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Geospatial Analysis of Oil Spill in the Selected Parts of the Niger Delta

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Abstract

Purpose: Oil pollution started as a cause of oil business in Nigeria that demonstrates political and economic undertone. Oil spills occurred during exploration, production and distribution of petroleum products, and created environmental impact. The nature of the business has indirect implicitness on the soil, water and the entire ecology as a whole. The aim of the paper was to analyse oil spill Geospatially and its objective was to discuss the causes, modelling and the sources of oil spill.

Methodology: The materials used were cover ArcGIS 10.7, MS word, ENVI 4.5 and Landsat imagery of 2019 and the methodology involved image classification, vectorization, and spatial analysis.

Findings: The study found out that illegal bunkering site are the causes of the spill, Asari-Toru reported 3, Delga 5 and Akulga 1. The study evaluated the impact level against thirty-four communities, Buguma, Tombia, Sama, Krakrama, Idama and Bille are placed under very high impacted state from ($0.111m^2$ - $0.133m^2$). Following the stratification of the impacted result, Ido, Abalama, Opurobokokiri, Ifoko and Sangama are recorded against high area ($0.083m^2$ -$0.111m^2$). The mapping showed that the spread of oil spill cover 79416.180ha against 24.976% from the classification scheme.

Conclusion: Satellite imageries have demonstrated the effectiveness of satellite-based mapping over the earth activity, especially oil pollution in the selected Local Government Area of Rivers State, Nigeria.

Recommendation: The study recommended that Oil bunkers should stop the bunkering, and oil companies should set up vigilante group to monitoring the network of pipelines.

Keywords: *Remote sensing, oil spill, causes, sources*

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1.0 INTRODUCTION

Environmental pollution is the introduction and concentration of toxic level of chemicals in the air, water and land. These chemicals alter the environment and interfere with functioning of the ecosystem (NOAA, 2018). Pollutants may be gaseous, liquid or solid discharged into the environment as a result of human activities. Most pollutants pose threats to the environment and human health and wellbeing.

The discovery of oil in Nigeria brought about a new dawn in the economic development of the country. However, research has shown that crude oil exploration and exploitation also led to numerous adverse environmental impacts including environmental degradation and pollution, particularly in the Niger Delta region of Nigeria (Paris et al., 2018; Voitier & Hoskins, 2019). Oil exploration has resulted in numerous oil spill incidents in the Niger Delta. For instance, the Department of Petroleum Resources (PPMC, 2015) noted that an estimated 1.89 million barrels out of a total of 2.4 million barrels of crude oil were spilled in the Niger Delta between 1976 and 1996 in 4,835 incidents.

Morrison and Vincent (2013) studied the effects of gas flaring on crops in the region. They observed that while crops like cassava are adversely affected by gas flaring, others such as waterleaf appears to thrive better in areas of gas flare (ELRL, 2021; Francis, et al., 2022). NOAA (2018) asserted that social disturbance experienced in the oil rich Niger Delta is related to environmental problems resulting from oil pollution in the region. Oshienemen et al., (2017) also noted the impact of oil spill on the means of livelihood of communities in the Niger Delta region.

Glory Oil spill likewise antagonistically influenced the biological pattern of the shore in 2002. 63,700 tons of the complete load were released into the undulated waters and polluted in the western world, and marine fishes, plants and creatures were accounted for death (Jorge et al., 2009; Diez et al., 2009; Tangley, 2018). During cross examination, organisms under the sub-bottom were not traced (Lobon et al., 2008). USWFS (2010) in her literature stated that high sea break out occurred within 2010, in the Adriatic sea. An aggregate of 6104 winged animals, 609 ocean turtles, 100 dolphins and different well evolved creatures and reptile had been watched dead. The aura of spill influences the natural surroundings of different creatures including sea-going spineless creatures, fish, ocean turtles, flying creatures and sea shore mouse following 7 Months of the fixing channel (OSAT-2, 2011).

