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Natural coastal risks and the Coastal Zone Integrated Management

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ABSTRACT

An analysis of the main natural risk factors of the Peninsula of Hicacos, on the coast center-west of Cuba is submitted. From an exhaustive bibliographic review, first it is presented a physical-geographical and socio-economic characterization of the peninsula of Hicacos, and on this basis are identified geological, geomorphological and hydrometeorological factors that determine natural hazards in the area under study. In particular an analysis of probabilities of extreme winds in the past 200 years associated with hurricanes, and the heights and periods of waves on the coast of the peninsula to different periods of return is materialize. Also it´s includes a brief analysis of the endogenous risks, and conclude that the hurricanes, the severe local storms and the frontal systems are the main natural dangers that affect the Peninsula. Finally the value of the MIZC for the study, prevision and confrontation of the natural risk is argued, and the positive experience of the application of that approach in the beach of Varadero.

KEYWORDS: *coastal process, coastal natural risks, integrated coastal management.*

RESUMEN

Se presenta un análisis de los principales factores de riesgos naturales de la Península de Hicacos, en la costa centro-occidental de Cuba. A partir de una revisión bibliográfica exhaustiva, se presenta primero una caracterización físico-geográfica y socio-económica de la península de Hicacos y sobre esta base se identifican los factores geológicos, geomorfológicos e hidrometeorológicos que condicionan los riesgos naturales en la zona objeto de estudio. En particular se realiza un análisis de probabilidades de los vientos extremos en los últimos 200 años asociados a los huracanes, y de las alturas y periodos del oleaje en el litoral de la península para diferentes periodos de retorno. Se incluye un breve análisis de los riesgos endógenos, y se concluye que son los huracanes, las tormentas locales severas y los frentes fríos los principales peligros naturales que afectan la a Península. Finalmente, se argumenta el valor del enfoque de MIZC para el estudio, previsión y enfrentamiento de los riesgos naturales, y se expone la positiva experiencia de aplicación de tal enfoque en la playa de Varadero.

PALABRAS CLAVE: *procesos costeros, riesgos naturales costeros, manejo integrado costero.*

INTRODUCTION

The natural disasters show an exponential increased in last decades, causing bigger economical losses and the death of a lot of people. This affirmation is enough to understand the necessity of an adequate disasters management and its reduction. The control of these risks has become in an essential objective face to this situation.

The knowledge of this hazard, the analysis the natural and social vulnerabilities, focusing in the risk management should be especially considered in the definition and assessment of the sustainable development. Gradually the coastal natural risks category has converted in an intrinsic part of the development category (Lavell, 1996), and in this context the characterization, diagnostic and monitoring of those risks are widely recognized as an interesting key in the planning and decisions making process.

It is discussed the role of the intensity and length of the natural risk and the vulnerabilities in the level of damage produced. As it can be seeing the line of thought is that are the pre-existents conditions of vulnerability who elevate the risk concept to a critical situation, and that the fundamental objective has to be the identification and reduction of the vulnerabilities and the promotion of compatible models of the interrelations society-economy-nature.

In particular in the small insular states of the Caribbean, the natural disasters have a big impact as a result of the combination of high levels of natural dangers, the increase of vulnerabilities generated by an inappropriate socio-economic developing model, and very feeble alert and natural risks fighting systems (PNUMA, 2005; Program of United Nations for the Development).

The increased the intellectual and technological capacity in the study of natural risks and especially in the application of a Civil Defence

system that has advanced from the initial efforts, more directed to notify the dangers, until the current improvement of a uniform group of measures related with all the stages of the disasters reduction cycle the prevention, the preparative, the answer and the recovery. In this article the physical- geographic and socio- economic characteristic of the coastal zone are analyzed, identifying geological-geomorphologic and hidro- meteorology factors in the coastal natural risks, and finally illustrate the inclusion of risk management in the Coastal Integrated Management potentiating the study, forecast and confrontation of the natural risks.

MATERIALS AND METHODS

For the analysis of the geological-geomorphologic and hydro-meteorological characteristics of the area, it was collected and processed information for approximately 40 years based on a large number of research reports with a local and general character, as well as the review of numerous articles, books, and other documents.

