Monitoring of Coastal Erosion - Study from Beaches of Rio Doce and Casa Caiada – Olinda/PE –Brazil

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Abstract. The surface of the Earth provides the most variable aspects of difficult classification, representation and interpretation. Know the topology of the terrain have a vital importance for the preservation of the environment. The physical spatial representation studied by the Cartography, provides excellent contributions for planning in distinct areas. The objective of this research is the coastal erosion in urban areas (contributions from Geoinformation Technology – in the research of coastal erosion) and the sustainable coastal management, specifically in areas where there are antropic effects due to human occupancy. This study aims to generate spatial data that will allow the preventive and corrective planning in coastal zones, to ensure the environmental and touristic potential of the region, as well as the economic Sustainable development of the local inhabitants. Selected for this study, were parts of the beaches of Casa Caiada and Rio Doce, located in the City of Olinda, State of Pernambuco, Brazil.
Keywords: monitoring map, coastal line, erosion

1. Introduction

The coastal area has one of the most dynamics features of the planet and its position varies on many time scales, affected by a lot of factors, of natural origin intrinsically linked, and others, caused by human interventions in their area, such as dredging, ports, dams, among other human activities.

Two aspects should be considered on relating to the coastal fringe. First,

the recreational use of beach called “foreshore”, and the second is the upside area, called of “inside platform”. In the present study will only aim the first point. Understanding the dynamic processes that occur in “foreshore” will became able to define the phenomenon of coastal erosion.

The finding of coastal erosion comes from the knowledge of the local situation, among other things, so the situation of a particular stretch of beach results in emerging of sediments. In the positive case the beach towards the sea, the phenomenon is called “progradation”; and in the negative, the shoreline retreats toward the mainland, this phenomenon is known as erosion.

In Brazil, the erosion has been explained as:

- the result of the intrinsic defaults dispersion and transportation of coastal sediments, and;
- a product of human interventions in coastal areas for construction of engineering works or inadequate use of the soil.

Olinda, the research area, is considered by UNESCO since 1982 as a World Heritage of Humanity, has in tourism as its main source of economy. Activity contained in globalization and that highlights the importance of the city within metropolitan, state and national levels.

The process of coastal erosion in Olinda was intensified in the last century, and to show the changes that occurred in the area, it must had to be recovery the conformation, to execute the monitoring of events through of old cartographic documents, been studied the progress of the sea and evolution of urban occupation.

The methodology use concepts of cartography, assuming that the occupation of the man should take place based on the physical and territorial planning. In this case, first is necessary to know the area. This is possible through the formulation of spatial database. In the acquisition of spatial data are used technologies of Geo-Information, particularly, in this study, we used the geodetic positioning by satellite, as well as population data. The Systems of Geo-Information are powered by a spatial database, and about this database are made analysis and simulations.

The research resulted in the production of cartographic documents, such as time series (1974, 1984, 1996 and 2000), consist of the following information plans: coastline, road network, hydrography and urban morphology.

2. Geoinformation Tecnologies

The concept covers the acquisition, the processing, the interpretation and the analysis of data referenced (geographic information, like latitude, longitude and altitude sometimes). Involving technologies: GPS (Global System of Positioning), Digital Cartography, GIS (Geo-Information System), orbital or aerial surveys, among others

These technologies include various areas of scientific knowledge, from the Geodesy and Cartography, until the computer science and various fields of engineering and geography, through Marketing and Management.

3. The Tendency of the atrophic occupation and the coastal urbanization

One of the major causes of environmental impact on the existing shoreline is, without doubt, his disorderly occupation (AGENDA 21, 1995). The intense process of population pressure in these regions are the result of the split for urban housing, leisure, tourist activities, policies, port and industrial, reflecting directly on a continuous destruction of the local environment and landscape, through of deforestation and destruction of mangroves, estuaries, among others.

The accelerated process of occupation of the coastal area worldwide, stimulated by the attractions of the area, generated an increase in the number of megacities and “protomegacities”. According to the theory of Ekistics, the trend of urban growth in the 21st century will lead to creation of an “ecumenopolis” (planetary urban system), including coastal ecumenópolis, in other words, the urbanization of all coasts of the planet. (Vallega, 2001).

