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Effect of Cloud Cover on Land Use Land Cover dynamics using Remotely Sensed Data of Western Niger Delta, Nigeria

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ABSTRACT: The effect of cloud cover on land use land cover (LULC) changes in the tropical region of Western Niger Delta was investigated. Landsat images of more than 1½ decades (2002-2019) of path 189 row 056 with bands 1-5 were used for the analysis. Supervised classification was applied to obtain the LULC statistics. Cloud cover for 2002, 2014 and 2019 were 0.48%, 0% and 32% respectively. The extracted statistics shows that cultivation, built-up area, exposed soil, secondary regrowth and water body increased between 2002 and 2014. These LULC except oil spills decreased between 2014 and 2019. These LULC were expected to record further increment between 2014 and 2019 due to increase in population. Dense forest and light forest maintained a decrease over the entire period. The real values were affected by cloud appearing as noise in 2019 image, which is a problem in a damp and humid climate. Climate change could be another reason because the data were acquired in the dry season. The satellite image of 2019 may not be used for accurate land mapping due to the high value of cloud cover. This has shown the effect of dynamic nature of climate in the region and the importance of supervised classification in the analysis of satellite images.

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Land cover monitoring is so significant that neglecting land use mitigation, which is made possible through documentation of land covers in an area, will lead to serious negative impact on the environment. There is the need for timely, accurate and documentation of land covers because of its dynamics and global impact (Hanson and Loveland 2012). A cloud consists of droplets of liquid water and it forms when air is heated by the sun. It covers the sky mainly in the wet seasons of tropical regions of the world, it is measured in okta. Clouds are significant in the earth's climate system because of their effects on radiation from the sun, radiation from the land, and rainfall. These effects depend on cloud altitude, thickness, horizontal extent, horizontal variability, water content, liquid or ice phase and the sizes of droplets and crystals. There is the need to distinguish different types of clouds. The appearance of clouds is always taken to show characteristic atmospheric dynamical processes. So the conventional classification by Meteorologists of cloud types based on their appearance continues to be used in classification of cloud study processes. Degree of cloud describes the extent of cover by clouds in the portion of the sky visible from the observation point. It is estimated by the weather observer and given in eighths by the synoptic service. The following classification is usually made. Clear – 0-1/10th covered; Scattered – 1/10th-5/10th covered; Broken – 5/10th-9/10th covered; Overcast – fully covered (Rokonuzzaman and Rahman, 2017). Generally, clouds formation happens in either of these ways: Foremost, clouds may form when the air mass is cooled below its dew point. This may occur when the air ascends or comes into contact with a cold surface. This can take place in situation when cold and warm air masses collide, and the less dense warmer air is lifted to higher altitude. It can also occur where air masses are moving across a mountain range, or it may be caused by convection current due to warming of the ground surface below. Secondly, Clouds may form when warm air blows over a low temperature surface such as a water surface. Lastly, Clouds can be formed where the air temperature increases gradually or remains stable, but the air mass quickly takes in water vapor from a surface under till it reaches the dew point. This often happens where cold and dry air masses flow across a warm ocean surface without ice cover (Rokonuzzaman and Rahman, 2017). Western Niger

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Delta is a major oil and gas producing area in southern Nigeria. Therefore, requires regular monitoring of its land covers to know the dynamics. Landsat images, being the satellite data of choice has offered Researchers the opportunity to assess and monitor land cover dynamics in different parts of the world (Yang and Lo, 2002; Bakr *et al* 2010). Land covers like dense and light forests in different parts of the world have been studied extensively using Landsat imagery. Twumasi and Merem (2006) utilized Geographic Information System (GIS) and remotely sensed data in the evaluation of change in a coastal environment in the Niger Delta Region of Nigeria. They reported increase in environmental issues such as habitat degradation, gas flaring, coastal wetland loss, water pollution, destruction of dense and light vegetation and other environmental concerns.