This cabinet work was complemented with the fieldwork that the authors have been developing over the past 12 -15 years, with the interpretation of cartographic materials, aerial and cosmic pictures of various scales and years, besides participate in interviews and exchanges of knowledge with several prominent scientists, specialists and personalities of the territory.

The analysis of hazards by hurricanes and strong winds is developed by statistical process. First this discrete variable responds to Poisson distribution and for the second case Fréchet distribution is applied.

The Poisson distribution is used to model the number of events occurring within a given time interval. The formula for the Poisson probability mass function is

$$p(x,\lambda) = \frac{e^{-\lambda}\lambda^{x}}{x!} \qquad \text{for } x = 0, 1, 2, \cdots$$

λ is the shape parameter which indicates the average number of events in the given time interval.

Figure 1 show following the plot of the Poisson probability density function for four values of λ.

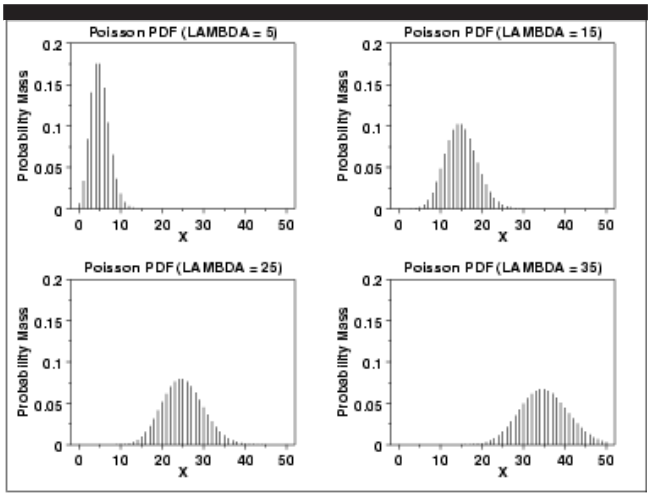

Fig. 1. Poisson probability density function.

For the analysis of maxim winds Frechet Distribution, was applied. A function f is Fréchet differentiable at (a) if

$$\lim_{x \to a} \frac{f(x) - f(a)}{x - a}$$

exists. This is equivalent to the statement that (ϕ) has a removable discontinuity at a, where

$$\phi(x) \equiv \frac{f(x) - f(a)}{x - a}.$$

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Parameters

α - continuous shape parameter ($\alpha > 0$)

β - continuous scale parameter ($\beta > 0$)

γ - continuous location parameter ($\gamma \equiv 0$ yields the two-parameter Frechet distribution)

Domain

$$\gamma < x < +\infty$$

and it is defined as:

Probability Density Function

$$f(x) = \frac{\alpha}{\beta}\left(\frac{\beta}{x}\right)^{\alpha+1} \exp\left(-\left(\frac{\beta}{x}\right)^{\alpha}\right)$$

Cumulative Distribution Function

$$F(x) = \exp\left(-\left(\frac{\beta}{x}\right)^{\alpha}\right)$$

Finally the evaluative documents in the integrated coastal management program of Varadero were studied, which has been implemented in the last 9 years, and accordingly sets out the benefits of applying this approach to studying and confronting the coastal natural hazards, and the challenges that are still ahead.

The assessment process of the management program of sand was distinguished by crossed utilization of three instruments: surveys to specialists, surveys to the population, and depth interviews with experts. This was supplemented by documentary analysis. All this methodology sequence, utilized in the development of our work is faithfully reflected in the structure of the article, its first part is referring to the physical and socioeconomic characterization, and on this basement, identify the principal coastal natural hazards that affect potentially these zones, and close with an argument for integrated coastal management approach in relation to the study and confrontation of coastal natural hazards.

General features of the coastal zone

The neo-tectonic activity, that has generated the forms of structures, is cause of the relief as much in the marine part as in the emerged areas. The region is constituted by a mosaic of blocks limited by tectonic flaws (Goatherd ET to, 2001).

Young plains, Recent and later Pleistocen, developed on a very extended sandy substrate, and over sandy and sandstone, where the fossil dunes are distinguished, are predominate, although also appear other forms of relief associated to the sea-land exchange processes Cabrera et al (2004). The prevalence of young and low plains in the coastal areas is characteristic of high risk for these areas.