To discuss the development trends of the coastal zone within the context of urbanization has led the scientific community in the 70s, to direct the researches and promote forums whose central theme was the awareness of environmental impacts caused by man, involving the areas and their ecosystems. According Vallega (2001), "... the activities undertaken by man are already influencing the atmosphere, which resulted in the calls of the greenhouse effect, which is the causative factor of the theory of the worldwide change package, which among other environmental problems have caused the changes in sea level”.

Still, according Vallega (2001) he has realized a study using estimates and presented at the United Nations Conference talking about Environment and Development, presented too to The International Geosphere-Biosphere Program (IGBP), raising the global changes, involving the coastal areas, and had prepared a summary table with the predictions of global change, with the situation of global warming and the changing of sea level in the year 2100.

According to Chapter 17 of the AGENDA 21, Brazil (1995), the population trend for the year 2020 estimated to exceed 8 billion people, also emphasizes that 65% of cities with more than 2.5 million residents were located in the coastal zone.

3.1. Brazilian Coastal Zone Population Dynamics.

The occupation of the Brazilian coastal zone by human groups with different objectives and different cultural components is historical, demonstrating the behavior of man in choosing the most favorable places for occupation. Initially, the groups occupied strategic locations able to exercise of fishing (beaches, edges of lagoons, lakes, rivers). (AB'Saber,1990).

In Brazil there are 258 (National Coastal Management, 2000) coastal municipalities, and eleven of the twenty-two metropolitan areas of Brazil, are available on the coastal areas, aggregating approximately 23.9% of the population of the country. The cities grow in a disorderly manner, especially with regard to sanitation, health and housing. The people of lower social classes live in precarious life style, in the margin of essential services, causing, in some situations, environmental degradation.

4. Study Area

4.1. City of Olinda

Olinda is one of the municipalities in the metropolitan region of Recife - RMR, state of Pernambuco (Figure 1), located in the eastern part of Northeast Brazil. Created by a decree dated in May 30 of 1815, and abolished in 1833.

The city is between the parallels 7 ° 57 '30" and 8 º 02' 30 " South latitude and meridians 39 º 49 '41" and 39 º 55' 00 "longitude Greenwich, occupy-

ing an area of 43, 55km² according IBGE (2002). The population according to Census 2000 (IBGE, 2000) is of 368,643 inhabitants, and has a demographic density is of 8991 inhabitants / km², the highest in the state and one of the largest of Brazil.

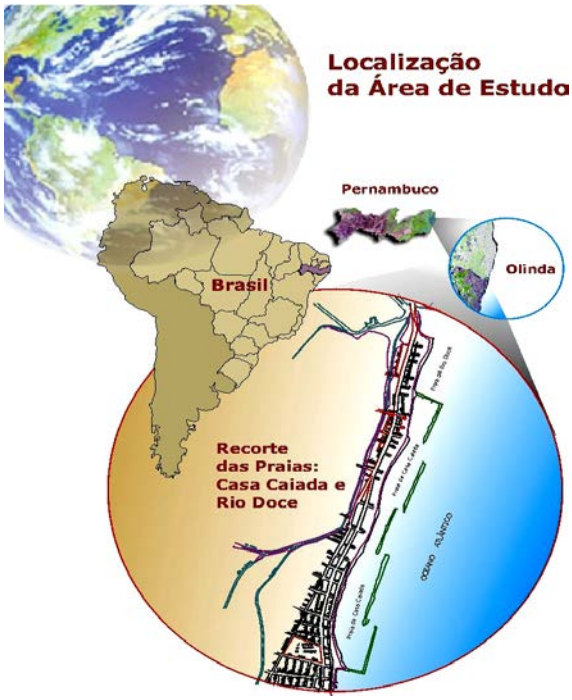

Figure 1 –location map of Olinda

4.2. The Coastal of Olinda

Olinda coast's consists of 10.5 kilometers of open coast, characterized by sandy deposits, comprising the beaches of: Istmo, Milagres, Carmo, São Francisco, Casa Caiada and Rio Doce.

