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Research Paper

Spatial analysis of land cover dynamics across gas flaring sites in Rivers state, Nigeria

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Abstract
The study analyzed land cover dynamics across gas flaring sites in Rivers state, Nigeria. Landsat imageries for vegetation/land cover change (LCC) analysis for year 2010 and year 2020 was downloaded and analyzed for the study with reference to wet and dry seasons. Descriptive statistics inform of maps was employed for the study with spatial reference to gas flaring sites. Findings showed that generally more land surface have been altered during the dry seasons due to anthropogenic factors. Lighter green color indicated more secondary forests. Thus, the impact of man is more visible in the dry season sequel to the spread of dryness which resulted to more bare surfaces adding to man's impact. The central and the south-eastern part of Rivers state showed more anthropogenic altered surfaces due to high population. This region belongs to the capital city Port Harcourt and it constitute a region of high socio-economic activities. More importantly, gas flaring activities coupled with anthropogenic activities are factors causing changes in land cover over time. Gas flare locations have a direct impact on land cover dynamics in Rivers state. It was recommended that government should enact laws that will checkmate gas flaring activities and its associated land cover impacts in the study area.

Keywords: Land cover change, Gas flare locations, Anthropogenic altered surfaces, Wet and dry seasons, Rivers state

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I. Introduction

Land cover is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to monitor and detect the changes to maintain a sustainable environment. Land cover change occurs through conversion and intensification by human intervention, altering the natural balance of ecosystems, generating a response expressed as the system changes (Kulakowski *et al*., 2011; Melese, 2016). In addition, land use and land cover modification comprise some of the most significant human shifts influencing the surface of the earth (Mendoza-González *et al*., 2012). The assessment of sources of problems, processes and effects of LUCC is one of the major research agendas in environmental conservation studies (Jacob *et al*., 2015). Driven by human activity and natural forces, land-use change (LUC) has culminated in the global depletion of native habitats and ecological processes and resources through diverse environments (Mahmood, 2013; Eludoyin *et al*., 2017).

Gas flaring is the unscientific burning of excess hydrocarbons gathered in an oil/gas production flow station (Ogidiolu, 2003; Odjugo 2004). The reason while flaring is done is to act as a safety device to protect vessels or pipes from over-pressuring due to unplanned upsets. Obi and Osang (2015) stated that flaring is a means of safely disposing of waste gases using combustion. They noted that with an elevated flare, the combustion is carried out through the top of a pipe or stack where the burner and igniters are located. The size and brightness of the resulting flame depends on the amount of released flammable material (World Bank, 2011). In the Delta of the Niger, there are still more than one-hundred flares of gas combusting offshore as well as onshore. The region is a 70,000km^{2}area that has been producing the oil in Nigeria, and now experiencing this menace of flaring since 1956 when the production of oil started at Oloibiri in Bayelsa State in 1956 (Nigerian Environmental Study/Action Team, 1991).

The ecosystem of the Niger Delta region of Nigeria has greatly been endangered by ongoing oil and gas exploration, which commenced in 1958. Among the various activities associated with oil and gas exploration that directly affects the environment are oil spillage and fire, deforestation, dredging and associated

waste, gas flaring has been indicted as a prominent agent of pollution in the region. With the absence or inadequacies of an efficient regulatory framework, inaccessibility to domestic and international markets and limited finances to undertake gas flaring reduction projects are major reasons for the continuous flaring of gas (World Bank, 2010). Gas flaring activities coupled with the surrounding activities have contributed to forest loss and deforestation in the Niger Delta. The flaring of gas has become most worrisome to communities as it is a trademark among host communities in the region.

