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Using Remote Sensing To Study the Land Use / Land Cover of Kamaran Island, Yemen

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----------ABSTRACT----------

*Yemen has a coastal line of more than 2,100 km along three different marine waters, i.e., the Gulf of Aden, Arabian Sea and Red Sea. Kamaran Island is one of the few populated Islands of Yemen, which has a strategic location in the Red Sea. It is the largest Island in the Red Sea, with an area of about 110 km^2. The coral reefs ecosystem, which are surrounding the island from three sides, and mangrove ecosystem in the northern side provide habitats for a diverse of flora and fauna populations. This study used remote sensing and GIS techniques to study land use/land cover of Kamaran Island using Land Sat 7 ETM$^+$ of the year 1987, and a high resolution (30*30 cm) of the year 2017 images. Land use/land cover of Kamaran Island were classified into three different classes. Those classes are mangrove areas, human activities (residential villages, dumping site, historical sits, fish landing sites, tourism activities), and Barren areas (Raised coral reef and lands (rocky, clay, and sandy beaches). The area of Kamaran Island was found to be 112 km^2 in the year of 1987, whereas it is at present (2017) found to be 110 km^2, with a difference of 2 Km^2 in 30 years. That is about 66.7 m^2 of diminution each year. This could be attributed to the erosion caused by strong waves and the nature of the coastal sediments.*

Keywords: *Red Sea, Kamaran Island, remote sensing, land use/land cover, climate changes.*

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I. INTRODUCTION

Yemen lies on the southwestern tip of the Arabian Peninsula, occupying an area of nearly 555,000 Km^2. It is bordered to the west and south by coastal line with over than 2,100 km along three different marine waters, *i.e.* the Gulf of Aden, Arabian Sea and Red Sea [1]. The Red Sea is a semi-enclosed basin [2] , with about 1,932 km long, and averages 280 km in width and the average depth is about 491 m [3] , [4] , [5]. The Red Sea connects in the south with the Gulf of Aden and Indian Ocean through the Strait of Bab-al-Mandab, where the seafloor reaches a maximum depth of about 120 m [6]. The Red Sea was formed by plate tectonics, *i.e.*, the African and Arabian plates drifting apart, and is part of a larger tear that includes the Dead Sea and the East African rift systems [7] , [8].

There are over thousand islands in the Red Sea [9]. More than 112 islands lie in the Red Sea region of Yemen [1], out of which, only six islands are inhabited. Kamaran island is one of these Yemeni inhabited islands with a population of about 2,465 according to 2004 census, and the total population of Kamaran Island expected in 2016 is reported to be 3,505 [10].

Kamaran name means in Arabic "the island of two moons"; the first is the sky moon and the second is its reflection by the Red Sea waters that surround it. Kamaran had been inhabited for centuries and is famous for number of its historic monuments [11]. Many important environmental habitats are distributed in and surrounding the island. Coral reefs of Kamaran Island are well known for attracting tourists to the island in recent years. Mangrove ecosystem which is located in its northern tip, is considered to be the most important ecosystem in the island. This area has been declared by the Prime Ministerial Decree No. 310 of the year 2009 as a nature reserve [12]. The total area of this mangrove ecosystem has been estimated to be about 3.61 km^2 [13].

The application of remote sensing technique is very important for monitoring the possible changes of the geo-morphological features, natural resources, and land use /land cover of studied areas. It was found that Geographic Information System (GIS) and modeling techniques are very useful tools for sound planning for the sustainable development of the coastal areas [14]. Remote sensing plays an important role in classifying various

types of vegetation, and it is a significant tool in inventorying, mapping, classifying, monitoring, management and development of effective strategies for the sustainable utilization of natural resources [15].

The objective of this research is to investigate the Land use/Land cover at present as well as studying the coastal line changes of Kamaran Island by using remote sensing techniques.

