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Research Article

Determination of the Carrying Capacity of the Beaches of the District of Mollendo, Islay, Arequipa, Peru

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Abstract: It is proposed to determine the tourist carrying capacity of the beaches of the district of Mollendo in the Province of Islay Arequipa, Peru. The methodology of Cifuentes (1994) was taken as a basis, a calculation of the physical carrying capacity is made, which is then recalculated through factors to the real carrying capacity and finally the effective carrying capacity; Of the four beaches analyzed, the third Beach has the lowest effective carrying capacity with 48 vacationers, while the first Beach has the highest effective capacity with a total of 858 vacationers; on the other hand, the beach sanitary quality index is determined, determining that the first beach and the second beach reach a level of "healthy" while Catarindo and the third beach are determined as "regularly healthy".

Keywords: carrying capacity, Beach, sanitary quality.

1. Introduction

The district of Mollendo, which belongs to the province of Islay, in the Arequipa region- Perú, has been considered a summer tourist destination, that is to say, beach, since time immemorial; in fact, the appearance of motorized transport and even rail transport promoted this activity since the end of the 19th century; Mainly due to the increase in populations not only in the district itself, but rather, in the surrounding cities, the number of tourists who receive the beaches of the demolishing district have been increasing exponentially in recent years (Maldonado, 2018); Although it is true that other beaches have been sought in neighboring areas for the use of vacationers, however, the number of visitors per season increases significantly year after year (Armas. 2019).

It is therefore important to be able to develop an adequate management of this tourist resource to be able to initially determine the carrying capacity of these beaches and, on the other hand, the beach quality index that is offered to the summer tourist (Manjarres et al., 2020).

In the Mollendo area, the presence of beach areas identified as independent units can be identified, for example Catarino beach is found, which corresponds to a cove, that is, a sandy beach area surrounded by rock formations; Then we have the so-called First Beach that is located to the north and that has a spatial continuity with the so-called Second Beach, the latter is limited towards the southern end with a rock formation further south, the so-called Third Beach is observed, all they have a sandy constitution; It is decided to carry out a separate analysis on each of these beaches, since despite there is a certain degree of continuity between them, the separation will notably improve the application of subsequent management models (Gutiérrez Fernández, 2018); and also because it has been a custom to name them, both for the location of tourists, and to provide the necessary services.

2. Material and methods

To determine the carrying capacity on the beaches of Mollendo, the methodology of Cifuentes (1999) cited by (Manjarres et al., 2020) has been considered, which has been considered in many studies related to the subject (Fernández & Bértola, 2014) (Coy, 2016) (Perruolo Laneti & Camargo Roa, 2017) (Gálvez-Izquieta & Mendoza-Tarabó, 2020)

The determination of the Total Carrying Capacity (CCT) is carried out considering three levels: Calculation of Physical Carrying Capacity (CCF), Calculation of Real Carrying Capacity (CCR) and Calculation of Effective Carrying Capacity (CCE). Between these three levels the following relationship is established.

$$CCF > CCR > CCE$$

2.1 Physical Carrying Capacity

It is defined as the maximum number of visits to the area during a day; It is considered as the relationship between: visiting factors (visiting hours and time), the available space and the need for space per visitor (Fernández & Bértola, 2014); is defined as:

$$CCF = (S / SP * NV)$$

The formula establishes that the physical carrying capacity (CCF) corresponds to the ratio between the available area in square meters for each beach (S) and the average area in square meters used by a person (SP) and that multiplied by the number of times the site can be visited by the same person in a day (NV); this last factor is obtained between the proportion of visiting hours and the average visiting time.

2.2 Real Carrying Capacity

The physical carrying capacity is subjected to a set of correction factors (Fernández & Bértola, 2014); These correction factors are obtained taking into account physical, ecological and social variables, which may vary for each destination or tourist site. The correction factors are established with qualitative criteria, so they must be carried out by experts in the destination analyzed.

