TOURISM AND THE ENVIRONMENT - SOME OBSERVATIONS ON THE CONCEPT OF CARRYING CAPACITY

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1. Introduction

The relationship of tourism and the main components of the man-nature system are subject to much discussion but relatively little investigation. This chapter is based on the hypothesis that tourism generates environmental externalities and is often affected by them. When the negative effects of such externalities exceed certain levels of disturbance of the environment significant and irreversible changes occur which alter the basic processes and characteristics of the environment. The carrying capacity (C.C.) concept has often been used to identify the "limits" of a system to absorb changes. The concept of carrying capacity as a planning tool is investigated in a systematic and comprehensive manner, by analyzing its major dimensions. The aim of this analysis is to increase our understanding of this important concept, discuss its applicability in the studies of the growing tourist industry and demonstrate how composite perspectives of the concept can provide valuable insights into some phenomena of interest to researchers in allied disciplines (such as resource management, planning, economics, sociology, anthropology, geography, business administration) as well as to those involved in the development and management of the tourist industry at various levels.

This chapter is designed to provide a theoretical base as well as an operational framework in an effort to establish carrying capacity as a useful tool for tourism planning and management. It will review a variety of different scientific approaches and methodological issues which focus on tourism and different aspects of carrying capacity. It will evaluate and compare techniques and methods suitable for the treatment of the issue, and it will indicate some critical factors affecting capacity and the related concept of saturation. The development of carrying capacity as an operational analytical tool could allow the reversal of damaging mistakes of the past, the anticipation of potential problems created by tourism development on the environment and the negative feedback effects on tourism itself in areas under development. Carrying capacity could also be applied at the planning stage for the imaginative design of projects and programs which are simultaneously environmentally sound and supportive of rising economic and social prosperity - the two major goals of sustainable development. As a management tool, the concept of carrying capacity could also be applied to mitigate negative effects in areas which already experience intensive tourism development.

2. Factors Determining Tourist Flows to an Area

Tourism and recreational behaviour are increasingly becoming important subjects of research in the environmental and the social sciences as the result of many socio-economic and environmental factors which influence the movements of persons (Nijkamp, 1974). Research on tourism is generally less developed than on other human activities from which tourism differs both in nature and in character (Pearce, 1987). Leisure and tourism have only recently attracted the interest of psychologists, sociologists and others, although the majority of studies have been concerned with only one zone of the tourist system - tourist destinations (the other two being tourist origins and linkages between origins and destinations).

The spatial interaction arising out of tourist movements from origin to destination has not been examined comprehensively in much of the existing tourism literature, although a sense of this interaction emerges from several studies (Miossec, 1977; Defert,1966). One of the most interesting problems, from a planning perspective, is saturation, which arises within each of the above mentioned three zones of the tourism system (WTO, 1983).

i. Origin (demand) where saturation is caused by failure to stagger departures (due to a number of limitations like climate, school holidays, employment conditions, etc.) or time concentration of demand on certain types of tourism.
ii. Linkage (transit) where saturation takes the form of bottlenecks in travel.
iii. Destination (supply) where saturation produces a wide range of negative impacts by overloading facilities and, thus, damages the environment and the image of the host area both in physical and human terms.

Although this chapter focuses on the zone of supply, the significance of the other two zones must be recognized and indeed an investigation of the total tourist system is needed because common issues underlie the problem of saturation stemming from the dynamic interrelationship between and within zones. However, the fundamental question, which underlies the phenomenon of saturation in tourism is why people leave their home area to visit other places? Which are the main factors determining tourist flows to a certain area? Indeed, the issues of motivation and demand directly affect the phenomenon of saturation, particularly in the zone of destination.

Briefly, the basic factors influencing the ability of a person to travel are: the rise in welfare (Chali, 1977) and the availability of more leisure time (Coccossis, 1987), the decline in the quality of life (Nijkamp, 1977), increased accessibility, improved telecommunication services and information systems (Vernicos, 1988), the increase in the supply of tourist services, social progress, the disappearance of old superstitions and prejudices, the response to "pull" factors (Leiper, 1984), socio-psychological motives and cultural motives (Nielsen, 1977), the development of more sophisticated advertising campaigns, the desire for change and a number of other minor but interrelated factors. The above mentioned motivation factors have in turn rapidly changed the conditions influencing the demand for travel and tourism on such a scale that within a short period of time international tourist demand has risen from 284.8 million arrivals in 1980 to 429.2 million in 1990 (see *Figure 1*), an unquestionably rapid increase compared to the past.