Main natural risks and vulnerabilities in the coastal zone

The coastal zone, and therefore, is exposed irremediably to the hazard of flood by marine penetrations but also by the intense rain. Penetrations of the sea they can occur so much in the winter as in summer, always associated to meteorological extremes, with strong cold fronts and subtropical Lows in the winter and the tropical low, disturb, depression, tropical storms and hurricanes between June and November. Other hydro meteorological extremes is the Severe Local Storm mainly from may to June, but also sometimes associated with the subtropical and tropical storms. (Alfonso, A y Florido, A, 1992). The most dangerous hazard in the tropical zone is the hurricanes, mainly when they have a trajectory along to the coasts. (Moya, et al. 2006)

The coastal zone is located W of the meridian 80°, considered the region of more frequency of occurrence of tropical hurricanes, tropical depressions and events migratory subtropical. They are the main generators of strong winds, intense rains and flooding low lying coasts.

On the other hand, the processes of coastal erosion have great relevance for the sand beach. The studies carried out during a long time, using topographical profiles and remote methods show that the beaches it is outstanding to execute a good program.Other important process, although slower and mostly concentrated in the winter station, it is the transfer of the grains of sand for the action of the wind, when this overcomes speeds bigger than 5 m/s. The balance of sediments produced by the interaction with the eolic effect is evidently significant, and it is object of specialized researches currently.

For all the above-mentioned it is evident that the most dangerous hydro-meteorological hazard that potentially can affect the tropical coastal zone is the presence of tropical storms and hurricanes, those can that produce significant impacts, in dependence of the speed of their winds, the precipitations and the elevation sea level over elevation (Juanes, J.L, 1996). Cuba is a typical example of very affected island for phenomena hidrometeorológical.

In Atlantic basin, Caribbean Sea and Gulf of Mexico, the multiannual variability shows periods of high and low activity with special period with moderate activity between 1825 and 1852. For instance in Varadero, located in Caribbean sea, (Fig. 2), being the June to November the riskiest period with the biggest frequencies in September and October (Table 1).(Moya, B.V. 2007).

In a 2009 years period, 32 hurricanes were reported, for an average of 0.15 hurricanes per year in Varadero, almost 1 hurricane every 6 years. During this period Hicacos was affected by 1 hurricane in 28 years and for 2 hurricanes in year in 2 occasions. (1933 and 2008). The period of more inactivity was between the 1953 and 1984 where they didn't register events, while in 3 occasions the affectation for hurricanes was in successive years. (1831 and 1832, 1875 and 1876 and 1894 and 1895). (Moya B. 2003).

The statistical analysis infers that the years with affectation for 1 hurricane have a period of return 5.9 years, while the years with 2 hurricanes they appear every 103 years (Table 2 and Fig. 3). Analyzing the hurricanes in last 200 year it was observed that at least 4 hurricanes reached great intensity in the area: in 1844, 1846, 1926 and 1933. The most probable hurricanes tracks in Matanzas, in general and near Varadero, in particular, shows in the follow figure. (Fig. 4)

Table 1. Hurricanes per month in Varadero and month's relative frequency. Period 1800-2008.

Months	June	July	August	Sept	Oct	Nov
Hurricanes	1	1	4	10	14	2
Frequence	0.005	0.005	0.019	0.044	0.067	0.010

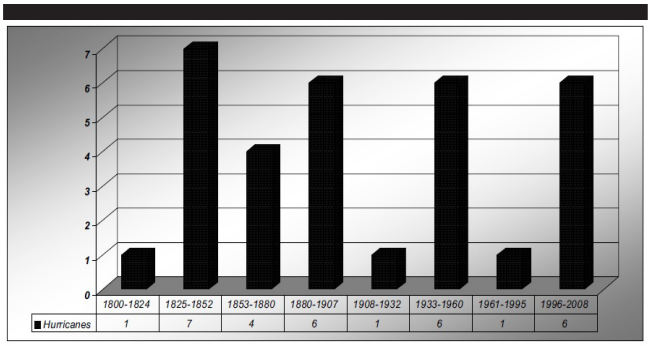

Fig. 2. Periods of high and low activity of hurricanes in the beach of Varadero, from 1800 up to 2008.

