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THE CONCEPT OF CARRYING CAPACITY IN TOURISM

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Abstract

Carrying capacity is often pragmatically, theoretically as well as purely intuitively considered as a concept in the context of tourism sustainability. The carrying capacity application has the greatest potential in protected areas, in frequently visited cultural and natural attractions, and in relation to sustaining of the lifestyle of the local community and tourism destination potential in general. Despite its importance, partial applications, determination of basic theoretical principles, and specifying connection to the other theoretical concepts in tourism (particularly destination life cycle, LAC concept, visitors management), there still is a rightful opinion of some authors suggesting that there is no consistent theory of tourism carrying capacity. This theory would be the base for sophisticated practical carrying capacity applications. This paper is therefore focused on introduction of the theoretical concept of carrying capacity, which can be discussed and possibly further elaborated.

Keywords: carrying capacity, tourism, visitors management, LAC, protected area

JEL Classification: L83

Introduction

Human society creates variously structured socio-cultural systems that coexist with natural ecosystems. Tourism is a heterogeneous social phenomenon. As such, it causes cumulative changes in socio-cultural and natural ecosystems as Pásková (2012) and others (Wagar, 1964) states and model in connection with other theoretical concepts. A lot of authors discuss the possibility of describing these changes in relation to their acceptability in the context of desirable state of socio-cultural and natural systems.

The fundament of discussions about carrying capacity (CC) is the analysis of behavioural dynamics, succession and establishing dynamic balance of natural ecosystems. Zelenka (2012) claims that ecosystems and populations of species present in the given biosphere dynamically adapt to the changing physical (climate changes, salinity of water, changes in the structure of soil, fires, etc.) and biological (above all migration of a new species into an area) conditions of the environment. Given a relatively long-term stable dynamic balance in the ecosystem it is possible to determine the ecosystem's carrying capacity for the given species, i.e. the number of its individuals the ecosystem is capable of subsisting in the long term. This is an objectively measurable amount although it is not exact and invariable. In

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fact, the number of individuals of the given species in a particular ecosystem (or an area consisting of a lot of ecosystems, as the case may be) fluctuates – more or less significantly (the rate of fluctuation corresponds to the examined species) in relation to disturbances in the ecosystem (in particular the weather in the given year) – around the mean value, known as carrying capacity.

In natural ecosystems as well as in manmade socio-cultural systems it is suitable, particularly in relation to the extent and kind of human activity and the adequate response of the system, to introduce carrying capacity as a significant indicator of the extent and kind of these impacts. According to Zelenka (2012), carrying capacity is implemented both expertly and intuitively. Many people intuitively perceive that mainly valuable natural areas (most frequently those labelled as protected areas) have certain limits of external impacts. If these are exceeded, it causes undesirable and irreversible changes in ecosystems in these protected areas and disturbs their natural development. When implemented intuitively or pseudo-professionally, a simplified or inaccurate way of determining and using carrying capacity is common. According to this simplified way of determining it, it is possible to express the carrying capacity of a given area by a relatively accurate figure (e.g. the number of visitors per day), which can be easily counted and does not change in time.

1. Objectives and methodology

The objective of this paper is to create a mathematical concept of the carrying capacity. It is based on an analysis of the essential published theoretical as well as practical approaches to implementing the concept of carrying capacity, its critical assessment by various authors, on the basis of interviews with experts having practical knowledge from this field and the knowledge from a previously published article and a chapter in a monograph of one of the authors (Zelenka, 2012; Zelenka et al, 2013). A discussion of simplified preconditions for basic equations of the proposed mathematical concept shows the practical utilization of the proposed concept. Furthermore, typical unsuitable practical simplifications are discussed and connections of simplified equations of the proposed concept with the practical utilization of carrying capacity are shown by means of case studies.

