

## GEOMORPHOLOGY OF RIO ITABAPOANA COASTAL PLAIN (ESPIRITO SANTO, BRAZIL) AND APPLICATION TO ITS VULNERABILITY

Contti Neto, Nery<sup>1,3</sup>; Albino, Jacqueline<sup>1</sup>; Coelho, André Luiz Nascentes<sup>2</sup>  
nerycn@usp.br

<sup>1</sup>- Departamento de Oceanografia e Ecologia - Universidade Federal do Espírito Santo;

<sup>2</sup>- Departamento de Geografia – Universidade Federal do Espírito Santo; <sup>3</sup>Instituto Oceanográfico - Universidade de São Paulo (Praça do Oceanográfico, 191)  
Cep:05508-120 - São Paulo - SP - Brasil

*Keywords: Presidente Kennedy, Coastal Vulnerability, Quaternary evolution*

### ABSTRACT

The geomorphologic vulnerability of Rio Itabapoana Coastal plain is studied from the perspective of beach and inland variables, splitting the area into five classes, ranging from high vulnerability to low vulnerability. Four stations over the beach were analyzed regarding sediment size statistics, beach profile and waves size. Also, an analysis of satellite images gave an idea of which areas within the coastal plain are flooded according to the river flow (measured data). The Quaternary evolution of the plain determined the vulnerability, as the most vulnerable areas are the lowest (ancient coastal lagoon) and closest to the current beach (affected by sea-level rise). The least vulnerable are the areas lying within the Holocene beach ridges, in the southernmost part of the beach arc, which are the highest (obtained from SRTM data). It is expected that this work could help stakeholders to make an occupation plan over the municipality.

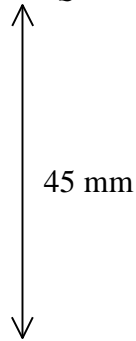
### INTRODUCTION

Although the term Vulnerability is not fully defined, it can be understood as a connection between two factors: susceptibility, which is intrinsic to the environment and determines its capability on resisting an impact given its natural aspects (biological, physical and geological); and risk, which is a function of human activity, and varies according to the type of this activity (DUTRIEUX *et al.*, 2000).

There is a current need for the elaboration of occupation plans, avoiding vulnerable areas, in order to prevent people from natural disasters, like floods, which are one of the greatest problems in Brazil lately (SUGUIO, 2001). Understanding geological settlement of the area is vital to avoid vulnerable areas. As Rio Itabapoana coastal plain was constructed during the Quaternary, its evolution during this period must be studied. The only study available for the area gives an age of about  $5,230 \pm 230$  years (MARTIN *et al.*, 1996)

The aim of the present work is to define vulnerable zones within Rio Itabapoana coastal plain, given its Quaternary evolution and sazonal dynamics (wet and dry seasons).

### MATERIAL AND METHODS



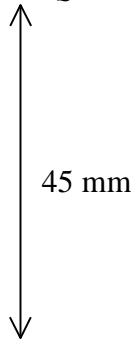
The beach vulnerability was studied with a different methodology from the coastal plain, apart from each other, but both were joined together after, giving a singular vulnerability result. To study the beach vulnerability, four stations along Praia das Neves and Marobá were sampled, each separated by about three km. On each station, one sample from the berm and one from the beach face were collected and analyzed according to Suguio (1973) methodology and separating the classes according to Folk and Ward (1957). The software Gradistat® was used to give the statistics of the samples. The beach profile, the mean wave high, the wave period were also collected and observed in each station. In laboratory this data could be calculated by Wieger (1964) classification (regarding mean grain size and beach slope), which separated the stations between exposed, semi-exposed and sheltered beach. Brunn rule (Brunn, 1962) was used to determine the local shore erosion, with the help of nautical charts, from the Brazilian navy. Those results were also put in comparison with the limits defined according to Muehe (2001) for the Brazilian shore.

The coastal plain vulnerability was studied through satellite images. First, aerial photographs from *Instituto Estadual do Meio Ambiente* (IEMA, 2008) and *Instituto de Defesa Agrícola e Florestal* (IDAF, during the 1970's, RADAM project) were used to determine geomorphology. Landsat and CEBERS series were used to monitor flooded areas as river flow increases or decreases (data obtained from the software SisCAH® and plotted in software ArcGis). Finally, the altimetry was obtained from SRTM data. With the use of this software and the data obtained, the vulnerable areas could be drawn.

## RESULTS AND DISCUSSION

Topography (FIGURE 1), mainly resultant from geomorphology (thus, Quaternary evolution), showed that Holocenic beach ridges constitute a high area (reaching 8m high) surrounded by low-areas. The backhand from the beach-ridges is practically uniform (varying only 4m), resulting from the drowning of Rio Itabapoana valley. Eventually, some Pleistocenic beach ridges reached over 8m high, but this is not true for all the ridges, as erosive processes took place over sandy deposits; besides, there had been an association of those beach ridges with the island-barrier system (DOMINGUEZ, 1981). MARTIN *et al.* (1988) found similar altimetry results for Barrier III in Rio Grande do Sul, with ages around 123.000 B.P.

