MULTIOBJECTIVE DECISION SUPPORT FOR THE TOURIST SECTOR

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ABSTRACT
The volume of recent sustainable tourism development literature has suggested a number of ideas and proposals to be taken into consideration, such as the establishment of some critical threshold to growth, known as carrying capacity. This theoretical concept, exported from the fields of Demography and Biology, is introduced in tourism research as a useful tool in order to put into practice different strategies for the operationalization of sustainable development. In this paper a multiple objective modeling process is suggested to allow for both positive and negative impacts of tourism. In this way, multiobjective programming techniques prove to be of great value for the determination of the tourist carrying capacity. The proposed strategy, which may be used to assist managers in the decision-making process, must be understood as a further attempt to approximate the quantification of such a complex concept.

Key words: tourist carrying capacity, multiobjective optimization, tourism planning.

MSC: 90B50

RESUMEN
El debate sobre el desarrollo turístico sostenible ha puesto sobre la mesa un buen número de ideas y propuestas a considerar, una de las cuales consiste en la determinación de un umbral máximo de crecimiento o capacidad de carga. Este concepto teórico, surgido en el marco de los modelos poblacionales, se introduce en el contexto turístico como una herramienta más para poner en práctica estrategias de desarrollo sostenible. En este trabajo se propone un enfoque de modelización con múltiples objetivos que contemple tanto los impactos positivos como negativos del turismo. De este modo, las técnicas de programación multiobjetivo demuestran su gran utilidad para determinar la capacidad de carga turística. La estrategia propuesta, que puede servir de ayuda en los procesos de toma de decisiones, debe ser interpretada como un nuevo intento para aproximarnos a la cuantificación de tal complejo concepto.

1. INTRODUCTION

The second half of the past century witnessed a spectacular development of the tourist sector in a vast number of regions around the world. Tourism became then a means of encouraging economic development through the generation of income, employment and government revenue, and many destinations started the exploitation of their tourist resources. Since the 1970s marketing efforts concentrated on achieving higher levels of tourist demand and, as a consequence, many destinations experienced an extraordinarily rapid development of the tourist supply frequently lacking a proper planning process that recognized the needs and limitations of each particular destination. Finally, the development of tourist infrastructures took place in many cases as an answer to the marketing forces that, following private concerns, failed to give attention to the environmental dimension of the problem.

Soon evidence emerged at an international level that unplanned tourism development would lead to an overexploitation of natural and cultural resources, eroding (and on some occasions permanently destroying) the physical and social environment of the destinations, and probably resulting in a loss of tourism demand. Then, with the rise of the debate focused on the concept of sustainable development, a new attitude began to prevail in the specialized literature (see Collins, 1999 and references therein). The search for sustainability of the physical and cultural environment opened new lines of action in the tourist sector, establishing new criteria for future development and suggesting the need of a limit to growth.

In this context, the concept of carrying capacity appeared as a good means of including control and predicting measures in tourism planning. According to O'Reilly (1986), although the concept cannot be used as an absolute limit, it can serve as a means to identify critical thresholds, and in any case it "should be considered as

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part of a systematic strategy plan for the development of tourism" (p.258). For this reason, it would be extremely desirable to have quantitative procedures available for the determination of the carrying capacity of a destination, since the examination and quantification of the pressures caused by tourism at different levels of influence provide the bedrock for sustainable growth.

The search for a standardized procedure of this kind is indeed a challenging task, and the aim of this paper walks in this precise direction. But perhaps the most remarkable feature of the material presented here concerns the methodology employed, which belongs to the area of Multicriteria Decision Making. In relation to this, it is worth noting that quantitative analyses in the tourist field largely rely on the use of statistical methods and predictive techniques. Only occasionally can we found some applications of Mathematical Programming to the field (see, for example, Van der Knijff and Oosterhaven, 1990; Canestrelli and Costa, 1991; Caballero et.al., 1998; Greiner et.al., 2001) and, particularly, the use of multicriteria methods as a sensitive option is very rare (Seely, Iglarsh and Edgell, 1980), although a few recent works are known that include some kind of multicriteria evaluation as a part of a complex tourism planning process (see Feick and Hall, 2000; Ocaña and Galacho, 2002). However, and disregarding all those general situations were mathematical programming methods fit (allocation of funds, selecting different tourist projects, tourist facilities and services location, etc.), it is not difficult to see that several conflicting factors are relevant when planning tourism development and, in this way, multicriteria methods appear as an ideal tool for this sector.

