

Change detection of Al Seefa Coastal Zone- Sultanate of Oman

تغيرات الخط الساحلي في منطقة السيِّفة - سلطنة عمان

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Abstract:

Al Seefa is a coastal area, eastern Muscat - Sultanate of Oman. The area is characterized by narrow sandy beaches formed over thousand years due to the deposits of short valleys flowing into Oman Sea. The study area is considered an important tourist area, but its coast is currently being relegated to erosion. Remote sensing and Fieldwork investigations revealed severe erosion taking place shoreline and the side parallel to the tarred road northern the study area.

This study aimed to identify the coastline change during the last 25 years using TM, Quick Bird and DEM images. The methodology depends mostly change detection tool using remote sensing (RS) to determine the change of the coastline in Al- Seefa area and spatial analysis tools to analyze and calculate the changes using Geographical information systems (GIS).

The results showed 14 meters of shoreline retreat and recorded 50-meter retreat in another area northern in the study

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area. It could be said that coastal erosion in the Al Seefa area related to the action and direction of waves, kind, and thick of deposits, surface slopes, and human activities furthermore sea level rise. However, the study recommends to make protection for the northern sector of shoreline and protect all shorelines of the Al Seefa area from an expected sea level rise in the future.

Key Words: Remote Sensing; Coastline; change detection; Shore retreats; Coastal Erosion.

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INTRODUCTION

Coastal erosion is a major global problem that threatens many beaches, and erosion is known as a reduction in the amount of beaches supplied with sand either for natural or human reasons. There are many natural and human factors that cause coast line changes, including: sea level rises due to glaciation or organic cycles, Flash flood due to heavy rainfall, wave action which is one of the important factors shaping the coasts, Marine currents, tidal wave movement and its role in coastal erosion. In addition, geological formations, slope degrees and the estuaries of valleys and sea levels (rise/fall) and tectonic activities that cause coastal land subsidence or emergence (Lee, 2005). So, the changes induced by erosion and accretion are natural processes that take place over a range of time scales. Sometimes, they may occur in response to smaller-scale (short-term) events, such as storms, regular wave action, tides and winds (Curran, 2002).

On the other hand, there is a lot of human activity such as: land reclamation, port development, settlement, dams which exacerbate coastal erosion in many places (Moller, 2006; Thieler et al., 2009). The Sultanate of Oman has a long coastline of about 3,165 km including a number of islands. A predominant proportion of the population inhabits the coastal areas, especially Al Batinah Coastal Plain, which has received a large share of development, mainly concentrated along the coastline. This includes recharge dams, fishing harbors,

corniches, desalination plants, groins, and ports (Al-Hatrushi, 2012).

There are several studies about Oman coasts such as: (Atkins, 2002, Azaz, 2012, Sherief & al Balushi, 2014, Al-Hatrushi & Sherief, 2015) which concentrated selected areas along coast of Oman to mentoring coastline changes due to sea level rise and climate changes, and only one used change detection tool determines the changes in wedam El Sahel, but until now there has been no study about Al Seefa area.

PROBLEM DEFINITION:

There are many factors that contribute to coastline change, including tectonic, geological, and climatic factors, in addition to human-induced climatic influences. Recently, attention has been increasingly focused on climate change and its impact on coastal areas, and this has become clear in the study area (Figure 1).

Climate change is currently considered one of the most significant natural challenges facing the world, prompting governments to hold global conferences to discuss the phenomenon. Many factors have contributed to climate changes, including volcanic activity and increased human activities. It is worth noting that according to the Intergovernmental Panel on Climate Change (IPCC), two-thirds of the world's population live near coastlines, within a distance not exceeding 200 km.

The European Environment Agency (2005) reported that 12% of the European continent lies below the 5-meter contour line, especially in delta regions and coastal plains, making its coasts vulnerable to sea level rise. Similarly, Oman's coasts—particularly in areas of alluvial fans, lagoons, and seaports—are also at risk. The international community has begun to pay attention to the phenomenon of climate change. The first official presentation of the issue was during the Environment Conference held in Stockholm in 1972, which drew global attention to climate change as a transboundary international issue due to its diverse impacts.

The global average temperature has increased by 1.2°C, which has contributed to the melting of polar ice and the subsequent rise in sea and ocean levels. This rise poses a direct threat to coastal countries, island nations, and delta regions around the world (El-Banna & Abdel-Fattah, 2009).