Uchegbulam and Ayolabi (2013) used Landsat imagery to study land cover changes in Western Niger Delta. They reported depletion of wetland and dense forest and an upsurge in builtup area. Varieties of spatial and temporal mappings has been successfully carried out using remote sensing (Foody, 2002). Wali *et al.*, (2019) investigated oil spill incidents and wetland loss in Niger Delta. They reported continuous incidences of oil spillage and loss of wetland in the area. Cloud cover is a major problem in satellite data acquisition in the humid climate of tropical regions (Ju and Roy, 2008) which Western Niger Delta region is not an exception. The effect of high humidity in the Niger Delta region is abundance of cloud cover. Mean annual rainfall in the region ranges 2540 – 4046 mm (Ishaku and Majid, 2010).Mapping land covers such as various vegetations covers in tropical and subtropical regions using optical sensors, more problems arises due to the frequent high cloud coverage, which further lowers the number of available and needed observations (Asner, 2001).

The effect of cloud cover on land cover classification has not been adequately investigated in the study area, hence the need to conduct such a study. The objectives of the study are to show the effect of cloud cover in the 2019 satellite image of the region, to compare it with land cover statistics of previous years and to make recommendations.

MATERIALS AND METHOD

Description of the Study Area: Nigeria lies between latitude 4^0N to 14^0N; and along longitude 3^0E to 15^0E. It is bounded in the North by Niger Republic, in the West by Benin Republic and in the East by Republic of Cameroon. To the North-East is Republic of Chad and Atlantic Ocean is to its South through the Gulf of Guinea. The study area is the Western part of Niger Delta (Figure 2). The area lie between latitude: 5^0 32’ N and 7^0 09’N and longitude: 5^0 09’E and 6^0 20’E and it covers about 180km x 180km which is approximately 32,000 km^2. A delta is an area where the rate of sediment supply is higher than rates of subsidence and is proximal to a body of standing water. The deposition of some of its sediment load from the rivers exceeds its rate of removal. River Niger is the main drainage system from which other distinct river systems originate. The region has a humid equatorial climate. The cloud cover is quite high, with relative humidity and average rainfall above 80% and 3000mm respectively. The study area consists of wetlands, coastal sands, mangrove swamps, and Sombreiro-Warri plains (Omo – Irabor and Oduyemi, 2006). Water table is close to surface; about 4 to 5 m beneath the surface. Directions of water flow are towards the tributaries which drain into the Atlantic Ocean. Figure 1 is map of Nigeria showing Niger Delta States, while Figure 2 shows Western and Eastern Niger Delta regions’ oil fields and pipelines.

Fig 1: Map of Nigeria showing Niger Delta States (GAMERS, 2017)

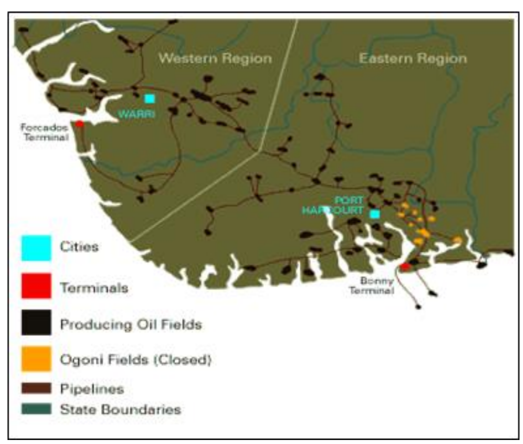

Fig 2: Map of Niger Delta showing the Western Region, oil fields and pipelines (Urhobo Historical Society, 2020).

Data sets and Image Pre-Processing: Satellite images of 2002, 2014 and 2019 of one scene from the Worldwide Reference System (WRS-2) of path 189 and row 056 (Table 1) were obtained from the Global Land Cover Facility (GLCF) of (2002, 2014 and 2019). The wavelengths used for the analysis were bands 1-5. ILWIS 3.1 software was used for image processing and GIS analysis. Geographic coordinate system (Longitude/Latitude) of the data were converted to metric coordinate system through the ILWIS 3.1 software application.

