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Mathematical Modeling and Forecast 11 Years in Advance of the Dumping of Sand in Varadero Beach, Cuba, Using the Regressive Objective Regression (Ror) Methodology

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ABSTRACT

The specialists estimate that the most important challenge on the beaches is the dumping of sand. Sustainable tourism in our time must be conceived towards the future to ensure that resources are managed with due protection of ecological processes, biological diversity and the environment in general, hence our objective is to know the amount of the following sand dumps on the beach of Varadero mathematically modeling according to the data we have. A database of the dumping of cubic meters of sand in Varadero was used from 1987 to 2012, the methodology used was the Regressive Objective Regression (ROR). We can conclude that the model explains 100% of the variance with an error that cannot be determined, over time, all the variables are significant, the model depends on the shedding twelve times ago (Lag12Vert). In the long term, resources can be saved and the resilience of coastal communities to climate change and rising sea levels can be improved, maintaining the quality indicators required of the sand strip for the enjoyment of bathers and protection of the dunes. The forecast obtained for the next discharges has a maximum of 2,225,140.6 m3, in t50 discharge, a value this May that the discharge occurred before 2012.

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Introduction

The beaches are not only potential for the development of tourist activity but also constitute natural barriers to protect the coastal area from the rising sea and the waves derived from various meteorological phenomena such as hurricanes.

Cuba has had a special interest in preparing to face this reality, and a reliable example is the state plan to confront climate change (Tarea Vida), approved by the Cuban government in April 2017.

In Cuba, of some 430 sandy beaches, it has been detected that more than 80% present symptoms of erosion. And it is valid to note that human activity such as the extraction of sand for various purposes has a great influence on these processes.

Since the 70s in Varadero, research has been carried out on the design and execution of artificial sand discharges from which the strip of sand was expanded and maintained with the required quality indicators for the enjoyment of bathers and protected dunes.

The specialists estimate that the most important challenge is the dumping of sand. Sustainable tourism in our time must be conceived towards the future to ensure that resources are managed with due protection of ecological processes, biological diversity and the environment in general, hence our objective is to know the amount of Following sand dumping on Varadero beach, mathematically modeling according to the data we have, this will bring an application of science to improve the resilience of coastal communities to climate change and rising sea levels [1].

Materials and methods

A database of the dumping of cubic meters of sand in Varadero from 1987 to 2012 was used, taken from the newspaper Juventud rebelde of August 4, 2019, with the title Safeguarding the beaches, in the science supplement, which is shown below (Table 1). The Objective Regressive Regression (ROR) methodology was used [2-4]. A forecast is made 11 years in advance of the dumping of sand, this period is selected because it is the 11-year cycle that the sun changes and therefore conditions all the processes on planet earth.

Table 1: Dumping of cubic meters of sand in Varadero

	Year	Shedding (m3)
1	1987	50000
2	1988	61000
3	1990	204000
4	1991	195000
5	1992	178000
6	1996	40000
7	1997	35000
8	1998	1087835
9	2000	2494
10	2002	6800

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11	2003-2004	460000
12	2008	136934
13	2009	394969
14	2010	142382
15	2012	413779
16	Next	
Total N	16	15

Results and Discussion

In figure 1 it can be seen that the highest dumping occurred in 1998 with 1087835 m3 of sand with a historical average of 227212.87 m3 with a standard deviation of 281229.478 m3, the minimum occurred in 2000 with 2494 m3.

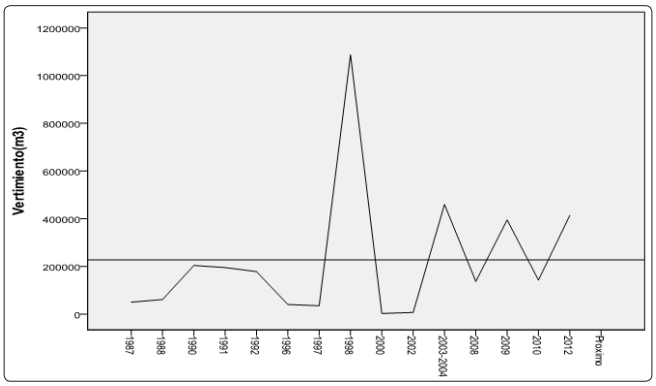

Figure 1: Behavior of sand dumping in Varadero by years

In table 2 the ROR model obtained for the dumping of sand in Varadero. This model explains 100% with an error that cannot be determined, Fisher's F cannot be determined because a division by zero is proposed in the statistics, the model depends on the shedding in twelve back shedding (Lag12Vert), it actually corresponds to 11 years ago as the short-term model depends on shedding one step back.