Ebele and Vincent (2013) "in like manner" tended to the ingenuity event of the oil slick on Maize-a typical rural item. Scientific estimations were taken a few years ago with a GER 1500 spectroradiometer. Results showed visual focused on side effects at leaf bearing level. It massively uncovered plant reactions to hydrocarbon-prompted pressure fluctuated with length and force of defilement. Wave duality was utilized to quantify the reflectance of the leaf influenced because of spillage in the unmistakable and close infrared locales of the range compared with the control individually. Waveband around 705nm was seen as the most touchy marker of hydrocarbon worry in the plant. Previously, experimentations indicated that soil and plants are influenced considerably by hydrocarbon pollution. For instance, gradual changes have been observed in biochemistry and reflectance in vegetation growing near natural hydrocarbon seepage (Muhammad et al., 2013; Yang et al., 1999).

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The need of change detection is becoming relevant in the research industry and several authorities embraced the theory as a well impactful and result oriented which implore quantitative manual inspection and automatic detection method (Zhao et al., 2014; Su et al., 2014; Pisano et al., 2015). Understanding the types of spills is occasioned by the behaviour and movement of the spill using numerical model. The behaviour of oil spills in shattered ice-fields with intermediate, to high ice concentrations is predicted using a numerical model. The formula is designed to emphasize unintentional reflectance oil spills than drill blowouts involving massive amounts of gas (Venkatesh et al., 2010). The mathematical operations require formula was never de-emphasize for the Baltic situation. It's a three-dimensional, completely baroclinic circulation model with an ice model thrown in for good measure. Research showed that between 1995 and 2017, HIROMB was the operational ocean forecast model at Swedish Meteorological and Hydrological Institute (SMHI), however, it has since been superseded by NEMO-Nordic. Funkquist and Kleine (2007) for HIROMB version 2.0 and Axell (2013) version 3.0 provide descriptions of the ice best model. This is the version that was mostly used in these simulations (HIROMB NS03).

Simultaneously, whether the time of oil release is unknown or the oil spill model is built from observed oil slicks, challenges in comprehensive oil spill modeling persist. It could be the scale of an oil spill is frequently unknown, the emulsification process and the total amount of oil must be estimated. The adoption of the droplet size distribution formulation could be useful in operational 9l models to reduce model sensitivity resulting from uncertainty in emulsification rates and slick thickness. This method is less susceptible to the emulsification rate, but it does necessitate knowledge of the thickness of the oil slick (Li et al., 2017; Röhrs et al., 2018; Spaulding, 2017). However, the Bragg model is another wise concept used in remote sensing which has a relationship with backscatter effect on the satellite image, that is specular reflection. The dynamic elasticity of the water surface, or changes in surface tension that occur when the surface is stretched or compressed, dampens short gravity waves and capillary waves. Oil slicks do this by damping Bragg waves on the water's reflectance surface, which lowers the radar backscatter coefficient. Dark patches or spots appear in satellite SAR photos as a result of this and is used to discriminate spill area from non-spill environment (Topouzelis et al., 2007; Omodanisi, 2013).

A technology in the twenty first century is an added advantage to the development of web-based software. A Sea track web is a web-program of an oil spill trajectory system with a user-friendly interface. The Sea track web is made up of three parts namely a forcing interface, a user interface, and a trajectory calculation. PADM is the name of the section of Sea track web that calculates the trajectory (Particle Dispersion Model). Around the world, eighty (80) parties and agencies in the Baltic Sea employ a web-based oil spill trajectory model. This software is developed by Swedish Meteorological and Hydrological Institute (SMHI) in Sweden (Liungman & Mattsson, 2011; Ambjorn et al., 2014; Axell, 2013). The study would address the causes, modelling and the sources of oil spill through Remote sensing and Geographical Information Systems.

2.0 LITERATURE REVIEW

This investigate the kinds of literature cited by authority, causes can be seen as the source or reason of an event or action, this is translated to a person or thing that makes something happen (Hornby, 2018). Some of the causes of pipe break in the Delta region may seem to be corrosion, poor maintenance of oil infrastructure, blow-outs, failure of equipment, sabotage and theft of oil (Amnesty International, 2013; Paris et al., 2018). hell stated that 28% of Oil spills were due to

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sabotage and Nigeria Agip Oil Company described the theft as a challenging problem to the industry and Nigeria at large, facts emanated that oil theft is intended not to interrupt the pipeline to cause spill (Amnesty International, 2013; Hamilton, 2019; Voitier & Hoskins, 2019).