The rapid growth of demand has created many difficulties in the above mentioned three-zone tourist system, one of which is saturation. Two reasons are responsible for this particular problem. One relates to the high concentration of demand in time and space and the other to the time lag involved in the creation of tourist centres (supply) and the seasonal fluctuations of tourism activities. The increase in tourist demand has been more rapid than the creation of new tourist centres for absorbing tourists, equipped with the minimum appropriate installations for

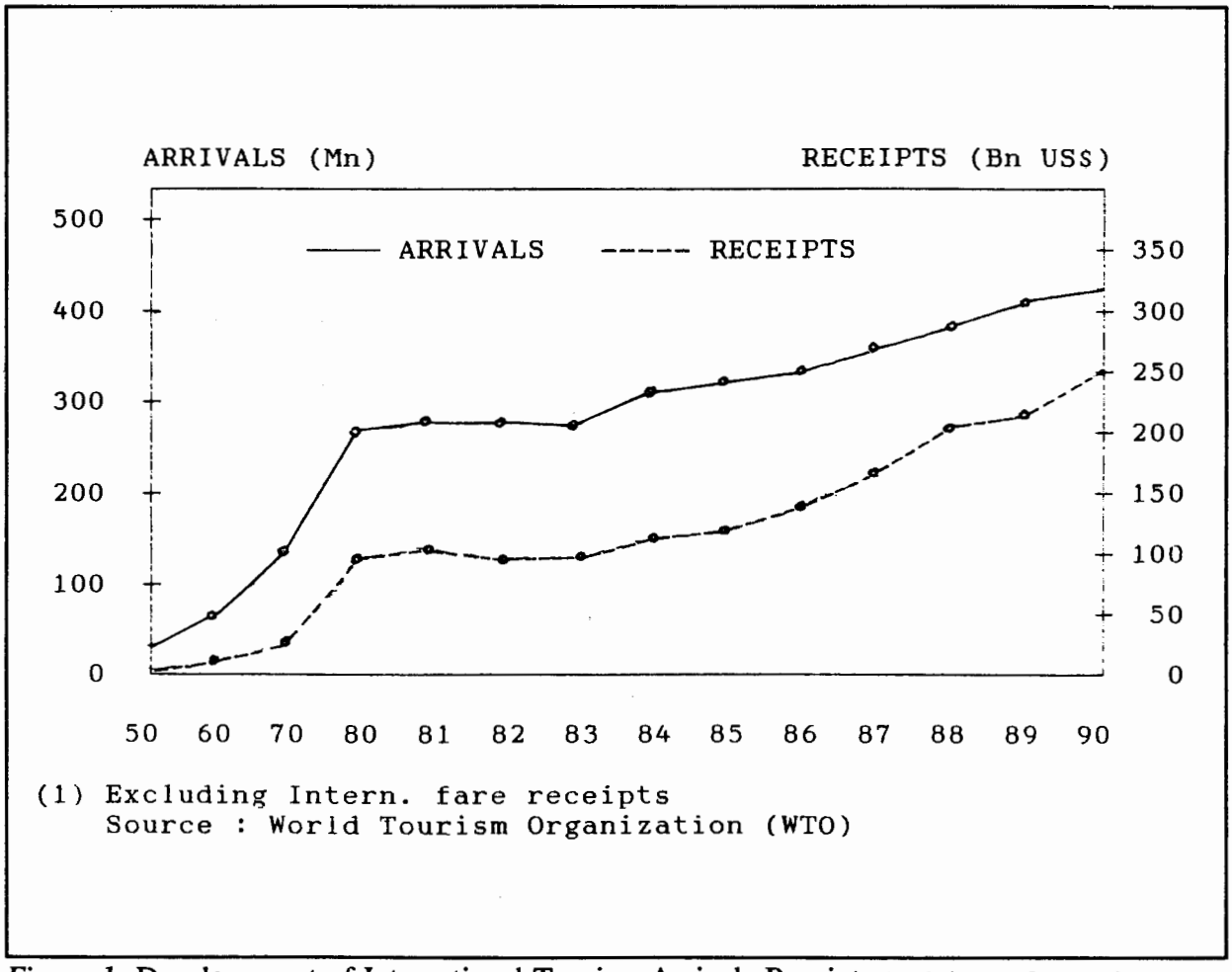

Figure 1. Developement of International Tourism Arrivals-Receipts (excl. intern. fare receipts)

optimum tourist development. This situation has not been brought about solely by the massive concentration of demand in the majority of traditional tourist areas. In most cases, such concentration takes place only during one or two months of the year, the capacity for reception being left virtually unused for the rest of the year. Saturation may also come about through an excessive growth of supply. Accordingly we should acknowledge that there are two distinct and interrelated kinds of saturation: supply- and demand-related which take place within the origin and destination zones. Each kind has its own characteristics and distinctive features which in turn determine distinctive types of saturation.