The rest of the paper is organized as follows: in the next section we compile a number of considerations and issues concerning the concept of carrying capacity and then we propose the application of a model with multiple objectives as a way of approaching an optimal value for the carrying capacity of a destination. In section 3 we summarize some well-known topics concerning the multicriteria approach, justifying the choice of a specific methodology within the field as the most appropriate for the problem of the determination of the tourist carrying capacity. Section 4 illustrates the applicability of the multiobjective methodology in the tourist sector. Finally, some concluding remarks are provided.

2. GROWTH AND SUSTAINABILITY: OBJECTIVES IN CONFLICT

Perhaps a general acknowledgement of the economic importance of tourism caused seminal research to focus on the favorable effects that made explicit when analyzing the available economic indicators. And besides the evidences found on some possible adverse economic effects that tourist development might cause, such as inflation and land speculation, economic dependence or opportunity costs, the argument of the many economic benefits generated by the activity was generally accepted (Mathieson and Wall, 1984).

However, the recognition that tourism is dependent on the natural and cultural resources forced a reorientation in the lines of tourist research in order to include further dimensions (psychological, cultural and environmental) of the impacts of tourism. It became clear that the whole of tourism repercussions appears as a result of the interaction between tourists and the destination area and its host population, and not only at a strictly economic level.

A specially interesting topic concerning the prediction of the negative effects of tourism development can be found in the determination of the ability that a destination presents to attract tourists and satisfy the generated demand in a way that economic benefits are obtained without causing irrecoverable damages in the physical environment or the resident population's quality of life. The concept of carrying capacity serves perfectly well for that purpose, and consequently it stands as a useful tool for undertaking an analysis of the limits to tourist growth.

The concept of the carrying capacity, which was firstly introduced to characterize limits to population growth, has frequently been employed to express environmental limits brought about by the expansion of economic activities, beyond which the negative impacts of the human intervention may be irrecoverable (Wetzel and Wetzel, 1995). Unfortunately, measuring the carrying capacity for it to take part in the planning of activities is by no means a straightforward process and in fact, the concept has been occasionally criticized for creating some kind of ambiguity and for requiring subjective and judgmental decisions (Ahn **et al**., 2002).

Regarding tourism analysis, the so-called tourist carrying capacity is conceived as the maximum number of visitors that a destination can tolerate without suffering an irreversible deterioration. Although in this field a number of definitions can be found (see Seidl and Tisdell, 1999 and references therein), there is a general agreement in considering that the concept must include all the dimensions of influence of tourist development over the socio-economic environment. In this way, the notion of carrying capacity would provide a framework for the integration of physical, social, economical and environmental subsystems in order to achieve a sustainable tourist planning.

In spite of the theoretical interest in identifying the value of the tourist carrying capacity, its determination by means of systematized quantitative methods is an unresolved problem. In fact, the identification of the tourist carrying capacity is difficult and rarely undertaken, as Collins (1999) recognizes. However, some attempts in that direction are worth to mention, such as the model proposed by Prato (2001) for national parks, which allows to evaluate if the state of the system is compliant with the fixed limits, the fuzzy linear programming model (Canestrelli and Costa, 1991), the use of geographical indicators (Lozato-Giotart, 1992) or some investigations aimed at deepening in the understanding of the interactions among visitors and residents, as a way to approaching social carrying capacity (Saveriades, 2000; Haralambopoulos and Pizam, 1996, among others).

The main difficulty concerning the evaluation of the tourist carrying capacity relates to the conflict between the maintenance of a level of environmental quality and social welfare at the destination and the regional economic development due to tourism, which must be taken into account if sustainability is to be achieved. In order to appropriately manage this problem we propose to approach the determination of the tourist carrying capacity by means of a multicriteria analysis, which allows a mathematical exploitation of the multiobjective nature of the problem. Specifically, we suggest investigating the maximum number of tourists a region can support that simultaneously maximize economic development and minimize environmental impacts.

Now, before focusing on the practical application of the methodology proposed, let us briefly explore the multicriteria decision paradigm.

3. THE MULTICRITERIA PARADIGM

The traditional decisional paradigm, based on the determination of the best attainable solution according to a single criterion function which reflects the preferences of the decision maker, has proved to be ineffective for the description of many real life situations, where several criteria are usually taken into consideration. M. Zeleny, in the introduction of his *Multiple Criteria Decision Making* (1982), describes a number of these multidimensional situations in order to show that "multiple objectives are all around us". This assertion is nowadays supported by the impressive amount of literature on the topic, concerning both theoretical developments and practical applications in a wide range of fields of study, recognizing the discipline as a major and rapidly growing area of research.