The Nigeria National Petroleum Corporation (NNPC) Department's Monthly Financial and Operations Report (MFOR) further highlighted the country record's growing, annoying and embarrassing attitude of vandalism. It showed that total oil and gas export receipts of $390.33 million were recorded in July compared to $312.93 million in June (NNPC, 2019). Reactions from these called for the collaborative measure to solve pipeline vandals which for the past 18 years recorded 45,347 pipeline breaks in the country. The PPMC (2015) also gathered that Aba- Enugu axis pipeline justified for 35 percent of the line breaks, while Port Harcourt route to Aba registered 22 percent, with Ibadan – Ilorin layout smacking 16 percent mark, and Lagos Mosimi Zone at 12 percent with remaining locations recorded 15 percent breaks after due Surveillance contracts to private security companies. Sabotage is deliberately destruction or damage of something to prevent it from being successful. Government efforts in Nigeria have seen sabotage through the process of "bunkering". Bunkering is the damage of oil installations or network of pipelines that connects from its source to distribution points, during this process of nefarious activities by irate youths, oil spilt to the ecological train to cause upsetting within the canopy of the place of action (Nwokedi, 1999; Egberongbe et al., 2006).

Surprisingly, there is another dangerous class of spill from tankers and oil operations that pollute the marine environment. Classification of the pollution by this standard is what is called an intentional act or industrial spill into the sea to cause unbalance in the marine Kingdom (Harahsheh et al., 2003; Reed et al., 1999; Michel & Fingas, 2016; Eleftheria et al., 2012). The issues surrounding oil spill prompted (Harahsheh et al., 2003) to investigate Arab Emirate oil spill with Remote Sensing techniques. Their findings showed that 52% of the spill is a mixture of waste materials.

Several debates were conducted on the rate of the spill at Ikarama in Bayelsa State (Amnesty International, 2013) agreed with photographic evidence that the spill was due to hacksaw cut but (Accufacts, 2013) opined diversionary view which previously clamp repair failed for poor installation. They noted many causes of the spill in the oil fields across the Niger Delta, the issue of Osiama one South-South (1s/s) flowline at the Osiama field was caused by a pinhole leak at the welded joint of the pipe. In 2008, Trans-Niger Pipeline spilt at Bodo creek in Ogoniland. The pipeline belongs to Nigeria's Shell Petroleum Company and the spill was caused by equipment failure that further released tens of thousands of barrels of oil pollution into the aquatic and upland environment (Amnesty International, 2013).

Green (2006) studied Guimaras spill incidence, a vessel of oil petrol tanker sank in Nueva Valencia, spilling 2.1 million litres of fuel oil. The spill was caused by a slick and it damaged ecological environment and livelihoods of the people. Still in the quest of providing an answer to the causes of the spill, (Ogbeni, 2012) took a study on Oil pipeline vandalism and National Security in Nigeria. Ogbeni (2012) reported that 398 cases of pipeline breaks were due to ruptures. Rupture means cracking of equipment infrastructures to be known as "very old and lack of regular inspection" and service (Deep-water, 2011). Statistics show that approximately twenty-seven (27) cases of oil rupture are associated with pipeline corrosion (Emmanuel & Amuah, 2019; Yesuf,

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2021; Gracethy, Anthony & Eziho, 2022) and undeserved vandalism alone accounted for 15, 685 breaks, representing 97.5% of the total number of cases visited.

