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Monitoring of Vegetation Change using Landsat 8 Imagery and GIS Technique in Tehama Coastal Plain, Yemen

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Abstract:- The aim of the study is to classify and monitor changes in vegetation and land cover in the Tehama region using Landsat 8 images for the periods 2015 and 2021, and geographic information systems (GIS). Vegetation cover can be classified and monitored using many indicators, such as Vegetation Index (VI), Difference Vegetation Index (DVI), Green Vegetation Index (GVI), and Optimized Soil-Adjusted Vegetation Index (OSAVI), but the most common index used to monitor vegetation cover is the Normalized Difference Vegetation Index (NDVI). NDVI was applied to two different periods, 2015 and 2021. For both periods, Landsat 8 satellite images have been used for the study area in order to assess changes in the vegetation cover of the Tehama Coastal Plain. The differences in NDVI for the two periods were detected and classified using ArcGIS software Ver. 10.8. The results of the classification showed a remarkable improvement in the vegetation cover, as they increased in 2021 compared to 2015 by about 9.5%, and the number of farms (uncultivated) increased by about 11.4%. This is attributed to the changes in the climate conditions in the area. The data showed an increase in rainfall in 2020 with a partial decrease in 2021. In general, the abundance of rainfall water for the last two years helped the growth rate of agricultural activities and spread in the region.

Keywords:- *Vegetation; NDVI; Satellite Images; GIS.*

I. INTRODUCTION

Tehama coastal plain is regarded as a significant agricultural area where most of the lands of Al-Hudaydah Governorate are located in the Tehama coastal plain area. This plain extends from Al-Lahiyah in the north of the western coastal plain to Al-Khokha in the southern part of the coastal plain strip, with a length of about (300 km) and a width ranging between (60-150 km), This coastal plain also crosses many valleys that are estuaries for torrential and rainwater, which comes from the internal heights of the governorate and the hills and mountains of the governorates of Ibb, Dhamar, Sana'a, Al-Mahwit, and Hajjah until it settles in the Red Sea [1].

Using remotely sensed data sources, such as Landsat 8, may contribute to monitoring the vegetation of a wide area for different periods. Also, satellite sensors can detect the spectral properties of plants and other phenomena by measuring the rays reflected from the surfaces of these features, which can be used later for differentiating and interpreting various features outcrop in the area [2]. Spectral properties of plants can be determined by applying band ratios, which often use the visible red band and infrared band. Many different band ratios, or indices, have been used by many authors for studying the changes in vegetation and soil cover, such as the difference in vegetation coverage index (NDVI), Vegetation Index (VI), Difference Vegetation Index (DVI), Green Vegetation Index (GVI), and Optimized Soil-Adjusted Vegetation Index (OSAVI) [3,4]. But the most common band ratio used for detecting the status of vegetation cover is NDVI, where the values of different radiations are calculated to improve images and reveal the characteristics of vegetation cover on the ground [5,6,7,8].

II. MATERIALS AND METHODS

A. *Study Area*

Tehama coastal plain area is an elongated, low, and flat land located on the western coast of Yemen and runs along the Red Sea. It extends over a length of about 88.3 km and lies between the mountain range to the east and the Red Sea coast to the west. The soil content of the Tehama area is mainly of loam and silt composition. The coastline is composed of sand and pebble beach [9,10]. The selected study lies between 1637422 - 1738229 N and 252631 – 277651 E and covers about 1248 km^2 (Fig 1).

Fig. 1: Study area location highlighted in red.

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B. Data

The major source for data extraction was Landsat 8 satellite images dated September 20th, 2015, and September 20th, 2021, which were downloaded from the USGS website (www.earthexplorer.usgs.gov) and used to identify vegetative areas in the Tehama region. Images from Landsat 8 were analyzed using Normalized Differential Vegetation Indices (NDVI) to delineate areas with vegetation cover [11]. The rainfall data for the study area was downloaded during the period from the beginning of 2010 until the end of 2021 from the Climate Engine website (https://app.climateengine.com/climateEngine).