II. METHODOLOGY

STUDY AREA

Kamaran Island, the second biggest Yemeni Island after Socotra, is one of the populated islands of Yemen, and the largest Yemen island in the Red Sea. [16] reported that the area of Kamaran Island was found to be about 108 km^2. It is located between 15° 15' 41" and 15° 28' 48" N latitudes, and 42° 31' 32", and 42° 39' 90" E longitudes, in the southern part of the Red Sea (. 1 Fig). The island is composed of coral mixed with coral sand, and is practically devoid of vegetation [17]. The topography of Kamaran Island is relatively flat with similar scrub-shrub vegetation. [18]. The island, in general, have narrow shores composed of coarse sand. In Kamaran, water is very shallow and coastal reefs are rarely found at a depth greater than 4 to 6 meters [19].

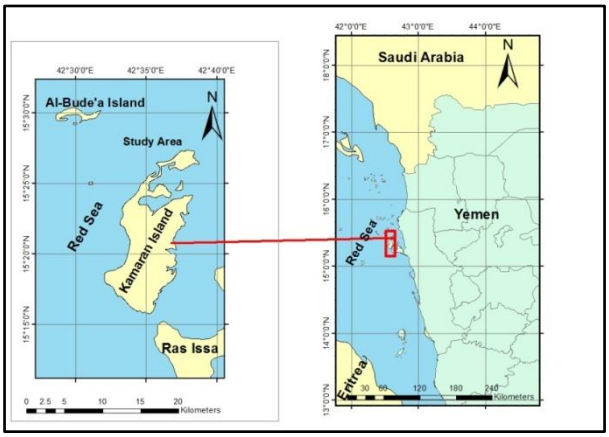

Fig. 1. Location map of the study area (Kamaran Island).

III. MATERIALS AND METHODS

Remote Sensing and GIS techniques were used in this study for mapping the land use/land cover and coastal line changes of Kamaran Island in Yemen.

Topographic sheet of 1:50,000 scale of the study area was used as a base map. Elevation contours at 50 m interval where digitized using a one-year survey using ARC/INFO GIS version 9.3, 10.3 software. Subsequently, these digitized contours were used for generation of a DEM with grid cell resolution of 30*30 cm under GIS environment. ESRI ARC GIS soft ware enabled the analysis of raster layers of Primary Topographic attributes from the DEM.

A GIS database has been developed using Arc GIS software. ERDAS IMAGINE 13 software was used to perform the supervised classification. Satellites image of high resolution (3 bands with 30cm spatial resolution of the year 2017 and satellites images of Land Sat ETM^+ 7 of the year 1987 were used to substantiate the doubted unclear areas and which were taken from Yemen Remote Sensing Center (YRSC) (Fig. 2). All these remote sensing data have been digitized, mosaicked and enhanced for better identification of different classes. All interpretations of remote sensing data were implemented in a GIS in order to obtain Kamaran Island location map, calculate the area of classification in each location and calculate the total area of Kamaran Island.

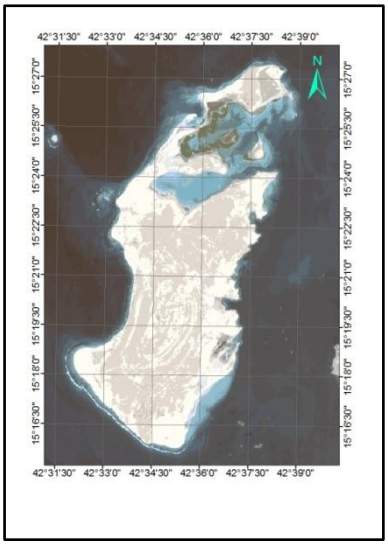

Fig. 2. Image for Kamaran Island by Land Sat 7 band.

Field check, old maps, photographs, or data, and geographical positioning system (GPS) of the study area are compared with the new images in order to assist in the interpretation process, and verify the information extracted from the RS data. Reference data are commonly referred to as "ground truth" [20] , [21].

In this paper, both enhancement techniques principal components method for (Land Sat 7 ETM^{+}, 7 bands 30*30, 2017) are used to emphasize changes between eroded and accreted areas, because of the low reflectivity of water at near-infrared (NIR) region of the electromagnetic spectrum.

Principal component (PC) analysis from PC1 until PC7 were used for obtaining high reflection of color of layers by using ERDAS IMAGINE 13 software. A supervised classification technique is applied in the PC7 for land sat 7 image 2017 to determine the classification of land use/land cover. Classification was done by subtype method at visual identification with field survey. Finally, comparing the two images of 1987 and of 2017 with respect of increasing or decreasing sea level and its influences on Kamaran Island.