A comprehensive study concerning the causes and modelling of spill is also given, both qualitative and quantitative approach from periodic point of view, deep water horizon (DWH) spill event take place in 2011 as a factor of explosion (Deep-water, 2011), reacting to the incidence of deep -water spill, Hazen et al. (2010) and Camilli et al. (2010) found it interesting to research because due global concern. Camilli et al. (2010) centered on the methodology as per tracking the extent and the plume generated, and autonomous subsea vehicle, in addition to, dissolved oxygen to accelerate biodegradation, while Hazen et al. (2010) cut across bio-degradation of bacteria by natural system. The works of Crone and Tolstoy (2010) and Kujawinski et al. (2011) also accounted for DH spill at the wellhead and calculates the rate of fluid mechanics as 4. million barrels of oil released by applying dispersants. The impact of a pipeline explosion in a rural village (Ilado-Odo) near Lagos, Nigeria, on December 26, 2006, which killed more than 250 people, is investigated in this paper. This pipeline explosion in the Ilado-Odo hamlet is one of 14 incidents in Nigeria between 1998 and 2006, the deadliest of which occurred in October 1998 in Jesse, Niger Delta, killing over 1200 persons. Pipeline explosions have also occurred in the past in various locations (Fadeyibi et al., 2011; White, 2006).

Since the 1970s, the number of oil tanker accidents weighing more than 7 tonnes has decreased, a trend that has been directly linked to the implementation of regulatory and technological developments such as upgrades to ship hulls and navigation systems are required (Burgherr, 2007; Kontovas et al., 2010; ITOPF, 2012). More researchers further mentioned transportation of crude through pipes and tankers are seamlessly contributing to the development of spill regarding eruption, break down of tanks or fallout on highway to cause deaths of human life, biodiversity and socioeconomic. The human factor which deliberately cause pollution through natural resources or industrial rascality disturbs agricultural land and marine division (Achebe et al., 2012). Human factors, such as individual errors or organizational failings have been blamed for up to 80% of oil spills and marine mishaps, according to (DeCola et al., 2006). This is because viscosities, specific gravity, light, medium, or heavy crudes or finished goods behave differently when exposed to the open sea, the impact of spills is difficult to assess.

The modelling of oil spill literature is also gaining a wider momentum in the area of the study which stipulates spatial and temporal changes in a spilled environment, considering the blow out, weathering, transportation and the level of impact within the locale. The state of an oil spill study calls for the formulation of models by researchers to reduce the potential issues created by the spill. Some of these models are SIMAP (French-McCay, 2004), GNOME (Beegle-Krause, 2001), BLOSOM (Duran et al., 2018), MEDSLICK (De Dominicis et al., 2013), OSCAR (Reed et al., 1999), OILMAP, MOHID and OPENOI. The General NOAA Operational Modeling Environment (GNOME) is utilized in this study to model the course of oil spill scenarios (Zelenke et al., 2012). The propound of these physical theories require high skilled physics and mathematical science in relation to spill, to reduce environmental problem. However, in order to quantify the quantity of spill jettison into the environment, the work of (Nelson & Grubesic, 2017) adopted the tracking and modelling of spill through spatiotemporal means to express his concern over a given area and others developed a comparative model to checkmate the previous made (Socolofsky et al., 2015).

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Several studies also mentioned spill model in their work to support the mitigation of an oil spill across the State. This is to ensure that the effect of oil does not pose a threat to the larger society and put all necessary framework to check mate its occurrences, and development of a model predictor in spill sector trajectories, including human impact aspect of the vulnerable state of the spill (Abascal et al., 2009; Broström et al., 2011; Webler & Lord 2010; Lord et al., 2012). The Gulf of Mexico disaster created a Lagrangian model to quantify the parameters of time and average spill concentration, as well as deterministic and probabilistic modes, which was found to be effective for evaluating emergency response drills and risk-based coastal prioritizing (Payam & Mohammad, 2018). Consequence modeling entails identifying and simulating accident scenarios in order to calculate the associated losses (Arunraj & Maiti, 2009). In the process industries, many consequence modeling methods have been created and used for emergency response planning. ESCAPE is a decision support system developed for emergency management of releases of radioactive materials into the atmosphere, and RODOS is a decision support system built for emergency management of releases of poisonous and flammable gases (Kukkonen et al., 2017, Leung et al., 2018).

