VEGETATION STRESS LEVEL AND NATURAL HYDROCARBON SEEPAGE IN UGWUEME, AWGU LOCAL GOVERNMENT AREA, ENUGU STATE, NIGERIA

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Abstract

Hydrocarbons that seep from the earth's sub-surface often affect the environment, soil, rocks and stress growing vegetation. In this study, natural hydrocarbon seepage was mapped in Ugwueme, Awgu Local Government Area of Enugu State, Nigeria using Remote Sensing and GIS techniques with the aim of detecting vegetation stress changes over a period of time. It was conducted using Landsat 7 ETM+ 1996, Landsat 7 ETM+ 2006 and Landsat 8 OLI/TIRS 2016. The global positioning system and the topographical maps of scale 1:100,000 were utilized for ground verification. Results revealed that the category of severely stressed vegetation rose progressively from 40.25% in 1996 to 54.73% in 2006 and then to 60.82% in 2016, while the category of less stressed vegetation reduced from 59.75% in 1996 to 45.27% in 2006 and then to 39.18% in 2016. There is an overall increase in the vegetation class cover classified as severely stressed, proving that remote sensing and GIS is a valuable tool for mapping hydrocarbon seepage areas. Thus, afforestation, re-afforestation and good land practices are recommended as preventive and remedial measures in the study area.

Keywords: *Hydrocarbon seepage, Image classification, Vegetation stress change detection, Mapping.*

Introduction

Vegetation stress adversely influences vegetation growth. When hydrocarbon oil and gas seep to the earth's surface, they deplete oxygen in the soil atmosphere and could cause stress to growing vegetation (Schumacher, 2012). The absence of oxygen in the atmosphere owed to hydrocarbon seepages is assumed to be one of the major causes of stress to growing vegetation because it inhibits the growth of root hairs in vegetation and hinder adequate uptake of nutrients by vegetation from the soil (Hoeks, 2010; Gilman et al., 2012; Arthur et al., 2012). Stress owed to seepages can cause vegetation to lose water (Carter 2001). Stress can affect any part of the plants, depending on its species (Noomen and Skidmore, 2009). The sensitivity of plants to any kind of stress is attributed to differences in biochemical mechanisms (Lichenthaler, 1998; Steven et al., 2010). Schumacher (2012) stated that vegetation growing within and around seepage areas are often stressed, stunted and unhealthy as compared to others, growing in areas not affected by the seepage. Smith (2002) stated that prolonged stress can cause damage to vegetation and even cause death if the stressor is not removed.

There are several studies which apply GIS and remote sensing techniques for vegetation stress change detection (Schumacher, 2012). This study aims to detect vegetation stress changes owing to natural hydrocarbon seepage in Ugwueme town of Awgu Local Government of Enugu State, Nigeria by using GIS and remote sensing techniques.

Study area

Ugwueme is a town in Awgu Local Government Area of Enugu State, Nigeria. It is bound by Latitude 6^0 0′ 00″*N* and 6^0 03′ 00″*N* and Longitude 7^0 24′ 00″*E* and 7^0 28′ 00″*E* of geographical co-ordinates. It is accessible through a network of untarred road, laterite-graded roads and several footpaths. The indigenes practice mixed farming where food crops (including yam, cassava, cocoyam and maize) and cash crops (cashew, oil palm and banana) are produced. They also keep local livestock such as goats and sheep for meat and for export (Onyeabor, 2013). The area has mainly ferralitic soils known as red earth. This soil is poorly drained and is particularly suitable for the cultivation of cash crops. The area often experiences heavy rainfall during the raining season and has a rainfall record of 1,800 mm (Aneke, 2006) annually which aids heavy flooding, soil leaching, erosion, extensive outwash, ground water infiltration and percolation and high temperature during the dry season with an annual temperature average of 26.6^0C. During the first quarter of the year, the temperature normally rises up to 37.7^0C and reaches its maximum towards the end of the dry season (Inyang, 1975). According to Nigerian Meteorological Agency, NIMET (2016), the study area experiences a minimum temperature of 25^0C and a maximum temperature of 34^0C.