The application of geospatial techniques is essential in the assessment of land cover changes overtime. The evolution of GIS, the Global Positioning System (GPS), and Remote Sensing (RS) technologies has enabled the collection and analysis of field data which can be used for strategic planning, modeling, monitoring and assessment of forest Resources (Sonti, 2015). Following the advances in high resolution Remote Sensing Digital Data and Aerial Photography, mapping of the trends of cover changes have become relevant source of information for understanding land cover pattern changes (Lambin *et al*., 2013). Gas faring as part of industrialization and a form of human activity usually encourages forest encroachments; and thus, in order to assess the extent of its impacts, the study carried out a spatial analysis of land cover dynamics with reference to gas flaring sites in Rivers state, Nigeria.

II. Materials and Methods

Description of the Study Area

Rivers State is one of the thirty-six (36) states of Nigeria (Figure 1). The state lies within the global positioning system (GPS) coordinates 4°45'N 6°50'E. Port Harcourt is the Capital City of the state. Rivers State occupies a total area of 11,077km^2 (4,277mi^2) consisting mainly of tropical rainforests in the inland part and mangrove swamps (typical of the Niger delta environment) towards the coastal part. Rivers State is one of the six (6) states in the South-South geopolitical zone and one of the nine (9) states in the Niger delta ecological region of Nigeria. .

