

Pop, Ruxandra-Eugenia

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Carrying capacity in Danube's Delta: Link between local economy development and environmental resources protection

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CARRYING CAPACITY IN DANUBE'S DELTA - LINK BETWEEN LOCAL ECONOMY DEVELOPMENT AND ENVIRONMENTAL RESOURCES PROTECTION

POP RUXANDRA-EUGENIA

RESEARCH INSTITUTE FOR THE ECONOMY OF AGRICULTURE AND RURAL DEVELOPMENT

Corresponding author e-mail: pop.ruxandra@iceadr.ro

Abstract: *During COASTAL project, financed through Horizon 2020 program, research team carried out a modelling activity, for the three main economic activities for Danube's Delta study case area: agriculture, aquaculture and tourism. Regarding the tourism in Danube's Delta region, we wanted to find the answer to the following question: How far can be developed Danube's Delta area without damaging the environment? To achieve one of the main objective of modelling activity, several parameters with which the model operates where used, such as carrying capacity, variable of interest both for generating income within the tourist activity and to ensure the sustainability of the area from environment perspective. Therefore, Carrying capacity represent the central theme of this paper and we used different approaches from a conceptual, mathematical and logical point of view. Also, we presented elements of tourist demand and supply in the Danube Delta, in order to be able to compare the currently existing carrying capacity of the study case area with the hypothetical value, calculated among this paper.*

Keywords: *Danube's Delta, tourism, carrying capacity, rural development, tourism marketing*

JEL classification: O13, Q18

INTRODUCTION

Within the project with COASTAL acronym, financed through Horizon 2020 program, under Grant Agreement no. 773782, was carried modeling activity out, using the VENSIM program, for the 3 main economic activities in Danube's Delta area: ecological agriculture, aquaculture and rural tourism. Regarding tourism, the dynamic system created in VENSIM tries to provide the solution to the following problem: *How much can the Danube Delta area be developed, without damaging the environment?* Finding the answer to the above question is a challenge, and also a necessity, especially for Danube's Delta area. The peculiarities of Danube's Delta ecosystem represents the main attraction for which tourists, both national and foreign, choose the Danube Delta as their holiday destination. Statistical data of the National Institute of Statistics shows that, the Covid-19 pandemic has obviously affected tourism practiced in areas all over the world, the Danube's Delta "threshold" has been further crossed by national tourists, perhaps even more than in others years, precisely because of the mentioned characteristics. Returning to the modeling activity, in order to be able to get closer to the truth, regarding the maximum supported level of Danube's Delta rural development, and the corresponding level for the safety of the environment, we used a series of parameters and variables, such as: tourist duration stay, obtained incomes from tourism activities, marketing budget, the impact on water quality, tourism workforce, attractiveness degree of t tourist area, number of tourists, *carrying capacity*. Last mentioned parameter shows a particular importance, both in achieving the goal of the model created within the COASTAL project, and in substantiating European and national strategies in order to establish sustainable economic development directions, in terms of tourism activity

MATERIALS AND METHODS

In order to create the model from which the parameter were withdrawn, specific techniques where used, from qualitative analysis field (workshop meetings, in which experts from fields such from tourism domanin, agrarian economy, rural development, the dissemination of the literature of specialty), but also elements related to quantitative's analysis scope (statistical data were processed, in order to outline a current overview of Tulcea county area, implicitly the Danube's Delta region, mathematical and logical formulas and algorithms establishment).

Regarding the present paper, in order to analyze the major interest parameters, the carrying capacity in the Danube Delta, a multidisciplinary approach was applied, by analyzing reference national and international publications, from different fields, such as statistics, mathematics, socio-economics, tourism management and marketing. Statistical data of interest, published by the National Institute of Statistics, were also processed

RESULTS AND DISSCUSION

The present paper starts from the following question "What does carrying capacity means and how can it be quantified?" and specialized publications and studies were analyzed, in order to establish the mathematical dimension of carrying capacity, but also the social dimension of this indicator.