2. The Concept of Carrying Capacity

According to Manning (2002), the carrying capacity was mentioned for the first time in 1936 (Sumner, 1936, see Manning, 2002). On the other hand, Saarinen (2006) indicates the year of 1930 and McMurray as the author. For the management of tourism and recreation the basic work is the one by Wagar (1964).

Carrying capacity can be expressed in several ways. Zelenka et al. (2013) state that their fundament is the rate of flexibility of the given natural or social system with respect to the acting external influence and the related reversibility or irreversibility of changes after or during the activity of external influence and desirability or undesirability (acceptability or unacceptability) of the resulting state of the given natural or social system. Carrying capacity is then determined by the relation between the rate and quality of the given impact and acceptability of the caused change. These considerations as well as those about the easier LAC (Limits of Acceptable Change) Model suffer from a lack of ways how to determine whether or not the change is reversible and the state of socio-cultural or natural system still acceptable (see e.g. Manning, 2002). For similar reasons, neither the LAC model (for applications and

analyses of the LAC model see e.g. Ahn, Lee and Shafer, 2002; Frauman and Banks, 2011) can overcome this principle problem. Some authors therefore doubt the concept of carrying capacity – e.g. Papageorgiou and Brotherton (1999) and McCool and Lime (2001) state that the mentioned concept lacks theory, it is unrealistic during implementation, and that it is impossible to measure carrying capacity. Others doubt that carrying capacity can be used for making an accurate analysis and in practical management (Buckley, 1999).

With respect to many aspects of tourism impacts it is vital to consider many dimensions of carrying capacity, as it is empirically as well as theoretically discussed by e.g. Pásková (2003), Pásková (2008), Saarinen (2006), Zelenka and Pásková (2012), and Salerno et al. (2013). These dimensions are related to various characteristics of the given natural or social systems. According to Pásková (2008), in case of tourism they are related to natural and socio-cultural qualities of the area and its inhabitants, to tourism infrastructure as well as visitor community and they are labelled (sometimes the same phenomena differently by various authors) as e.g. psychological/perceptual carrying capacity, physical carrying capacity, socio-cultural carrying capacity, economic carrying capacity, organisational carrying capacity. Manning (2002) as well as Pásková (2008) come to a conclusion that in order to determine carrying capacity or, alternatively, the indicators of Limits of Acceptable Change Model, the management's decision, which is based on the predetermined targets of nature and landscape protection and socio-cultural and economic environment of the local community, is needed.

Saveriades (2000) and other authors (e.g. Pásková, 2003; Pásková, 2008; Salerno et al., 2013) also emphasize the dynamic character of carrying capacity. For instance, Saveriades (2000) states that “carrying capacity is not a scientific concept or formula whose output are figures or a formula used to get some figures or intervals outside of which any development must be stopped. Possible limits must be seen as a guideline. These limits must be thoroughly determined and monitored, supplemented with other standards, etc. Carrying capacity is not fixed. It develops with time and with the growth of tourism and can be influenced by managerial techniques and controls.”

By generalizing many researches (particularly those by McCool and Lime, 2001; Cole, 2004; Simón et al., 2004; Monz, 2006; Pásková, 2008; Salerno et al., 2013), it is possible to come to the following conclusions:

- There is nothing like “intrinsic” carrying capacity of an area.
- An area can have many dimensions of carrying capacity. It is necessary to consider what the substantial research criteria are, what the purpose of using the area in question is, whether and to what extent the visitors to the area are prepared for their visit, where the research is done, etc.
- Carrying capacity in tourism is not exclusively a function of the number of visitors. Other important variables are the distribution of visitors in the area, their activities, behaviour, the state of tourism infrastructure, etc.
- Carrying capacity changes in time and it is therefore a dynamic concept, which can depend on the speed of change.
- In ecosystems and social systems the impact can be strengthened by positive feedback and its development can follow its cause belatedly.
- Carrying capacity depends on many changeable conditions. If the conditions change, it is necessary to verify or as the case may be newly determine the environment's maximum load, i.e. its carrying capacity.

