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Change Detection of Libyan Costal Erosion Using Satellite Imagery

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ABSTRACT

This study, deals with the coastal analysis for the changes in the watersheds of Zletin, El-merage, Darna, Al-sahealasahele, and Bayad along the Libyan Coastline by using Satellite Imagery. Landsat TM/ETM+ images were used for this study which was covering the previous watersheds in the following years: 1986, 1987, 1990, 2005 and 2006. The image change detection in this study was based on supervised image classification. Rule-based classification technique is applied by using fuzzy functions, aiming to extract information of the erosion and accretion spatially. The images were processed using ERDASE-Imagine Version 9.2 and Arc-Map version 9.3 for the GIS operations. The results of the analyses show among other things that coastline erosion was dominant over accretion in Darna, El-merage and Bayad watersheds, whereas the coastal accretion was dominant over erosion in Zletin and Sirt watersheds. Also that the total area of observed changes along the coastlines was 243.65 Acres Of this, 174.65 Acres constitutes eroded area, and 69 Acres of the area showed coastal sediment accretion.

Keywords: Coastal erosion, Accretion, Watershed.

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1. INTRODUCTION

The coastline is generally considered to be the edge or margin of land next to the sea or ocean. Various technical definitions of coastline are used by different coastal management and regulatory agencies but most coastal zone researchers describe the coastline as the interface between land and water (Bird, 1967; Dolan et al., 1980).

Coastlines are dynamic and are therefore areas of constant change (Boak & Turner, 2005). The changes in the coastline largely depend on its geology and geomorphology; the nature of tidal waves impacting the coastline; changes in sea-level; and sediment transport by long shore currents (Carter and Woodroffe, 1994; Cowell and Thorn, 1994; Pidwirny, 2006a). Coastline changes often result in erosion of coastal areas or accretion of sediments, depending on the dominant processes acting on the coastline (Pidwirny, 2006b).

Also human activities that impact coastlines include dredging, construction of breakwater infrastructure and physical development; mineral exploration, ports construction, removal of backshore vegetation, construction of barrages and coastal control works (Fanos et al, 1995; Berger and Lams, 1996; Ibe, 1998; Pandian et al., 2004).

The coastline is the bridge between aquatic life and terrestrial life, and it is usually a fragile ecozone. As a result, the study of coastline changes can be of immense benefit to the understanding of complex coastal ecosystems.

Coastlines are widely used as ports for navigation and maritime commerce. They are therefore of economic value and critical to the socio-economic development of non-land locked nations.

Several methods have been employed to study and monitor coastlines, including traditional methods that incorporate local observations and basic surveying techniques. Analysis of coastline changes can also be carried out using survey maps (e.g., Kadib, 1969), historical coastline mapping (e.g. XYZ), and comparison of beach profiles over a period of time (e.g. Inman and Jenkins, 1984; Ibe, 1998). Other more recent methods include simulation of coastline changes using numerical models (e.g., El-Serafy, 1984); combination of coastline survey using Global Positioning System (GPS) receivers; long-shore sediment transport using numerical modeling packages such as MIKE21 and LITPACK (Pandian et al., 2004); and airborne Light Detection and Ranging (LIDAR) survey methods (e.g., Robertson et al, 2004). All these methods can be used with varying accuracy to determine the position of the coastline at specific time periods and to detect coastline changes over time.

The use of satellite remote sensing techniques and geographic information systems (GIS) for the identification, mapping and analyses of coastline changes have gained prominence in recent years as high resolution satellite data have become more readily available. Previous works in this direction include Moore (2000), El-Raey et al (1997), El-Amsar (2002) and Liu et al (2003). These studies showed that remote sensing techniques when combined with geomorphologic and sedimentary data can be effectively used to assess coastline changes over time.

The portion of the study covering the Libyan coastline focused primarily on five major locations: Darna, El-merage, Bayaad, Zletin and Sirt watersheds (Figure 1). The coastal changes at these locations were monitored using a combination of historical data (Landsat Satellite Images) from the 1980's to 2000's. Their study over the 20-year period between 1980's and 2000's documented numerous cases of both erosion and accretion, but erosion was predominant. The study intends to map, analyze and identify the recent changes along the coastline of the Libyan in different Geological structure using satellite imagery in a GIS environment.