Table 1: Landsat Image Characteristics

S/N	Source	Date	Satellite Data Type	Sensor	Path/ Row	Resolution	Band	Cloud Cover
1	GLCF	29/01/2002	LandSat – 7	Enhanced Thematic Mapper Plus (ETM+)	189/056	28.5m	1 – 5	0.48%
2	GLCF	27/01/2014	LandSat – 7	Enhanced Thematic Mapper Plus (ETM+)	189/056	28m	1 – 5	0
3	GLCF	15/12/2019	LandSat – 7	Enhanced Thematic Mapper Plus (ETM+)	189/056	28m	1 – 5	32%

Bands: Sensor wavelengths (bands) acquired were bands 1, 2 and 3 which are visible bands with wavelength range (0.4 µm – 0.7 µm). Bands 4 and 5 are near infrared bands (0.7 µm – 1.1µm). Filtering of the images were done band by band, one band at a time using the ILWIS algorithm AVG 3x3based on matrix operation.

Classifications: Nine (9) land cover classes comprising, bare-land/cultivation, built-up area, dense forest, exposed soil, light forest and oil spills were extracted from the images. Others include secondary regrowth, water body and cloud cover. Supervised Maximum Likelihood Classification Algorithm was adopted because the area is a familiar terrain. Moreover, ground truth was done to compare the extracted covers with what is on ground. The study area was the training ground during the classification process. Colour composite of B543 (bands 5, 4 and 3) were established during the filtering, to give the vegetation the required green colour.

RESULTS AND DISCUSSION

The results are presented as maps, tables and histograms. Figures 3, 4 and 5 show the processed satellite images of 2002, 2014 and 2019 respectively. While tables 2, 3 and 4 show the extracted land cover statistics from the images of 2002, 2014 and 2019 respectively. The histograms of the images 2002, 2014 and 2019 are displayed in Figures 6, 7 and 8 respectively.

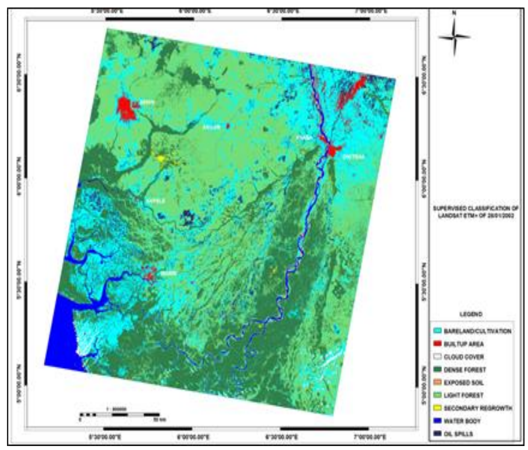

Fig 3: 2002 Land cover satellite image

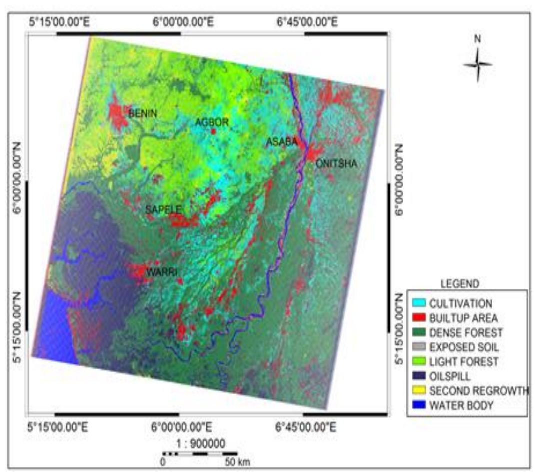

Fig 4: 2014 Land cover satellite image.

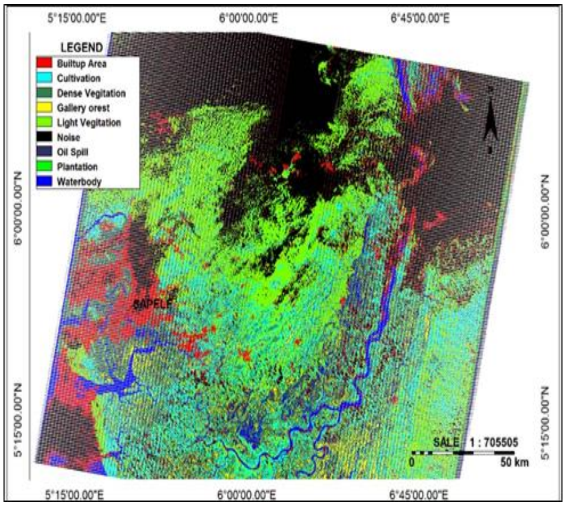

Fig 5: 2019 Land cover satellite image.