In a related study, Prasad et al. (2018) used the combination of GNOME and Global Ocean Data Assimilation System (GODAS) based on Modular Ocean Model 4p1 (GM4p1). The distribution of Heavy Furnace Oil (HFO) calculated using the GNOME oil spill trajectory model matched the observed spread from the Sentinel-1A satellite dataset quite well. This is driven with projected GM4p1 currents. However, the trajectory model underestimated the spread of the Heavy HFO. This discovery is backed up by additional ground truth observations from the Indian Coast Guard. Hence, in a series of study (Victor, 2009; Liu et al., 2015; Yuxin, et al., 2018; Jianbo & Liang, 2019) advocated for hydrodynamic models (Mike21 OS software) to map the changes along the shoreline due to spill and the amount of run-off into rivers. Sicong Liu et al. (2017) also delved into a methodological approach of change detection principle of solving spill problem in the Gulf of Mexico and found its usefulness in discriminating actual spill from similar molecules based on binary and multiple detection processes.

Nwankwoala and Nwaogu (2009) conducted a pollution analysis in Etche Local Government Area in the Delta Region of Nigeria to develop a natural resource geodatabase. The materials and method used for the study included the collection of relevant oil spill data, topographical map, administrative map of Rivers State, route map of the Local Government Area (LGA), Land use/Land Cover, ArcView 3.5 software and multi-criteria precisely. GIS techniques were used in the management of oil spills, which concentrated on identifying various activities and socio-economic components (infrastructures) that could trigger oil spill in the area of study. The successful command was given to the system to create a buffer of 500m, 1km, and 1.5km away from the water body, roads, and pipeline as the cause of the spill. The three different regions buffered were used to find the effects of oil spill concerning the existing land use/land cover as well as ascertaining the area of each land use/land cover classes in each buffered zone. The rating is basing on the following parameters or criteria: possibility or challenge of cleaning after the spill, ecological category socio-economic importance, biodiversity, shoreline and oil contact, biological environment tolerance, slope exposure and physical environments, grain substratum size and permeability. Geodata imported into ArcInfo 3.5.1 and Arc views 3.5 environments for analysis. The results showed that the agricultural land is more affecting, as the water body ranked highest

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due to its resistance to land use ground cover. The study also recommended making available consisting ESI maps of the area.

Udoh and Ekanem (2011) developed a risk assessment model in the Coastal Local Government Areas of Akwa Ibom State, situated in the Niger Delta because of oil spill losses and damages within the region concerning its aim. Materials and method include ArcMap 9.1, Landsat image, and multi-criteria principle is incorporated. The study went further and identified the sources of spill in the environment, pipeline (30%), oil well (20%), tank farm and flow station (35%), Ocean (10%) and river (5%). These indicators are zones from one to four as very high hazard zone, high zone, moderate zone and marginal zone. The reason behind the ranking was to know which these parameters constitute vary the degree of pollution into the system and GIS as a tool is an effective pre-requisite data in modelling oil spill risk assessment as spatial. Therefore, a combination of data layers of hazard and vulnerability is the method used in the study to evaluate the GIS-based risk. Impedance surface was created in the study area because of the petroleum oil spill, while vulnerability modelling data on crop suitability, socio-economy, environmental sensitivity, accessibility, and settlement development were used. The risk layer outcome grades into four mediums, high, moderate and low-risk areas. The result analysis proved beyond reasonable doubt that Iko and the surrounding area found to be in the high-risk region. This is because of increased industrialization in Akwa-Ibom State, these impediments indicated the creation of a contingency plan.

Safoora et al. (2012) looked at the disastrous nature and greatness of oil spill close to the central Philippines within the Guimaras Strait, travelling off Negros Island. The web journal of the chew over point at confirming L band wave conduct for oil spill location overseas from today farther detecting sensors. Two sorts of information are utilized for this ponder: to begin with, one is recreated information for preparing neural organize and the moment is the lackey information as the input of the prepared organize. The capability of the inversion technique is utilized to create a realization of the job, which indispensably conditions show (IEM), and little irritation show (SPM). They are diffusing models for isotropically arbitrary surfaces that can be categorized into hypothetical and observational models. Both can give backscattering coefficients (σ) based on the characteristics of the sensor (wavelength, occurrence blessed messenger and polarization) and the target (surface harshness, dielectric consistent). The result appeared a multi-layer perceptron neural arrange with two covered up layers of 20 and 15 nodes were found as the finest demonstrate for the relationship between the water surface parameters (root mean square surface stature and dielectric steady) and the backscattering coefficients without overfitting.