The most frequently considered biophysical impacts of tourism depend on many variables. Among other, there belong the rate of use, visitors' behaviour, types of visitors' activities, the area management's activities, realized investments into the protection of nature and landscape, types of tourism facilities and ways of their utilization, weather, seasons, localization of the use, soil, geological, vegetation and topographic characteristics. According to Cole (2004:12), biophysical impacts of tourism can be described by the model of primary factors that influence biophysical impacts (see figure no. 1):

With respect to all socio-cultural, economic and environmental systems of a given tourism destination (see e.g. Pásková, 2003; Pásková, 2008), carrying capacity cannot be taken into consideration as an accurate figure or limit. Instead, development trends of influences and their impacts must be considered with respect to managerially (expertly) determined and set interval values of acceptable conditions/parameters applicable to particular natural and social system in given conditions and time (see discussions about time-related changes of carrying capacity).

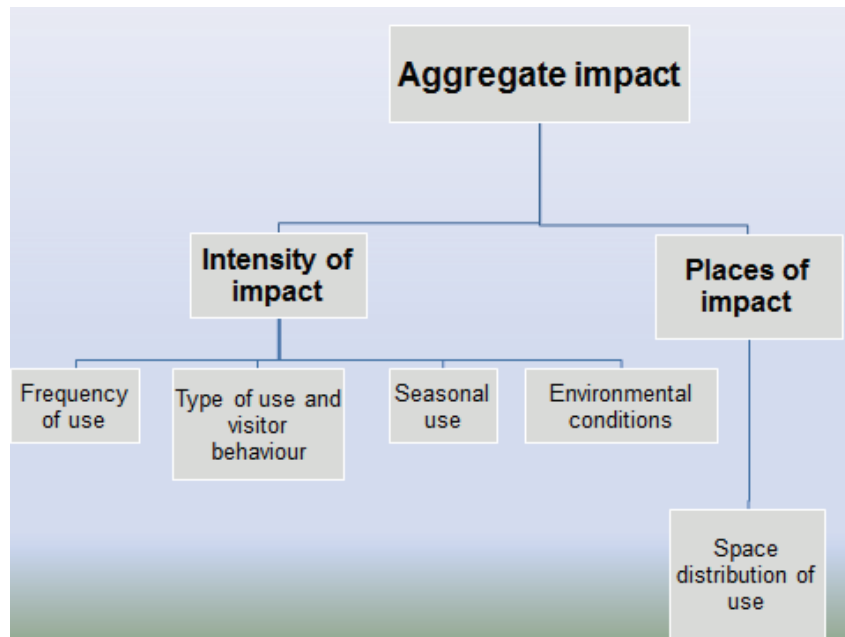


Figure no. 1: Model of primary factors that influence total biophysical impacts
 Source: Cole, 2004

3. Multidimensional and systemic concept of carrying capacity

As it has already been mentioned, carrying capacity is multidimensional and there are many ways of describing it. Based on the purpose of its utilization in tourism management it is necessary to select its dimensions and the terms of its specification in relation to a suitably chosen and specified area, type of phenomenon, possibilities of monitoring the given influence and its impact. Figure no. 2 depicts it for tourism destinations according to Zelenka (2012), who maintains that carrying capacity should be considered as a managerial concept in the context of systemic approach to the given area and influenced natural or

social system, motivation, activities, perception and cognition of tourism stakeholders as well as external influences and conditions in the area (e.g. weather). That should all be analysed in relation to the time factor (e.g. the history of development of the given area, its previous tourism burden, season, and so on).