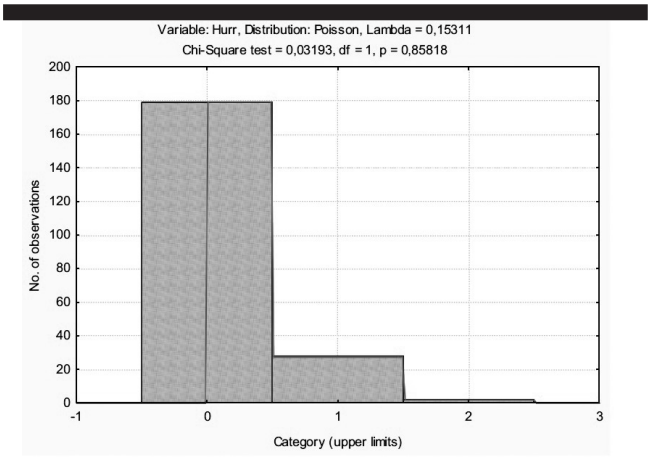

Fig 3. Years without, with one and with two hurricanes. Period 1800-2008.

Table 2. Hurricanes observed, expected and period of return in Varadero.

	Observed (hurricanes)	%	Expected (hurricanes)	%	Observed-Expected	Period Return (years)
Year=0	179	85,64593	179,3294	85,80353	-0,329376	
Year=1	28	13,39713	27,4571	13,13738	0,542871	5.9
Year=2	2	0,95694	2,2135	1,05909	-0,213495	103

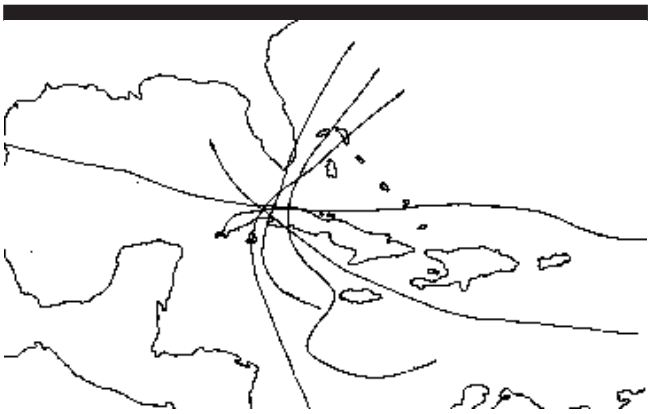

Fig. 4. Most frequent hurricane track in Matanzas and Varadero.

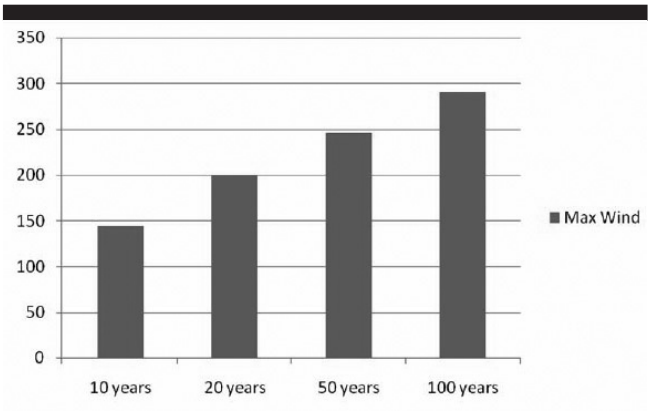

Fig 5. Estimated Values of the maximum winds. Period 1909-2005. (Lower limit) (Pérez R, et al. 2007).

The theoretical analysis of the maximum annual winds, developed by R. Vega in 1993 and Pérez R in 2007, expects an extreme value between 60 and 70 m/s in a 100 year period. However, in the meteorological series of Casablanca in the City of Havana (representative for the peninsula of Hicacos), there are two values upper the suggested by the theoretical distribution in the 80 year.

They are related with two hurricanes: one measured of 72.8 m/s and other estimated, from the minimum observed pressure and the damages produced damages, of 80 m/s in 1926. The study on hurricanes, estimated that a hurricane of maximum intensity with superior winds to 80 m/s can affect the area once every 100 years.

The following graph (Fig.5) shows the maximum probable gusts for different periods of return.