IV. RESULTS

The processing of the digitized satellite image showed that the land use/land cover of Kamaran island could be classified into three classes. The first class represents the areas of anthropogenic activities such as residential villages, dumping sites, historical sites, fish landing sites, and tourism activities. The second class represents mangrove habitats, and the third class represents the barren lands. The distribution of each class is illustrated in Figure 3.

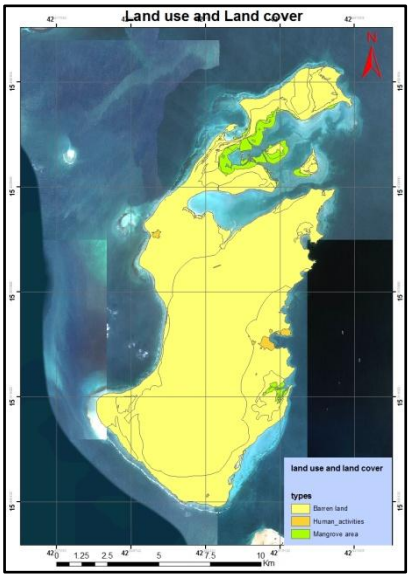

Fig.3. Land use/Land cover map of Kamaran Island.

The area of each class is shown in table 1. This study showed that the area of human activities are estimated to be about 0.70 Km^2. The of mangrove habitats is calculated to be about 4.02 Km^2, whereas the area of barren land is estimated to be approximately 105.66 Km^2. The percentage area of those classes are illustrated in Figure 4.

	Classifications	Area (Km^2)
1	Human activities	0.70
2	Mangrove habitats	4.02
3	Barren lands	105.66
	Total Area	110.38

Table 1. Area of each classification.

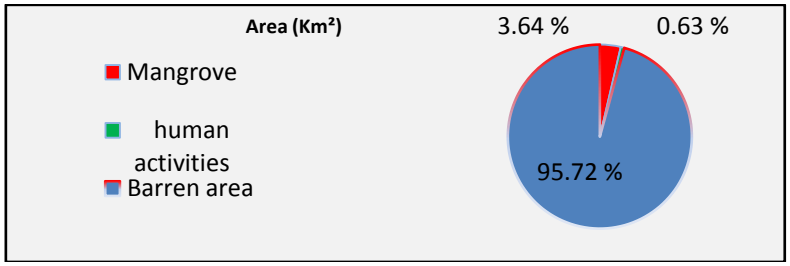

Fig. 4. Area Percentage of Land Use and Land Cover in Kamaran Island.

The three types of shores were noticed in Kamaran Island during the survey of this research study. The clay shores, sandy shores, and rocky shores are found to be approximately 149.4 km, 99.7 km, and 49.9 km long, respectively (Table 2). The location of each shore type is illustrated in Figure 5.

Shore types	Length (km)	%
Rocky	49.9	16.7
Sandy	99.7	33.3
Clay	149.5	50
Total shore line	299.1	100

Table 2. The length of shore types in Kamaran Island.