2. STUDY AREA

The Libyan coastal region is located in the central part of Africa and bounded to the North by the Mediterranean Sea. This region has a coastline extending from the Tunisian in the West to the Egyptian in the East for about 1900 km (Figure 1).

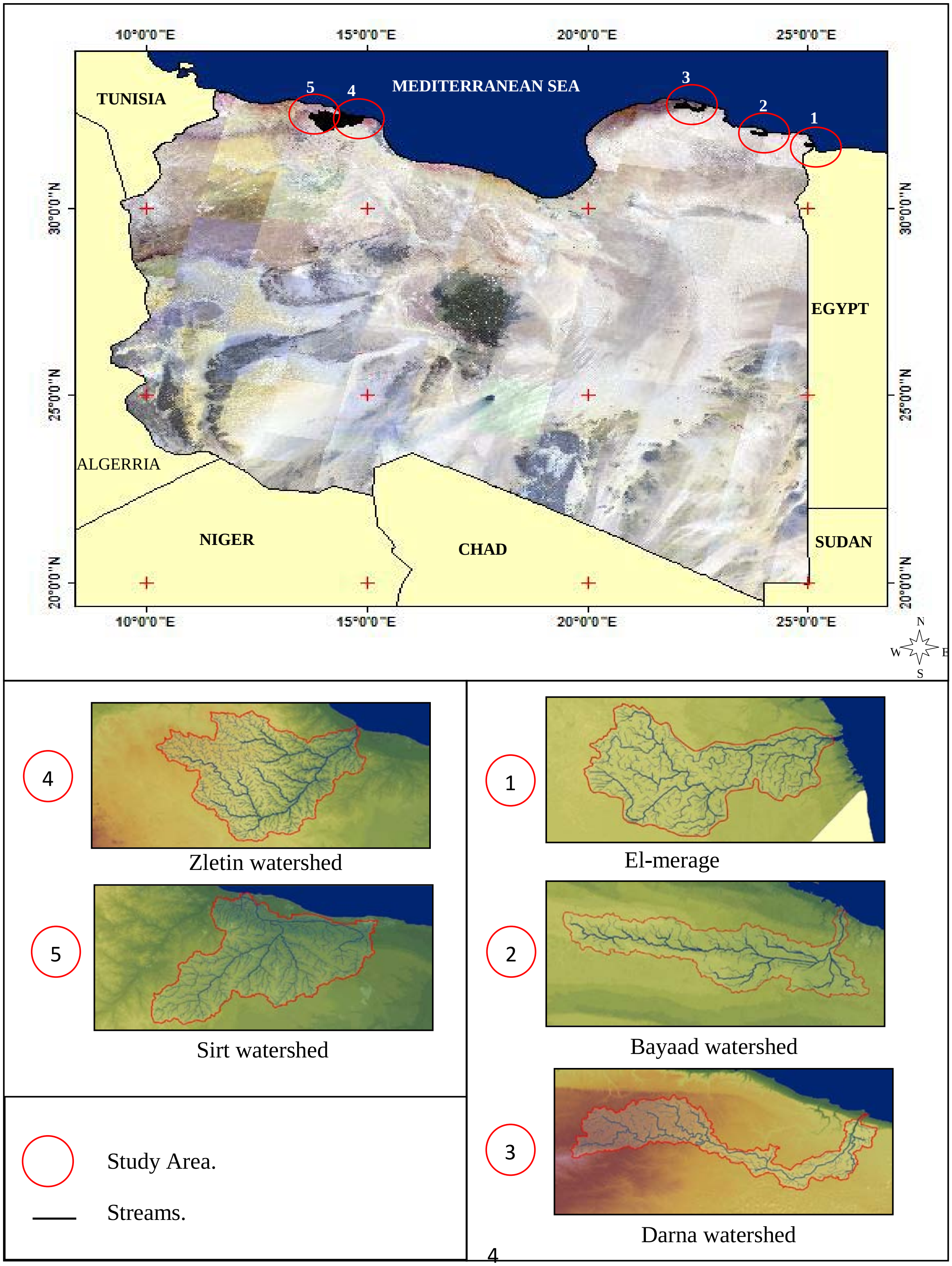


Fig. (1): Shows the location of the study area.