This hazard assessment is always necessary for the risk management. The knowledge of the hazard is the first step to develop an adequate risk program face to meteorological extremes.Following with the example of Varadero, the physical-geographical characteristics of the peninsula of Hicacos contributes in a certain natural susceptibility to the coastal risks (Cabrera, 2008).

Between the factors of susceptibility or natural vulnerability we can highlight the following ones:

– The configuration of the Peninsula, lengthened and it narrows, with less than two kilometers in their wider portion; and their southwest northeast orientation–

– Their geographical location, very near to the North American continent and the subtropical area, and of great exposure to the tropical and subtropical storms, and to the strong and persistent influence of the winds.

– The relief of young and unstable plains, with very little height on the sea level, and developed mostly on soft, sandy and sandy-loamy deposits, or weakly consolidated rocks

– The prevalence of climatic conditions of low precipitation and unfavorable hydric balance with a deficit upper 1000 mm a year

– A little developed soils covering.

To the above-mentioned it is necessary to add the action of the antropic process with economic taking place in the urbanization and tourism exploitation, producing modifications of the natural and original environment that are reverted in many cases in additional factors of the vulnerability of the territory. The knowledge of the vulnerability is the second necessary step for the risk determination and with this information and the hazard assessment, so it is possible develop a risk assessment as important part of the risk management.

Coast risk and integrated coastal management.

The World Meteorological Organization (WMO) sustains that, although the disasters cannot be avoided**,** the integrated evaluation of the risks and the early warming play an important role in the decreasing of their devastating effects and avoid the lost of the human lives. The Coastal integrated Management is convenient tool or mechanism where insert the coastal risk program.

In effect, the Integrated Management of Coastal (IMCZ) Zones have been constituted in a theoretical-methodological appropriate framework to approach the problem of the coastal risks.

It is considered the concept of integrated coastal Handling of Barragán (2008) which describes it as a process centered in the management and administration of the space and the resources guided to the sustainability of the coastal-marine environment, that is guided to the search of more balanced models between conservation / restoration of the resources and the human development, and in its application are implied public and private institutions.

It will be understood, then, that this management and administration the space and the coastal resources should necessarily include the study and management of the natural coastal risks.

Among the theoretical-practical principles in which the Programs of Integrated Coastal Handling are based stand out the following ones:

– The coastal areas are systems with high richness in elements, resources, ecological processes and natural fragility natural that require of a holistic focus holistic in its protection, management and rational exploitation.

– The identification of the impacts and the environmental problems produced by human activities, constitute the diagnostic and the first challenge, in the conformation, implementation and continuous improvement of the Program of Integrated Coastal Management.

The Integrated Coastal Management constitutes an adequate framework to develop strategies and programs face to coastal risks. The holistic knowledge focusing to the coastal area, avoiding the application of punctual solutions, often with negative effects in the adjacent areas.

The classic methodological sequence (using cycles, and the same way with other public politics) which evolves the implementation and design of a Program of Integrated Handling of Coastal areas (MIZC) is shown in the following figure (Fig.6)

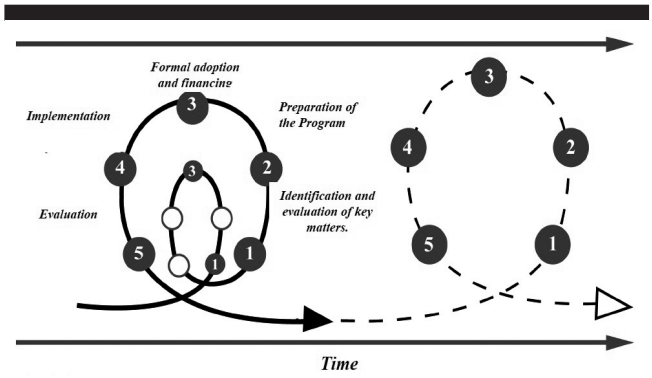

Fig. 6. Successive cycles of a program of integrated management of the coastal area. (GESAMP, 1996, Olsen *et to the one.*, 1999).

How do face the coastal risk's study and the management in the context of the integrated coastal management?

Following the methodological sequence which evolves the implementation and design of the Program of MIZC, its first step should be clarified it is the politic-legal and institutional framework for the risks management and study.