The multicriteria decision problem is mathematically defined as

$$\underset{\text{s.t.}}{\max}\text{imize } (z_1(x), z_2(x), \ldots, z_k(x))_{x \in X} \qquad [1]$$

where X represents the set of possible alternatives or feasible region, $x \in X$ is a n-dimensional vector containing decision variables and z_j are the objective functions representing the criteria that the decision-maker wants to attain. In this context, the traditional notion of optimum is naturally associated to the existence of a given point, known as ideal point, which attains the maximum value of all the objectives. However, given that the objectives are usually of a conflictive nature –increasing one of them makes some other(s) to decrease– the ideal point rarely exists. Hence the notion of efficient solution, defined as a feasible solution such that no other feasible solution exists that improves simultaneously all the considered criteria, is introduced. More formally, a solution $x^* \in X$ is said to be efficient (nondominated or Pareto optimal) if and only if there does not exist any $x \in X$ such that $z_i(x) \geq z_i(x^*)$ for all i and $z_i(x) > z_i(x^*)$ for at least one j.

When the feasible region is given implicitly through a set of mathematical restrictions in the form $X = \{g_j(x) \leq 0, j = 1,\ldots,mx \in R^n\}$, we are dealing with a multiobjective optimization problem. Furthermore, if all the functions comprising the model are linear in the variables, then the problem at hand is a multiobjective linear program (MOLP).

Many different techniques are available for handling an arbitrary multicriteria decision problem. The multiobjective programming approach searches for the set of efficient solutions in X. The problem of generating the efficient set is mathematically well-defined and studied, and is a completely objective procedure that requires no information from the decision making. Several methods exist to accomplish this task, all of them usually entailing heavy computational burdens. Additionally, note that generating the efficient set does not necessarily enable the identification of the optimal solution, since the number of efficient solutions is typically very large, still leaving the decision maker with a difficult choice. For this reason, these methods are rarely used directly in applications, although they constitute the basis for more practical techniques.

Consequently, it seems more meaningful to define the multiobjective optimization problem as finding the feasible alternative that yields the most preferred vector of objective function values (Ringuest, 1992). Then, having in mind that, according to Zeleny's axiom of choice "alternatives that are closer to the ideal are preferred to those that are farther away" (Zeleny, 1982; p.156), a very intuitive approach would seek for an efficient solution that is as close as possible to the ideal point. This is the idea underlying Compromise Programming, which finds the solution that minimizes the distance, given a certain metric, from the ideal point (see, for example, Ehrgott, 2000)

Alternatively, some preference information can be obtained from the decision maker before solving the problem ("a priori" articulation of preferences) or during the process of resolution ("progressive" articulation of preferences).

Within the first group of these methods, the methodology known as Goal Programming is worth mentioning due to its valuable applicability in a wide range of disciplines (see White, 1990; Aouni and Kettani, 2001; Lin, 1980 and references therein). The approach, introduced in the late 1960´s in relation to industrial planning problems, suggests to fix some goals or aspiration levels for each objective and then choosing as a preferred solution that one that minimizes the deviations from the set goals. According to Ballestero and Romero (1998), Goal Programming represents the operational dimension of the Simonian philosophy of "satisfying", which states that in complex decisional contexts the most important is achieving satisfaction in relation to a set of targets established. However, note that in many contexts, the decision maker finds it difficult to provide the required preference information (Evans, 1984).

Interactive methods have also received considerable attention in the specialized literature. These algorithms usually begin by finding the optimal solution with an only objective, related in some way to the original problem. Next, the solution is presented to the decision maker, whose preference structure is investigated by means of simple questions concerning the results just obtained. Using this information, the algorithm finds a new single objective problem to be optimized for the next iteration. The process continues in this way until the current solution is close enough to the preferred solution. This class of methods, just as the ones relying on a priori articulation of preferences, requires relatively easy optimization techniques. Additionally, the information requested to the decision maker is not very difficult to attain (although incongruities may be generated). However, convergence of this kind of methods can be very slow.