3. DATA SOURCES AND PREPROCESSING

Three sets of spatial data were used for the study. The first datasets consists of Landsat TM images of 1987, 1990 and Landsat ETM+ of 2005, 2006 both covering the part of Libyan coastline area. The resolution of the Landsat TM and ETM+ images was 28.5m. Based on the available image scenes, the entire Libyan coastline area was divided into two main sections, namely: West Coast and East Coast. The images covering the West Coast and East Coast regions of the study area were in UTM Zone 33N, 34N, and 35N, WGS 84 Datum. These coordinate systems were maintained throughout the project. We acquired the images from the University of Maryland Global Land Cover Facility (URL: http://glcf.umiacs.umd.edu/index.shtml).

The second dataset consists mainly GIS vector layers of the Libyan Coastline including, administrative boundary, settlement distribution, and towns.

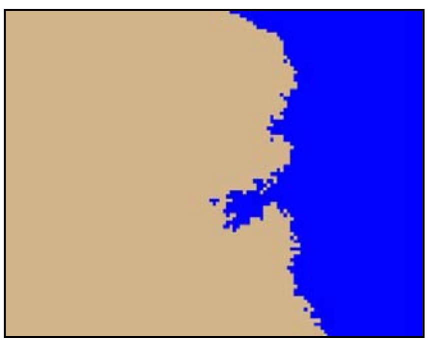
The third datasets consists of 30m resolution of a Digital Elevation Model (DEM) provided by Shuttle Radar Topography Mission (STRM) for the study area to eliminate the boundaries of studied watersheds.

4. METHODOLOGY

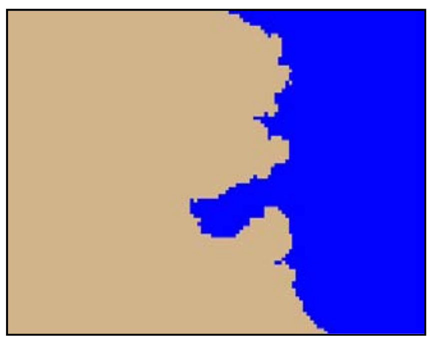
4.1 Image Processing

The image processing for the project was carried out using ERDASE Imagine version 9.2. The acquired Landsat TM and ETM images scenes for this research work were pre-processed, that is the radiometric and geometric corrections, and geo-referencing have been done. However, the coastlines boundaries were verified using existing vector maps for consistency and accuracy. The Landsat ETM+ coastline was compared with the coastline boundaries of the Topographic Map of Libya digitized at the Biruni Remote Sensing Center (BRSC) GIS/Remote Sensing Laboratory in Tripoli, Libya.

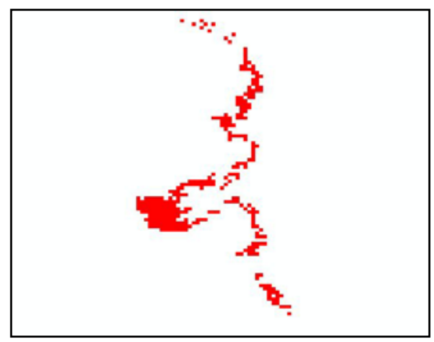
Histogram equalization enhancements were carried out on all the images so as to produce sharper images. The band combination used for the images was: Red – band 6, Green – band 4, and Blue – band 2. The reason for using these bands was for clear distinction of the coastline boundary (El-Asmar, 2002). The image change detection in this study was based on supervised image classification. Rule-based classification technique is applied by using fuzzy functions, aiming to extract information of the erosion and accretion spatially as shown in Figure (2, 3). Difference images (change detection analysis) were generated between the before images (Landsat TM) and the after images (Landsat ETM+). The software was programmed to detect the minimum level of change of 1%. This means that an area identified to have changed for as low as 1% over the period of consideration should be duly highlighted.