Then it is necessary a complex characterization and an integrated diagnostic of the coastal area allowing know the baseline of the natural hazards, the natural and anthropogenic vulnerabilities in the zone.

An analysis of the natural hazards is necessary at this time, focused to know its frequency, occurrence probability and period of return. It is necessary the hazard intensity and magnitude assessment, too. In the same way, the possible impacts should be known. In this sense it is good to know the worst option, but also the other hazards magnitudes and intensities. For the hazards simulation, the implementation of models is a useful tool to understand the hazards.

This characterization should show the strengths social weaknesses and the economic impacts that face to different hazards. In these studies the knowledge of hazard´s chronology is interesting because allow us to know from the past and present and facilitating what should be in the future. For this study is convenient the analysis of historic-evolutionary studies to know how has gone changing the natural vulnerability of the ecosystem.

The history of the land use change and the transformations in the socio-economic area. This knowledge is indispensable knowledge for the analysis about how the man has influenced in the vulnerability of the ecosystem. The use of cartographic of tools and teledetection are very useful in this analysis, and the historic knowledge of population and specialist is sometime very important for it. That matters.

In this phase it is interesting to study the level of hazard perception in the society, the same way the level of preparation of the people to face it, and know what are the vulnerability and strength for the risk management and their integration with MIZC. All this help in the determination of the key matters for the management, making the identification of the coastal risks play an important role.

The identification of the stakeholders participating in the implementation of the integrated management of the coastal area, is another steps in the risk management and its implementation in Coastal management. The identification and the stakeholder characterization, the clarification of their knowledge and their capacities or weaknesses, is a fundamental task to establish the operative framework in that risk management.

Arrived the moment to conform the Program of MIZC, is accepted include in an independent sub-program or a group of sub-programs. The actions addressed to reducing natural coastal risks and facilitate the adaptation to climate change are interrelated. The final goal is to reduce the vulnerability to the meteorological and climatic hazards.

The identification and forecast of the natural coastal risks, the emission of early warning, the communication the decision makers and the population in general, the capacitating and education in risks management and the systematic monitoring, among other, they are essential actions for the risk control and also constitute operative measures for the group of the integrated management in the coastal area.

For the best operation of coastal risk management in the MIZC context, is mandatory the conformation of executives and scientist-technical structures in charge to the implementation of each one of the actions. The 3rd table shows up in a synthesized way all the moments to develop the coastal risks management in the MIZC.

Table 3. Sequence of the coast risks management in the context of MIZC.

Phases	Essential Actions.
Previous Phase	Analysis of the policy framework of the beginnings.
	Analysis of the existing normative-legal base.
	Identification of institutions and the task assign them.
Characterization and Diagnostic	Integrated characterization in the work area (Baseline).
	Identification and characterization of hazards, including frequency, intensity and potential impacts.
	Analysis of the vulnerabilities.
	Risk assessments.
	Studies of the risks perception, particularly in decision makers and local population.
Planning of uses: adequation to the map of risks	Analysis of the functional sectorization of the coastal area and their correspondence with the levels of hazards and risks.
	Current and potential uses in function of the risks mapping.
Design of the action program	Establishment of the actions addressed to the detecting and forecast, emission of early warning and other warnings, capacitance and education about risk control, etc.
	Definitions of the measures of coastal defense, adaptation to the uses of the territories and planned retreat of housings and facilities of any type at the coast.
	Establishment of the actions in the stages that defines the Civil Defense: informative, alerts, warnings and recuperation.
Insurance, implementation and evaluation of the Program	Establishment of the institutional structure under those which to be implemented the planning and financial budget.
	Implement actions to pilot scale.
	Planning and development of program assessments, facilitating their permanent improvement.

Coast risks and integrated coastal management

The Integrated Program of actions for the sand beach proposes several work addresses, using subprograms with exchange among them, and their fundamental achievement has been the convergence of all the actors in the environmental and tourism management of the beach, led by a Coordinating Unit.

Among the main adopted measures stand out the absolute prohibition of the sand extractions, the elimination of facilities in the beach first line, the defense of some touristc facilities with high importance, building artificial dunes, with reinforced areas with geotextile padded of sand, allowing the dissipation of the wave energy. The same way a rigorous planning and control of the new investment is developed in the peninsula.