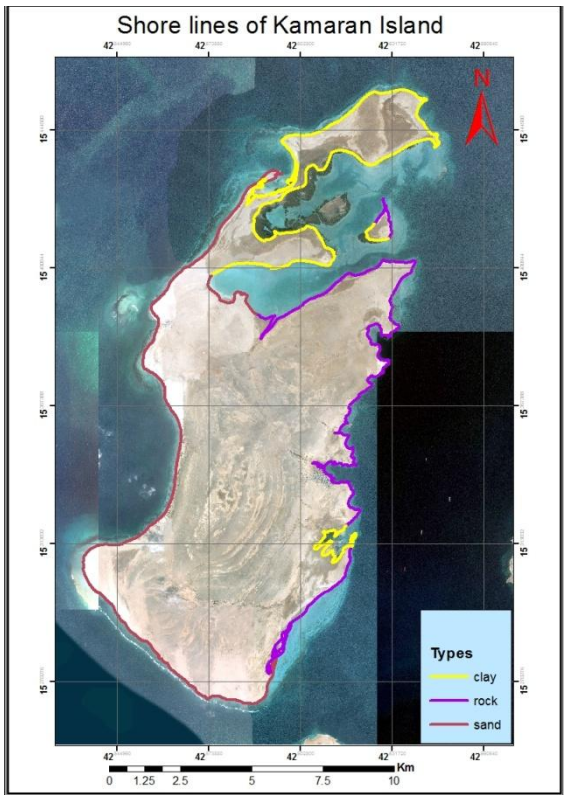

Fig. 5 . Types of shore lines in Kamaran Island

The comparison between the two time-lapsed images of Kamaran Island of the year 1987 and current image of the year 2017, showed that some areas were disappeared in recent years. Those disappeared areas were noticed in northern and eastern parts of the island (Fig. 3 and Fig. 6). Area of Kamaran Island in 1987 was estimated to be approximately 112 Km^2. The area estimated from the present satellite image was found to be about 110.38 Km^2. Approximately, 1.62 Km^2 of area was decreased during the past 30 years, *i.e.* about 66.7 m^2 of area were deducted from Kamaran Island each year.

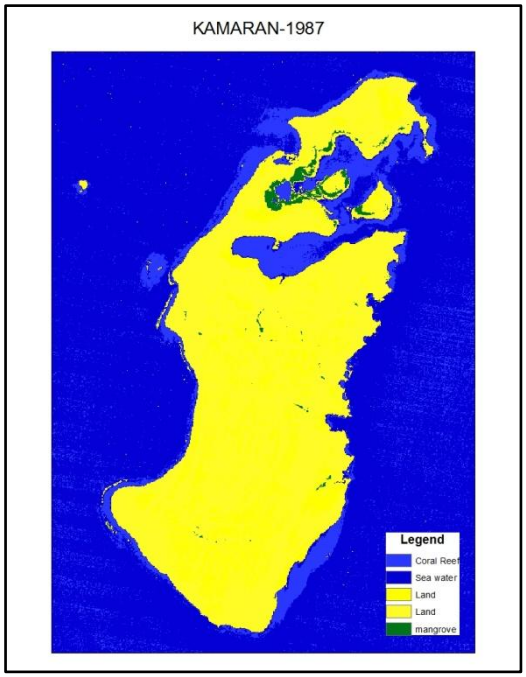

Fig. 6. Image of Kamaran Island during the year 1987.

V. DISCUSSION

Kamaran Island is the second important island to Yemen after Socotra Archipelago. Historically, the island is well known as a quarantine station for hosting Muslim pilgrims on their way to Mecca for "Hajj". It was estimated that the island was receiving about 44 thousand pilgrims each season [22]. The island is also known of the conflicts between several countries over its strategic location.

The island has narrow shores composed of coarse sand. In Kamaran, water is very shallow and coastal reefs are rarely found at a depth greater than between 4 and 6 meters [18]. Kamaran is famous for its black and gold corals and it is also one of the most important centers of the aquarium fish trade.

These systems are capable of handling both location data and attribute data about any feature. These attributes might include descriptive information about a given point, line, or area of a feature. The location data can be also called "spatial data", which gives information about the geometrical orientation, shape and size of a feature, and its relative position with respect to the position of other features. The attribute data is called "non-spatial data", which gives information about various attributes such as length, area, population, acreage, names, etc. The most important benefits of a GIS are its ability to spatially interrelate multiple types of information stemming from a range of sources [23].

In the present study, land use/land cover of Kamaran Island has been classified into three classes, *i.e.* mangrove areas, human activities, and barren lands. The human activities are including residential areas, dumping site, historical sites, fish landing sites, in addition to tourism activities.

During the supervised classification in image processing, there was an interference between the clay land reflection and the village areas. This could be attributed to that the building materials of village houses are clay. The total area of anthropogenic activities was estimated to be 0.70 Km^2, which is about 0.63 percent of Kamaran's total area (110.38 Km^2). There are three villages in Kamaran Island, *i.e.* *Kamaran* village, *Makram* village, and *Ras Al-Yemen* village. *Kamaran* village is located in the northeast of the island. This village is the largest village in the Island, and it consists of three neighborhoods (*Sihlah*, *Yemen*, *Sham*). *Makram* village is located in the western side of the island. *Ras Al-Yemen* village is located in the southeastern side, which is the smallest village in the Island.