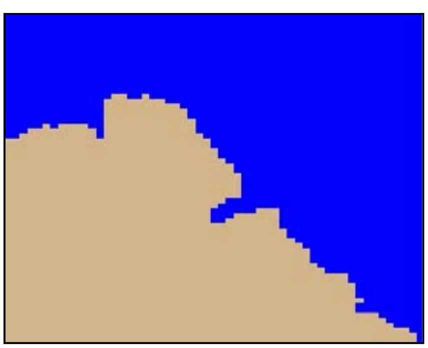
Supervised classification for El-merage 1987



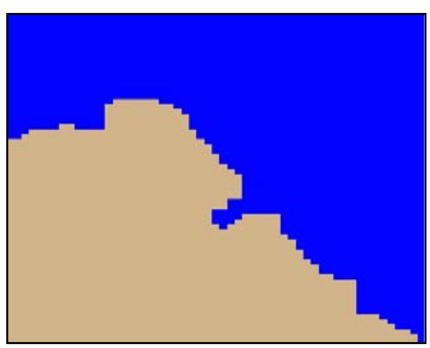
Supervised classification for El-merage 2006



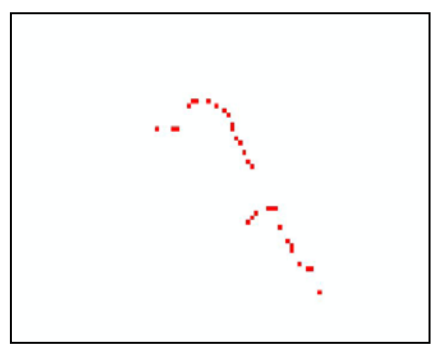
Change detection in El-merage (1987-2006)



Supervised classification for e 1987



Supervised classification for Bayaad 2005



Change detection in Bayaad (1987-2005)

Accretion Erosion Watershed

Fig. (2): Shows Image Change Detection based on supervised classification for El-merage and Bayaad watersheds.