In synthesis the follow measures and actions have been introduced in the coastal zone.

Shedding and maintenance of the beach

The feeding of sand to the beach has been implemented, mainly in the critical sectors where the erosion process has decreasing the areas of sand, in which the narrowing of the sand is appraised, with rocky upwelling. Developing technical projects and tasks previously elaborated leading the feedings. This process also contributes to the restoration of morphology of the beach and the retention and accumulation of sand.

Actions of particular technological scientific meaning and great socioeconomic repercussion have been the great sand shedding, and have allowed to improve in short time the physical conditions and the sand strip in the beach.

The execution of the project of shedding of beach is one of the most important actions developed in the coastal zone. For instance, in 1998 1 087 000 m^3 of sand that extended to the 12 kilometers With the preparation from Institute of Oceanographic of Cuba and executed with high quality and minimum time by the Dutch Company of dredged Blankevoort, and it is considered as one of the most effective in the world. The results monitoring developed 4 years later showed a very positive 80% of retention of the added sand.

The artificial accommodation of the sand with transportation of the excessive sand deposited in zones of increase of the beach towards the critics zones of coastal erosion. Besides to all this actions focused to the solution of the problems have been implemented that cause the eolic erosion during the winter season and the pluvial erosion in some specific zones of the beach.

These actions also include, the dune conformation and the reinforcing of the ones already existing, because many parts of the coastal zones are of low-lying land with risk of inundation by sea flooding , with which also was fulfilled the objective to create a defense for cases of extreme events.

It is important to emphasize that these methods to develop the shedding and all the actions of maintenance of the sand have been very effective in the physical improvement of the beach with a minimum impact on the ecology and environment. These actions improve the resistance of the beach, decreasing the vulnerability and risk and also avoiding the implementation of costal engineering, with hard measure and bigger impacts in the environment.

Dune rehabilitation

The morphologic of the dune and vegetal of the dunes rehabilitation, it have a significant role in the natural stability of beaches. Some problems have been identified in different sectors, such as inadequate deforestation of the native vegetation, ecosystem fragmentation, inadequate access, deterioration in landscape and its general function. Face this situation, was orchestrated scientist-technical solutions improving the morphologic conformation and reforesting with typical species of dunes. (Cruz, 2008).

Physical planning and ordering of the coastal zone

The environmental regulations related to the coastal ordering have become more and more rigorous, and in this sense it is possible to emphasize in the correct location of facilities behind dunes, the use of a detachable rustic design of those facilities, mainly on piles, and the optimal management of the liquids or solids wastes, from the temporary facilities that offer gastronomical and recreational services in the zone of beach.

Complementarily, other measures addressed to regulating the accesses have been orchestrated in the beach, stimulating the effective construction of wood path and other techniques, as well as regulating the behavior of the users of the beach, applying informative and regulative signs with the objective to contribute to the environment education of the users.

Demolition of walls and facilities. Environmental reordering of the coastal zone

From the beginnings of the beach protection integrated management, the presence of facilities in the beach and in the dune, was reason of preoccupation by the fort impact that causes its actions for the natural dynamics of the beach.

In those places where constructions are located on the dune it is necessary the elaboration and put it in practice a demolitions plan and rehabilitation of areas of the beach. An example in Caribbean Sea is found in Varadero beach with the demolition of more than 80 facilities, mainly houses from tourist facilities, second houses and more than 3 000 meters of walls and fences in the critics zones from the point of view of the erosion of the beach, it is a good example. This continuous program in execution at this moment goes on to the demolition of other facilities that cause greater coastal erosion.

This work should be coordinated agreement of the Coordinating Unit of the coastal Zone Program with the authorities of the Tourism and other economic activity in the coast, and the Government, making joint decisions, taking in consideration the situation of the beach in each sector, the technological possibilities to execute the actions and the recuperation of these zones, the plans for the future development of the tourist destiny, the present use of the facilities and its economic behavior as well as the cultural and social historical values, and the level of conservation of the building (Institute of Oceanology, 1996). Later very positive valuations have taken place about the benefits that this measurement in the beach stability, although is clear that these processes are also influenced by natural factors still presents in the zone.