3. Definition of Carrying Capacity

The concept of carrying capacity is well defined in ecology in terms of population (Ricci, 1976; Laursen, 1981; Wolf, 1984) and describes the upper asymptote of the rate of population growth. An example that typifies the measurement of carrying capacity and gives a practical interpretation to the concept is provided by solving the logistic equation, under the assumption, for example, that fresh water is the limiting factor to population growth. Ecologists have developed also more complex approaches which range from the early work of Lotka (1932) and the population model

of Volterra (1931), which couple two differential equations that describe different growth rates to represent the predator-prey interaction, to the recent work by May (1973) studying the effects of deterministic and stochastic environments on biological population growth and stability (Conrad, 1986).

Additional insight into the concept, with the inherent preoccupation of how much and how far a population can expand, is provided by anthropology and geography. Thus, carrying capacity is defined as the theoretical limit up to which a population can grow and still be supported permanently by the environment (Vernicos, 1985). Here it involves calculations of the maximum number of individuals forming a stable population given a set of environmental resources. The capacity is also defined in terms of ecosystem characteristics. An ecosystem's carrying capacity is often estimated by dividing the estimate of the total available strategic resource or mix of resources, considered to be the limiting factor, by the individual resource need over a certain time period. The denominator (individual need) is normally weighted by a coefficient that reflects effectiveness of resource use and possible energy maximization (e.g. the feeding strategy in which organisms maximize food yields). Obviously, it makes a lot of difference whether the resources are renewable or not.

Cybernetics has contributed also to the definition of the concept, starting from the idea that every species has a number of interlinked variables which form a mechanism of control and which are closely related to "survival". Carrying capacity is derived from the idea that an organism can exist only within a limited range of physical conditions.

A related concept which is broad enough to embrace most of the viewpoints regarding the ability of the natural environment to sustain itself is that of sustainability (Brundtland-Report, 1987) or sustainable development (De Vries; 1989, Nijkamp, 1989). This definition originates in ecology and biology and has been transferred to economics where it has gradually found wider and richer, although less well-defined, applications (Conrad, 1986). In most definitions the carrying capacity of a certain system is related to its potential for sustaining certain population species and it denotes a living system (ecosystem) which is capable of sustaining itself indefinitely and without help from another such system.

4. Definition of Tourist Carrying Capacity

As regards the application of the concept of carrying capacity to tourism and recreation, most of the research has approached it mainly through the ecological and man-made environment traditions (Burton, 1979). It was pointed out, many years ago, that carrying capacity must be considered as a means to an end and not as an absolutely definite limit that is unalterable for each type of environment under discussion. In that respect, one of the most convenient definitions is the number of user unit use periods that a recreation/tourist area can provide each year without permanent biological or physical deterioration of the area's ability to support recreation and without appreciable impairment of the recreational experience. From an ecological point of view, the definition of carrying capacity in this context is "The maximum level of recreation use, in terms of visitor numbers and activities, that can be accommodated before a decline in ecological value sets in".

Theoretically, the carrying capacity of a tourist area could be defined as the point where the minimum infrastructure/superstructure requirements as well as the natural resource assets (beaches, etc.) which create demand become insufficient to meet the needs of both the resident population and the visiting tourists, whereupon the threat of environmental hazards appears. The

problem, therefore, refers to the quantitative levels of change of the environment which can be permitted in the area under consideration. However, the above ecological definition of carrying capacity does not seem to take into account the ways in which recreational activities interact with natural ecosystems. The length of stay, the time and level of use, the way it is distributed over time and space and the desires of management, should be considered in any comprehensive definition in ecological terms.