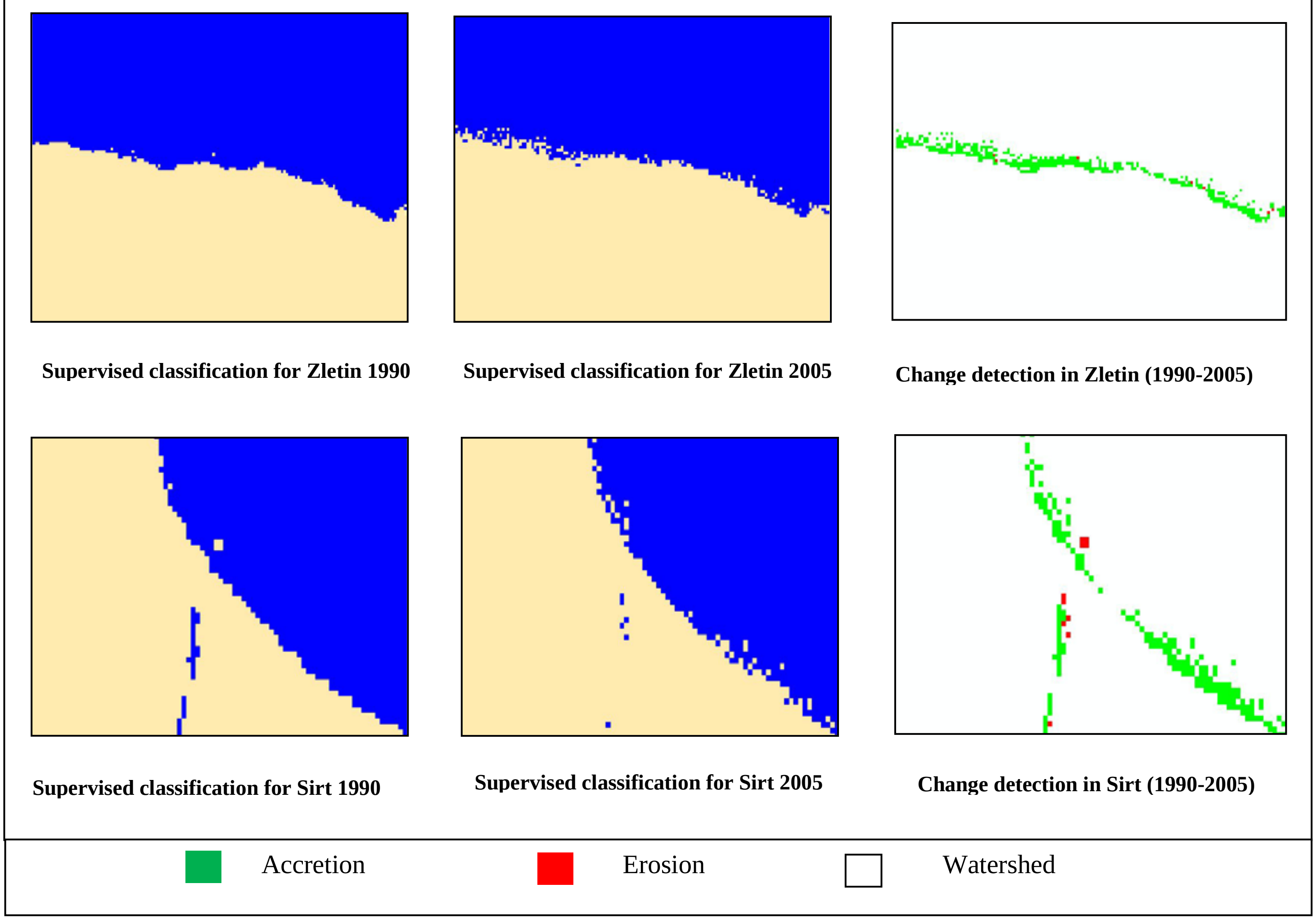


Fig. (3): Shows Image Change Detection based on supervised classification for Zletin and Sirt watersheds.

Visual analysis and comparison of the difference images with the original images was used to identify areas of positive changes seawards (coastline accretion) represented in

Green, and areas of negative changes (coastline erosion) shown in Red. The areas of observed changes were extracted into a GIS database using Arc-Map 9.3.

4.2 GIS operations

The basic GIS operations carried out on the processed images are digital extraction of identified areas of changes along the coastline (in Acres). All GIS operations were carried out using Arc-Map 9.3.

5. RESULTS AND DISCUSSION

Along the entire coastline, coastline erosion was observed to be dominant over accretion or sediment deposition. The total area of observed changes along the coastline was 243.65 Acres Of this, 174.65 Acres constitutes eroded area, while 69 Acres of the area showed coastal sediment accretion.

5.1 West coast region of the study area

The West coast includes Zletin and Sirt watersheds records more accretion than erosion. A total area of 41.78 Acres of changes was observed in Zletin watershed and a total area of 28.57 Acres changes was observed in Sirt watershed. Accretion accounts for 41.2 Acres (98.61%), while erosion accounts for 0.58 Acres (1.38%) in Zletin watershed whereas in Sirt watershed, the accretion accounts for 27.8 Acres (97.30 %), while erosion accounts for 0.77 Acres (2.69 %).

Annual rate of accretion and erosion are 2.06 Acres and 0.029 Acres respectively in Zletin watershed, while the annual rate of accretion and erosion are 1.39 Acres and 0.038 Acres respectively in Sirt watershed as shown in table (1).

5.2 East Coast region of the study area

The East region of the coastline includes; Darna, El-merage and Bayaad watersheds. Along this portion of the coastline was recorded massive erosion. The total area of change along the coastline stretch in this region amounts to 40.9 Acres, 159 Acres and

9.4 Acres in Darna, El-merage and Bayaad watersheds irrespectively, whereas accretion in this region is not recorded. The annual rates of erosion this region are 2.045 Acres, 7.95 Acres and .047 Acres in Darna, El-merage and Bayaad watersheds respectively as shown in Table (1).

Table (1): Shows a highlight of the changes observed in the study area.

Watershed Name	**Mission-1**	**Mission-2**	**Change Detection (Acres)**				
	Year	Year	Erosion	Accretion	Total (Sediment +Accretion)	No-Changed	Comments
Darna Watershed	1987	2006	40.9	0	40.9	Changed	The calculations for 1000m right and left of the outlet station of watershed
AL-Marage Watershed	1987	2006	159	0	159	Changed	=
Bayaad Watershed	1987	2005	9.4	0	9.4	Changed	=
Zletin Watershed	1990	2005	0.58	41.2	41.78	Changed	=
Sirt Watershed	1990	2005	0.77	27.8	28.57	Changed	=

6. CONCLUSION

Limitations for this project may include the spatial resolution of the satellite imagery used. To further enhance the project, high-resolution images of selected sites may be used to increase the accuracy of measurements of coastline changes. Nonetheless, this study has been able to ascertain that through satellite remote sensing and GIS techniques, the Nigerian coastline can adequately be monitored for various changes that take place.

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