The coastline of Olinda is certainly the largest municipal landscaped site and is of great economic importance, since it is on the coast that are concentrated most of the population and commercial activities, recreation and tourism.

The Environmental Audit of Olinda (CPRH, 1994) has identified four stretches of the coastline (Figure 2) which they submit different environmental problems such as water unsuitable for swimming, sea erosion, difficult access to the beach, disposal of waste, including others, as: the Sector 1 - from Istmo beach from Milagres beach, Sector 2 – Milagres, Carmo and

São Francisco Beach, Sector 3 - beaches of Farol and Bairro Novo, and finally, Section 4 – beaches of Casa Caiada and Rio Doce. The area selected for this study is consisted of the beaches of Casa Caiada and Rio Doce, which is located in Sector 4, because, presents erosion.

4.3. Beaches of Casa Caiada and Rio Doce

The stretch between the Dr. Manoel R. Lima Street until the mouth of the river Paratibe has a length of approximately 4km. It features sandy beaches in some places are completely submerged by water during high tide.

In the study area showed the presence of protective buildings, five dams built in the sea, away from the beach, and two Groin implanted perpendicularly to the coast. The Photo 1 shows a view of the beach of Casa Caiada. The area is heavily used for swimming, playing football and contact sports such as swimming, sailing, rowing, as well as for fishing and mussel.

5. Coastal Moviment in Olinda

According to the study of the Coastal Monitoring of Olinda (CPRH, 2000) changes in the Istmos beach were initially caused by the works of the Port of Recife. The works have resulted in big impacts on coastal systems on north of the city of Recife. Initially, the vision of the interventions was to protect the Port of Recife from stock caused by the waves, but that was prolonged the natural breakwater, and than were built a coral-collimated wall until the coast, reaching 4km long, the building of Olinda with 800 meters and the breakwater of the “Banco Ingles” with 1.150m long.