Scientific reports indicate that during the 20th century, sea level rose by approximately 10 to 25 cm (Mangor, K., 2004). Reports from the Intergovernmental Panel on Climate Change (IPCC) project that sea level may rise by 26 to 59 cm by the year 2100. Other studies predict an even higher rise, ranging from 38 to 100 cm by 2100, while a study focused on Vietnam projected a sea level rise of 50 to 140 cm (Nguyen, Pham Khoi, 2009).

The Sultanate of Oman is uniquely positioned with three coastal fronts, and its total coastline extends about 3,165 km, including the shores of its islands. Most of the population is concentrated directly along or near the coastline, particularly in cities such as Muscat, Sohar, Sur, and Salalah. This makes these areas vulnerable to the impacts of sea level rise, including coastal erosion, flooding, and threats to infrastructure.



Figure 1: Climate changes and coastal areas In Al Seefa

THE STUDY AREA:

The study area is a residential area located in Muscat; its population is estimated at 2000 capita according to the 2010 census of the National Center for Statistics. It extends between the states of Matrah and Qaryat. Surrounding the region on the

western and southern sides by eastern Mountain rock, while in the northern and eastern parts protected by the Gulf of Muscat and Oman Sea (Figure 2).

MATERIALS AND METHODS :

Several studies have used by Remote sensing data to detect shoreline changes such as (Shaghude et al. 2003; Vanderstraete et al. 2006; Bayram et al. 2008; Sesli et al. 2008; Kuleli 2010; El-Asmar, et al, 2011; Azaz,2012; sherief et al 2015). The integration of the latest remote sensing techniques with GIS has proved to be a very useful approach to coastal-scale analysis studies because of the simultaneous and frequent data coverage, high accuracy, and multi-spectral database, and their cost-effectiveness compared to traditional techniques. The study depends on change detection tools to determine the coastline changes between 1990, 2000, 2008, and 2013, and analyze physical and human reasons which caused these changes (Figure 3).