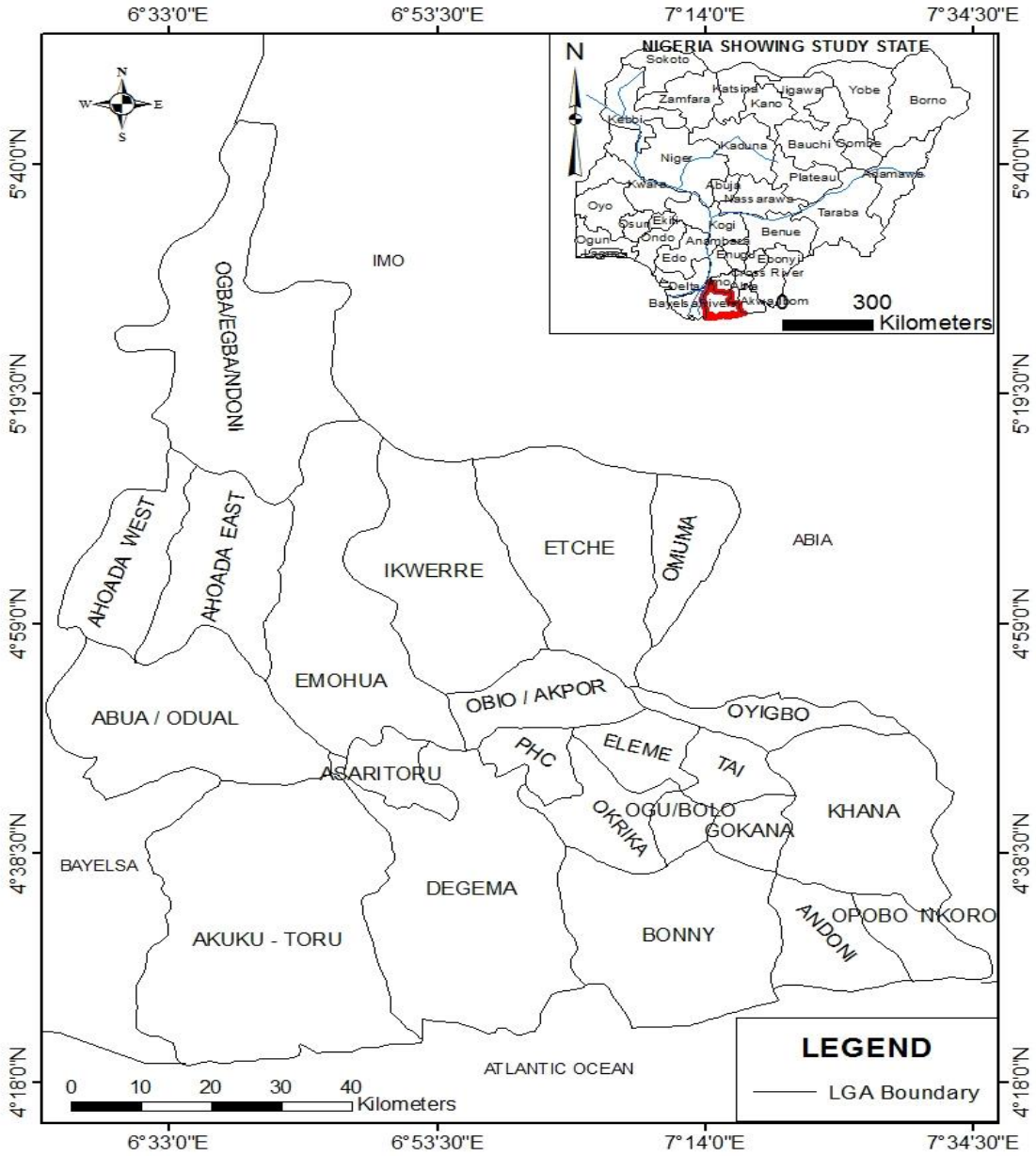

Figure 1: Rivers state and its LGAs (Inset- Rivers state location in Nigeria)

Rivers state lies on the recent coastal plain of the eastern Niger Delta. Its surface geology consists of fluvial sediments. This includes the recent sediments transported by Niger River distributaries and other rivers, such as Andoni, Bonny, and New Calabar. These materials deposited as regoliths overburden of 30m thickness are clays, peats, silts and gravels. Fourteen of the twenty-three LGAs of the State are located on the upland with varying heights between thirteen to 45m above sea level. These include Ogoni, Ikwerre LGAs, Ahoada, Abua/Odual, Ogba/Egbema, Ndoni LGAs and Port Harcourt LGAs (Figure 1). The entire topography of the state is characterized by a maze of effluents, rivers, lakes, creeks, lagoons and swamps crisscrossing the low-lying plains in varying dimensions. Rainfall in River state is seasonal, variable, and heavy. Generally, south of latitude 05N, rain occurs, on the average, every month of the year, but with varying duration. The state is characterized by high rainfall, which decreases from south to north. Total annual rainfall decreases from about 4,700 mm on the coast to about 1,700 mm in extreme north of the state. Deforestation is among the ecological problems confronting the state, as mass deforestation of both mangrove and rain forest is extensive. In fact, in some parts of the state, derived savannah exists. Rivers State is a state of physical difficulties, such as low-lying terrain riddled with an intricate system of natural water channels; much surface water and a high rainfall; and uninhabitable mangrove swamps and some part of the state suffer from inaccessibility. Rivers State and its

capital city Port Harcourt has long been an important merchant port and it is today, the center of Nigeria's oil industry. The area is the chief oil refining centers in Nigeria, oil being one of Nigeria's most important commodities and the main foreign exchange earner. Agriculture is the main occupation of the people of Rivers State and the agricultural policy of the state government is anchored on food production (Adeomo, 2013).

Data Acquisition

Landsat imageries of years 2010 and 2020 were downloaded to determine the land use/land cover types and changes for the different periods. The imageries were downloaded during the wet and dry season periods. The wet season period considered for the study was July while the dry season considered was December. Landsat Thematic Mapper imagery constitutes the base data layer from which the land use and land cover (built-up and non-built up) maps were derived. Landsat TM sheets were corrected for cloud cover and other interference. The corrections are executed at ground receiving stations. System correction refers to the corrections performed at the ground receiving station based on previously known sensor (system) distortions such as the pitch, roll, and velocity of the satellite platform. The images of the study area were gridded and numbers were assigned. The images were further processed and the bands collapsed into composite band in the Arc GIS 10.5 environment, which were classified, using the supervised classification methods to differentiate areas covered by vegetation, etc., and other land cover types over for the years (2010 and 2020) under consideration.