Marghany and Genderen (2014), explored the transportation of oil spill within the Inlet of Mexico, which secured an add up to a zone of 150 km and over. In other to account for the causes and the impacts of the spill, they considered point to plan programmed discovery methods for the oil spill in manufactured opening radar (SAR) lackey information. The assisted fabric for the job is Radarsat-2 SAR that includes the Standard bar mode (S2); W1beam mode (F1) picture. SAR information is C-band and has a lower signal-to clamour proportion due to their HH polarization with a wavelength of 5.6 cm and a recurrence of 5.3 GHz. An entropy algorithm is utilized within the investigation stage to the degree of unusualness or data substance. Grey surface examination particularly depicts the vitality, homogeneity, cruelty, change, differentiate disparity, and entropy relationship. The study appears that entropy calculation gives the precise design of oil smooth in SAR information. Using the collector-operating characteristics bend, the appeared results revealed

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ninety percent oil spill, three percent similarity, and seven percent unpleasantness in the ocean. Agunobi et al. (2014) investigated the name "Investigation of the History and Environmental Impact of Oil Spillage in Etche Local Government Area of Rivers State, Nigeria" work to address the ongoing oil spill in the Delta area of Niger. Remote Sensing technology such as satellite observation carried out coupled with interviews. Questionnaires and observation instrument were employed in data generation and collection. Results revealing that twenty-nine oil spill incidents occurred in the early two thousand. With the accumulated volume of oil spilt to 4,270 barrels, 2003 recorded the highest (4171.5 barrels) and 0.1 barrel was the least record shown in the year 2005. The major causes of the oil spill include sabotage 75.9%, pipeline equipment 17.2%, corrosion 3.5% and 3.5% for others too insignificant to mention

In other to strengthening the body of literature, Emil and Manfred (2016) conducted a study titled "Modeling the rate of oil spills, leakage sources and the risk of pollution in the Caspian Sea using multi-temporal SAR images and stochastic modelling." The study utilized ENVI Radar Satellite, wind speed, and water current and segmentation procedure. Results showed that on 136 multi-temporal ENVISAT Large Swath Medium Resolution images and 2.5-12.4 m / s wind speed range, oil slicks have been observed. The important reason for the literature review is the contingency planning account (MEDESS 4MS, 2015) and the training for effective response measures to tackle dangerous oil spills at sea. The study focused on the development of oil spill models for the Mediterranean Sea in France to forecast sea meteo-marine conditions through the use of numerical models for atmospheric, wave and hydrodynamics. The materials considered for the spill motion are image/animation (GIF), GIS/Microsoft excel (DBF), Google earth /Google maps (KML/KMZ), GIS /GPS/ interactive web-mapping (GPX), SAR detection, and ESA images while the methodology applied a Lagrangian representation of the oil slick. The study resulted in three (3) - dimensional models namely MEDSLIK, MEDSLIK-11, and POSEIDON- OSM respectively.

Pablo and Beatriz (2018), moreover examined the oil spill diagram on Spanish coasts. The point of the work was to identify dim spots regions inside the marine environment utilizing Terma-Side-Looking airborne Radar Partisan. The technique comprised picture highlight and locale division, which were separated into two; the clamour locales caused by aeroplane developments are identified and labelled in arrange to dodge the location of false positives. Moment, a division prepare guided by an outline saliency method is utilized to distinguish picture locales that speak to oil slicks with the assistant of Fourier change. The result of the first step gives a picture in which the boundary pixels having a place to the clamour are recognized, couple with K- implies clustering algorithm to find straight lines as an approach fitting in arrange to decide the border commotion zones. The moment result gave knowledge to saliency outline, subsequently, gives a pre-processing step with which to perform an important division prepare that recognizes the pixels speaking to the oil spills within the picture.