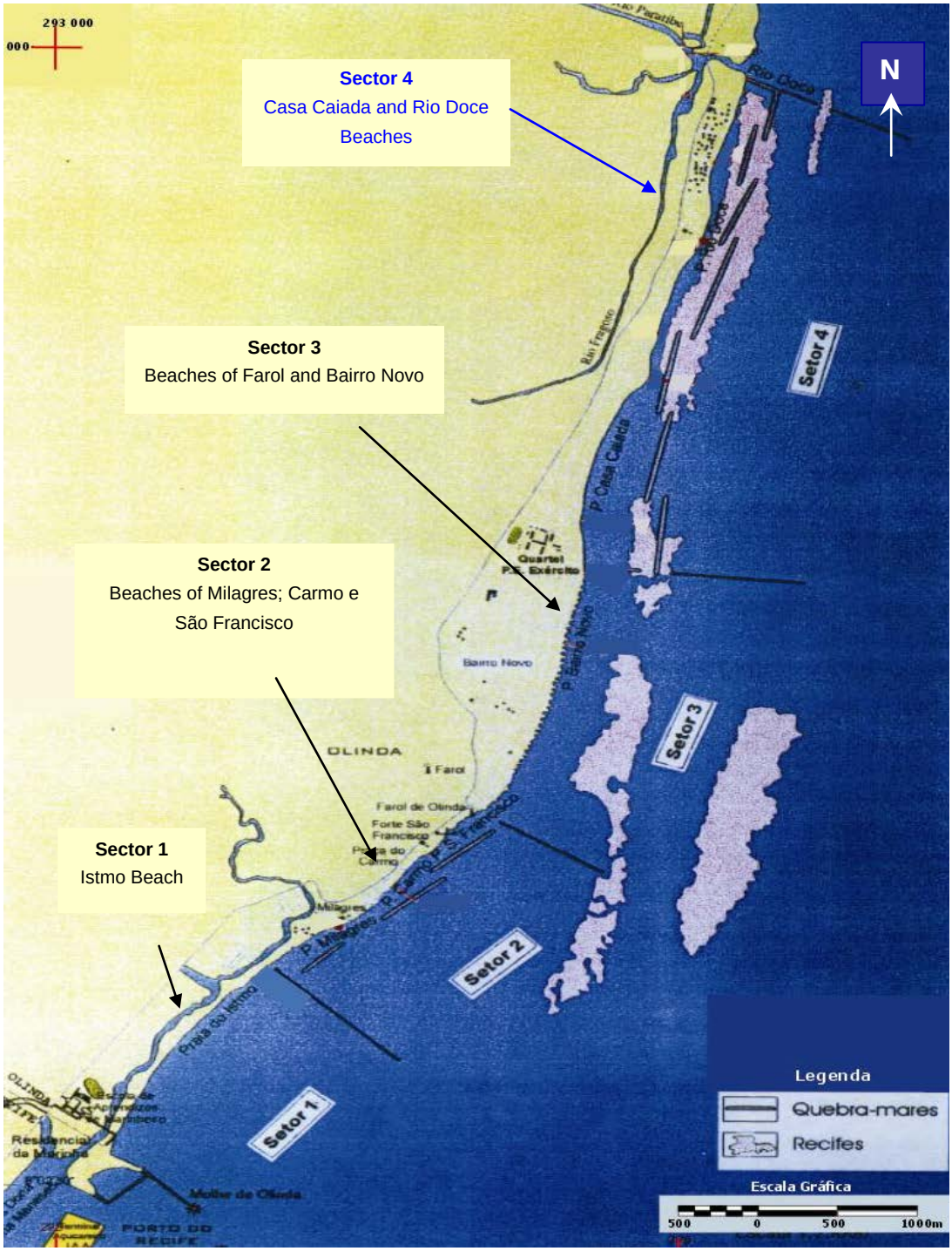

Figure 2 - Map of Sectors of Olinda . Source: CPRH (2000)

Photo 1 - View of Casa Caiada Beach

The position of the coastline of Olinda, between 1915 and 1950, experienced a significant decrease of approximately 80meters, resulting in an intense erosive processes, who settled mainly on the beaches of Milagres, do Carmo and São Francisco.

The Photo 2 shows a house hit by the sea, in the beach of Milagres, which serves as testimony of the advancing of the sea at the beginning of last century.

The Navy Ministry called in 1953, Laboratori Dauphinois d'Hydraulique Neyrpic (Grenobre, France) a proposal for the feasibility study whose objective was the construction of a Naval Base in Recife.

Photo 2 – View of the beach of Milagres in 1950. Source: Mr. José Maria, 1940.

The deterioration of coastal erosion on the beaches which includes the area between the pier and the lighthouse of Olinda, was noted by the National Department of Ports, Rivers and Canals (DNPRC) which approve the extension of the offer made by the French (CPRH, 2000), including a new study of protection of beaches, which was initiated in 1954 and works started in 1958. The project appoint for the construction of two long breakwaters semi-submerged, opposite to the beaches of Milagress, do Carmo and São Francisco, in association with six short Groin, consisting of released rocks, three in north and three in South of the stretch protected by the breakwaters.

The works carried ensured the protection of the coast, however there was not concern about the regeneration of beaches. In the while the city grow to the north, the problem of erosion shown to be uncontrollable and is became more severe (CPRH, 2000).

During the last decades, various interventions were performed in order to maintain and restore existing structures. The other projects were not implemented due to the high cost and scarcity of resources, CPRH (2000).

5.1. Moving of Casa Caiada and Rio Doce Coastline

The coastline of Casa Caiada and Rio Doce beaches has three small coves, corresponding to the portion of the coastal plain, represented by a narrow strip of beach. The signs of retreat of the coastline in the last fifty years are evident (Photo 3).

The calculation of the evolution of the coast, as well as indefinition rates of erosion and sedimentation and the degree of vulnerability, require the comparison of cartographic documents of different periods.

According to MLO (CPRH, 2000), almost all coast of Olinda is stabilized by the works of engineering, directed towards in the containment of the advance of the sea. The only exception is the beach of Istmo, which is in its natural state.