Spatial variation in land cover types and changes (2010 and 2020)

The information displayed on Figure 1 is for the land cover change for the year 2010 during the wet season. The displayed information revealed a growing population of anthropogenic activities a center area of the map and the South-eastern part of the study area. There was a high level of interplay between the primary and secondary forest in the Northern part of the study area while the Southern part of the study remain dominantly swamp forest and water bodies. Figure 2 displays the land cover change for the year 2010 during the dry season. It was revealed that the area was dominantly characterized by primary and secondary forest and swamp forest. However, anthropogenic alteration can be seen at the center of the map as observed during the wet season period. ▼

The information on Figure 3 shows the spatial variation in land cover change in year 2020 during the wet season. Land cover parameters from anthropogenic altered surfaces secondary forest, swamp forest, water bodies and primary forest were identified. It thus revealed that anthropogenic altered surface are evident when compared with the analysis for year 2010. The anthropogenic altered areas are notable within the central, south-eastern and north-eastern parts of Rivers state. The information displayed on Figure 4 revealed that more anthropogenic altered surfaces are evident in Rivers state. It was revealed that the dry season period for year 2020 recorded higher spatial coverage of surfaces altered by anthropogenic activities as represented by the brown color which spread dominantly from the central to the Eastern part of the study area with pockets of its occurrence in the southern and Northern parts of the study area. A secondary forest represented with a light green color as shown in little pocket neighboring the anthropogenic water surfaces implies a level of near distance alteration of the primary forest by the humans while the swamp forest and the water bodies are visible in the southern part of the study area. This is the implication of its proximity to the Atlantic Ocean. The impact of man is more visible in the dry season sequel to the spread of dryness which is resulted to more bare surfaces adding to man's impact.