Table 2: 2002 Global Land Use Cover Statistics

Land Cover	Area (M^2)	Area Hectare (Ha)	Percentage (%)
Bareland/Cultivation	2695620600	269562.06	7.96
Built-up Area	1476163700	147616.37	4.36
Dense Forest	11715608100	1171560.81	34.59
Exposed Soil	403005100	40300.51	1.19
Light Forest	14138889400	1413888.94	41.74
Oil Spills	2077752100	207775.21	6.13
Secondary Regrowth	64461000	6446.10	0.19
Water Body	1143166300	114316.63	3.37
Cloud Cover	161791300	16179.13	0.48

Table 3: 2014 Global Land Use Cover Statistics

Land Cover	Area (M^2)	Area Hectare (Ha)	Percentage (%)
Bareland/Cultivation	5552331300	555233.13	17.79
Built Up Area	2589212700	258921.27	8.29
Dense Forest	6687981000	668798.10	21.42
Exposed Soil	1541864700	154186.47	4.94
Light Forest	9349983900	934998.39	29.95
Oil spill	2004023700	200402.37	6.42
Second. Regrowth	1285753500	128575.35	4.22
Water Body	2205482900	220548.29	7.06
Cloud Cover	-	-	-

Fig 4: Global Land cover statistics of 2019

Land Cover	Area (M^2)	Area Hectare (Ha)	Percentage (%)
Bareland/Cultivation	3659316300	365931.4	12.1
Built Up Area	2449527300	244952.4	7.7
Dense Forest	2317666500	231766.7	7.7
Exposed Soil	-	-	-
Light Forest	5879139300	587913.7	3.3
Oil spill	3272073300	327207.1	11.0
Secondary Regrowth (Galley Forest)	1519585200	151958.4	5.5
Water Body	1067953500	106795.7	3.3
Cloud Cover (Noise)	9559265400	955926.4	31.9

Bareland/cultivation increased from 269,562.06Ha in 2002 to 555233.13Ha in 2014 (Table 2) but decreased to 365931.4Ha in 2019 (Table 3).