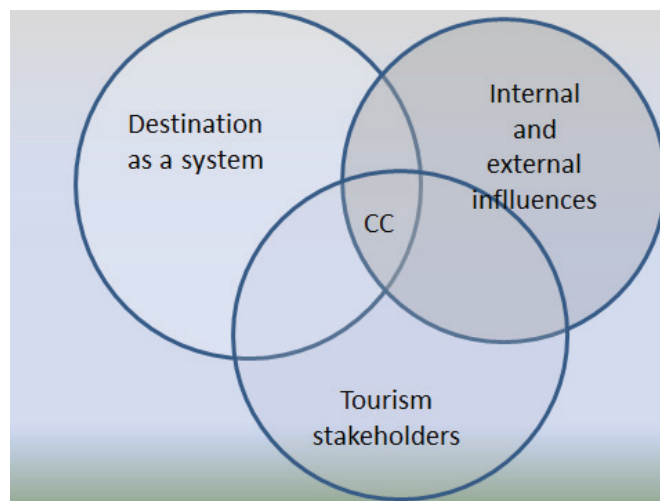


Figure no. 2: Carrying capacity of the destination as a managerial concept in the context of systemic approach to the destination, tourism stakeholders and external influences.

Source: adjusted according to Zelenka, 2012

According to Zelenka et al. (2013) and Zelenka (2012), the concrete component of multidimensional carrying capacity should be precisely specified in relation to the type of influence, that of impact as well as that of monitored phenomenon on a suitably delineated part of geographical area (optimally the geographical area where carrying capacity remains the same if other variables stay constant) and all this in the context of the way of monitoring, tourism management, research and time (see figure no. 3). Thus specified carrying capacity is therefore a function of space, time, type of influence, type of impact, type of monitored phenomenon as it is mathematically expressed in chapter named Mathematical formalization of carrying capacity.

An example of the type of tourism influence on the destination can be the number of visitors. The type of impact then may be changes in its residents' standard of living (e.g. traffic congestion caused by visitors, an increase in prices in the core of the destination, income from jobs related to tourism in the destination see Pásková, 2008; Zelenka – Pásková, 2012), the way of monitoring and the monitored indicator is residents' (dis)satisfaction related to the influence of tourism on their standard of living. The type of phenomenon is socio-cultural influence of tourism and the concrete component of multidimensional carrying capacity is socio-cultural carrying capacity.

4. Mathematical formalization of carrying capacity

Authors offer their own model of mathematical formalization of the carrying capacity based on previous works, namely Zelenka (2012) and Zelenka et al. (2013). According to Zelenka (2012) and Zelenka et al. (2013) it is possible to mathematically express the component of carrying capacity CC_k for the monitored type of phenomenon P_k , and for the given area G , while bearing in mind that the value of carrying capacity changes in time:

$$CC_k^G(t) = fce \left(G, \sum IM_{i,j}, \sum IN_j, P_k, t \right) \tag{1}$$

where:

G - a suitably specified part of geographical space

$\sum IM_{i,j}$ - the sum of impacts caused by individual influences related to IN_j , standing for the type of impact

t - time.

The dependence of carrying capacity on time, which is in practice often underestimated, is typically very complex. The symbolically mentioned time dependence in the equation (1) means in reality changes of all equation (1) components in time. Carrying capacity is therefore influenced by changes in type, frequency, and intensity of the influences. Carrying capacity is also influenced by types, intensity and geographical distribution of caused impacts (for inspiration see the specific model of biophysical impacts by Cole, 2004:12 in the Figure no. 1), and in the equation only implicitly included external and internal conditions (seasonal, weather, economic, social and psychological and other conditions). The equation (1) can be rewritten in a more explicit version as

$$CC_k^G(t) = fce \left(G, \sum IM_{i,j}(t), \sum IN_j(t), \sum C_{ext}(t), \sum C_{int}(t), P_k, t \right) \tag{2}$$

where:

$\sum C_{ext}(t)$ - the sum of time dependent external conditions

$\sum C_{int}$ - the sum of time dependent internal conditions.