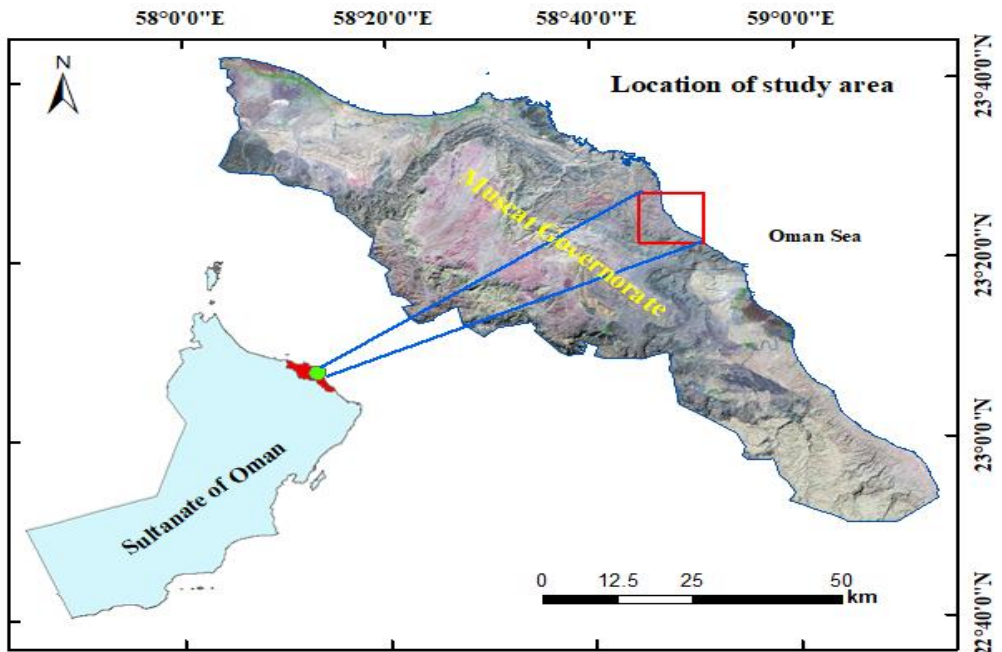


Figure 2 : Location of Study area

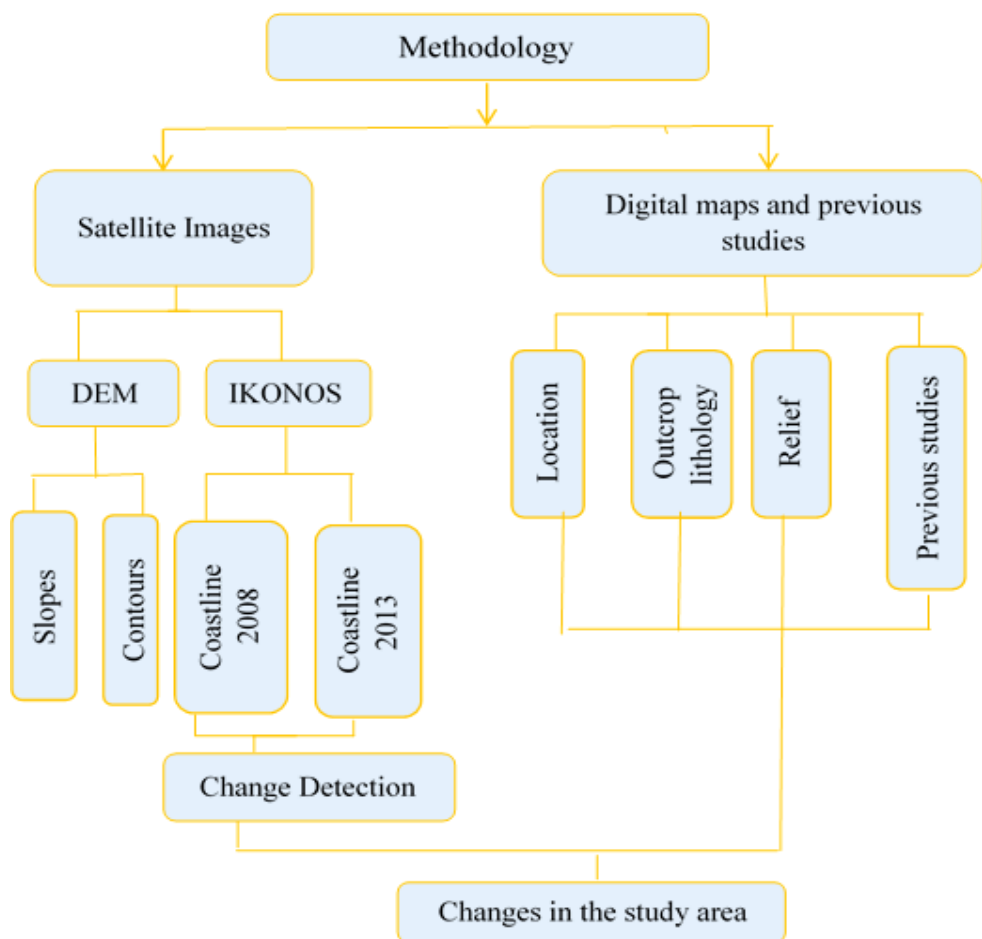


Figure 3 : Methodology of the study area

DATA COLLECTION:

Digital geologic map and 5 satellites images were used in this paper, the first one of the images is Digital Elevation Moodle (DEM) with one band and 5 meter spatial resolution, it was used to extract contours, slopes, and relief for analyzing the surface of the study area and its influence to varying the changes along the coast of Al Seefa area (Figures 4, 5).