3.0 METHODOLOGY

The materials used for the work are ArcGIS 10.7, MS word, ENVI 4.5 and Landsat imagery. The image of 2019 with spatial resolution of 30m was gotten from Global Land Cover Facility, for land cover and land use mapping. Bands 5, 4 and 3 were composited to give real earth reflectance. Further methodology involves image classification, vectorization, and spatial analysis in ENVI 4.5 and ArcGIS 10.7.

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3.1 Study Area

The study area comprises the three Local Government Areas in Kalabari County, namely Asari-Toru, Degema, and Akuku-Toru, which are situated between Longitudes 6° 40' 0" E to 7° 0' 0" E and Latitudes 4° 20' 0" N to 4° 40' 0" N (Fig. 1). Degema Local Government Area was established on May 27, 1967, covering all the communities speaking Kalabari. According to the National Population Census (2006), the population of the region, estimates to be 249,773 and Land mass definition is a parametric indicator, which significantly places its area to be 1,011 km². Degema Local Government Area's headquarters is Degema Town as enshrined in the Rivers State Government's White Paper. Degema is the name of a clan that includes Usokun-Degema and Degema City (Jonah & Ifeanyi, 2022).

3.2 Vegetation and Topography

Oteiva and Ndokiari (2018) discussed that the vegetation in the Delta cuts across swarm, mangrove and tropical rain forest. They also stated that the Sombriero River evacuates the western part of Rivers state and it is around the swarm mangrove zone with tropical rain forest. The mangrove forest is typical vegetation found along the Sombrero River which includes complicated trophic level and covers the river at both banks consisting of mangrove trees (Rhizophora, Avicennia and Nypa fruticans) that form a characteristic muddy substrate that produces a foul odour which occasionally served as fuel wood for biodiversity. The land surface of the upland zone of Streams State is 20m over the mean ocean level (61%) whereas the riverine region, for example, Asalga, Delga and Akulga, alleviation run from 2m to 5m, covering (39%) of the State. Labyrinth of rivers, lakes, creeks and swamps dominated the topography of the study area with low-lying plains (Environmental and Social Management Plan, 2015).

3.3 Soil Profile

Normally, the dirt comprises different minerals, natural constituents and broken rocks that have been modified in responses to the earth. Essentially, all over the country, the soil characteristic allegedly reveals a similar type. Clay soil, silt and sand are distributed naturally by definition, exhibiting measurable characteristics in the area of study (Dori & Iyama, 2017). Ayo et al. (2017) quoted Geologic formation given by (Oyegun & Adeyemo, 1999) better classified them as Fluvial-marine and marine sediments which aligned along the wet coastal region of the delta, they are characteristically organic and sandy. A second class of the soil is called alluvial soil of the mangroves, which are brownish in colour and rich in organic matter, deposited in the north. Sany loams and freshwater brown loams are in the freshwater zone where the soil is more acidic. These soil types are seen under the Benin formation, which is a combination of silty clay and sandy properties (Gobo, 1990; Offodile, 1992; Edet, 1993; Udom et al., 1999).