Table 1 presents the main definitions regarding tourism carrying capacity, in specialized publications:

Table 1 – Carrying capacity's conceptual definition

No.	Definition	Source
1	<i>The maximum tourist number allowed in a tourist area, at the same time, so that there are no negative consequences from an ecological, economic, social point of view.</i>	Danube Parks Network, Association of Ecotourism in Romania, 2010
2	<i>Totalitatea activităților umane pe care o zonă turistică o poate găzdui, fără a deteriora zona respectivă și fără a provoca disconfort la nivelul comunității rurale.</i>	Middleton & Chamberlain, 1997
3	<i>Organizația Globală de Turism definește capacitatea de cazare ca fiind un anumit nivel de utilizare al unei zone turistice de către totalitatea utilizatorilor, ce se poate înregistra sub aceleași coordonate temporale și spațiale.</i>	Buckley, R., 1999
4	<i>Densitatea sau dimensiunea medie a populației unei specii sub care numărul său tinde să crească și peste care numărul său tinde să scadă din cauza lipsei de resurse.</i>	Enciclopedia Britannica, 2019
5	<i>The average population density or size of a species below which its numbers tend to increase and above which its numbers tend to decrease due to resources lack.</i>	M.E. Geores, 2001
6	<i>Coming from the ecological point of view, carrying capacity is a suitable concept for reflecting the environment limits for a certain socioeconomic system.</i>	Zekan, B., Weismayer C., Gunter, U., Scuh, B., Sedlacek, S., 2022
7	<i>Carrying capacity of a tourist area has been applied in the context of the tourist activities impact on the environment, especially in the case of management of natural resources and protected areas, such as national parks</i>	Seidl & Tisdell, 1999

Source: processing specialist literature publications, according to the indicated sources

Analyzing some of the many definitions for the carrying capacity concept, it can be seen the three types of potential types approaches, regarding this term: from the ecological, experience of the consumer in tourism services and from the socio-economic point of view. Thus, the specialists recommends that the carrying capacity value estimation be carried out in an integrated manner, analyzing the parameter's generated impact, through the number of tourists correlated with the average length of their staying, bul also with the area's specific seasonality. Also, the tourist services consumer's behavior and its customs, the type of tourism carried out mainly within the analyzed tourist destination and the specific tourist offer, the performance measurement system at the administrative level and the characteristics of the decision-makers, are also important in terms of establishing the proper value for carrying capacity.

From a mathematical point of view, to establish the value of the optimal carrying capacity, specialists use a series of algorithms, depending on its typology: physical, real, effective (Table 2):

Table 2 – Calculations for deterring the carrying capacity level, depending on its type

No.	Carrying capacity typology	Semnification	Calculation formulas	Observations
1	<i>Physical (C_f)</i>	The maximum number of visitors that can be in the same place and time.	$C_{cf} = S_{touristic} / (S/T) / F_r$ (1) $F_r = \text{average duration of tourist stay}$ (2)	(1) S touristic =surface of the area; S/T = the required space per visitor, so that he does not bump into another visitor, usually this parameter has the 1 m ² value; Fr = rotation factor;
2	<i>Real (C_r)</i>	The maximum number of visitors for a tourist destination taking into account the limiting factors (ecological, biophysical, social, legislative) resulted from the specific area's conditions.	$C_{cr} = C_{cf} * ((100 - F_1)/100) * ((100 - F_2)/100) * ((100 - F_3)/100)$ (3) $F = M_1 / M_+ * 100$ (4)	(3) C _f = physical carrting capacity; F1,F2,F3 = restrictive factors,of analyzed area; (4) M ₁ = superior limit of one certain variable; M ₊ = the total amount of the analized variable;
3	<i>Effective (C_e)</i>	The maximum number of visitors for a tourist destination that can be managed by the current administration of the area.	$C_{ce} = C_{cr} * M_c$ (5); $M_c = (100 - F_m)/100$ (6); $F_m = ((M_{c\ ideal} - M_{c\ effective}) / M_{c\ ideal}) * 100$ (7).	(5) C _r = Real carrying capacity; (6) M _c = management capacity; (7) F _m = management factor; M _{cideal} = optimal management capacity; M _{ceffective} = effective management capacity.

Source: after Kourandeh H., Fataei M. (2013).