Photo 3 - Ruins of an Old Residence Source: CPRH (2000)

5.2. The Cause of Erosion in Olinda

According MLO (CPRH, 2000) the advance of the sea has caused severe environmental damage in the coastal area of Olinda, which may have been caused by a combination of several events, particularly the reduction of sediment supply of the beaches, the presence of lines reefs parallel to the coast, connected to the large development of calcareous algae, inhibiting the transport of sand from the inner shelf to the beach, and finally, the numerous interventions for improving the Port of Recife, and the protecting system itself ,which modifies the pattern of movement of sediments in the area.

6. Development of Research

Different cartographic survey and various methods of spatial data can be adopted, for the determination of the coastline. The most common cartographic documents are aerial photographs, satellite imagery, maps and Orthophotos. In the surveys are used total station, levels of precision and GPS.

6.1. Methodology

The methodology (figure 3) used in this study, is based in the application of Geoinformation System allied with the GPS technology. The area was a clipping from the beaches of Casa Caiada and Rio Doce, was generated weather series of the years 1974, 1984, 1999 and 2000. The coverage coastline, a containment and urban fabric were overlapped in the GIS, in order to track and monitor changes in the coastline, as well as significant changes in the landscape.

6.2. Acquisition of Cartographic Documents

In the research were carried out bibliographic and interviews surveys, allowing the understanding and analysis of the dynamic of the beaches. The study of urban occupation was essential to assess the displacement of the shoreline/coastline and anthropogenic interference with this process.

The cartographic databases used in the study were provided by the Municipal Development Foundation of Pernambuco - FIDEM.

6.2.1 Scanning

The cartographic base was not available from magnetic media, it was necessary to do a conversion of cartographic documents to a digital medium, the structure of vector representation. The Orthophoto were digitalized in the program like CAD, Microstation.

To form the coverages were digitalized, the following levels: blocks, place names, road system, measured points, hydrography, municipal boundary, the boundary between neighborhoods, vacant land, notable points such as: church, barracks, etc.; spikes members , reefs, and finally, the coastline