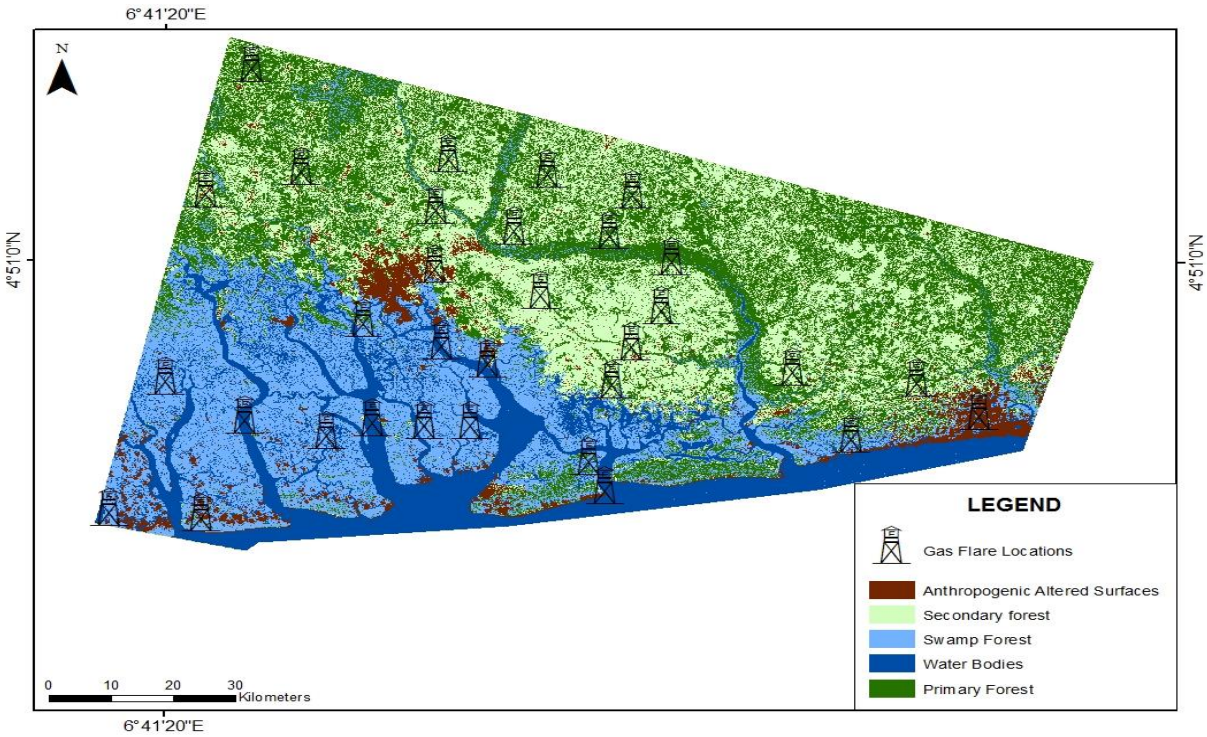

Figure 1: Land cover change (LCC) for year 2010 (wet season)

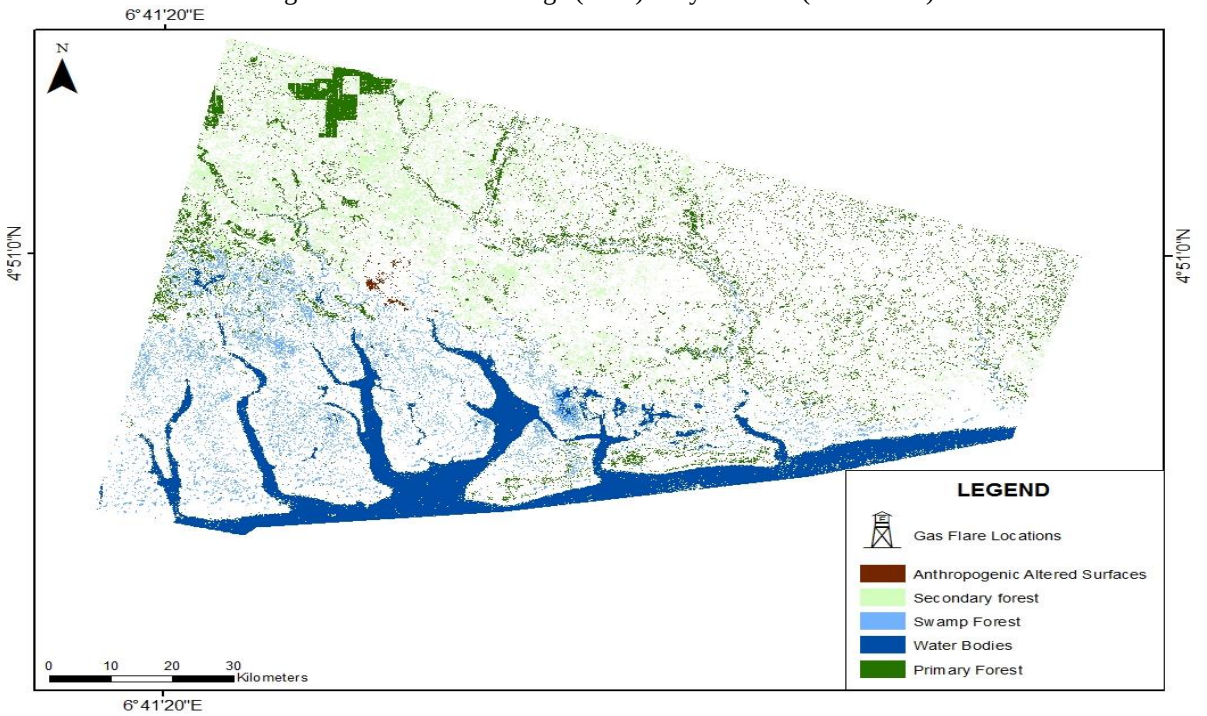

Figure 2: Land cover change (LCC) for year 2010 (dry season)