Satellite images (over 30 were used) showed that the geomorphology of the barrier-island, in direct discordance with paludal deposits practically stayed the same over flood events. However, the whole coastal plain of Itabapoana River during flood events ( $Q_5$ , return period of 2 years) is flooded, and fortunately it is barely occupied. Thus, it can be inferred that even the greatest flood events that took place over the last 30 years weren't able to modify the landscape (examples are given in FIGURE 2). The shoreline hasn't changed greatly either (since 1970), which indicates that this is a stable area regarding oceanographic aspects. In regards to the vulnerability of the shoreline, the southernmost station was the least vulnerable, being classified as sheltered beach, as the northern part was classified as exposed beach and the most vulnerable. The Brunn's rule for all the stations agreed with Muehe (2001) proposal,



with small variations, thus, the last one was used. FIGURE 3 shows the areas and the vulnerability of each one.

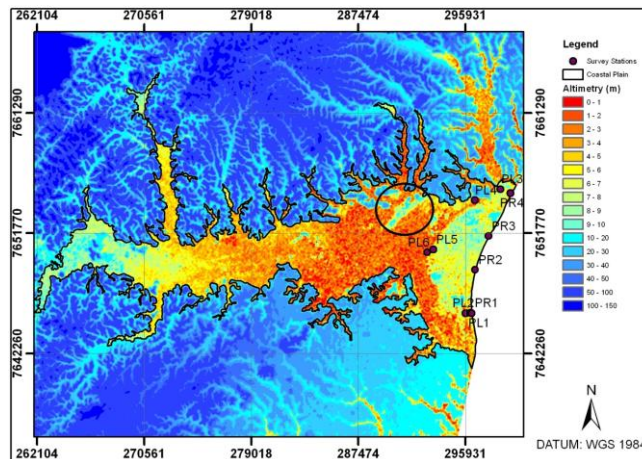


FIGURE 1: Altimetry of study area

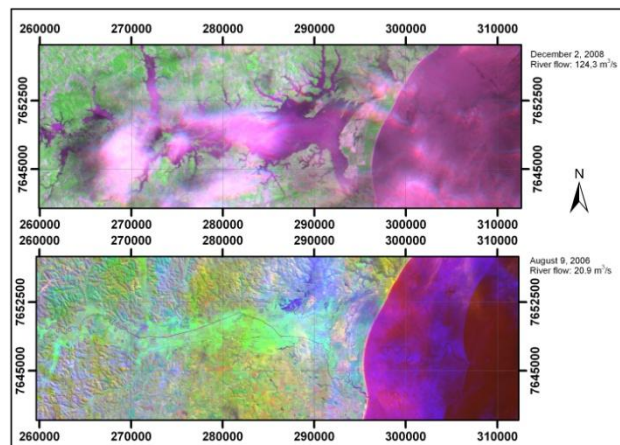


FIGURE 2: Satellite images showing flooded areas and permanence flow

Very High vulnerability zone corresponds to Mangroove areas; the ones over the coastal plain that are constantly flooded (as shown above); and a zone within 50m to the actual sea-level, that would react to a sea-level rise of 30 cm. The High Vulnerability zone corresponds to the area that would react to a 1m of sea-level raise and the Pleistocenic beach ridges, which, despite from reaching over 6m high, are surrounded by low-areas. The Medium Vulnerability zones corresponds either to the paleo-barrier-island (DILLENBURG AND HESP, 2009) and to a zone within 500m from the actual sea-level, that would respond through its groundwater to a rise of sea-level. Low to Medium vulnerability corresponds to the low area within the Holocenic beach-ridges, which are eventually flooded.

45 mm

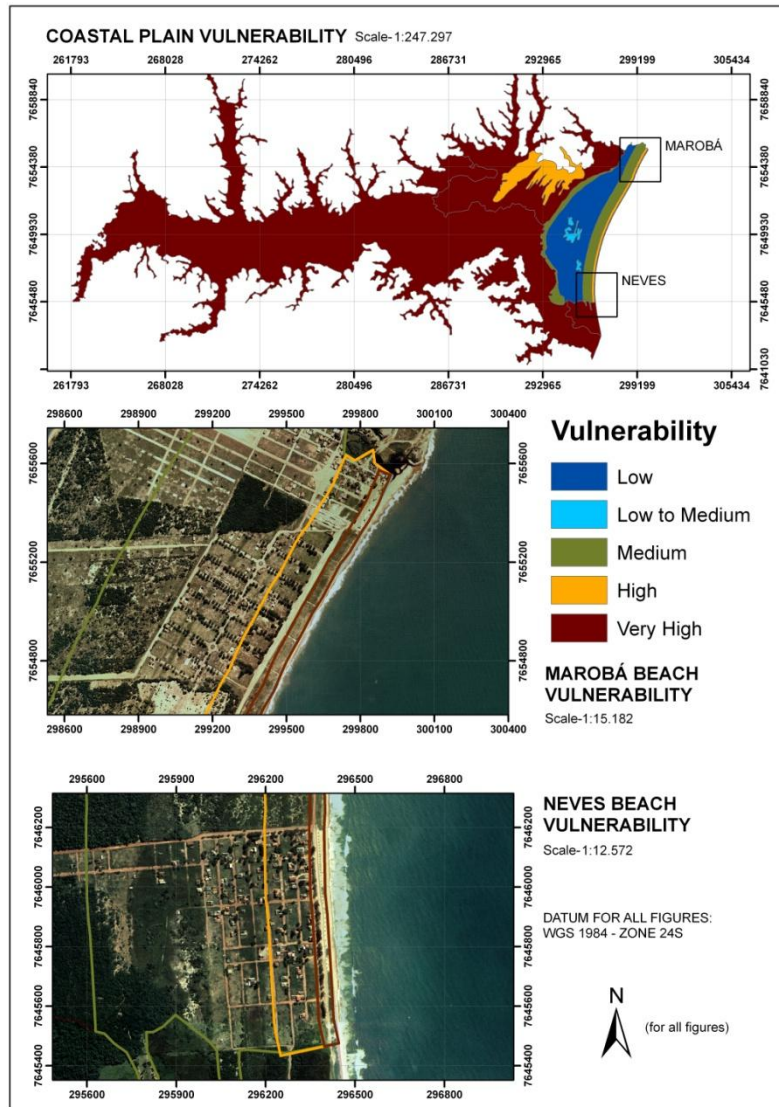
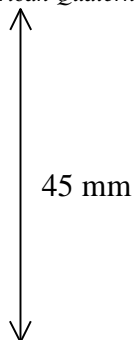