Table 2: Model obtained for the dumping of sand in Varadero

Coefficients

Model	Non-standardized coefficients		Standardized coefficients	t	Sig.
	B	Standard error	Beta		
1 DI	18653,966	,000	,043	.	.
Lag12Vert	2,028	,000	,987	.	.

a. Dependent variable: Shedding (m3)
b. Linear regression through the origin

The forecast obtained for the next discharges according to the forecast by year is the last one made according to the data. Table 3 and figure 2.

Table 3: Result of the forecast for the next discharge

Case summaries

	Year	Forecast year	Shedding (m3)	Shedding forecast	Unstandardized Residual
1	1987	.	50000	.	.
2	1988	.	61000	.	.
3	1990	.	204000	.	.
4	1991	.	195000	.	.
5	1992	.	178000	.	.
6	1996	.	40000	.	.
7	1997	.	35000	.	.
8	1998	.	1087835	.	.
9	2000	.	2494	.	.
10	2002	.	6800	.	.
11	.	.	460000	.	.
12	2008	.	136934	.	.
13	2009	.	394969	101416,42157	293552,57843
14	2010	2010,00000	142382	142382,00000	,00000
15	2012	2012,00000	413779	413779,00000	,00000
16	.	2013,03622	.	414178,00980	.
17	.	2015,03622	.	361042,46078	.
18	.	2015,06036	.	99787,10294	.
19	.	2020,09658	.	70991,49510	.
20	.	2020,12072	.	2225140,62483	.
21	.	2022,12072	.	5058,65111	.

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22		.	2023,15694	.	32446,59902	.
23		.	2026,16901	.	933031,07843	.
24		.	.	.	296401,09111	.
25		.	2032,24145	.	801126,85221	.
26		.	2032,26559	.	307451,42440	.
Total	N	14	12	15	14	3

a. Limited to the first 100 cases.

In figure 2 the graph of the actual and predicted values, the 5th discharge is the highest predicted in the data series with a value of 2,225,140,624 m3, corresponding to the year 2020.

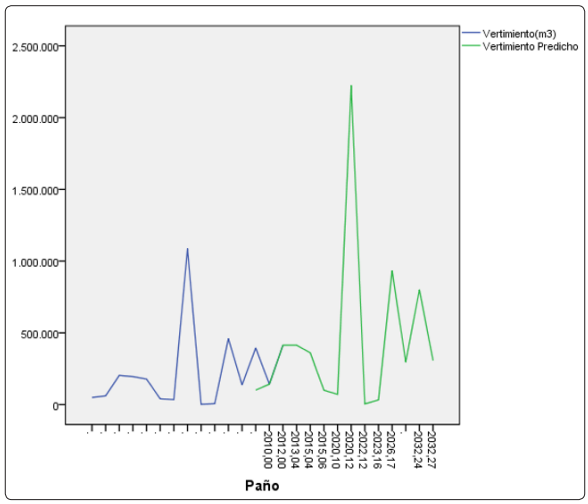

Figure 2: Real value of the discharge and value predicted by the model according to predicted year (Cloth).

Conclusions

We can conclude that the model explains 100% of the variance with an error that cannot be determined over time, all the variables are significant, the model depends on the shedding twelve times ago (Lag12Vert), with a forecast at very More certain long-term resources can be saved and the resilience of coastal communities to climate change and sea level rise can be improved, maintaining the quality indicators required of the sand strip for the enjoyment of bathers and the protection of the dunes. The forecast obtained for the next discharges expresses that the highest value must occur for the 5th discharge after 2012.

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