The real carrying capacity (CCR) is obtained from affecting the physical carrying capacity (CCF) with the correction factors according to the following expression

$$CCR = CCF\ (FC1 \times FC2 \times FC3 \times FC4 \times FC5 \times ... \times FCn)$$

Where the correction factors (FC) are expressed as a percentage or probability that is discounted from the CCF. To calculate them the general formula is used:

$$FC = 1 - (Ml / Mt)$$

The correction factor is represented by the relationship between the limiting quantity (Ml) and the total quantity (Mt).

The possibility of considering all the relationships or phenomena of a system is extremely unlikely, so a selection must be made according to the reality of the site.

For the present work, only the solar brightness factor (FCb sol) has been considered; For this, the limiting hours of sunshine were calculated for the days of the summer months. The maximum intensity hours of sun were taken as limiting hours, these being 5 hours, between 11:00 and 16:00. The latter were related to the total of 12 hours of sunshine for the summer months, between 6:00 and 18:00.

2.3 Effective Carrying Capacity

Finally, the Effective Carrying Capacity (CCE) represents the maximum number of visits that can be allowed in a given place on a daily basis (taking into account the management capacity of the beach administrators and the services provided to the visitor). The CCE is determined by the product of the real carrying capacity (CCR) by the management capacity (CG)

The Management Capacity (CG) is defined as the economic and social limit that the municipality and / or the private sector have for the management of its activities and the achievement of objectives. Here, factors such as: legal regulations, policies and actions, specific equipment for the tourism sector, technical and operational personnel, financing, infrastructure and available facilities or facilities intervene (Fernández & Bértola, 2014). The variables of each selected factor are valued by their presence or absence. The presence of the total number of variables of each factor will be given the value of 1. Each absent variable is discounted according to the number

of items that each factor has and what percentage it represents of this. A total of 23 items selected and analyzed are presented. To achieve an objective estimation of the CG, it is essential to standardize the rating mechanism for all variables (Fernández & Bértola, 2014). The factors used were:

1. Infrastructure Factor: (10 items):

    A: lifeguard booths;

    B: bathrooms;

    C: lighting;

    D: information services;

    E: spa construction;

    F: bathrooms with changing rooms;

    G: supply;

    H: tents and umbrellas;

    I: signaling;

    J: ease of access;

2. Equipment Factor: (7 items):

    K: trash cans;

    L: kiosk;

    M: bar;

    N: restaurant;

    Or: solarium;

    P: pool;

    Q: spaces for recreational activities;

3. Personal Factor: (3 items):

    R: environmental training;

    S: adequate endowment;

    T: consistent workday

4. Factor Legal support: (2 items):

    U: coastal space management plan;

    V: regulation of spa constructions.

2.4 Determination of the Beaches Sanitary Quality Index

To determine the sanitary quality of the beaches of Mollendo, the Beaches Sanitary Quality Index (ICSP) was applied, taking into account the criteria of Sanitary Directive N ° 038-MINSA / DIGESA-V.01. "Sanitary Directive that establishes the Procedure for the Evaluation of the Sanitary Quality of the Beaches of the Peruvian Coast"

The ICSP calculation works with 3 evaluation criteria:

Microbiological Quality, Cleaning Quality (Beach cleaning and solid waste containers) and Presence of Hygienic Services.

Each of the evaluation criteria acquires a score that, added together, must be given by the unit (1 = 100%), being distributed in priority as follows:

- Microbiological Quality Control 0.50

- Cleaning Quality Control 0.45

• Beach Cleaning 0.40

• Containers for Solid Waste 0.05

- Presence Control of Hygienic Services 0.05

2.5 Determination of Microbiological Quality Control

The microbiological qualification of seawater is established by the variable density of fecal coliforms, determined in the seawater sample collected from each beach.

This rating is divided into 3 categories: Good, Fair and Bad; Each of these categories has a range of fecal coliform values (MPN / 100 mL), which have been established according to the recommendations of the World Health Organization and the National Environmental Quality Standards for water, at which a score has been assigned to each category. The results of the analysis of fecal coliforms obtained from a beach should be compared with the range of values of fecal coliforms, to determine its category and score.