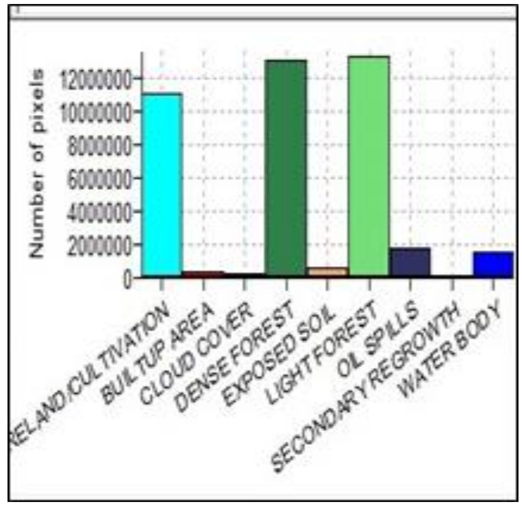

Fig 6: Histogram of 2002 LULC

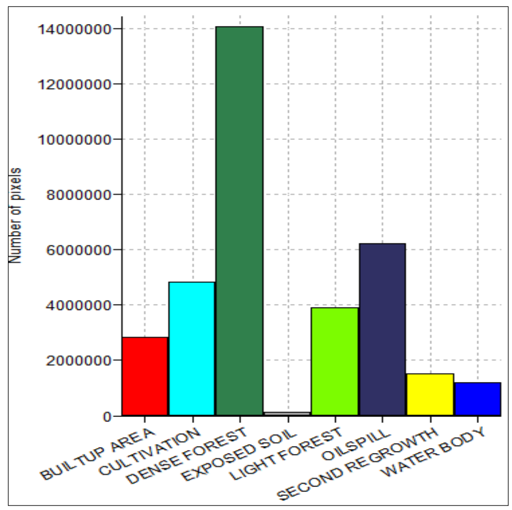

Fig 7: Histogram of 2014 LULC

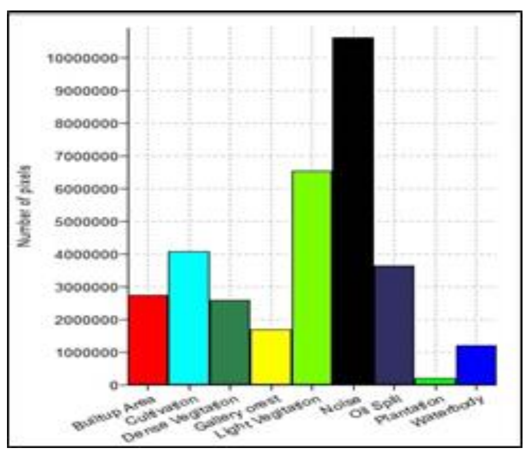

Fig 8: Histogram of 2019 LULC

The decrease in 2019 can be attributed to the obstruction of the whole cultivated land and bareland by cloud. There have been campaigns by various Governments on the need to increase food production due to increasing population. It has been yielding results in the study area as many people have gone into farming. Built-up area which comprises buildings and other physical structures decreased from 258,921.27Ha in 2014 (Table 3) to 244,952.4Ha in 2019 (Table 4). These may not be the true value due to the presence of high cloud cover. Builtup area is expected to maintain continued increment over the years. Wali *et al,* (2019) reported increment in built-up area (1984-2013) in Port Harcourt, a city in the Eastern Niger Delta. The Western region should follow the same trend because of increasing population, migration, increase in socioeconomic activities and hosts of other reasons. Dense forest maintained decrement from 2002 through to 2019 in spite of the cloud cover. This is understandable because of the percentage of depletion throughout the period. It can be attributed to the continuous logging activities for economic development-constructions of buildings, furniture and other uses of timber. Though there has been campaign on tree planting, the rate of wetland forest loss is alarming, since the rate of depletion is more than the replacement. Uchegbulam *et al* (2017) reported depletion of dense forest in the Western Niger delta region. Exposed soil increased from 40300.5Ha in 2002 to 154186.47Ha in 2014, but is not captured or did not appear in 2019 statistics. Exposed soil may have been captured as builtup area in the land cover. The obstruction may have been caused by cloud cover. Light forest decreased throughout the period under consideration. The decrement can be attributed to the same reasons for the depletion of dense forest. Oil spills decreased from in 207775.21Ha in 2002 to 200402.37Ha in 2014 and increased to 327207.1Ha in 2019. Though the cloud cover is high, but the increment is understandable due the upsurge of illegal makeshift refineries in the creeks of Niger Delta which leads to spillage of oil in the region. Wali *et al,* (2019) reported cases of oil spillage in the region. Secondary regrowth which include mangrove forest increased from 6446.10Ha in 2002 to 128575.35Ha in 2014 and decreased to 151958.4Ha in 2019. The true value may not have been captured due to the cloud cover.

Water bodies increased between 2002 and 2014, but decreased in 2019. There have been incidents of flooding in the region. So the depletion of water bodies may not be the true picture in the region due to the cloud cover. Cloud cover appearing as noise in the land cover statistics had a cover of 16179.13Ha in 2002. It did not appear in 2014, but has coverage of 955926.4 in 2019. Though the satellite data were acquired in the dry season (December 15, 2019), there have been records of heavy rains in the December period in recent years. The Niger Delta region records the highest rain (≥3000mm) in Southern Nigeria (Ishaku and Majid, 2010).Climate change may have been the reason considering the high resolution of the satellite in acquisition of the data. Cloud cover has always been a problem in the acquisition of satellite imagery in the tropics (Asner, 2001). Being that supervised classification was employed, it could be said that the land cover statistics of 2019 may not be the true picture at this time due the high value of noise in the satellite image.

Conclusion: The satellite image analysis of the region has further shown that cloud cover is a problem in the tropics. The research work has demonstrated the importance of supervised classification as the training ground is known to the Researchers as indicated by ground truths. Environmental Watchers and Government agencies are to put into considerations the dynamics of land use land cover for optimal environmental planning in the region.

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