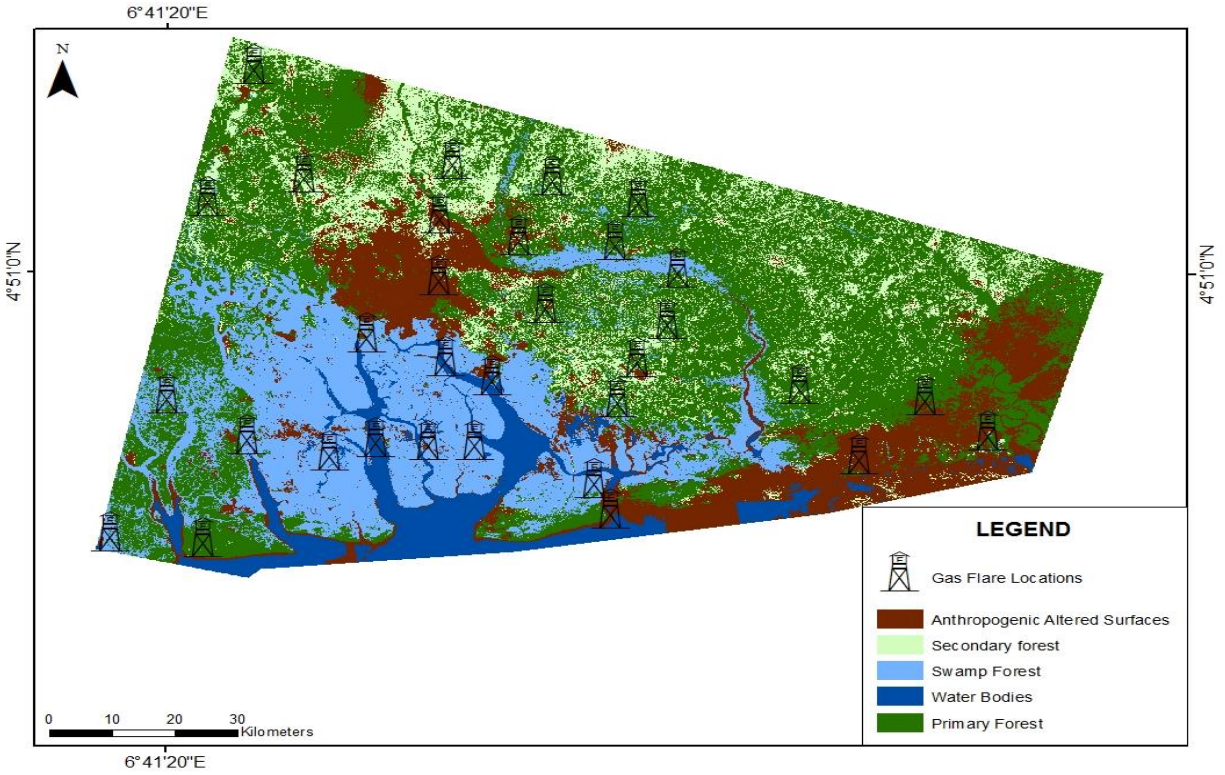

Figure 3: Land cover change (LCC) for year 2020 (wet season)