Another method to select the most preferred efficient solution would rely on the optimization of a linear function over the efficient set of the original multiobjective program, a problem that has proved to serve several purposes within the field of multicriteria decision making (Benson and Lee, 1996). Note that the new objective introduced can be justified in order to discern among the many efficient solutions, as if measuring their importance according to a new criterion. The optimization of a linear function over the efficient set of a MOLP is a global optimization problem, which has been studied for more than 30 years. Now, in the light of some recent contributions concerning the resolution of this problem (Jorge, 2005), we can state that it constitutes a promising approach for encouraging the practical applications of vector programming, since a single solution is finally presented to the decision maker without having generated the whole efficient set.

Any of the multiobjective approaches described so far are of incalculable value for the analysis of different efficient policies concerning tourist development. However, as the tourist carrying capacity regards, it is worth noting that the approach based on the optimization of a linear function over the efficient set seems to fit particularly well, given the definition provided in section 2 involved with the maximum number of tourist that simultaneously maximize economic development and minimize environmental impacts.

Hence, the approach proposed here to approximate the tourist carrying capacity lies in the formulation of a multiobjective program for the simultaneous optimization of two or more objectives that tourist managers want to attain, and then looking for the maximum number of tourists over the efficient set of this multiobjective program. Next, we will see how this process can be accomplished in practice.

4. MULTIOBJECTIVE DETERMINATION OF THE TOURIST CARRYING CAPACITY: AN EXAMPLE

In this section we will illustrate the applicability of the multiobjective methodology through the determination of the tourist carrying capacity for a particular destination. As suggested, the first step for achieving this task would find some mathematical (linear) formulations of economic development and environmental impacts due to the exploitation of tourist resources as well as a number of limitations of the tourist expansion. With the aim of avoiding a complex modeling process, which in fact is highly dependent of each individual case, we will take as our starting point a model proposed by Canestrelli and Costa (1991) for studying the tourist carrying capacity of the city of Venice.

These authors undertake the determination of the optimal level of tourist use of Venice through the maximization of the total daily outlays, expressed in terms of the number of visitors, subject to a few constraints measuring the degree of expansion of some relevant supporting facilities. Three types of visitors were considered in the model: tourist using hotel accommodation (TH), those using non-hotel accommodation (TNH) and day-trippers (DT). The constraints included account for availability of hotel beds, availability of non-hotel beds, number of lunches which can be daily served, number of parking places offered at Venetian terminals, number of trips offered on the local water transport system, capacity of solid waste disposal and number of daily visits to the Saint Mark's Basilica (as a representative point within the whole historical center of Venice). Further details concerning the model or the type of analysis performed can be found in the original work (Canestrelli and Costa, 1991).

Now, with that basic modeling information, we will start a multiobjective analysis, simultaneously accounting for positive and negative impacts of tourism. Hence, we propose two main objectives to achieve: maximizing total outlays, as an indicator of economic development, and minimizing waste disposal brought about by tourism, as an indicator of the environmental impacts. These assumptions leave us with the following model:

$$
\left\{
\begin{array}{lll}
\begin{cases}\text{Max} & z = 221\text{TH} + 85.4\text{TNH} + 149\text{DT} \\ \text{Min} & u = 2.3\text{TH} + 2\text{TNH} + 1.5\text{DT}\end{cases} & & \begin{array}{l}\text{Total outlays (milliom lire / day)} \\ \text{Waste disposal (kg / day)}\end{array} \\
\\
\text{s.t.} & & \\
 & \text{TH} \le 9780 & \text{Hotel beds availabilility} \\
 & \text{TNH} \le 2380 & \text{Non} - \text{hotel beds availabilility} \\
 & \text{TH} + 0.75\text{TNH} + 0.5\text{DT} \le 30850 & \text{Daily lunches} \\
 & 0.33\text{TH} + 0.33\text{TNH} + 0.75\text{DT} \le 20850 & \text{Parking places} \\
 & \text{TH} \le \text{TNH} + 2\text{DT} \le 33900 & \text{Water transport system} \\
 & 2.3\text{TH} + 2\text{TNH} + 1.5\text{DT} \le 41700 & \text{Solid waste disposal} \\
 & 0.4\text{TH} + 0.3\text{TNH} + 0.7\text{DT} \le 11950 & \text{Saint Mark´s Basilistical} \\
 & \text{TH} \ge 0.\text{TNH} \ge 0.\text{DT} \ge 0 &
\end{array}
\right.
$$