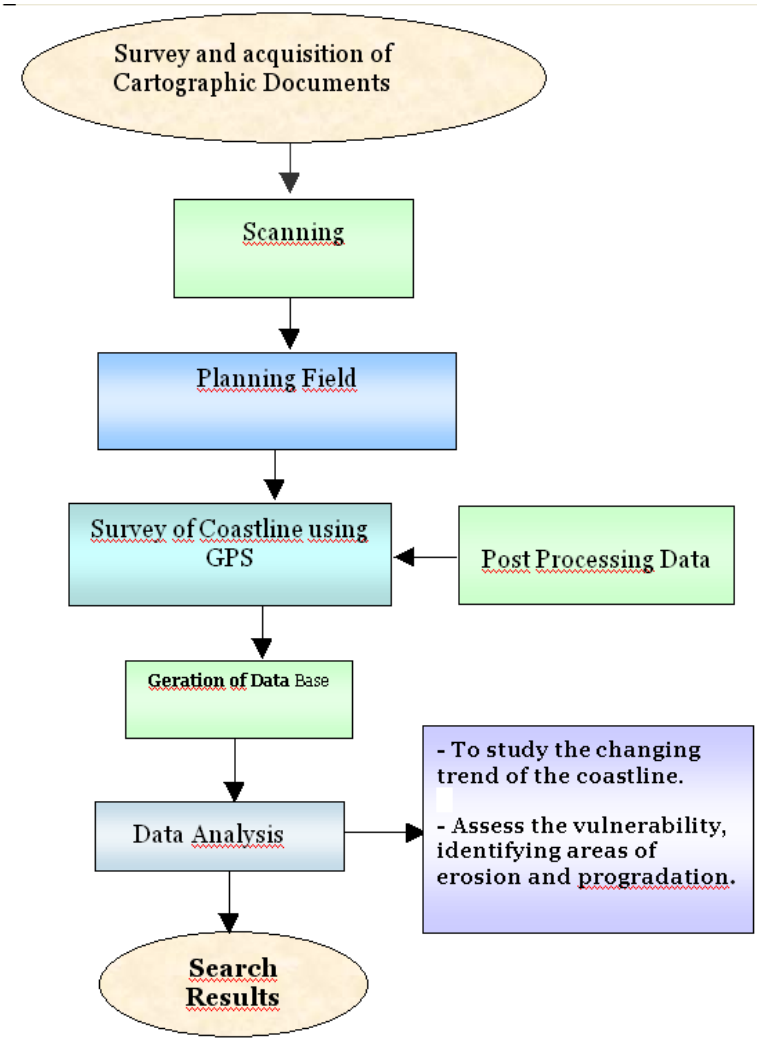

Figure 3 - Outline of Methodology

6.2.2 Editing of Cartographic Documents

The junction of cartographic documents was executed in the ArcView, as shown in Figure 4.

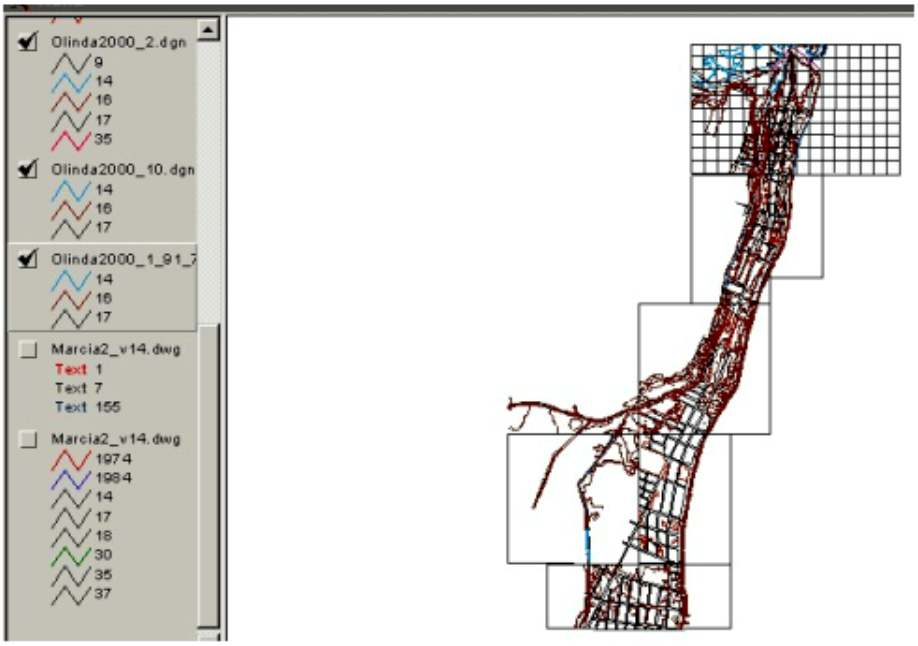

Figure 4 - Merge Data Charts

In the edition was performed the merge of the scanned files, after the transformation of Datum and coordinate system. They were then imported the files produced by the field survey. Adopted as a zero quota coastline of 1976.

6.3. Planning Field

The field Planning is essential to covered by the survey with geodetic GPS to determine the pre-defined timetable rivers with the largest number of satellites on the horizon combined with low tide, allowing through the coastline. In the planning were defined locations of reference stations to avoid problems such as obstruction of the signal. In the studying of data corrections are transmitted via radio taken to the moving dots. The stations were cho-

sen in recognition of the field, when criteria were verified, such as location, access, condition of facilities, among others.

Conduct a pre-planning prior to the field survey, to detect where time can be counted on more satellites contributing to obtaining a low PDOP. Combining this with the best time period of low tide. Choose sites better visibility and unobstructed deployment to the reference station.

6.4. Survey of the Coastline of Olinda

The coastline of Olinda was raised in real time from the station installed in the building Olinda. In Photo 4, there are the equipment installed at the building, 1 receiver Trimble geodetic 4000SSI, 1 Pacific Crest radio to 35W for the transmission of differential corrections to the mobile station and the computer program GNREF / GNRT-K. The train-ment was held on GPS 325 (20/11/2000).

Photo 4 - Reference Station (Eolie).Source: Krueger (2001)

The survey was conducted on GPS 327 (22/11/2000). The base station building was in Olinda and the mobile station was a person traveling the coastli ed from stations Lipari, UFPE, SOLA, TELE and 3rd. DL . -The methods employed in the survey were still cinematic.