C. Method

a) NDVI Image

Landsat 8 has been used to get information about the status and changes in the vegetation cover of the study area. The data have been processed and interpreted using ArcGIS 10.8. The spectral characteristics of vegetation cover were obtained from Landsat 8 and represented by Normalized Differential Vegetation Index (NDVI). The index was applied to the cropped study area and calculated the presence and distribution of vegetation cover in the study area. NDVI is calculated by determining the ratio of the near-infrared (NIR) and red channels of the reflected images (Eq. 1). In Landsat 8 OLI, NIR will be Band 5 and Red will be Band 4. The output values for using NDVI are between 1 and -1 [12]. NDVI can be calculated according to the following formula:

$$NDVI = (NIR — Red) / (NIR + Red) \quad (1)$$

NDVI was calculated for two images (2015 and 2021) using the NDVI tool in ArcGIS to get a panorama view of the vegetation status during these two periods. Hence, depending on the values extracted from the NDVI, the vegetation cover is classified, and the better the vegetation coverage, the higher the NDVI value [13].

b) NDVI Image Classification

Image ratio and classification processes have been performed using the ArcGIS package. The classification technique's main objective is to identify distinct land cover features such as vegetation cover, soil, and water body in the study area. The features distribution in the study area was detected using the NDVI values for both periods 2015 and 2021. The classification process Maximum Likelihood classification (ML) was performed on the NDVI ratio image using the semi-automatically (supervised) method, which requires training the data [14,15,16]. Based on the statistical values of the selected trained polygon regions (Table 1), three signatures types have been recorded for the regions as follows:

- Agriculture (Vegetation) (NDVI value > 0.2),
- Farms-Uncultivated (NDVI value > 0.13), and
- Barren land (NDVI value <= 0.13).

Class	*Range of NDVI*
Agriculture	>= 0.2
Farms - Uncultivated	> 0.13
Barren land	<= 0.13

Table 1: Each land cover's NDVI value range

For each image, a classification map was created using the previous classification (ML), illustrating the distribution of agricultural regions, uncultivated farms, and barren lands for the years 2015 and 2021(Fig. 2).

c) Verification of Classification Method

The accuracy of classification was verified using visual examination with Google Earth Pro for the same selected areas and at the same time. The results showed a high precision match between the areas in Google Earth and the classified areas for both periods 2015 and 2021 of the study area.

d) Climate analysis

Rainfall data were analyzed and represented graphically to find out the distribution of precipitation over the study area for the two periods. (Fig. 3) shows that about four major periods of rainfall values are represented by four peaks ranging from about 30 – 60 mm, which have been recorded for the years 2011, 2016, 2020, and 2021 respectively. The highest peak was 60 mm in 2020 then inclined to about 30 mm in 2021.

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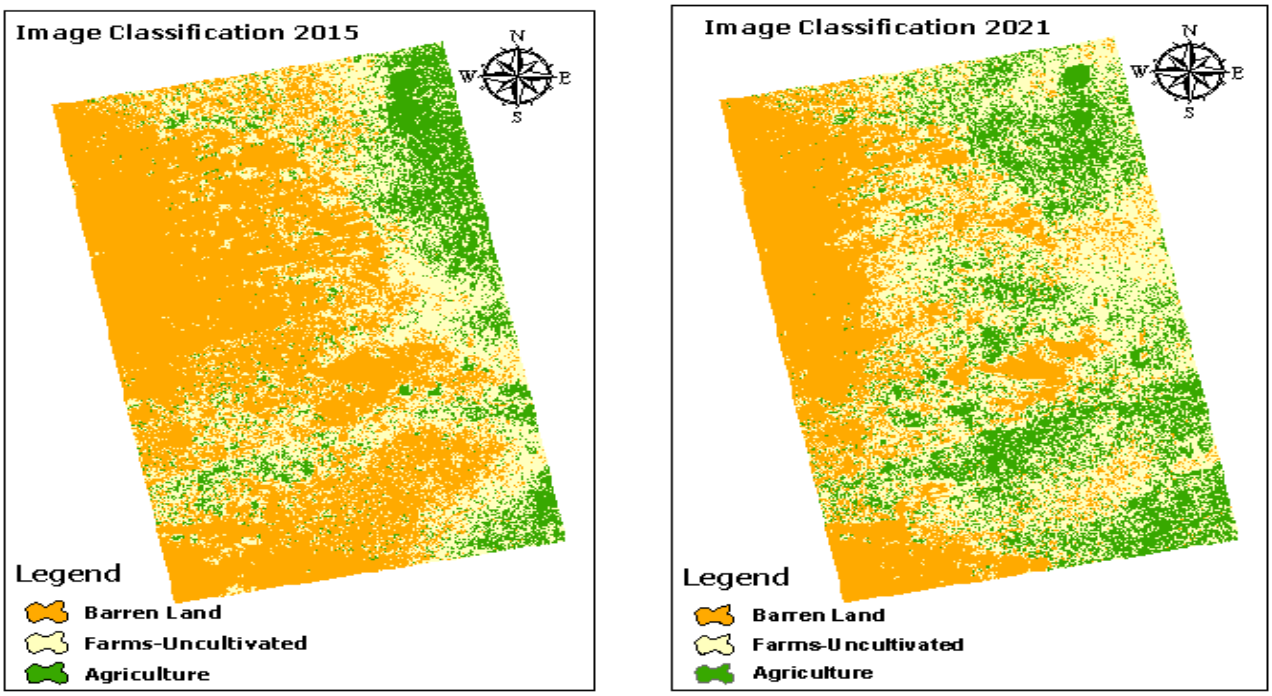

