

## **PHOTOGRAMMETRY AND GIS TECHNOLOGIES FOR MONITORING COASTAL EROSION ALONG DAR ES SALAAM COASTLINE.**

**By:  
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### **Abstract**

Dar Es salaam coastline is seriously suffering from coastal soil erosion and pollution and it has been neglected from its famous attractive scenarios/ scenes since the past decades. Each year the situation becoming worse as coastal erosion continues to destroy the ocean shore and other man made infrastructures along the coastal zone. Kunduchi area is the most affected area due to the 1977 storm surge and climatical changes in the world. Aerial photography taken from 1967 to 1992 of Dar Es Salaam area were used to investigate the rate of erosion along the coast. GIS being a tool for geo-spatial analysis, was used to examine the recent development of integrated coastal zone management and the distribution of geospatial data. The requirements for geo spatial database of the coastal zone are outlined and the contribution of photogrammetric technique is examined. The paper further discusses the trend, the direction and the amount of soil erosion of the study area for effective control and management of the coastal zone. The paper concludes by suggesting methods for control and management of Dar Es Salaam cost.

### **1.0 INTRODUCTION**

Through out the world, Individuals, groups and government institutions are committed on environmental conservation particularly after the RIO DE JENEIRO earth summit in June 1992. The outcome of the Earth summit was publication of "agenda 21" whose chapter 17 recommended the use of integrated approaches for monitoring and management of coastal areas. Monitoring of coastal zone is defined as a systematic observation of parameters that provide an up to date information related to change for a specified period. The increased concern on coastal protection, management and distribution of geospatial data is due to the following factors:-

- i) About 20 - 30 percent of the Tanzania's population live in the coastal zone.
- ii) The after effect of the United Nations conference on Environment and development.

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particularly the "agenda 21" whose chapter 17 addresses the management of the coastal zone using the integrated coastal management approach. This kind of approach suggested four targets to be reached including:-

- Ø To identify the problems of coastal erosion within government jurisdiction
- Ø To suggest preventive and precautionary approaches to any developments along the coastal zone.
- Ø To encourage public participation in the protection and management of the coastal zone

The International coastal management guidelines described by Cicin-Sain et al. (1995) after examining the world bank policies came up with what is called "spatial integration" which combines all areas which in one way affect coastal areas and their resources. 1

Considering the case of Tanzania, what is the organizational nature of the coastal zone management? The organizational nature indicates that, there are permanent bodies with the responsibility for the coastal zone. All these bodies are mainly involved by the following tasks:-

- Ø Groups and Individuals of environmental protection
- Ø Governmental bodies

The problems of these groups is accelerated by the different approaches used to capture, measure, process and manage coastal erosion problems. In this respect the approaches to deal with coastal erosion problems are certainly not integrated; massive effort is probably needed to make it so. However, are geospatial experts willing to participate full to promote the integration and management of Tanzania coastal areas.

## 2.0 CAUSES OF COASTAL EROSION

In general behavior, the boundary between land and water will experience shift in position with time as a result of external processes created by nature or man made activities. When this shift advances towards the ocean, always there is accretion and when advances away from the ocean we say there is erosion. Since these advances can either be of short or long term it is very important to study the causes and rate of these advances before you can design ways of prevention. In this study, the possible causes of coastal erosion are as follows:-

### 1, Wind behavior

The wind pattern along Dar Es Salaam coast is due to the movement of inter-tropical convergence zone (ITCZ) on which wind moves from sub-tropical high pressure zone. It usually creates the North East monsoon winds which<sup>2</sup>

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blow from November to March and the south - east winds blow between May and October. Experience shows that the Dar Es Salaam coastal shore land form erosion is caused by the south - east.

## 2. Tide behavior

Dar Es Salaam coastal tides are of semi mixed diurnal type. Hartnoll, (1974) noted that, the mean spring range was 3.14m and the maximum tidal range was 4.27m. In 1982 the tidal measurements were conducted and found that the range was 3.84m and in 1992 was 4.21m. It is evident that the higher the tidal range the greater the coastal soil erosion.

## 3. Land use practices

In Tanzania, like other countries in the world the coastal zone is increasingly becoming a major sitting of industries and other commercial activities and, consequently, this trend results in the increase of human settlement. The recreational value of beaches is growing very fast as more people are investing along the beaches. With this in mind, there is a growing concern to minimize economic and social activities along the coastal zone in order to preserve the area from severe coastal erosion.

### **3.0 DATA CAPTURE METHODS**

In order to have an integrated approach on coastal zone monitoring, a proper consideration has to be given to the appropriate method for data capture, and management of geospatial information. One such method is Photogrammetry, which is a simple technique of data capture using aerial photographs using specialized instruments. In order to utilize this technique effectively, the knowledge of the coastal system is essential; i.e. the knowledge of sedimentation (its erosion, transport and accretion) that will lead to an understanding of the coastal erosion and silting which affect many areas in the world.