As it would be difficult to work with carrying capacity considered in such minute details (it would be necessary to monitor a large amount of types of influence and a wide spectrum of their impacts, and subsequently relate them to carrying capacity for an array of phenomena), only the most important types of influences IN_j^1 and the most significant types of impacts IM_j^1 , labelled as components of carrying capacity, are taken into account for the given type of the monitored phenomenon (i.e. a component of carrying capacity k). Components of carrying capacity can be qualitatively as well as quantitatively delineated by indicators that suitably capture the state of the given impact (e.g. the irritation index, or irridex, for impacts on local community, see originally Doxey, 1975, a discussion in Paskova, 2008; Zelenka – Paskova, 2012). Carrying capacity is evaluated in relation to this chosen simplified metrics of the degree of influence and impact, thus in a simplified way

(although both equations have formally almost the same content, the simplification is in a substantial reduction of the number of analysed influences and impacts):

$$CC_k^G(t) = fce \left(G, \sum IM_{ij}^I(t), \sum IN_j^I, P_k, t \right) \quad (3)$$

Analogically, this equation can be represented in a more explicit version as

$$CC_k^G(t) = fce \left(G, \sum IM_{ij}^I(t), \sum IN_j^I(t), \sum C_{ext}^I(t), \sum C_{int}^I(t), P_k, t \right) \quad (4)$$

Analogically to the “influences/impacts” simplification above, the method mentioning and calculating only important factors can be applied to the external and internal conditions, as it is expressed by the following equation:

$$CC_k^G(t) = fce \left(G, \sum IM_{ij}^I(t), \sum IN_j^I(t), \sum C_{ext}^I(t), \sum C_{int}^I(t), P_k, t \right) \quad (5)$$

where

$$\sum C_{ext}^I(t) \quad (t) - \text{the sum of the most important time dependent external conditions}$$

$$\sum C_{int}^I(t) \quad (t) - \text{the sum of the most important time dependent internal conditions}$$

The condition of delineating a part of geographical area \underline{G} in such a way that its carrying capacity remains the same providing other variables stay constant, would lead to choosing only very small space units, particularly in the case of ecological carrying capacity. Therefore, optimization of the size of the area for determining carrying capacity must be done. Then, for the given area an average value of carrying capacity for a larger area will be adapted. In other words, in order to decrease the number of space units average carrying capacity is used for several neighbouring areas or units. The formula derived from the “implicitly written” equation (3) then is as follows:

$$CC_k^{\hat{G}}(t) = fce \left(\hat{G}, \sum IN_{ij}^I(t), \sum IM_j^I(t), P_k, t \right) \quad (6)$$

and analogically derived from “explicit written” equation (5)

$$CC_k^{\hat{G}}(t) = fce \left(\hat{G}, \sum IM_{ij}^I(t), \sum IN_j^I(t), \sum C_{ext}^I(t), \sum C_{int}^I(t), P_k, t \right) \quad (7)$$

where usually $\hat{G} \gg G$ (or, at least, $\hat{G} > G$).

Equations (6) or (7) for the k dimension of carrying capacity can be considered as basic formulas for practical applications of the proposed mathematical approach for suitable understanding, computing, modelling, and managerial use of the concept of carrying

capacity. For practical use, a substantially simplified formula for specific conditions can be used, as it is described mathematically in the following formulas and practically in the chapter “5. The practical application of carrying capacity”.

If only one type of influence will be significant and providing it will cause only one type of impact within the frame of the monitored phenomenon P_k , the expression (6) for carrying capacity may be further simplified:

$$CC_k^{\hat{G}}(t) = fce(\hat{G}, IM^I(t), IN^I(t), P_k, t), \tag{8}$$

Analogically, the expression (7) for carrying capacity may be further simplified:

$$CC_k^{\hat{G}}(t) = fce\left(\hat{G}, IM^I(t), IN^I(t), \sum C_{ext}^I(t), \sum C_{int}^I(t), P_k, t\right), \tag{9}$$

If external and internal conditions can be considered as constant during the analysed period of time, the equation (9) can be simplified as

$$CC_k^{\hat{G}}(t) = fce\left(\hat{G}, IM^I(t), IN^I(t), \sum C_{ext}^I, \sum C_{int}^I, P_k, t\right), \tag{10}$$

where external and internal conditions can be considered as functional parameters, thus equation (10) can be simply re-written as equation (8).

