather factor is taken as a limiting factor:

$M1$: 60 days (two month Sept., Oct.);

Mt : 365 days (one year).

Limiting factor for weather (Cf_1):

$$Cf_1 = \frac{60}{365} = 0.164 \quad (=16.4\%)$$

+ Noise (Cf2): Statistical analysis of questionnaires filled by managers, tour guides and tourists at the National Park has indicated that the noise from boat engine has affected tourists (they must bear the noise and are almost unable to communicate when being on boat). Therefore, the noise is taken as a limiting factor. The results of questionnaires are analysed and shown in Fig. 1.

The following formula is used to estimate the noise limiting factor:

Cf_2 = The number of people uncomfortable by noise/ Total people survey

= 16/ 69 = 23.2% .

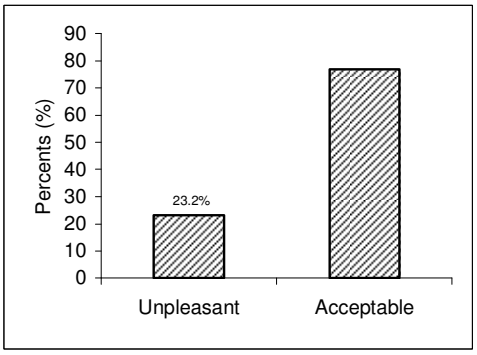

Fig. 1. Comment of tourists on the noise from boat engines.

+ Infrastructure limiting factor (Cf_3)

The authors used questionnaires for infrastructure quality assessment. Respondents chosen for the survey were staff of the tourism center and tourists. The subjects included the quality of guest house, hotel and traffic, difficulties met in waiting house, on boat and in cave. According to the assessment of tourists and staff (Fig. 2):

Cf_3 = 11/ 69 = 15.9 %

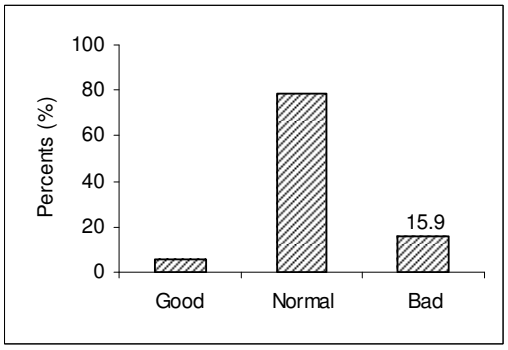

Fig. 2. Infrastructure quality assessment.

+ Management limiting factor (resources management and tourism services - Cf_4)

For capacity of resource use and management, an attention is paid on the following issues: scenery management, fresh water and energy (fuels) supply, waste and environmental pollution (Fig. 3).

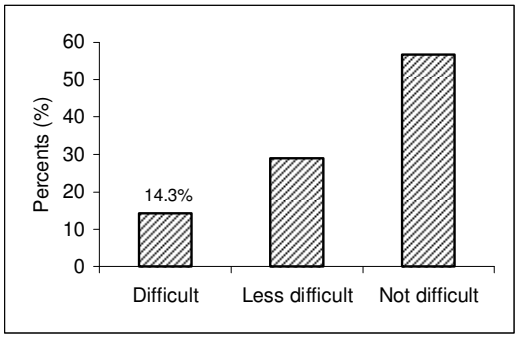

Fig. 3. Assessment of resources use and management capacity.

Capacity of tourism service exploitation and management: service management includes issuing regulations, rules for business enterprises, controlling high quality services, supplying news service activities and enhancing knowledge of local people about tourism services (Fig. 4).

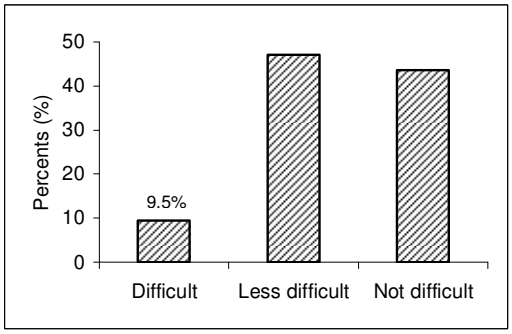

Fig. 4. Assessment of tourism service exploitation and management capacity.