Fig. 3.1: ***Hydrocarbon seepage observed in the study area during field visit***

MATERIALS AND METHODS

Data collection

The study used three Landsat imageries: Landsat 7 TM 1996, Landsat 7 ETM+ 2006 and Landsat 8 OLI/TIRS 2016 imageries which were acquired freely online from the site www.http://earthexplorer.usgs.gov from path 188 and row 55, path 188 and row 56 and path 189 and row 55 at a scale resolution of 30m. Topographic sheet of part of the study area was acquired from OSGOF (Office of the surveyor General of the federation) at a scale resolution of 1:100,000 and used with the global positioning system (GPS) during field studies for ground trothing.

Vegetation stress detection

Remote Sensing Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) sensors capture reflected solar energy. It often converts the data to radiance and then rescales it into an 8-bits digital number (DN) which is between 0 and 255. DNs can be manually converted to reflectance in two steps. The first step involves converting the DNs to radiance values which involves the bias and gain values specific to the individual scene the researcher is working with and the second step involves converting the radiance data to a reflectance. Since the Landsat 8 OLI/TIRS sensor is more sensitive, it is rescale into 16 – bit DNs with range values from 0 and 65536. In the study, remote sensing Erdas Imagine was adopted for processing.

Data analysis

In order to determine the vegetation stress change, Landsat 7 TM 1996, Landsat 7 ETM+ 2006 and Landsat 8 OLI/TIRS 2016 were used to calculate the Normalized Difference Vegetation Index (NDVI). NDVI is an empirical formula which is adopted to separate green vegetation from other surfaces based on the vegetation reflectance properties of the area. It is a function of two bands, which is the red band and the near – infrared spectral band. By using the NDVI results of 1996, 2006 and 2016 imageries, vegetation changes were detected which is calculated (Temesgen et al., 2014) as NDVI = (NIR – RED) / (NIR + RED) Where NIR is the near infrared band response for a given pixel and RED is the red response.

Results and Discussions

Table 3.1 shows the vegetation stress classes for the years 1996, 2006 and 2016. The values were classified into severely stressed and less stressed vegetation areas. The vegetation stressed classification maps clearly illustrated the spatial patterns of vegetation stress cover distribution within the study area (Figures 3.3, 3.4 and 3.5). The category of severely stressed vegetation was observed to rise from 40.25% in 1996 to 54.73% in 2006 and then to 60.82% in 2016. In contrast, the category of less stressed vegetation were visualize to reduce from 59.75% in 1996 to 45.27% in 2006 and then to 39.18% in 2016.

Table 3.1: ***Vegetation Stress Statistical Analysis of the study area***

Vegetation Stress level	**1996**		**2006**		**2016**	
	Area (Km^2)	**(%)**	**Area (Km^2)**	**(%)**	**Area (Km^2)**	**(%)**
Severely Stressed	191.349	40.25	260.207	54.73	289.143	60.82
Less Stressed	284.08	59.75	215.222	45.27	186.287	39.18
Total	**475.429**	**100**	**475.429**	**100**	**475.429**	**100**

The statistical chart (Figure 3.2) and the vegetation stressed classification maps (Figures 3.3, 3.4 and 3.5) clearly illustrate the spatial patterns of vegetation stress cover distribution within the study area.