In practice, an even more significantly simplified version is often used. Namely, in case of a homogenous territory (e.g. a vast coastal area with the same type of ecosystems) it is assumed that an influence in one part of the area does not have any impact in the other ones and these impacts are due to the homogeneity of the area the same for the different parts of the area that are of the same size. If the carrying capacity component k applies to a part of the area on the area unit A_k^{unit} , then the total carrying capacity can be counted as a product of unit carrying capacity and the total area of the homogenous territory A^{total} , thus:

$$CC_k^{\hat{G}}(t) = CC_k^{unit}(t) * A^{total} \tag{11}$$

More generally, in the case of non-homogenous territories it is also possible to assume in a very simplified way that the influence in one part of the area does not have any impact on influences in its other parts and consequently does not have any impacts there. Then the total carrying capacity component k of the non-homogenous territory, consisting of n homogenous parts, is given as a sum of all n homogenous parts of the territory, thus:

$$CC_k^{\hat{G}}(t) = \sum_{i=1}^n CC_i^{k,unit}(t) * A_i^k \tag{12}$$

Carrying capacity understood in these ways (according to formulas (4) and (5) in general, and according to formulas (6) and (7) while being aware of significant simplification and inaccuracy of the main influence and impact simplifications) is the most suitable for practical utilization. If it is estimated according to formulas (4) or (5), it may be expressed for practical utilization in the following way: for a chosen territory of a suitable size one or more suitable parameters characterizing the extent of impact are considered in relation to a

given influence and to a suitably chosen type of impact. The average value of carrying capacity is determined while taking into account a suitably chosen time factor (e.g. seasonal changes in ecosystems). Namely, e.g. carrying capacity is determined for territories of a suitable size (e.g. a part of a protected area; for instance, it could be the number of canoeists on a river within a unit of time), while the intention is to curb the influence in a suitable way (typically by setting the rules of visitor behaviour and restricting their space distribution in the area).

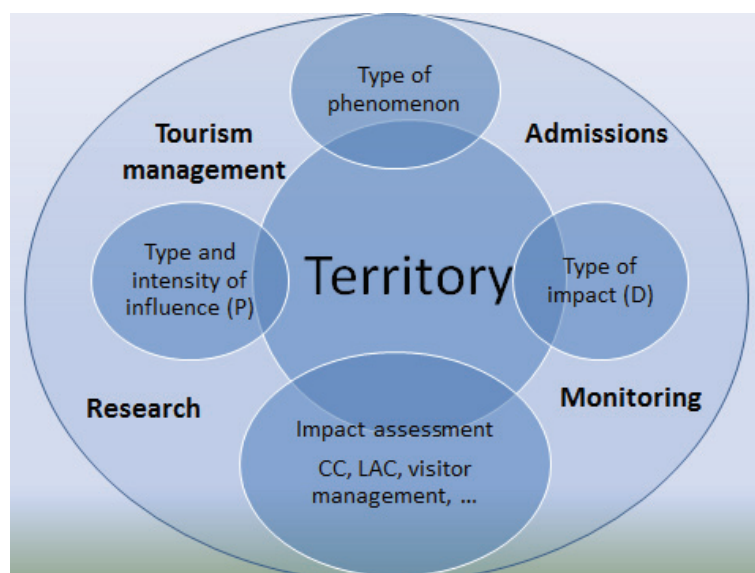


Figure no. 3: Carrying capacity in the context of assessing the impact, type of monitored phenomenon and the intensity of influence and the type of impact in relation to the area and the context of monitoring, research, admissions and tourism management