The size of physical carrying capacity of the area for the present work, in Danube's Delta, will be estimated, using the presented calculation algorithms, in table 2. According to *Organization and Operation Statute of the "Danube Delta" Biosphere Reserve Administration*, (published in the MO in 18th April 2002), but also with *ARBDD Report on the state of the environment in the Danube Delta biosphere reserve.*, in Danube's Delta case, the economic activities, including tourism, can only be carried out in the "**buffer zones**" of the Danube Delta; more precisely, on the territory of *Matița-*

Merhei-Letea, Şontea, Caraorman, Lumina-Vătafu, Dranov, Sărături-Murighiol, Lac Rotundu, Popina Island, Cap Doloşman, Zmeica-Sinoie, Lac Potcoava, Periteaşca Leahova, Marine area up to the isolated of 20m. These mentioned areas measures a 222 996 hectares surface. Therefore, the surface of the Danube Delta, on the territory of which economic activities can be carried out, is 222,996 hectares. From the latest Report's data provided on the state of the environment in the Danube Delta Biosphere Reserve (2017), the agricultural land totals 61,453 ha, thus remaining, on average, an area of **161,543 ha**. According to the same indicated source, from the total active population, a share of approximately **16% works in tourism**, transport, communications field. Keeping the proportionality with this aspect, it can be hypothetical declared for this paper that a area of 25,846 hectares, (**representing 258,460,000 m²**) (1) has the tourism activities as main purpose.

From the specialized literature, it follows that the needed space for a tourist, so that he does not interact physically with other people or phenomena, measures 1m². Of course, the size of this surface may differ, depending on the particularities of the certain human or according to other restrictions. For the present paper we will use this value, of **S/T = 1m² /tourist for the S/T value (2)**.

Regarding the rotation factor value, in the present case it is reported according to the average length of stay of a tourist in the Danube Delta area. Following the meetings with tourism stakeholders held within the COASTAL project (university professors, researchers, economic operators), but also from various specialized publications, it follows that the duration of a tourist stay in the Danube Delta is 2.5 days, Thus, the rotation factor applied for the calculation of the formula in the present paper is **2.5 tourist days. (3)**

Thus, the maximum possible threshold of carrying capacity for the Danube Delta area can be calculated as follows:

$$C_{cf} = 25,846 \text{ (ha)} / 1 \text{ (m}^2 \text{ /tourist)} / 2.5 \text{ (tourist days)} = 258,460,000 \text{ (m}^2 \text{)} / 1 \text{ (m}^2 \text{ /tourist)} / 2.5 \text{ (tourist days)} = \mathbf{103,384,000 \text{ (persons)}}$$

The calculated value for carrying capacity in Danube's Delta area, respectively, 103,384,000 persons, reflects the maximum number of people who can be simultaneously on the entire tourist surface of the area of interest, taking into account the average length of stay of 2.5 days. But this approach doesn't take into account the other determining factors, for example, the resident population of the Danube Delta region or the regulations regarding the Methodological Norms for different accommodation forms (MT Order 415/2016; MT Order 798/2018).

Considering this, in accordance with the Methodological Norms for the operation and classification of accommodation units, published under Order no. 65/2013 (*Annex no. 1, Definitions and mandatory minimum criteria regarding the classification of tourist reception structures with accommodation functions of the hotel, hotel-apartment and motel type*), the average area for providing a place of accommodation should be 13 m² (room area for one person), to which 3.5 m² is added (area allocated to own sanitary group). Therefore, in order for a tourist accommodation, is necessary to allocate a space of at least 16.5 m². Taking these requirements into account, the physical carrying capacity can be calculated for Danube's Delta area, depending on the average duration of a tourist's stay, but also depending on the legislative regulations as follows:

$$C_{cf} = 25,846 \text{ (ha)} / 16.5 \text{ (m}^2 \text{ /tourist)} / 2.5 \text{ (tourist days)} = 258,460,000 \text{ (m}^2 \text{)} / 16.5 \text{ (m}^2 \text{ /tourist)} / 2.5 \text{ (tourist days)} = \mathbf{6,265,697 \text{ (person)}}$$

These resulted values for carrying capacity parameter, are hypothetical and more than permissive. However, taking as a reference the threshold of 6,265,697 maximum tourist and based on the surface area of the tourist part of Danube's Delta, the duration of a tourist stay, but also the

average areas necessary to ensure an accommodation place, we can make a parallel between the hypothetically possible situation and the current situation regarding tourism in Danube's Delta. From the provided data by the National Institute of Statistics, emerges the informations (figure 1). The provided statistical data don't fully reflect the situation of the number of visitors in the Danube Delta or the accommodation capacity. According to the statements of the representatives of the Administration of the Danube Delta Biosphere Reserve from Tulcea, some of the tourists choose to stay in the houses of the locals from localities such as Sulina, Sfântu Gheorghe, Crişan, thus practicing rural tourism.