Other human activities on the Kamaran Island are the fish landing sites distributed along the island close to the three villages. It is interesting to know that most of Kamaran's people are fishermen. They used to

go for fishing in order to gain their livelihoods. The other anthropogenic activities including, a tourism resort, an abandoned former British camp, schools, a health center, a dumping site, and a government compound. The dumping site has an area of about 1250 m^2, and is located between *Kamaran* and *Ras-Al Yemen* villages.

Mangrove habitats is located in the northern and eastern side of Kamaran Island. The northern batch of mangrove is declared by the government of Yemen as a nature reserve in 2009. This batch is composed of two types of mangrove species, which are *Avicennia marina* and *Rhizophora mucronata*. The eastern mangrove habitat is a small batch of mangrove trees. The total area of mangrove habitats in Kamaran Island is estimated by this study to be approximately 4.02 Km^2. It is calculated to be about 3.62 % of the total area of the island. A previous study on mangrove area of Kamaran was conducted by [13], which estimated mangrove area of Kamaran Island that was 5.13 Km^2. With comparison with that study, it is clear that the protected area of mangrove habitats was subjected to destruction by local people of Kamaran that has degraded the area by 1.11 Km^2 in the past five years. The lack of LPG (Liquefied Petroleum Gas) cylinders supply to the island have been forcing the island local people to cut mangrove trees in order to use it as wood fuel for cooking [24].

The current study showed that most of Kamaran Island area is a barren land. About 105.66 Km^2 (95.72 %) of the island's total area is a raised coral reef, or either rocky, clay, or sandy beaches. Only few trees or palms are scattered in the middle of the island. The lack of water sources in the island deprived it from vegetation cover, either by farming or naturally grown. Also, the migration habits of Kamaran's people eased the anthropogenic pressure on the land of the island. Most of Kamaran's people has left the island to the major cities, either for jobs or education.

Most of Kamaran Island shore lines are clay shores, which stretched to a length of 149.5 Km; that is about 50% of the island total coastal line (Table 2). Clay shores are considered as a perfect ground that encouraging mangrove seedlings to settle and grow. These areas are characterized with low marine waves which allow the sediments to accumulate in those areas without disturbance. Sandy beaches also account to 33.3 percent of the island beaches. Sandy beaches are prolonged to about 99.7 Km length. Those beaches are important for fishermen to park their boats, and also important for tourism and recreation. Approximately, 49.9 Km length (16.7 %) of the island is rocky shores. Those shores are dominated in the area of strong currents which remove sediments and transfer it to the marine bottom. The physical and geological marine processes are the main factors for the location of those beaches in the island. Rock shores could be found in the eastern side of the island, whereas sandy shores are found in the north, west, and south of the island. Clay shores are found in the areas where mangrove habitats are located; *i.e.* in the northern and western side of Kamaran Island.

Strong waves and the characteristics of beach sediments determined the geological process dominated in the island. The current research observations showed that Kamaran Island is subjected to coastal erosion. In the present study, the comparison between 1987 and 2017 images has emphasized this fact and showed that the island has been losing its terrestrial land throughout the last 30 years. The 1987 image showed that the total area of Kamaran is approximately 112 Km^2. This area decreased to about 110 Km^2 in 2017, with a difference of 2 Km^2 in 30 years. That is about 66.7 m^2 of diminution each year. This could be attributed to either flooding due to sea level rise, or erosion due to strong waves. The marine spit adjacent to the *Sabiq Ar-Rih* area in the eastern part of the island has disappeared and faded from recent images. However, the decrease in Kamaran Island's area in recent years could be attributed to the erosion caused by strong waves and the nature of the coastal sediments.

VI. CONCLUSION

The present investigation showed that Land use/land cover of Kamaran Island could be classified into three classes. These classes are mangrove area, human activities and Barren area. The nature reserve of mangrove habitat in the northern side of the island is subjected to wood cutting, which would effects this important sensitive marine ecosystem. Woodcutting must be stopped in order to protect this habitat. LPG cylinders should be made available at affordable prices to Kamaran's poor community. An actions should be taken against the erosion processes dominated in the island due to strong waves and weak sediments. Protection structures should be installed or established in order to prevent the decrease in Kamaran's land.

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