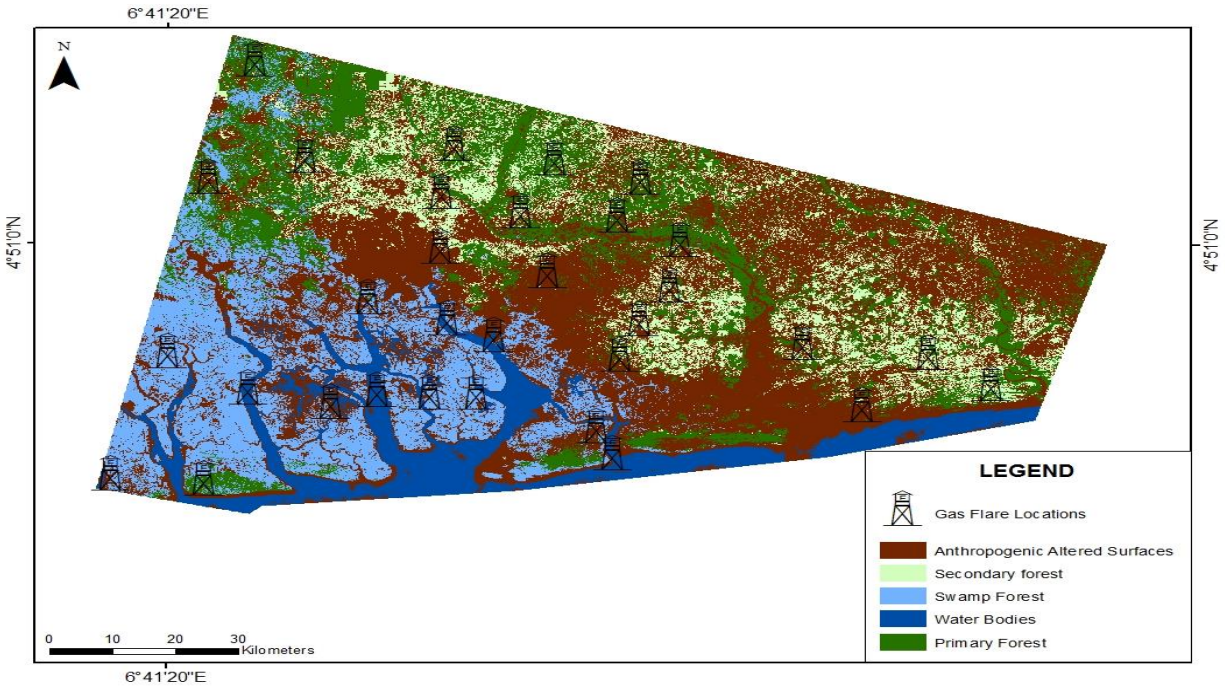

Figure 4: Land cover change (LCC) for year 2020 (dry season)

III. Discussion

There was a change in the vegetation land cover due to anthropogenic activities especially at the urban centres. Tram (2022) reported that anthropogenic activity has resulted in the degradation of nearly a billion hectares of land globally either as a result of agricultural or industrial activities. This is causing the decline in many ecosystem services worldwide and is now threatening livelihoods and resulting in socioeconomic instability. Although the land surface-induced global climate changes are not significantly captured, anthropogenic land surface processes such as urbanization, the conversion of mid-latitude natural forests to cropland and pastures, wood harvesting, and shifting cultivation in the tropics have been validated as exerting

remarkable effects on regional climate extremes through surface energy partitioning and water balance (Pielke et al., 2011; Mahmood et al., 2013; Findell et al., 2019) and thereby, causing changes in land cover overtime. Furthermore, socioeconomic changes such as population growth, rapid economic development, and industrialization modes are accelerating the urbanization process and gradually becoming critical factors that trigger environmental changes, especially for land cover dynamics.

IV. Conclusion and Recommendation

The land cover change analysis shows that as at 2020 the dry season recorded high level coverage of surfaces altered by anthropogenic activities as represented by the brown color which spread dominantly from the central to the Eastern part of the study area with pockets of its occurrence in the southern and Northern parts of Rivers State. The impact of man is more visible in the dry season sequel to the spread of dryness which is resulted to more bare surfaces adding to man's impact. Land cover change for wet season in the year 2020 as examined revealed that anthropogenic activities are more focused in the central and its south-south eastern part of the study area this is visibly as a result of high population within the Port Harcourt region. In other words, increasing human activities have influenced land cover changes over time with spatial reference to gas flare locations in Rivers state. The study recommends that: the government should enact laws that will checkmate gas flaring activities and its associated land cover impacts in the study area presence of gas flare locations; environmental laws guiding against uncontrolled human activities should be instituted and enforced; oil exploration activities removing vegetation land cover for the purpose of expansion should be adequately checkmated to reduce its impact on the primary forests cover in the study area.

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