Table No. 01 Determination of Microbiological Quality Control

Variable	Value Range	Score	Qualification	Maximum Score
Fecal Coliforms (NMP/100 ml)	0- 200	0.50	Good	0.50
	201 - 1000	0.25	Regular	
	>1000	0.00	Bad	

Source: Sanitary Directive that establishes the Procedure for the Evaluation of the Sanitary Quality of the Beaches of the Peruvian Coast

2.6 Determination of Cleaning Quality Control

For this qualification criterion, 2 variables are considered: cleanliness of the beach and the existence of containers for the deposit of solid waste on the beach, which must be in good condition. Each of these variables has a score, which added must give up to 0.45 The Beach Cleanliness variable works with 3 rating categories: Good, Fair and Bad, which are determined by the amount of solid waste that is observed on the beach on the day of the inspection. The rating of Good is considered when the sand is raked, which can be done manually or with machinery, this activity is the responsibility of local governments or individuals, if applicable, likewise no solid residues should be observed on the surface for both sandy and stone beaches. For the Regular rating, the expression of dispersed solid waste refers to a maximum of 15 units per 10 m^2. For the rating of Bad, solid waste is found throughout the beach and is referred to exceeding 15 units per 10 m^2. The results of the inspection of the cleanliness of a beach must be compared with the range of values established for each category and its respective score.

Table No 02 Determination of Cleaning Quality Control

Variable	Range Value	Score	Qualification	Maximun score per Variable
Beach Cleaning (Solid Waste / 10 m^2)	Absence of solid residues	0.40	Good	0.40
	Solid waste up to 1 to 15 in 10 m^2	0.20	Regular	
	Solid waste greater than 15 in 10 m^2	0.00	Bad	
Solid Waste Containers	Available and in good condition	0.05	Presence	0.05
	Unavailable or in poor condition	0.00	Absence	

Source: Sanitary Directive that establishes the Procedure for the Evaluation of the Sanitary Quality of the Beaches of the Peruvian Coast

Once the score of each variable has been obtained, they are added, the result achieved will be the score corresponding to the Cleaning Quality Control criterion, which is applied in the final calculation of the ICSP.

2.7 Determination of Control of Presence of Hygienic Services

The following score is established for the verification of the operation of the hygienic services, which must be clean and operational:

Table No. 03. Determination of the Control of the Presence of Hygienic Services

Variable	Range Value	Score	Qualification	Maximun score per Variable
Availability of Hygienic Services	Available, clean and working	0.05	Presence	0.05
	Not available or dirty or not working	0.00	Absence	

Source: Sanitary Directive that establishes the Procedure for the Evaluation of the Sanitary Quality of the Beaches of the Peruvian Coast

2.8 Calculation of the Beaches Sanitary Quality Index

To determine the ICSP, the results obtained in each of the criteria are added: Microbiological Quality, Cleaning Quality and Presence of Hygienic Services. The previously obtained value is compared with the qualifications established in the following table.

Table No. 04 Sanitary Assessment of Beaches

Sanitary Qualification	ICSP Value Ranges
Healthy	0.68 - 1
Regularly Healthy	0.34 – 0.67
Not healthy	0.0 - 0.33

Source: Sanitary Directive that establishes the Procedure for the Evaluation of the Sanitary Quality of the Beaches of the Peruvian Coast

3. Results and Discussion

3.1 Determination of Physical carrying Capacity

Table No. 05 Determination of the physical carrying capacity CCF, for beaches in the district of Mollendo

BEACH	**S =** Available surface **m^2**	**SP =** Average surface per person	**NV = Hv Tv^{-1}** Visits per person per day	**CCF** Physical Carrying Capacity
Catarindo	2350.80	4	0.8	470
First Beach	10130.34	4	0.8	2026
Second Beach	9328.33	4	0.8	1866
Third Beach	1295.31	4	0.8	259

The value of available surface (S) was obtained from topographic surveys carried out in each of the beaches, the special case of the third beach marks only 1295, 31 m² because the rest of the area is not enabled for the use, however, a refurbishment could be carried out, increasing the area in a significant way, by around 10,000 m² more; however, according to the current results, this third beach has the lowest physical carrying capacity with 269 vacationers per day. On the other hand is Catarindo beach,

The value of visits per person per day (NV) was obtained considering a total of 10 potential visiting hours, from 8:00 am to 6:00 pm; while the average number of visits per bather was established from 10:00 to 18:00, with an average of eight hours per bather.