The shoreline was covered, leaving about 5 minutes at the start point of the trajectory. We tried to maintain a line of at least 4 satellites, using data from

dual frequency code and the combination of the carrier. These factors are necessary when you want to recover the cycle's slips in kinematic method.

6.5. Data Processing of Coastline

The data collected using the method cinematic to determine the coastline were terminated by pro-GPS survey program, based on data obtained through the post-processing to the network.

Figure 5 illustrates the screen of the program with co-ordinates of the base station.

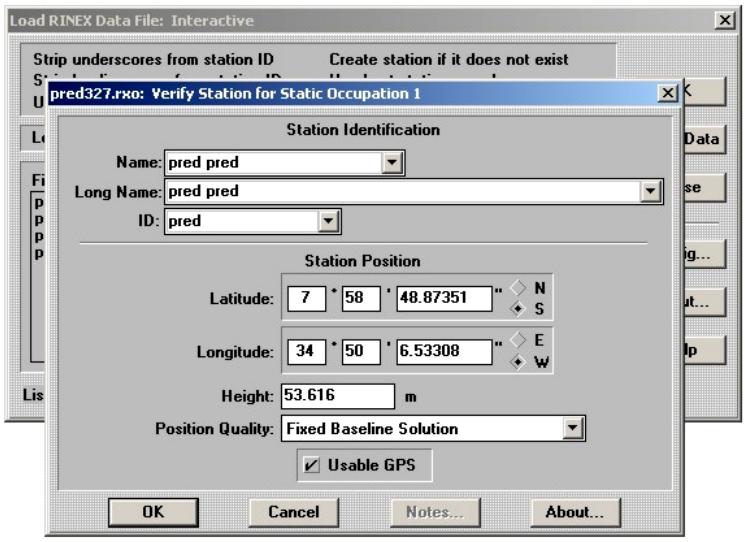

Figure 5. Coordinates of the base station.

6.6. Analysis of Spatial Data

To prepare this analysis were used aerial photo-spellings provided by FIDEM. The focus of the relevant in this step was identification of elements that are associated with images in the urban environment, using techniques of photo interpretation. The photographs were interpreted visually, having been demarcated spaces were occupied by men.

Another source used as a base, was the map of Olinda in 1943, despite having been generated at 1:50,000 scales, allows for association with the theme set in remote sensing, since it had the outlines of vegetation and hydrography.

The steps performed in ArcView follows:

* Import files. Microstation DGN, con-with lines and place names;
* conversion of files. DGN for. SHP file format graphic program;
* identification of contour lines, with the inclusion of their shares;
* selection information plan curve cruzamen-to spatial data, and generation of thematic map.

The crossing of the files containing the shorelines of the years 1974, 1984 and 2000, the program ArcView, resulted in the elaboration of the Statement of Changes in Coastline in the beaches of Casa Caiada and Rio Doce, the layout was generated for printing as shown in Figure 6.