Complementarily, given historical, architectonic or social values in some facilities have a great economic value, also orchestrated protections, using the technique of geotextiles (sandttainer or sandbags), which are made of textile materials, with a high resistance to the tension and the wearing down by abrasion, and have been placed in such a way that they work like dissipater of the energy of the wave This technique with sandbag, that has been applied in numerous important facilities of the tourism, has the advantage of which when happening the years and breaking the material, the sand is recover for the dynamic of the

beach and it contributes to improve the beach profile, without negative consequences for environment.

Scientific and integrated Monitoring of the beach

A monitoring of a group of structural and functional parameters of the beach it is very important, and this information contributes for the characterization of the ecosystem, and it has constituted in a solid base for the decision making in relation to the operation and the protection of the beach too. At the same time the monitoring has served to assess the effectiveness of the measures taken in any coastal area of sandy beach.

Coastal integrated Management also includes actions directed to the researches, the information and for environmental education and supervision. Scientific projects have studied the biological sand production, the rehabilitation of dunes. The influences of the global climatic changes and of the coastal risks have priority in the scientist activity.

The capacitating and environmental education extend more and more towards the different sectors from the local population, keeping integration between environmental culture and the general culture. This integration has taken deep root with the protection and use of the beach (Cabrera, 2008).

As is possible understand, this program for the coastal integrates management has journeyed important phases already. First the key subjects were identified, from the previous diagnostic, was later obtained the conformation and the formal adoption of the program, which implied an arduous process of consultations, questions and successive readjustments, until to obtain the approval from the local government, and the essential definitions of budgets.

Important aspects in the program for the coastal integrate management are:

– The real solution of the problems and risks previously identified

– The Inter-institutional coordination and the qualification of the personnel with responsibility in the environmental and tourist management of the beach

– The continuous monitoring and the development of new researches that guarantee the necessary feedback for the planning and attention to new problems and exigencies of the development. Recently a first assessment process of the implementation of the Program was culminated, and it was possible to be responded to key questions, such as

– What has been reached, how has changed the context since the program began?

– What new approaches and actions must be adopted like part of the continuous improvement of the Program?

The assessment shows that the program is causing positive changes in key aspects, very closely related to the control of the coastal natural risks and the decreasing of the vulnerabilities, such as a maintenance and systematic improvement of the sand area, the rehabilitation of dunes, as much from the morphology like the vegetal cover, the rigorous coastal environmental ordering, the increasing development of the monitoring actions and the development of research projects and scientific exchanges. All these actions have transformed into a strong support of the integrated coastal management, decreasing the vulnerabilities of coastal zone to natural hazards and off course, decreasing risk too.

CONCLUSIONS

It has been argued that the focus of the Coastal integrated Management is a general philosophy of work, with methodological phases perfectly established and a very good opportunity to develop adaptative capacities and decrease vulnerability face to the natural hazards. It is a special space to develop a risk integrated management.

The application of the risk management into the Coastal integrated Management in the sand beach requires an appropriate mark: of coastal governance, a permanent process of identification, assessment and monitoring of coastal risks, decreasing the natural and antropic vulnerabilities. In this way also has contributed to the high quality environmental education and capacitating for decision makers, stakeholders and people in general. All that allow an improved answer, an effective recuperation and a better risk damage prevention face to coastal natural hazards, finally allow a real decreasing of the coastal risks.

RELATIONSHIP OF FIGURES AND CHARTS

Fig.1. The Poisson probability density function for four values of λ.
Fig.2. Periods of more and smaller activity of hurricanes in the beach of Varadero, from 1800 up to 2008.
Fig 3. Years without, with one and with two hurricanes. Period 1800-2008.
Fig 4. Most frequent hurricane track in Matanzas and Varadero.
Fig 5. Estimated Value of the maximun wind. Period 1909-2005. (lower limit).
Fig. 6. The successive cycles of a program of integrated management of the coastal area (GESAMP, 1996, Olsen *et al.*, 1999).
Tabla 1. Hurricanes per moth in Varadero and month relative frequency. Period 1800-2008.
Tabla 2. Hurricanes observed, expected and period of return in Varadero.
Tabla 3. Sequence of the administration of coast risks in the context of the MIZC.

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