Source: Zelenka, 2012

5. The practical application of carrying capacity

The practical application of carrying capacity usually involves simplifications, which nevertheless often go beyond limits of permissible simplification and stem either from the lack of knowledge concerning the concept of carrying capacity, or from the effort to simplify its operationalization. These simplifications often concern the influence, which is considered only quantitatively. In other words, the impact rate of the influence on the given area and on tourism stakeholders is directly proportional (it is often simplified to the linearity of this relation) to the number of visitors to the area. Such simplifications are erroneous in two aspects – above all, the impact rate of the influence is not linear (see e.g. McCool and Lime, 2001; Cole and Monz, 2003; Cole, 2004); moreover, there might exist a synergy of influences (another non-linearity – e.g. strengthening erosion in the area where vegetation has been trampled by visitors, see Cole, 2004; Zelenka et al., 2013). Moreover, this influence cannot always be considered as homogenous (various behaviour and activities of different visitors). Typical simplification of the applied concept of carrying capacity to determining tourism carrying capacity in relation to the number of visitors (i.e.

the maximum number of people that may visit a tourist destination in the course of one day, as e.g. Pásková, 2008 states it for the table mountain of Roraima, Venezuela) it would be beneficial and relatively accurate if visitors performed the same activities with mutually more or less the same space distribution. It would apply to e.g. hikers walking the same trails under the same weather conditions (particularly weather). It is however a difficult-to-fulfil requirement concerning the stability of external conditions, time and space distribution of visitors (it does not take into account walking outside trails) and their behaviour. Carrying capacity is in this rough outline considered in relation to the influence, but only to its quantity, which radically simplifies derived results and makes them inaccurate.

6. Case studies of the practical application of carrying capacity

This chapter shortly presents two case studies of the practical application of carrying capacity with an emphasis on simplicity of these examples and their relation to the proposed mathematical concept of carrying capacity.

Case study 1. Psychological and social culture carrying capacity

Visitors' psychological carrying capacity is determined by physical or virtual testing of visitors' perception and its internal emotional interpretation. As Sterl et al. (2004) showed when measuring psychological carrying capacity in the Austrian national park Danube Floodplains, carrying capacity can be expressed as the maximum number of ships that visitors encounter per one kilometre, or the total number of ships they encounter. It showed the limits of linear calculation of carrying capacity expressed by the equation (11), here applied to a river unit. Also in relation to the study by Arnberger, Haider, and Muhar (2004) for the same type of social/social-cultural carrying capacity it shows that psychological carrying capacity demonstrates non-linear behaviour and dependence on a lot of parameters, not only e.g. on the number of further visitors.

Case study 2. Ecological carrying capacity

Ecological carrying capacity belongs to the components of carrying capacity which it is the most difficult to utilize in destination and visitor management. The reason is the dependence on local conditions as well as on the influence in effect (see e.g. discussions in Hammitt and Cole (1998), Cole (2004), Cole and Monz (2003; 2004), Lobo et al. (2013). Its determining should be based on a relatively complex equation (9). For its correct implementation in the given area the complex approach described in Stursa (2002) is suitable.

Conclusions

The concept of carrying capacity is from the theoretical point of view undoubtedly a useful approach as well as a base for other sustainability tools including sustainable tourism management. Nonetheless, its practical application to the protection of nature and landscape is full of possible pitfalls (see discussions and explications in e.g. Papageorgiou and Brotherton (1999), Buckley (1999), Saveriades (2000), McCool a Lime (2001), Pásková (2003), Zelenka (2007), Pásková (2008)). Despite problems, it is widely used in a lot of protected areas and other valuable and fragile landscapes as a tool for avoiding or suppressing negative and, on the other hand, strengthening positive impacts of tourism. Considering carrying capacity, or more generally limits of tourism development, is of a

significant predictive potential. To apply this concept correctly and efficiently, it is useful to follow the following list of advice, ideas, and findings that concern carrying capacity (see Pásková, 2003; Zelenka, 2007; Pásková, 2008; Zelenka, 2012):

- Carrying capacity is not recommended to consider only as an objective characteristics of a given area. At the same time, it should be seen as a managerial concept in relation to its utilization (see e.g. Pásková, 2008). Carrying capacity is multidimensional and it may be described in a lot of different ways. This multidimensionality must be borne in mind in relation to the character of impacts on the natural and socio-cultural parts of the area. According to the purpose of its utilization in management, it is relevant to choose dimensions and their specifications in relation to the appropriately defined area, the type of phenomena, possibilities of influence and impact monitoring.