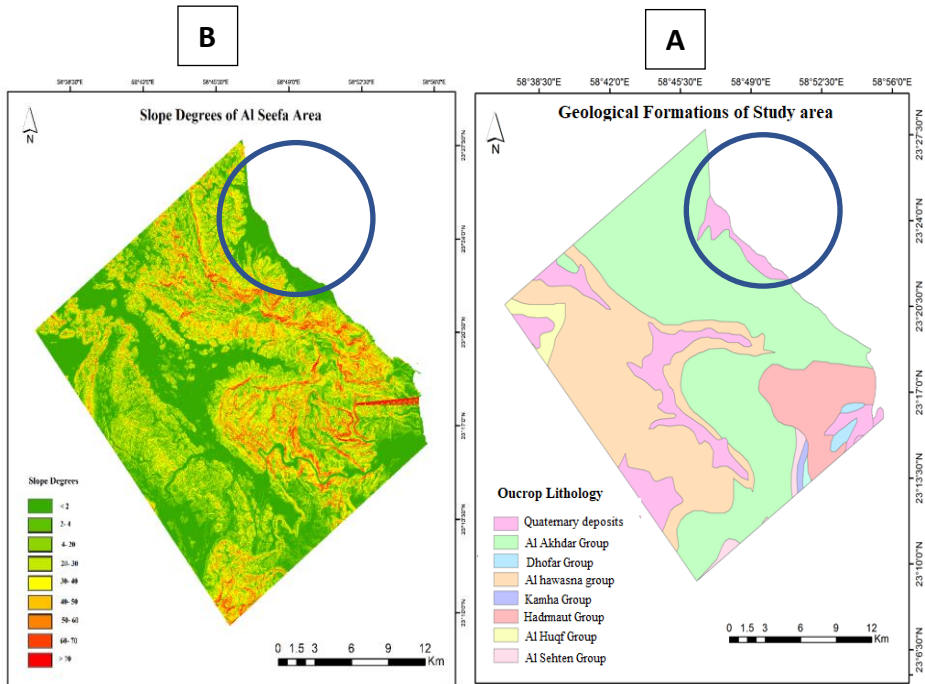


Figure 4 : physical sittings of the study

The others images available of the study area were Landsat TM 1990, 2000 with 6 bands and 28, and IKONOS 2008, 2013 with three bands and 1 meters. Finally, the digital geologic map was used for determining the outcrop lithology and deposits in Al seefa area which had been direct effects of coastline changes specially, fluvial, coastal, and wadi deposits along coastline.

IMAGE PROCESSING :

ERDAS Imagine 14 and ArcGIS 10.3 Software's were used to prepare, process and analyze satellite data in this article. The satellite images were rectified to the Universal Transverse Mercator (UTM) projection, zone 40 projection and WGS84 Spheroid and datum. DEM image was rectified and processed by spatial analysis tools in Arc Map using the hydrology module to

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fill the Image for repairing and computing the loss pixels, after that, Surface module was used to extract contour lines, slope degrees, and relief. Change detection of the images has been using ERDAS 14 program through using raster analysis, zonal changes, and difference between images 1990, 2000, 2008, and 2013.

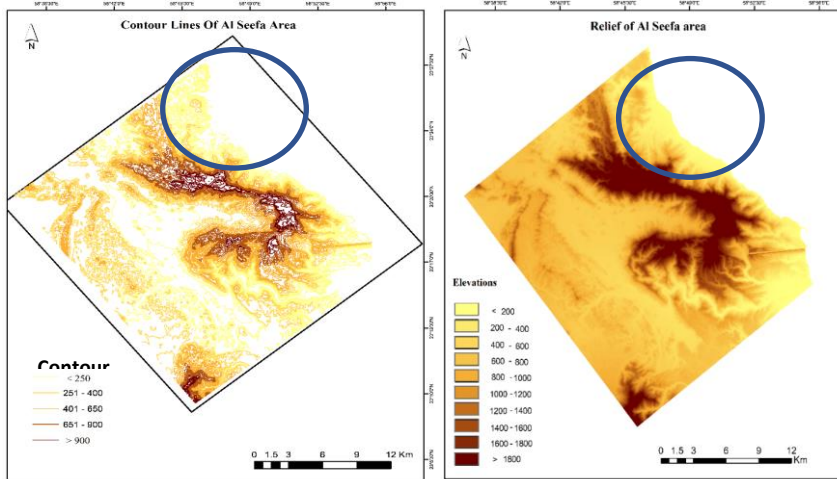


Figure 5 : physical settings of the study

RESULTS AND DISCUSSION :

Change detection in coastline of Al Seefa area in the period from 1990 to 2013 indicates to the study area had been changed due to physical settings and human activities. The outcrop lithology and deposits consist mostly of sedimentary rocks and alluvial deposits (Figure 4-A), these formations had been playing an important role in increasing the beach area during running wadis and decrease during droughts. Surface analysis of the study area showed that most of the changes occurred in areas with a slope of less than 10 degrees. Low-lying areas are less than 20 meters above sea level (Figure 4, 5).