For Photogrammetry investigation, one study area was selected where the coastal erosion is severe and photogrammetric procedures were subsequently used to investigate the amount of soil removed for about 17 years and transfer all gathered information into a GIS system. Once all these information about coastal erosion are gathered, and included in the geospatial database objects in a GIS, a model is developed and the conservation measures can now proceed<sup>1</sup>

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Photogrammetry usually supply information as a means to represent all features in three dimension in a geo- spatial database.

Using Photogrammetric technique aerial photographs at scale of 1:12,500 taken from 1967 to 1992 and flown at 800 m above mean sea level were used to investigate on the rate of coastal erosion per year which can produce an accuracy of 2.5m in planimetry and 0.5m in height.

The first Aerial photography taken for this study was flown in 1967 covering Dar Es Salaam city (including the study area) at scale of 1:12,500; (with flight height of about 800m ; f= 152mm). A series of ground control points were established using classical methods in 1967 while those established in 1992 used "Global positioning System" (GPS). Subsequent control points were densified using aerial triangulation process of which extra points were produced as check points of the plotted features.

After aerial triangulation process, the corresponding models were plotted based on the year of photography, then after the plotted maps were merged and a digital terrain model (DEM) was generated. A DEM is a main way to represent the affected area i.e. a DEM produced using aerial photography taken in 1967, and a DEM generated using aerial photography taken in 1992 is likely to provide information useful in sedimentation modeling.

#### **4.0 GIS IN COASTAL ZONE MANAGEMENT**

Integrated Coastal Management (ICM) as explained by (Cicin-Sain et al., 1995)

Incorporates all areas which affect the coastal waters and their resources, and also includes all features of the coastal zone which can effect the land of the coast zone. Apart from plotted features from photogrammetric technique, an understanding of marine, biological forces causing sedimentation is required for proper modeling of sedimentation in order to manage the "dynamic zone". Such information must be augmented with the result obtained from photogrammetry which may be of up to date at a certain scale.

It is evident that to manage sedimentation needs a large database archive of geospatial information having been located at the same geometric reference system. In this respect a GIS provides a tool to allow geospatial data from different sources to be stored, transformed to the same reference system, and be accessed when required.

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## 4.1 CONTENTS OF GEO-SPATIAL DATABASE

Assuming that there will be a spatial integration on coastal monitoring and management, techniques such as risk assessment and vulnerability assessments are properties of GIS. Hoping that there will be an effective legislation in Tanzania to unit all organizations responsible for control and protection of coastal zone, an integrated approach to such cooperation and management could be achieved. This cooperation can only be effective if the coastal geospatial database is available.

## 4.2 DESIGN OF A GIS TO ICM

The design of a GIS suitable for the Integrated Coastal Management comprises of the following:-

### 1. Geospatial database

All coastal zone features are to be represented as objects in the geospatial database. The objects are:-

- . pollutant sources (points)
- . lines
- . polygons
- . Surfaces (DEM)

### 2. Reference system

All coastal zone data must be converted to fit into one reference system to represent all spatial database and be capable of representing features in three dimension.<sup>1</sup>

### 3. Processes

A range of information must be specific to coastal environment and must act as a database to generate and predict new information on erosion, pollution e.t.c

From this paper so far we have limited information required to build a geo-spatial database. A variety of data is required from other government Institutions or organization having activities in the coast zone (geology, zoology, hydrographic department), and from other study conducted by scientists having interest in the coastal environment.

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## 5.0 PHOTOGRAMMETRY AS A TOOL FOR BUILDING A GIS

When building a GIS for an Integrated Coastal Management (ICM), consideration has to be given to appropriate method for capturing new relevant data, and one such method is Photogrammetry. Although a complete knowledge of the coastal system is necessary for efficient use of coastal resources, but also the knowledge of sedimentation is essential. Such understanding will lead to the knowledge of coastal erosion and pollution which affect many Tanzania coastal settlements. Investigation of coastal erosion using Photogrammetric technique transferred a three dimensional model of all features existed at a certain period of time to a G.I.S. One these feature are included as geospatial database objects in a G.I.S, a model development of eroded area can take place.

## 6.0 THE FUTURE

With regard to Photogrammetric technique of data capture, some further efforts are needed to improve the quality of results, perhaps by carrying out new aerial photography of the study area at scale of 1:3000 and establishing permanent ground control points. <sup>1</sup>

At the present the authors requires geospatial information containing all data from (hydrography, meteorology, oceanography and geology) of Dar Es Salaam coast. However the experience gained from this small findings will enable authors a greater understanding of the applicability of geographic Information Systems to Integrated Coastal Management and it will thereby contribute to what is now an "Environment debate

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## **REFERENCES**

1. DRUMOND, J. E., TAIT, D.A and ZAMPOLE, Z., 1996. An investigation into usefulness of digital photogrammetry in coastal monitoring. Proceedings of the 22nd Annual Conference of Remote Sensing Society. 699 pages; 187 – 195<sup>3</sup>
2. DUBI, M. A., NYANDWI, N., 1998 The experience of Tanzania coastal protection: success, failures and new strategies
3. WOLF, P.R., 1974. Elements of photogrammetry<sup>1</sup>. McGraw Hill, New York. 562 pages.

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