- Capacity to absorb tourism impacts must be perceived as a time-space variable, e.g. in the case of ecological carrying capacity, its manifestations must be considered in relation to the local changeability of ecosystems, time changeability (seasons, weather, belated effects of certain influences) and a suitable size of the area for its determining and utilization (making an average across dissimilar ecosystems)

- Carrying capacity should be viewed as a dynamic quantity – under dissimilar conditions tourism effects on nature and landscape might be much different even if there are otherwise the same numbers of visitors. For example, the same amount of hiking visitors behaving in the same way in the given area in dry and rainy weather, respectively. Carrying capacity is also different in different seasons. Concretely, e.g. biophysical impacts result from a lot of variables: the rate of area utilization, visitor behaviour, types of visitor activities, destination management activities, realized investments in the protection of nature and landscape, types of tourism facilities and ways of their utilization, weather, seasonality and localisation of utilization, soil, geologic, vegetation and topographic characteristics.

- Thoroughly describe how the value (interval, delineation) of carrying capacity was determined and for what conditions (e.g. for what segment of visitors); then it is possible to determine (estimate) the carrying capacity under different circumstances.

- When ignoring mutual interactions, energy and matter flows and animal migration, carrying capacity could be determined by dividing the given area into individual ecosystems with different characteristics. Even so, it is necessary to consider several different environmental carrying capacities as individual components are variously sensitive to external influences (see figure no. 3). It is essential to select a suitable representative part of every ecosystem. Determining environmental carrying capacity should be related to these representative parts (e.g. the most endangered endemic species in the given ecosystem, or a critically endangered species that occurs there). In other words, it is essential to be aware of the fact that the given area can have multiple carrying capacities and the rate of their importance for managerial decision-making depends on the essential parameter, the purpose of area utilization, how visitors are prepared to enter the area, when the research was done, etc.

- The resilience of the system, its subsystems or components may be influenced by management both positively and negatively (see figure no. 3). This can be done in tourism by preparing for the influence caused by an external factor (e.g. by educating local community), by planning tourism infrastructure (its size, location, type, etc.), by optimizing visitor flows and visitor concentration (optimizing paths and trails – their location, type of

surface, etc.). The increased resilience of protected areas has to do with visitor management and zoning of tourism.

- Carrying capacity should be seen as an approximate value, or an interval. It should be periodically determined, made more accurate, and interpreted. Therefore, it is important to do constant monitoring and tourism research, non-linear modelling, modelling using techniques of artificial intelligence and cognitive sciences, and utilize Delphi method and experts from different fields.

- It is also vital to consider how difficult it is to determine the relation between the impact of tourism and nature and landscape changes. It is so, among other reasons, because our current knowledge of processes in complex ecosystems is still limited, impacts caused by certain influences often manifest in the area belatedly, there are overlaps with impacts of other human activities (e.g. residents' activities in the area, transmission of pollutants from distant areas), overlaps with the influences caused by unstable and fluctuating natural conditions (e.g. different weather in different monitored years).

- Geographical conditions should be taken into account as well – different ecosystems are variously sensitive to certain types of impact.

- Realize that determined values (intervals) are managerial decision – it is impossible to determine them objectively. Nobody can therefore say whether certain changes in the given ecosystem are still acceptable or not (the same applies to the Limits of Acceptable Change Model, or the LAC Model, as well as to indicators of sustainable tourism).

- It is appropriate to combine the approach of carrying capacity with the LAC Model. Moreover, the LAC Model is the basis for most models of visitor management.

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