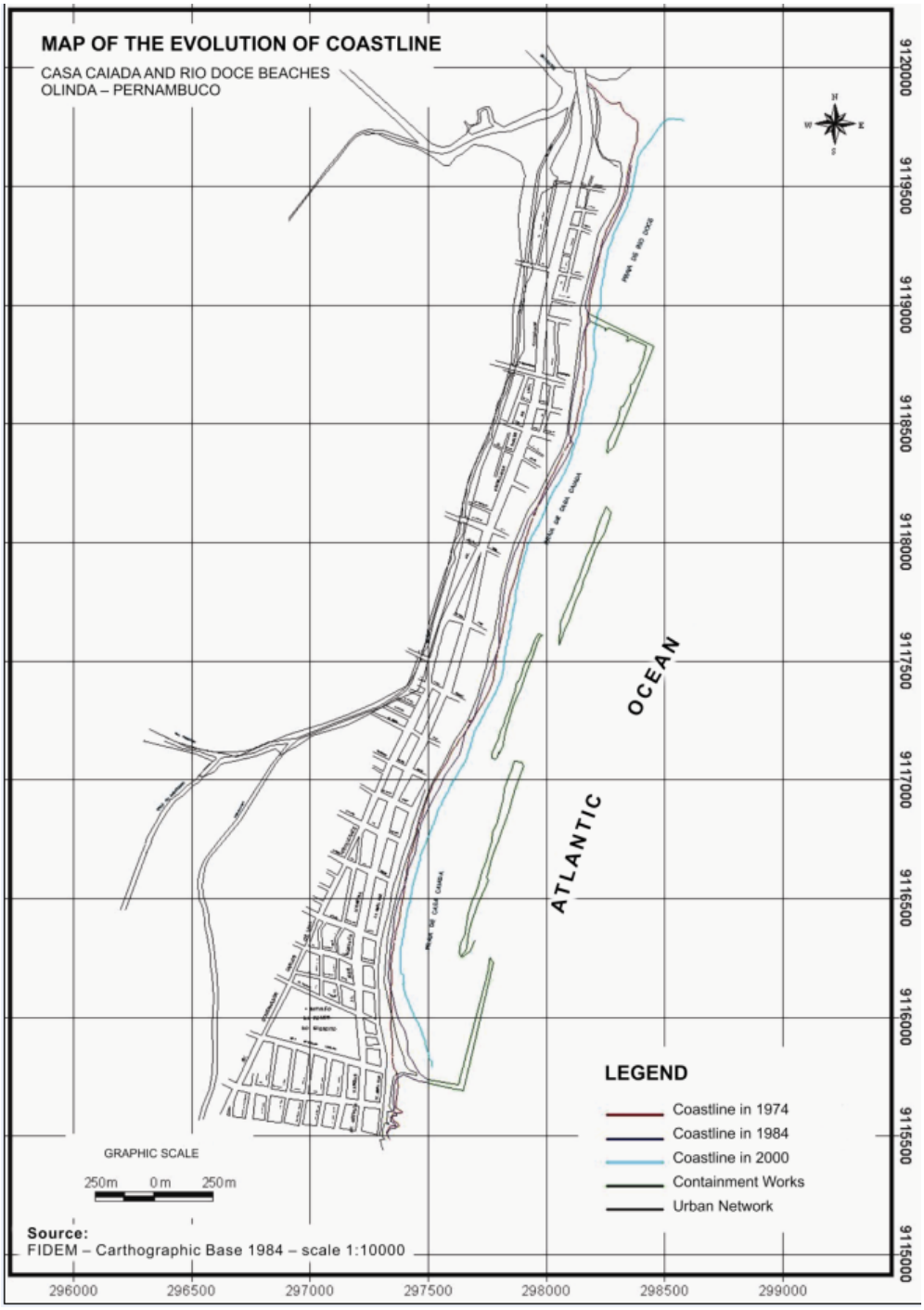

Figure 6 - Map of the Evolution of Coastline

7. Conclusions

The race for development allied to the needs of a population growing in number and poverty, has justified the savage exploitation of coastal resources, causing serious consequences to the environment.

However, the sustainable development must count with public policies sensitive to the impacts caused by rapid urban expansion, targeted not only at the point of view of environment and natural, but from the perspective of social equity, which is the bigger challenge.

The problem of erosion resulting in conflict between the natural and human activities, the solutions of problems depend on the issues of land use. The current process of stabilization of the shoreline through the construction of containment work has been presented in poor control, and usually does not allow the recreational use of the beach.

The objective of generating a spatial database for monitoring of coastal erosion in the city of Olinda using Geoinformation Technologies has been reached. Since the mapping provided the spatial data for monitoring past survey, the Satellite Geodesy permitted to be given the position of the coastline in the current situation. The spatial data collected in a database applied to space Geoinformation Systems - GIS made it possible to detect the trend of coastal erosion.

The study revealed significant changes in coastline. Looking at the map of Evolution of the Coastline the artificial progradation in the last 30 years, in this stretch of coast, was approximately 50 meters, with an average annual 1.6 meters per year , with occasional exceptions. However, in Casa Caiada Beach, was to create an artificial beach of 280 meters wide.

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