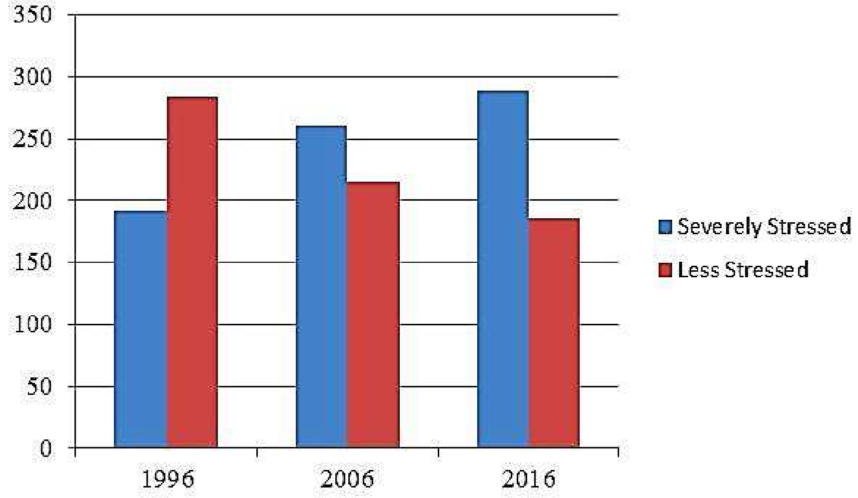

Figure 3.2: ***Vegetation stress regions***

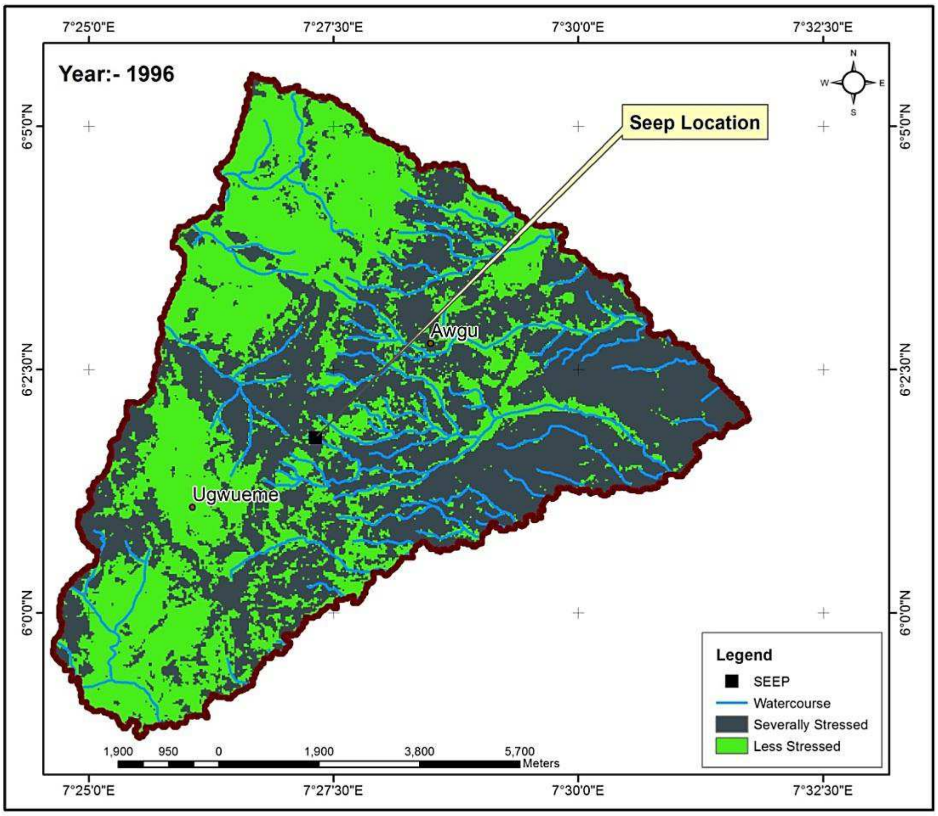

Figure 3.3: ***Vegetation Stress for 1996***

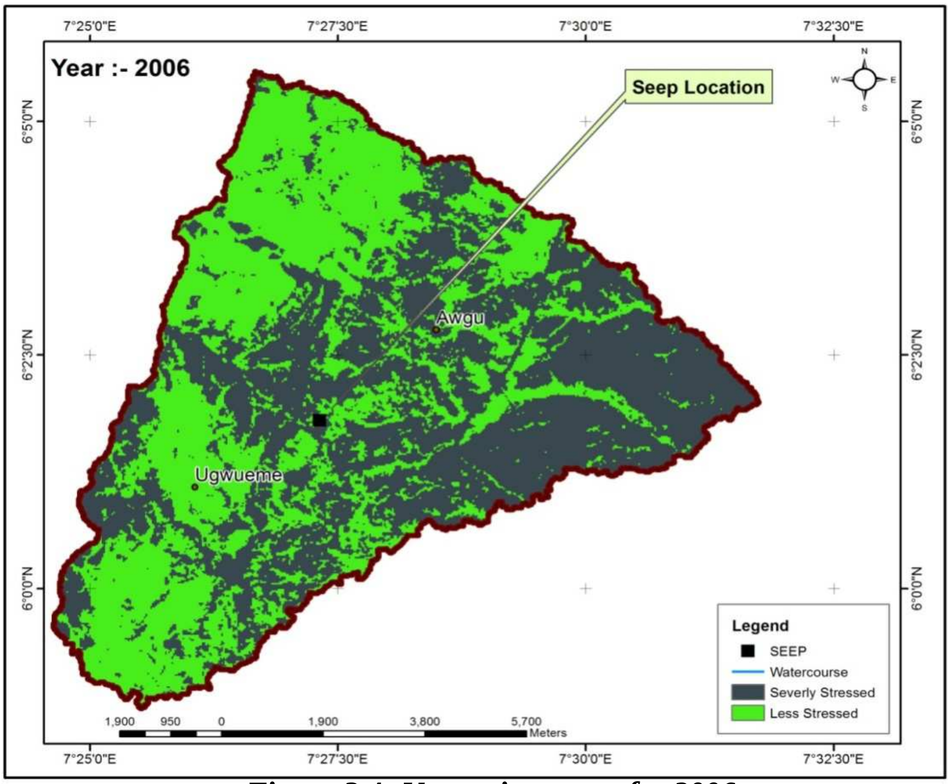

Figure 3.4: ***Vegetation stress for 2006***

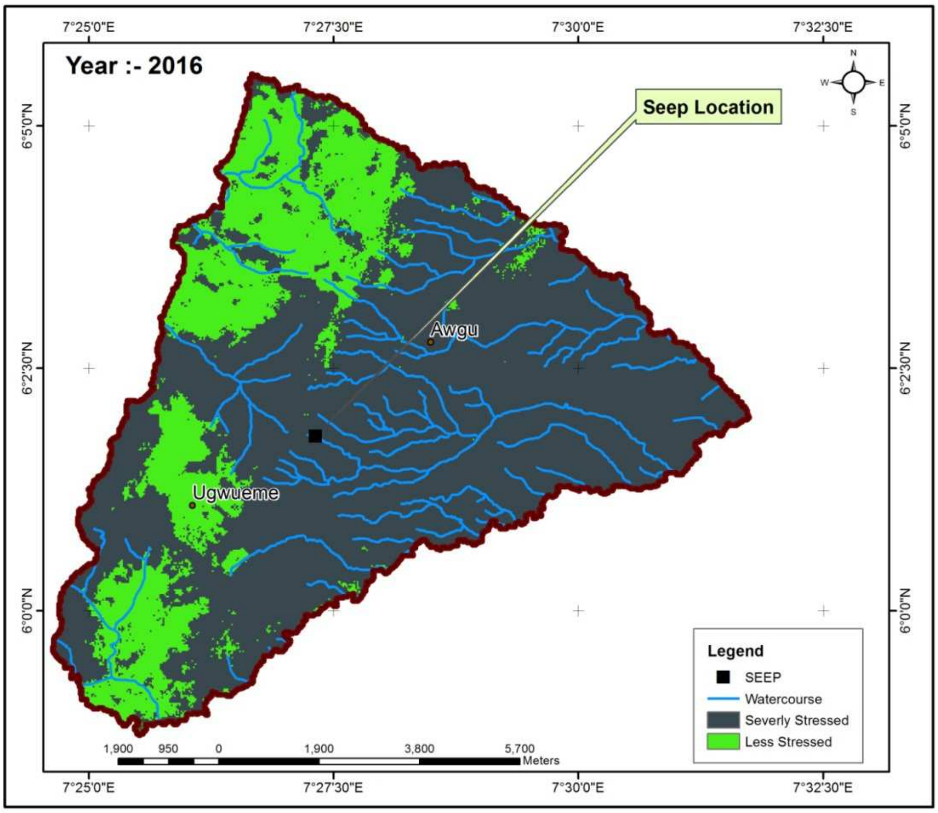

Figure 3.5: ***Vegetation stress for 2016***

Conclusions

The result of the study shows that there was an overall increase in the vegetation class cover classified as severely stressed, proving that hydrocarbon seepage stress growing vegetation. The study recommends good and adequate measures such as afforestation, re-afforestation, good land planning in the study area as preventive and remedial measures agaainst stress of vegetation by natural hydrocarbon seepage.

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