We could start exploring those efficient solutions that are closer to the ideal point in some specified metric by means of the Compromise Programming method. Hence, after identifying the ideal and nadir points (respectively, the best and worst attainable values of both objectives within the efficient region) we would minimize a normalized measure of the distance to the ideal alternative. Formally, if z is the vector objective function and zI and zN denote the ideal and nadir points, we would face with the following class of problems:

$$
\begin{array}{l}
\min \left(\sum_{i=1}^{k} w_i^p \left(\frac{z_i^I - z_i(x)}{z_i^I - z_i^N -} \right)^p \right)^{1/p} \\
\text{s.t.} \\
\qquad x \in X
\end{array}
\qquad (2)
$$

where p is the metric defining the distance function and wi measures the relative importance of each objective. It can be seen that for p = 1 and p = ∞ metrics, (2) is a linear program. Furthermore, it is known that for bi-objective problems, the compromise solutions for these two metrics, L_1 and L_∞, characterize the bounds of the whole compromise set (Ballestero y Romero, 1998).

Table 1 shows the results of the Compromise Programming method applied to the example considered here, considering equally important objectives. Notice that the solution L_∞ represents a well-equilibrated solution regarding the percentage of achievement of the objectives respect their ideal values. However, from a practical point of view, it does not seem desirable to let the tourist sector exclusively rest on day-trippers.

Consequently, a further modeling effort would be advisable in order to avoid such counter-intuition solutions.

If a satisfying philosophy is preferred, the decision maker could fix some acceptable achievement levels for the objectives and then a goal programming model would be solved. Formally, if z_i^* denotes the target selected for the ith objective, the Lexicographic Goal Programming approach would solve the following program:

$$\text{lexmin } (h_1(n, p), h_2(n,p),\dots,h_m(n,p)) \tag{3}$$

$$\text{s.t.}$$

$$z_i(x) + ni - pi = z_i^*, \ \forall i = 1\dots k$$

$$x \in X, n_i, p_i \geq 0, \forall_i = 1\dots k$$

where n_i and p_i denote the deviational variables (representing resp. under-achievement and over-achievement of the ith goal) and h_j is a function of the unwanted deviational variables for the goals placed in priority j.

For the example considered here, and taking the target values to be z* = 3318 and u* = 33360, we obtained the solutions LGP1, when the first priority was defined by the economic goal and LGP2, when the environmental goal occupied the first priority. Note that both solutions (see Table 1) are very similar in their outcomes and suggest the elimination of non-hotel accommodations in favor of tourists with higher outlays and day-trippers.

On the other hand, if the aim of the analysis is an estimation of the tourist carrying capacity of the destination, neither of the previous methods provides an accurate answer. In this case, the maximization of the total number of tourists, over the efficient set of program (1) is the approach suggested.

Indeed, using the algorithm EFC described in Jorge (2005), which allows the optimization of a linear function over the efficient set of a MOLP, we obtain as a solution the values TH = 9780, TNH = 1460 and DT=10857, which are the same presented in the original work (Canestrelli and Costa, 1991). Consequently, and under the hypothesis considered in the original model, it can be said that solution EFC (see Table 1) is interpreted as the maximum number of tourists that Venice can support efficiently (as far as tourist outlays and waste disposal are concerned), thus providing valuable information for a tourist development planning process.

	z	**u**	**TH**	**TNH**	**DT**
L_1	3872.3	39718	9780	0	11482
L_∞	2009.7	20232	0	0	13488
LGP_1	3318.2	33833	5701	0	13813
LGP_2	3273.6	33360	5373	0	14000
EFC	3903.7	41700	9780	1460	10857

5. CONCLUSIONS

The exploitation of a zone's tourist capabilities generates several impacts of diverse characteristics: economic, physical and social impacts must be taken into consideration when an evaluation of the limit to tourist growth or carrying capacity is being performed as a means of approaching sustainable development.

Due to its very nature, the determination of the tourist carrying capacity must agree with several conflictive criteria and consequently, a multiobjective approach seems to be appropriate for a mathematical treatment of the problem.

In this paper we propose the use of methods within the field of vector programming for a multiobjective analysis of a tourist destination. Particularly, the problem of optimizing a linear function over the efficient set of a multiobjective linear program finds a practical application, since the carrying capacity can be determined as the maximum number of tourists a destination can support in an efficient manner, according to some attainable criteria. In a further step, the comparison of the model outcomes with the current situation of the destination would allow an evaluation of the degree of tourist development achieved in order to decide if the area is being overexploited.