FIGURE 3: Vulnerability of the Coastal plain

It is right to assert that the most recommended areas to occupy (Low Vulnerability) are the Holocene beach ridges, especially the ones closer to its backhand side.

## CONCLUSIONS

Quaternary evolution is mostly likely the cause for vulnerability, as it is responsible for the altimetry. The methodology applied to study the coastal plain origin from its sediment and geomorphology fit within the reasons for which the areas are currently flooded. The Pleistocene beach ridges, that were flooded by a coastal lagoon during the late Quaternary



was eroded, being lower, thus, more vulnerable. On the contrary, Holocenic beach ridges, that constitute ancient beaches are higher and the, less vulnerable. The use of satellite images together with river flow data was satisfactory and easy to apply. The relationship between riverflow and flooded areas can help stakeholders to decide whether the occupation is feasible or not within a region.

## REFERENCES

- BRUUN, P., 1962. Sea level rise as a cause of shoreline erosion. *Journal of Waterways and Harbor*, 88: 117
- DILLENBURG, S.R.; HESP, P.A., 2009 *Geology and Geomorphology of Holocene coastal barriers of Brazil*. Springer
- DOMINGUEZ, J., BITTENCOURT, A., & MARTIN, L., 1981. Esquema evolutivo da sedimentação quaternária nas feições deltaicas dos rios São Francisco (SE/AL), Jequitinhonha (BA), Doce (ES) e Paraíba do Sul (RJ). *Revista Brasileira de Geociências*, vol. 11, n.4, pp. 227-237.
- DUTRIEUX, E., CANOVAS, J. D., HÉNOCQUE, Y., QUOD, J., & BIGOT, L. (2000). Guide méthodologique pour l'élaboration de Cartes de Vulnérabilité des zones côtières de l'Océan Indien. 40p.: *IFREMER/UNESCO.IOC Guides and Manuals* 38.
- Instituto Estadual de Meio Ambiente e Recursos Hídricos – IEMA, 2009. Aerolevantamento do Estado do Espírito Santo na escala de 1:10.000 nos anos de 2008-2009. *Instituto Estadual de Meio Ambiente e Recursos Hídricos – IEMA*.
- MAZZER, A., 2007. Proposta metodológica para análise de vulnerabilidade da Orla marítima à erosão costeira: aplicação em praias arenosas da costa sudeste da Ilha de Santa Catarina (Florianópolis, Santa Catarina-Brasil). Porto Alegre: *Tese de Doutorado em Ciências*.
- MARTIN, L., SUGUIO, K., FLEXOR, J.M. (1988). Hauts niveaux marins Pleistocenes du littoral Brésilien. *Paleogeography, Paleoclimatology, Paleoecology*, 68:231-239
- MARTIN, L., SUGUIO, K. F., & ARCHANJO, J. (1996). Coastal Quaternary Formations of the southern part of the State of Espírito Santo (Brazil). *Academia Brasileira de Ciências*,
- MCFADDEN, L., & GREEN, C., 2007. Defining "vulnerability": conflicts, complexities and implications for Coastal Zone Management. *Journal of Coastal Research*, Special Issue 50 (Proceedings of the 9th International Coastal Symposium), pp. 120-124.
- MUEHE, D. (2001). Critérios morfodinâmicos para o estabelecimento de limites da orla costeira para fins de gerenciamento. *Revista Brasileira de Geomorfologia*, 2, 35-44.
- SUGUIO K, (1973). *Introdução à sedimentologia*. Edgard Blucher, Sao Paulo, 317p
- SUGUIO, K., 2001. *Geologia do Quaternário e Mudanças Ambientais: Passado + presente = futuro?* São Paulo: Paulo's Comunicação e artes gráficas.