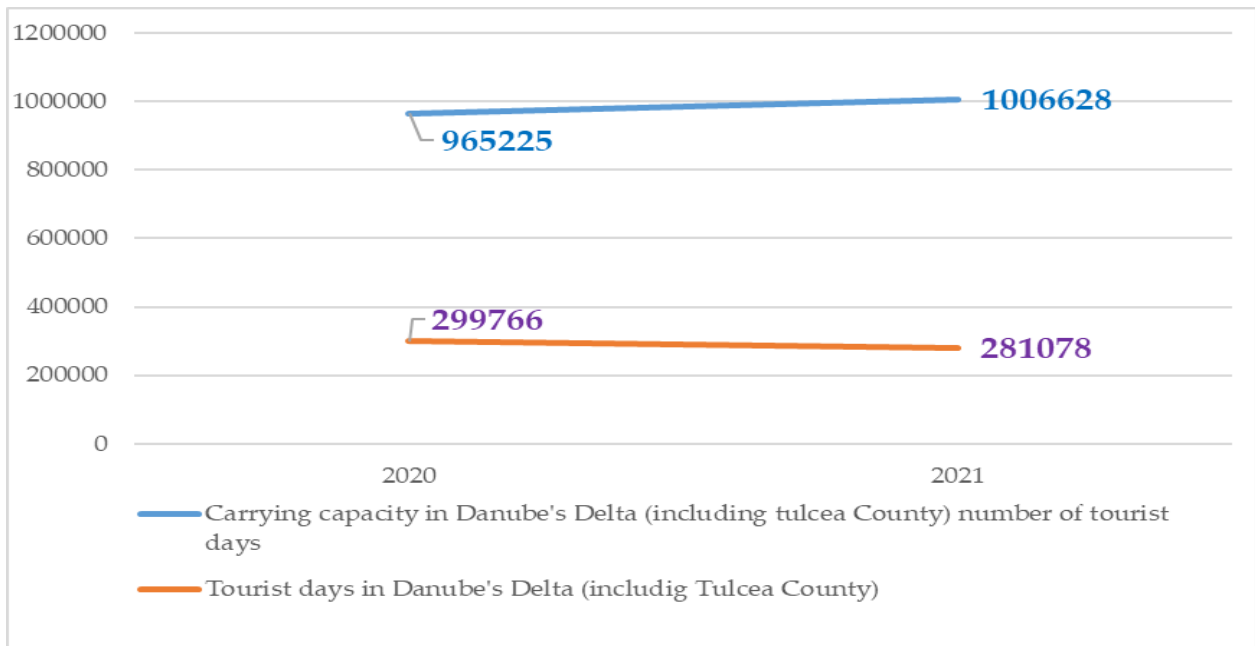


Figure 1 – Danube’s Delta number of visitators and the carrying capacity, in 2020-2021

Source: INSSE data processing, available at <http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse->

Tourist demand was higher when the tourist services offer was lower, (accommodation capacity of 965,225 tourist days in 2020 and 1006628 tourist days available in 2021). The main cause of this imbalance situation in terms of the ratio between supply and demand, it probably originates in the adjustment element of the market, price.

Therefore, we can compare the two values, representative of a hypothetical situation, calculated, respectively, for the current situation in the Danube Delta area (figure 2):