From a sociological point of view, the definition of carrying capacity incorporates a relationship between "amount of use and user satisfaction" (Nielsen, 1977; Stankey, 1982). Some geographers have utilized the term of carrying capacity, defined as the maximum theoretical population that can be supported by a given resource base:

$$\left[\frac{\text{available land}}{\text{utilized land}} * \frac{\text{theoretical population}}{\text{actual population}} \right]$$

From a physical planning point of view, the concept of carrying capacity has to do with determining the spatial ability of an area to accommodate visitors (physical capacity is concerned with the size and number of places suitable to this activity). The existence of three different types of carrying capacity - environmental, physical and perceptual or psychological - of an area has been suggested by Pearce (1989), relating broadly to the degradation of the environment, the saturation of facilities and the enjoyment of visitors.

5. Factors Affecting Carrying Capacity

In order to understand the concept of tourist carrying capacity, it is necessary to explore the main factors involved and the relationships between them. It is proposed that the concept of carrying capacity could be understood in terms of three basic dimensions: natural environment, man-made environment and social environment, to which a fourth one, time, should also be included. The carrying capacity of the natural environment cannot be easily measured in quantitative and qualitative terms although individual natural resource parameters can be quantified and measured. However, ecological indicators are not so easily estimated in quantitative terms and even if this were possible, the dynamics of their interaction are so complex and, to a great extent, so unknown that any attempt to achieve an optimum quality/quantity level seems futile. In spite of these limitations, a certain level of an area's natural environment carrying capacity can be measured. To a certain extent, technology could be employed to extend the limits imposed by the carrying capacity of the natural environment (for example, through a sewage treatment plant which can reduce pollution levels).

The carrying capacity of the man-made environment is even less well defined. Its distinguishing characteristic is that it can be improved to a great extent (for example, by means of new facilities, investment in new products, incentives, management techniques etc.). Obviously, technological and institutional solutions can be employed to extend the carrying capacity of the man-made environment (for example, by improving the existing infrastructure or allowing lower densities).

The natural environmental carrying capacity imposes usually much more binding and less flexible limits than the man-made environment carrying capacity. When the latter reaches the natural environment carrying capacity of an area, it usually indicates that the natural resources (which influence tourist demand) have become sufficient to meet the needs of both residents and

visitors, while if the man-made environment carrying capacity exceeds the natural environment carrying capacity then the natural resources become insufficient to meet these needs and indeed, in this case, the threat of environmental hazards appears imminent.

The social carrying capacity is even less well defined than the other two categories, since it involves subtle and relatively unexpected relationships between man and the environment, both natural and man-made. Although certain relationships and feedback mechanisms can be expressed qualitatively or quantitatively, defining the social carrying capacity is still difficult because of the tremendous variability and diversity of these relationships. Furthermore, strong behaviour adaptation mechanisms seem to exist which can alter the perception of crowding or saturation. In spite of the fact that quantitative and/or qualitative expressions of the concept require models which have not been constructed, yet because of the complexity of the interactions and the number of variables involved, the concept has an operational validity in policy-making since it provides a conceptual tool which can serve as a basis and as an indicator of whether the man-environment system is getting better or worse and which can be used as a vehicle to specify policy options. In this respect, it would be useful if the concept or carrying capacity could be integrated into a single operational definition under an umbrella including ecological, socio-economic, institutional and policy spaces (De Vries, 1989).

For the above three distinct categories and their main components (natural, economic, social/psychological, cultural/political, and man-made) of the environmental resources affecting carrying capacity, it is recognized that a single and absolute measure of the carrying capacity of an area is difficult to estimate since the factors involved are not all quantifiable or even measurable, although a variety of methods and techniques have been occasionally employed.

6. Models and Techniques for Determining Carrying Capacity

Most of the research on carrying capacity has been approached mainly through one particular discipline, while the complex and dynamic phenomenon of tourism requires a combined view. The emphasis in some studies has been on the description and explanation of processes accounting for variations in the carrying capacity of different areas. There are many studies which attempt to establish the carrying capacity of the natural environment for various types of ecosystems (Laursen, 1981), but the results cannot be easily or universally applied because management objectives and the characteristics of the natural environment vary from site to site. Research on both natural and man-made environment carrying capacity demonstrates the way in which multiple measurement techniques can be used in data collection (combined field studies with direct observation, social surveys, behavioral inquiries and simulation). Over the past twenty years, several methods of estimating carrying capacity have been developed and applied with limited success. These methods have not been commonly used and may not be generalized to other situations. However, some aspects of each method can be applicable independently or be combined with conventional methods for particular problems (Gold, 1980). There is no common dimension to these methods except for an attempt to be less arbitrary than intuition in estimating carrying capacity. The following approaches and techniques have often been used:

a. *Ecology. Cause and effect relationships* (COAP, 1970), associated with different land uses and the specific activities under each land use. The final product is a set of charts which relate specific actions to possible adverse environmental impacts, which are in turn classified according to initial conditions, consequent conditions and final effects. *Surveys* determining conflicts between recreation and flora-fauna (Wolf, 1984). *Matrix analysis* classifying the elements of

environmental quality and the range of possible recreational impacts which can be used to assist the identification of problems and indicate which resources in certain areas are approaching their carrying capacity. *Behavioural studies* analyzing attitudes and behavioural patterns of recreationists using interviews in order to assess the various factors that contribute to an awareness of environmental carrying capacity. The questionnaires allow respondents to provide spontaneous responses to both satisfactory and unsatisfactory elements of their experiences and to assess the degree of frustration resulting from congestion and crowding. *The Travel behaviour* model (Fisher and Krutilla, 1972) is similar to modelling techniques used for transportation planning and migration; this Markov model was used to establish visitor distribution programmes (entry rates and quotas were derived from the study used to simulate lake-to-lake movements by campers). *Physical resource & human activity studies* concentrate upon identifying satisfactory development densities and actual carrying capacity of an area. The resource component leads to mapping and evaluation of the capacity of the land and water to sustain different uses. Overlays of different capability maps allows resource use suitabilities to be compared against existing and potentially desirable patterns.

b. *Economics*. Since the impacts of tourism on the economic environment can be (directly or indirectly) quantified and statistically evaluated (Mauren, 1979), the concept of carrying capacity can also be determined. Some of the conventional economic analysis methods used in this respect include: cost-benefit analysis; cost of congestion (Cichetti, 1976); single and multiple-use patterns (Smith and Krutilla, 1976).

c. *Social-Psychology. Quantitative Measurement Studies* (Kreimer, 1977), based on the assumptions that the visual and other characteristics (e.g. noise) of the environment can be measured and described adequately in terms of a limited set of specific quantitative parameters, that people's preferences are generally clear-cut and fixed, that there is isomorphism between the real environment and people's perception of that environment and there is also isomorphism between the real and the simulated environment. However, the social/psychological carrying capacity is only very partially quantifiable and thus its evaluation is more subject to subjective factors depending on each evaluator's value system.

d. *Cultural Studies*. As a conceptual analysis of intercultural interaction between tourists and locals (Nederlof, 1989), the research will produce some theoretical outlines, presented in a model, concerning the different interactions in the field of tourist experiences. Obviously, the evaluation of the cultural carrying capacity depends entirely on totally subjective criteria, so it is not quantifiable at all.

e. *Built Environment Studies*. The carrying capacity of an area can be constrained by the availability of basic resources, like water, power supplies, drainage system, waste disposal, telecommunications capacity, etc. For most of these resources, there are levels determining the carrying capacity in relation to the needs of the tourists and the local population. Attempts have also been made to determine the carrying capacity of an area in relation to accommodation, services and facilities, supporting tourist and population demand. A WTO report (1983) proposes planning and capacity standards to be used as indicators as well as optimum capacity levels, in different areas, expressed as: hotel density (from 13-35 m^2 per person) and overall resort density (from 20-100 beds per hectare up to 200-1000) for urban type resorts, a set of densities which also depend on the image, land availability, cost parameters, building heights and allowable density, etc.

In the work of OECD (Case Study Spain, 1980), reference is made to the absorptive capacity of a tourist area using such indices as: tourist capacity in relation to population, beds, land area, restaurants, commercial licences; tourist density in relation to number of hotels, normal

population of the area, number of nights spent by foreigners in each hotel and in the area. Tourist density indicates the accommodation potential of an area expressed in terms of places available per km^2 or surface area, overall or by hotel category. Such indices can be used fot yjr classification of tourist regions. For example, a tourist intensity index has been estimated at the national and regional level in France producing a six-fold classifiction of French Communes (Boyer, 1972 and Pearce, 1979) A tourist function index has been taken as a measure of tourist activity or intensity also (Defert, 1966). It is derived by comparing the number of beds available to tourists in an area with the resident population of the same area. Plettner (1979) advocates use of tourist nights rather than bed capacity and proposes a tourist density index which is the quotient of tourist nights to the local population. The tourist comfort index (Mirloup, 1974) is based on a formula which distinguishes the quality between different types of accomodation using certain criteria. The concentration index (Girard, 1968) is an attempt to determine the degree of concentration of tourist activity (hotels, restaurants, etc.) and the occupied land area. The attractiveness index, derived by comparing the number of bed nights between international and domestic tourists, can be used in order to evaluate a region's profile in attracting specific types of tourism overall or by category.