Cf_4 is determined by the following equation:

$Cf_4 = \frac{1}{2}$(capacity of resource use and management + service exploitation)

$$= \frac{1}{2}(14.3 + 9.5) = 11.9\%$$

+ *Tourist safety limiting factor (Cf_5)*:

According to regulation of Earth Check™ (refer to Green Globe 21 – Standard for cave sightseeing visitors [5]) each group of cave visitors has maximum 10 to 12 people and 1 tour guide. The number of guides in Phong Nha Tourism Center is 32 and it is enough to meet the service demand even in festival days. Therefore, at present this is not a limiting factor.

The number of visitors on one boat is 13 people (a group of visitors on boat is equivalent to one group). The exceeding number of visitors is a factor which can bring risk to the safety of visitors. Thus,

$$Cf_5 = 1/12 = 0.083 = 8.3\%$$

The effective real carrying capacity of Phong Nha cave is:

$$ERCC_{Ca} = PCC \times \frac{100 - Cf_1}{100} \times ... \times \frac{100 - Cf_5}{100}$$

$$= 3354 \times 83.6 \times 76.8 \times 84.1 \times 88.1 \times 91.7$$

$$= 1463 \text{ visitors / day } (= 43893 \text{ visitors / month})$$

b. Ecotourism forest hiking in the National Park

This tourism service activity is about to be put in operation. The observed parameters are:

- Length of ecotourism forest hiking route: 14000m.
- Maximum number of tourists in one group: 15 visitors.
- Average distance between two people: 1m.
- Distance between two groups: 50m.
- Average time for a visit: 6 hours.
- Open period: 7 AM- 16 PM (9 hours).

Let x to be the number of groups:

$$x \times 15 + (x - 1) \times 50 = 14000$$

$$\Rightarrow x = 216 \text{ groups.}$$

Open period is 9 hours, average time for a visit is 6 hours, so each visitor just goes sightseeing one time per day, or $Rf = 1$.

$$PCC = 216 \times 15 \times 1 = 3240 \text{ (visitors/ day)}$$

Corrective factors

+ *Excessive sunshine (Cf_1):* June and July are the two months having the highest average temperature in the year. At noon (from 11 AM to 14 PM) visitors can hardly walk on the concretized routes. This can be considered as a limiting factor.

$M1$: 60 days (June and July) × 3 hours (11 AM to 14 PM) = 180 hours.

Mt : 180 days (6 months have sunshine) × 12 hours = 2160 hours.

Therefore: $Cf_1 = M1/Mt = 180/2160 = 8.33\%$

+ *Flood season* (Cf_2): Heavy rains and storms often occur in September and October affecting tourists' sightseeing. Hence, it can be taken as a limiting factor.

$M2$: 60 days (September and October).

Mt: 365 days (12 months).

Therefore, $Cf_2 = M1/Mt = 60/365 = 16.44\%$.

+ *Hiking route limiting factor* (Cf_3):

According to the assessment of World Tourism Organization, the route slope of 10^o or greater has impact on the traveling speed and health of tourists. Thus, it is the factor limiting the tourism capacity. As it is derived from the topography map, more than 4 km (30% of route length) has the slope of 10^o or greater. Thus, $Cf_3 = 30\%$.

+ *Wild animal and plant limiting factor* (Cf_4):

Most kinds of fruits ripen in June and July, so birds and small animals go to near track finding food. They will fear and go to another place when visitors walk into the National Park. Thus, $Cf_4 = 60/365 = 16.44\%$.

From the above assessment, $ERCC$ of ecotourism forest hiking can be computed as:

$$ERCC_{Eco} = 3240 \times 91.67\% \times 83.56\% \times \\ \times 70\% \times 83.56\% = 1450 \text{ (visits/day)}.$$

c. Cable car ridding

This type of tourism service activity has been put in operation in Da Lat, Ninh Thuan, Yen Tu, Chua Huong,... Safety standards are applied to the cable car route at Phong Nha - Ke Bang with the similar length.

Design parameters:

- Length of ridding route (one-way): 2500m.
- The number of tourists per cabin: 6 people.
- Average distance between two visitors: 1m.
- Distance between cabins: 50m.
- Average time for route: 15 min.
- Open period: 7 AM- 16 PM (9 hours).
- Cable car moving speed: 1-5m/s.
- Maximum visitors (by design): 1000 - 1200 visitors/hour (or 9000 - 10800 visitors/day).
- The number of cabins: 2500/50 = 50 cabins.

$PCC = 50 \times 6 \times 540/15 = 10800$ visits/day.

Corrective factors

+ *Excessive sunshine* (Cf_1): June and July are the two months that have the highest average temperature in the year. At noon (11 AM - 14 PM) visitors are difficult to move by cable cars.