Fig. 2: Classification of images for the years 2015 and 2021

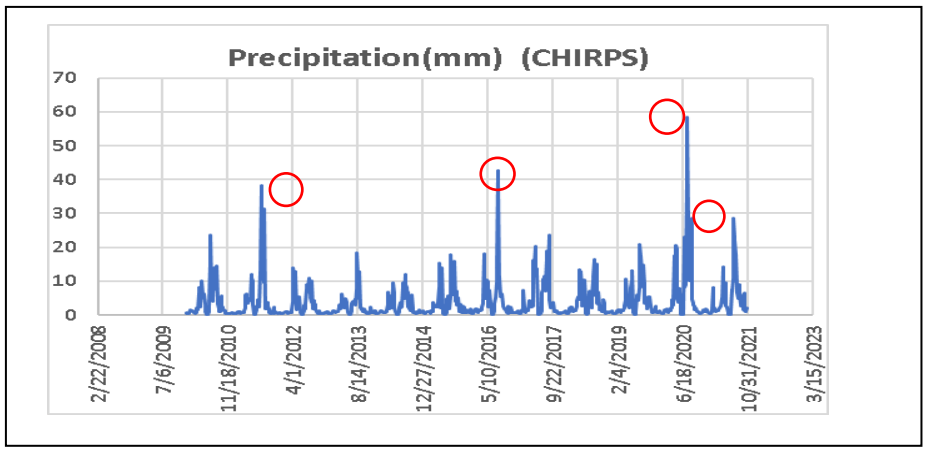

Fig. 3: Precipitation chart for the study area from 2010 to the end of 2021

III. RESULTS AND DISCUSSION

Agricultural lands constituted about (13.9%) of the total area of the study area in 2015, and increased to (23.4%) in 2021, with a growth rate of (9.5%), while barren lands constituted (56.9%) in 2015, it decreased to (36.1%) in 2021, a decrease of (20.8%), and the farms(uncultivated) formed (29.2%) in 2015 increased to (40.5%) in 2021, meaning that the number of farms(uncultivated) increased at a growth rate of (11.4%) (Fig 4). Based on the results of the classification, it is clear that the agricultural areas have improved significantly in the year 2021 attributed to the increase in rainfall water in 2020 and 2021, as well as the improvement in the climate (Fig.3), which is one of the reasons for the spread of agricultural activities in the region.

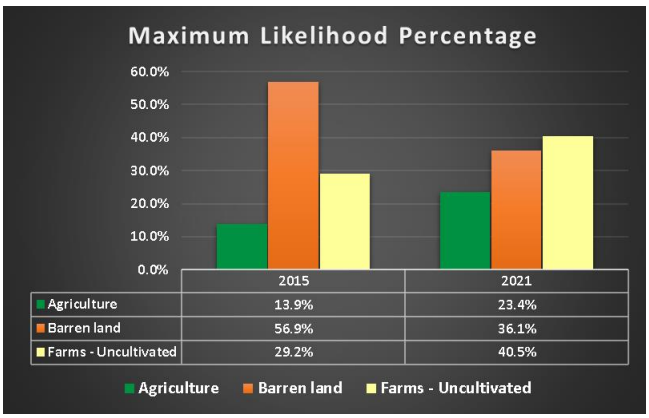

Fig. 4: Comparison of land cover classifications for 2015 and 2021

IV. CONCLUSION

The normalized difference vegetation index technique was used to extract the characteristics of the Tehama region as a case study. The classification results presented in this paper clearly show that the percentage of vegetation cover has improved in 2021 compared to what it was in 2015, as the percentage of cultivated areas increased and the number of farms increased as a result of the remarkable improvement in the amount of rainwater in recent years, which encouraged the spread of activity in agriculture in the Tehama coastal plain.

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