However, apart from the above attempts to identify models for calculating the carrying capacity for individual aspects of the environment of a given area, it is also useful to review those techniques and methodologies developed in order to determine an overall measure of carrying capacity (including physical and human environment variables). Ricci (1976) provides an operational overall carrying capacity estimate by combining critical factors and resources which are the principal determinants of social and economic life. These determinants include renewable and nonrenewable resources, population dynamics as well as the feedback mechanisms which relate to these. His approach indicates that the dynamic nature of carrying capacity is affected by its previous and present values, nonlinearities, thresholds and the unexpected disturbances imparted on the entire system by the real world.

Cicchetti and Smith (1976) developed the concept of congestion and its implications by modeling variables determining the cost of congestion. The main purpose has been to develop a methodology for measuring the effects of congestion so that the cost associated with it might be taken into account in public allocation decisions. It is well known that the problem of pollution and congestion is now recognized as among the most challenging ones for the efficient allocation of resources. The congestion model was also developed by Smith and Krutilla (1976) in the form of a large-scale traffic simulation model which, in fact, provides the required technical data on use patterns and the associated expected levels of encounters.

Nijkamp (1977) developed the impact structure matrix combining environmental elements and the range of possible impacts on these elements from the development of tourism to a certain level (carrying capacity level). To fill out the structure matrix a set of tools is needed such as: comparative studies; user satisfaction survey; natural resource parameters; ecological indicators; certain criteria and values; environmental impact studies; multiple measurement techniques; field studies; social surveys; behavioural inquiries; norms and standards determining the human environment carrying capacity, etc. This multidimensional model aims at providing an integrated rather than a partial picture of the carrying capacity concept to be used operationally.

7. Conclusions

Some important lessons emerge from the brief review of the concept of carrying capacity attempted in the preceding sections. It becomes obvious that all methods described have deficiencies although some of them are better for specific purposes than some others. As a general observation: (1) more research is needed on the qualitative aspects of the carrying capacity concept before any of these methods is employed in planning, (2) carrying capacity can be estimated more easily on a case-by-case basis using an approximation method oriented towards a specific resource while general limits should be expected to be difficult and dependent on a variable mix of the three main components, (3) due to particularities of each area and in view of the uncertainties involved about the interactions of environmental factors, it is necessary that the limits imposed be considered as adaptive, flexible, and open to reappraisal.

Some related concepts, such as sustainable development, can be explored in conjunction with carrying capacity. For example, De Vries (1989) proposed five perspectives on sustainable development without sharp boundaries between them: (1) The technological (technology regarded as the major driving force); (2) The resource economic (system dynamics with an emphasis on a succession of limits which will constrain exponential growth of population and material output, natural resources, energy analysis based on physical constraints on energy supply or land productivity, manager engineer ensuring that the cost of material inputs and outputs reflect the cost to maintain or restore the natural environment); (3) The anthropological; (4) The ecological and (5) The cultural. All these relate to a great extent to the concept of carrying capacity.

The concept of carrying capacity has already been employed in several outdoor recreation projects and can serve as a useful conceptual tool in tourist studies, especially when it is seen as a means to encourage tourism planners and others to give greater consideration to environmental matters, to qualitative aspects such as the experiences of both hosts and guests and as a supportive tool for the specification of goals and objectives. At present, the possibility of establishing quantitative limits through carrying capacity expressions as absolute figures seems rather remote. In any case, the concept of tourist carrying capacity is not the panacea it may seem to be.

The development of an operational tool for tourism planning seems to be a necessity. This need was expressed in the Manila Declaration (WTO, 1983): "Tourism resources available in the various countries consist at the same time of space, facilities and values. These are resources whose use cannot be left uncontrolled without running the risk of their deterioration, or even their destruction. The satisfaction of tourism requirements must be not prejudicial to the social and economic interests of the population in tourist areas, to the environment or above all, to natural resources (which are the fundamental attraction of tourism), historical, and cultural sites". Accordingly, tourism development should be planned in such a way and at such levels that it meets the physical and human carrying capacity requirements of the area under consideration. This chapter intends to stimulate further thought towards this end.

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