3.2 Determination of Real Carrying capacity

The real carrying capacity is established by applying certain correction factors to the Physical carrying capacity. In the case of the beaches of the Mollendo district, the solar brightness factor (FCb sol) has been considered as the only correction factor, for which hours were calculated are limiting for the days of the summer months. The hours of maximum intensity sun were taken as limitations, they are between 11:00 and 16:00, making a total of five hours; These are related to the total daylight hours offered to vacationers, they comprise from 6:00 a.m. to 6:00 p.m., the correction factor is obtained by calculating the inverse of the relationship of the limiting hours and the total hours HR sun = 1- (5/12), obtaining a value of 0.58.

Table No. 06 Determination of the real carrying capacity for the beaches of Mollendo

BEACH	**FC** Correction factor	**CCF** Physical carrying Capacity	**CCR** Real carrying Capacity
Catarindo	0.58	470	273
First Beach	0.58	2026	1175
Second Beach	0.58	1866	1082
Third Beach	0.58	259	150

3.3. Determination of effective carrying capacity

To determine the effective carrying capacity (CCE), the so-called management capacity is applied to the real carrying capacity; The latter is calculated by determining whether certain actions or elements are presented or executed on the beaches.

Table No. 07. Determination of the management capacity of the beaches of Mollendo

FACTORS FOR THE CALCULATION OF MANAGEMENT CAPACITY		BEACH			
		Catarindo	**First Beach**	**Second beach**	**Third Beach**
INFRASTRUCTURE	A: lifeguard booths;	X	X	X	
	B: bathrooms;	X	X	X	X
	C: lighting;	X	X	X	
	D: information services;				
	E: spa construction;	X	X	X	
	F: bathrooms with changing rooms;	X	X	X	
	G: supply;				
	H: tents and umbrellas;	X	X	X	X
	I: signaling;		X	X	
	J: ease of access;		X	X	X
EQUIPMENT	K: trash cans;	X	X	X	
	L: kiosk;	X	X	X	X
	M: bar;	X	X	X	X
	N: restaurant;	X	X	X	X
	Or: solarium;				
	P: pool;		X		
	Q: spaces for recreational activities		X	X	
PERSONAL	R: environmental training;				
	S: adequate endowment;	X	X	X	
	T: consistent workday	X	X	X	X
LEGAL	U: coastal space management plan;				
	V: regulation of spa constructions.				
MANAGEMENT CAPACITY		0.54	0.73	0.68	0.32

Table No. 08 Determination of the effective carrying capacity for the beaches of Mollendo

BEACH	MICROBIOLOGICAL QUALITY	CLEANING QUALITY	HYGIENIC SERVICES CONTROL	**ICSP** Beach sanitary quality index	VALUATION
Catarindo	0.5	0	0	0.5	Regularly healthy
First Beach	0.5	0.2	0.05	0.75	Healthy
Second Beach	0.5	0.2	0.05	0.75	Healthy
Third Beach	0.5	0	0	0.5	Regularly healthy

The application of the sanitary quality index of the beaches, results in the fact that the first beach and the second beach of the Mollendo district, the valuation of healthy, which is counterproductive to the data obtained in the calculation of the capacity of carrying.

4. Conclusions

After applying the proposed methodology, effective carrying capacities are established that vary from values from 48 vacationers for the third Beach to 858 for the first Beach; It should be noted that the element that affects the aforementioned effective carrying capacity corresponds fundamentally to the management capacity, which is very low, especially in the Third Beach of the Mollendo district; On the other hand, regarding the sanitary quality indices of the beaches of Mollendo, it is determined that the first Beach and the Second Beach have an assessment of "healthy", while Catarindo and the third Beach are "regularly healthy", this is fundamentally related with the quality of cleanliness and hygienic services.

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