Finally, in order to show the plausibility of the approach presented, we also provide an illustration based on a very simple model extracted from a previously published work.

REFERENCES

AHN, B.; B. LEE and C. SHAFER (2002): "Operationalizing sustainability in regional tourism planning: an application of the limits of acceptable change framework", **Tourism Management**, 23, 1-15.

AOUNI, B. and KETTANI, O. (2001): "Goal programming model: A glorious history and a promising future", **European Journal of Operational Research**, l 133, 225-231.

BALLESTERO, E. and C. ROMERO (1998): **Multiple Criteria Decision Making and its Applications to Economic Problems**. Kluwer Academic Publishers, Boston.

BENSON, H. and D. LEE (1996): "Oucome-based algorithm for optimizing over the efficient set of a bicriteria linear programming problem", **Journal of Optimization Theory and Applications**, 88, 77-105.

CABALLERO, R. **et al**. (1998): "Un modelo de programación lineal para el análisis del sector turístico", Actas de la XII Reunión anual ASEPELT-España, Córdoba, Junio 1998.

CANESTRELLI, E. and P. COSTA (1991): "Tourist carrying capacity: a fuzzy approach", **Annals of Tourism Research**, 18, 295-311.

COLLINS, A. (1999): "Tourism development and natural capital", **Annals of Tourism Research**, 26, 98-109.

EHRGOTT, M. (2000): Multicriteria Optimization. Springer Verlag, Berlín.

EVANS, G.W. (1984): "An overview of techniques for solving multiobjective mathematical programs", **Management Science** 30, 1268-1282.

FEICK, R.D. and G.B. HALL (2000): "The application of a spatial decision support system to tourism-based land management in small island states", **Journal of Travel Research**, 39, 163-171.

GREINER, A. **et al**. (2001): "Optimal periodic development of a pollution generating tourism industry", **European Journal of Operational Research**, 134, 582-591.

HARALAMBOPOULOS, N. and A. PIZAM (1996): "Perceived impacts of tourism. The case of Samos", **Annals of Tourism Research**, 23, 503-526.

JORGE, J.M. (2005): "A bilinear algorithm for optimizing a linear function over the efficient set of a multiple objective linear programming problem", **Journal of Global Optimization**, to appear.

LIN, W.T. (1980): "A survey of goal programming applications". **OMEGA**, 8, 115-117.

LOZATO-GIOTART, J.P. (1992): "Geographical rating in tourism development", **Tourism Management**, 13, 141-144.

MATHIESON, A. and G. WALL (1984): **Tourism. Economic, Physical and Social Impacts**, Longman, London.

OCAÑA, C. and F. GALACHO (2002): "Un modelo de aplicación de SIG y evaluación multicriterio, al análisis de la capacidad del territorio en relación a funciones turísticas", Actas del IV Congreso "Turismo y Tecnologías de la Información y las Comunicaciones" TuriTec 2002.

O'REILLY, A.M. (1986): "Tourism carrying capacity. Concept and issues". **Tourism Management** 7, 254-258.

PRATO, T. (2001): "Modeling carrying capacity for national parks", **Ecological Economics**, 39, 321-331.

RINGUEST, J.L. (1992): **Multiobjective optimization: Behavioral and computational considerations**. Kluwer Academic Publishers, Boston.

SAVERIADES, A. (2000): "Establishing the social tourism carrying capacity for the tourist resorts of the east coast of the Republic of Cyprus", **Tourism Management**, 21, 147-156.

SEELY, R.L.; H.J. IGLARSH and D.L. EDGELL (1980): "Goal Programming. Planning process of tourism organizations", **Annals of Tourism Research** 7, 353-365.

SEIDL, I. and C.A. TISDELL (1999): "Carrying capacity reconsidered: from Malthus' population theory to cultural carrying capacity". **Ecological Economics** 31, 395-408.

VAN der KNIJFF, E. and J. OOSTERHAVEN (1990): "Optimizing tourist policy: a linear programming approach", **Regional Studies** 24, 54-64.

WETZEL, K.R. and J.F. WETZEL (1995): "Sizing the earth: recognition of economic carrying capacity", **Ecological Economics** 12, 13-21.

WHITE, D.J. (1990): "A bibliography on the applications of mathematical programming mutiple-objective methods". **Journal of the Operational Research Society** 41, 669-691.

ZELENY, M. (1982): Multiple Criteria Decision Making. McGraw Hill, New York.