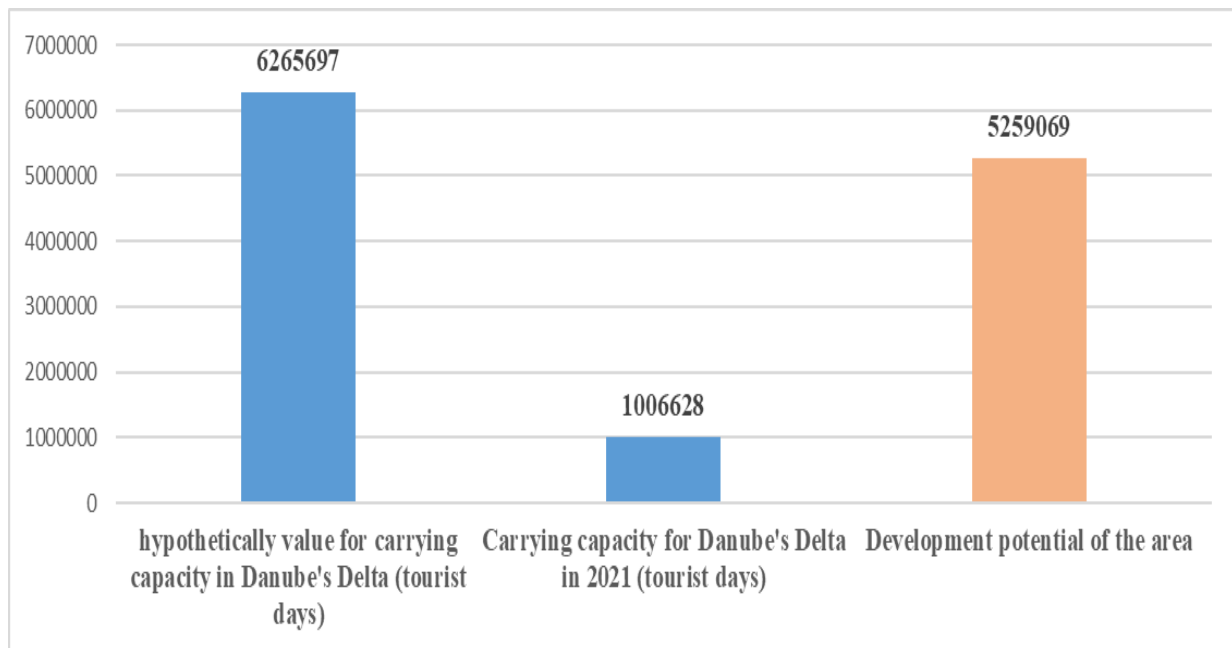


Figure 2 - Parallel between a hypothetically situation and the current situation, regarding the potential development for tourism in Danube's Delta

Source: after INSSE data processing and present paper calculations

Although the resulting carrying capacity value (expressed in tourist days) far exceeds the descriptive reference parameters for the current situation in the Danube Delta, it is necessary to mention that this value does not take into account the other restrictive factors, referring - especially *to environmental factors*. From a physical point of view, we can say that the development of tourism in the area is allowed (taking into account the tourist area of the Danube Delta area and the average length of stay of a tourist), but in order to ensure the sustainability of the development of the region, it is imperative to include other factors: the degree of pollution of the area, water quality, the evolution of climate change and others.

CONCLUSIONS

In the present work, the carrying capacity related to the tourist destination in Danube's Delta was analyzed as a parameter, thus going through publications of specialized interest in order to present a series of mathematical algorithms to define an estimated value of the mentioned indicator. This paper starts from the conceptual definition of the term, with several approaches examples founded in the specialized literature (ecological, social perspective), as well as the carrying capacity typology (physical, real, effective). Depending on the used approach and tipology, several calculation formulas were presented, in order to establish the value of the maximum physical carrying capacity. The used formula took into account the duration of a tourist's stay in the area and the tourist area of Danube's Delta on which economic activities can be carried out. Danube's Delta is an area with a specific legislative framework but also with specific methodological norms.

In the last part of this paper, reference statistical data were presented for the description of the demand and tourist offers in the Danube Delta area. There is a major difference between the hypothetical value calculated for the carrying capacity in Danube's Delta and the existing one, in the sense that calculated value is higher than the real one. However, it is necessary that the carrying capacity threshold be established according to the current situation and the estimated evolution of

some important phenomena, such as climate change, the impact of the pressure of tourism activity on the environment, water quality, etc. Moreover, in the present work, the modeling activity of tourism in the Danube Delta area, carried out within the COASTAL project (H2020), was mentioned, operating with the phenomena mentioned above, the value of the accommodation capacity being much lower, in comparison with the one calculated in the present work, being estimated at 2,120,000 tourist days. In this manner, the indisputable influence of environmental factors on taking the correct decision, in establishing the accommodation capacity threshold, can be observed..

Ultimately, to estimate a certain threshold of the optimal carrying capacity is very ambitious, a value for which the balance between the economic development of the area and the surrounding environment would certainly favor. Instead of numbers, a social and consumer behaviour profile of can be outlined, for of each of us, in relation to the natural resources, so important in general and especially in terms of the tourist attractiveness of the Danube Delta area. It is desirable to facilitate the transition, from conventional tourism, practiced today in the area, to a slower tourism, which corresponds to a longer duration of a tourist's stay in the area. Such an approach in Danube's Delta area could bring important benefits for the sustainable use of environmental resources, such as: decreasing the consumption rate, a less harmful impact on the environment, changing the perception of the area's inhabitants regarding the presence of tourists, in the sense in which they will perceive the development of tourism in the area as a positive factor, bringing income, and not as a threat in terms of the quality of their standard of living.

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