Figure 6 shows the main results which have 4 maps and diagram. Change detection between TM Image 1990 and TM Image 2000 reflects more decrease in the beach area of for about 400000 m² while the increase area for about 1500 m²

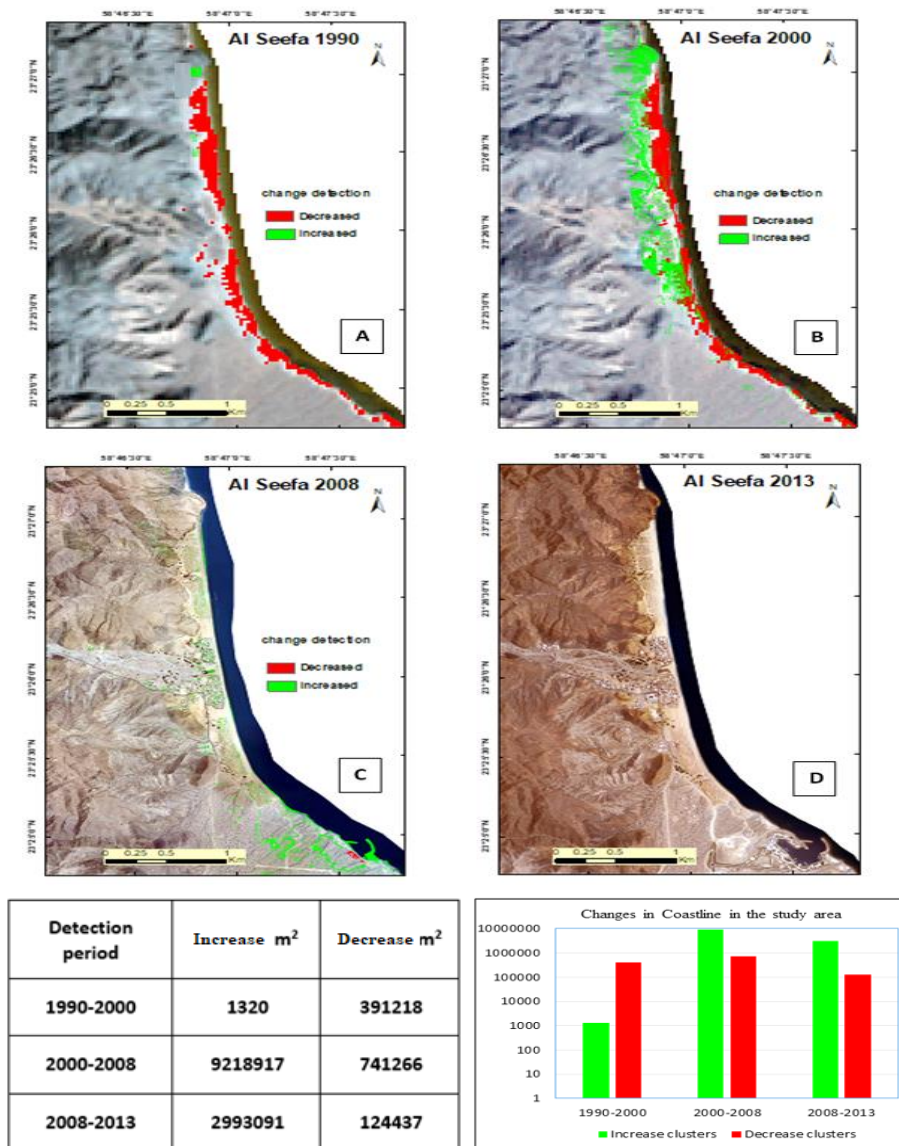


Figure 6 : Coastline changes along Al Seefa area during 1990, 2000, 2008, and 2013, using Zonal changes and image difference in ERDAS Imagine.

due to lake of human and economic activities. During the period between 2000 -2008, this area had more economic activities such as building, coastal road, and infrastructure resulting in higher rates of change along the coastline, both increasing and decreasing (Figure 6-B).

Figure 6-C shows that change detections between 2008 and 2013 using IKONO images with 3 Bands and 1 m, the rates of change are relatively low due to the stability of the region and the short time between the images only 5 years, but the rates of change resulted from the construction of a barrier to the waves and a small harbor for fishers.

Finally, the beach of Al Seefa currently needs more attention and rehabilitation in proportion to the rates of change observed.

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