So, $Cf_1 = M1/Mt = 180/2160 = 8.33\%$.

+ *Flood season* (Cf_2): September and October usually have heavy rains and storms to affect recreation of tourist:

$$Cf_2 = M1/Mt = 60/365 = 16.44\%$$

+ *Safety factor* (Cf_3): It is designed by safety standards (O.I.T.A.F), risk probability is calculated less than 1%, or $Cf_3 = 1\%$.

Effective real carrying capacity of cable car ridding:

$$ERCC_{CableCar} = 10800 \times 91.67\% \times 83.56\% \times 99\% \\ = 8190 \text{ (visits/day)}.$$

Therefore, real carrying capacity of Phong Nha - Ke Bang center equals:

$$ERCC_{PN} = ERCC_{Ca} + ERCC_{Eco} + ERCC_{CableCar} \\ = 1463 + 1450 + 8190 \\ = 11100 \text{ visits/day} \\ = 333000 \text{ visits/month}.$$

3.2. Dong Hoi tourism center

The main tourism activities in Dong Hoi are beach tour, sightseeing sand bar and ostrich farmer. The corrective factors are:

Winter season (Cf_1):

During winter months (from September to March next year), the beach is temporarily closed for a period of 6 months. So, $Cf_1 = 6/12 = 50\%$.

Excessive sunshine (Cf_2):

The period from May to July has the highest temperature in Quang Binh. At noon (10 AM - 15 PM) in this period, visitors hardly want to go to the beach.

$M1$: 90 days (May, June, and July) $\times$ 5 hours.

Mt: 180 days $\times$ 12 hours.

$Cf_2 = 90 \times 5/180 \times 12 = 20.8\%$.

Table 1. Beach quality assessment matrix of Dong Hoi

No	Beach	Tide	Nearshore Current	Mud/ sand	Thickness of sand layer (m)	Slope (Degree)	Clean sand Md/ So	Quality of sea water*	Quality of beach
1.	Bao Ninh	+	+	+	+	+	+	+	7/7
2.	Nhat Le	+	+	0	0	+	+	0	4/7
3.	North Nhat Le (Quang Phu)	+	+	+	0	+	+	+	6/7

Notation: "+" Good or suitable quality; "0" Average or no impact quality; "-" Low or unsuitable quality.

Quality of sea water (Cf_3):

According to the statistical data obtained by Coastal Water Quality Monitoring Center (quarterly data), Department of Environment and Natural Resource and some coastal investment projects, concentrations of pollutants (such at BOD_5, SS) exceed Vietnamese standard (TCVN 5942 level B) during period from May to August. In other areas, almost all indicators are less than standard. Therefore, quality of sea water is a corrective factor in Nhat Le.

$M1$: from May to August (120 days).

Mt : 1 year (365 days).

$Cf_{3NL} = 120/365 = 32.88\%$.

Quality of beach (Cf_4):

This factor is assessed by geological criterion through a matrix table (Table 1).

Safety factor (Cf_5):

There exist underwater vortices and sand bar along the nearshore area of Quang Binh. Around 10% of the length of the coastal line was assessed by scientists to have potential risk for tourists' safety. Therefore, $Cf_5 = 10\%$.

From the above assessment, the $ERCC$ of beach in Dong Hoi center is:

$$ERCC_{DH} = ERCC_{BN} + ERCC_{NL} + ERCC_{QP}$$
$$= 38000 + 5468 + 27493$$
$$= 71000 \text{ (visits/day)}.$$

4. Conclusions

The tourism carrying capacity assessment method used in this article is mainly based on general equations which proposed by Cifuentes [2] and Ceballos - Lascurain [3] with a slightly modification. There are three levels of tourism carrying capacity: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC) and Effective Carrying Capacity. These three are reduced into PCC and ERCC by considering infrastructure and management capacities as the limiting factors in computation of RCC.

The authors have calculated the tourism carrying capacity in Dong Hoi and Phong Nha centers by using the adjustment from PCC to RCC or ERCC based on various limiting factors. The obtained results are as follows: i) Dong Hoi center has the highest tourism carrying capacity, about 71000 visits per day. The main tourism activities are beach recreation, sand bar sightseeing and ecotourism; ii) Phong Nha National Park has a lower tourism carrying capacity than other centers in Quang Binh, with 11000 visits per day. There are many tourism activities in this area such as: cave sightseeing, adventure tourism, cable car ridding, mountain climbing, ecotourism forest hiking in National park, geotop,...

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