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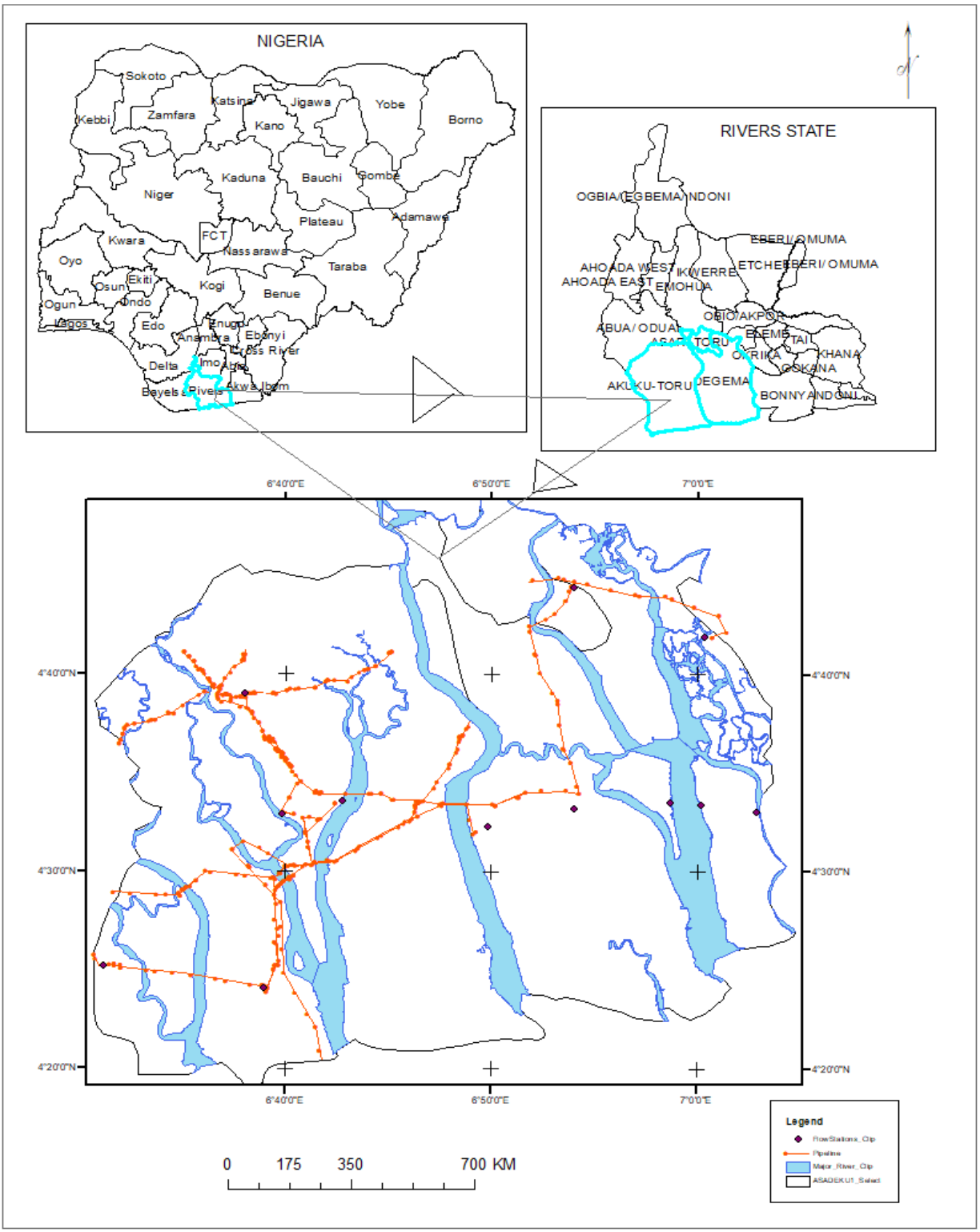

Figure 1: Map of the Study Area

Source: Jonah and Ifeanyi (2022)

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4.0 RESULTS AND DISCUSSION

Table 1 is a land use and land cover for 2019, the tabulation embodies spill, waterbody, vegetation, built-up, cloud cover and strip line. The degree of the spill is 79416.180hactres which amount to 24.97% in the classification cover. The position of the waterbody occupies 56590.200 hectares (17.97%). In the period considered, built –up constitute 3993.210 hectares, approximating it to be 1.255% in the pixel locations. Accordingly, cloud cover and open space also have a spectral signature that is quite different from another land cover. They are not vital in the study but are considered to avoid misclassification in data mining. Cloud cover is 6.8% while open space has 31.54% in the minimum distance classification as shown in figure 2 and figure 3.

Table 1: Land use and land cover for 2019

Category	Area (Hectares)	Percentage (%)
Spill	79416.180	24.976
Waterbody	56590.200	17.798
Vegetation	56044.170	17.626
Built-up	3993.210	1.256
Cloud cover	21629.340	6.802
Open Space	100290.690	31.542
Total	**317963.79**	**100**

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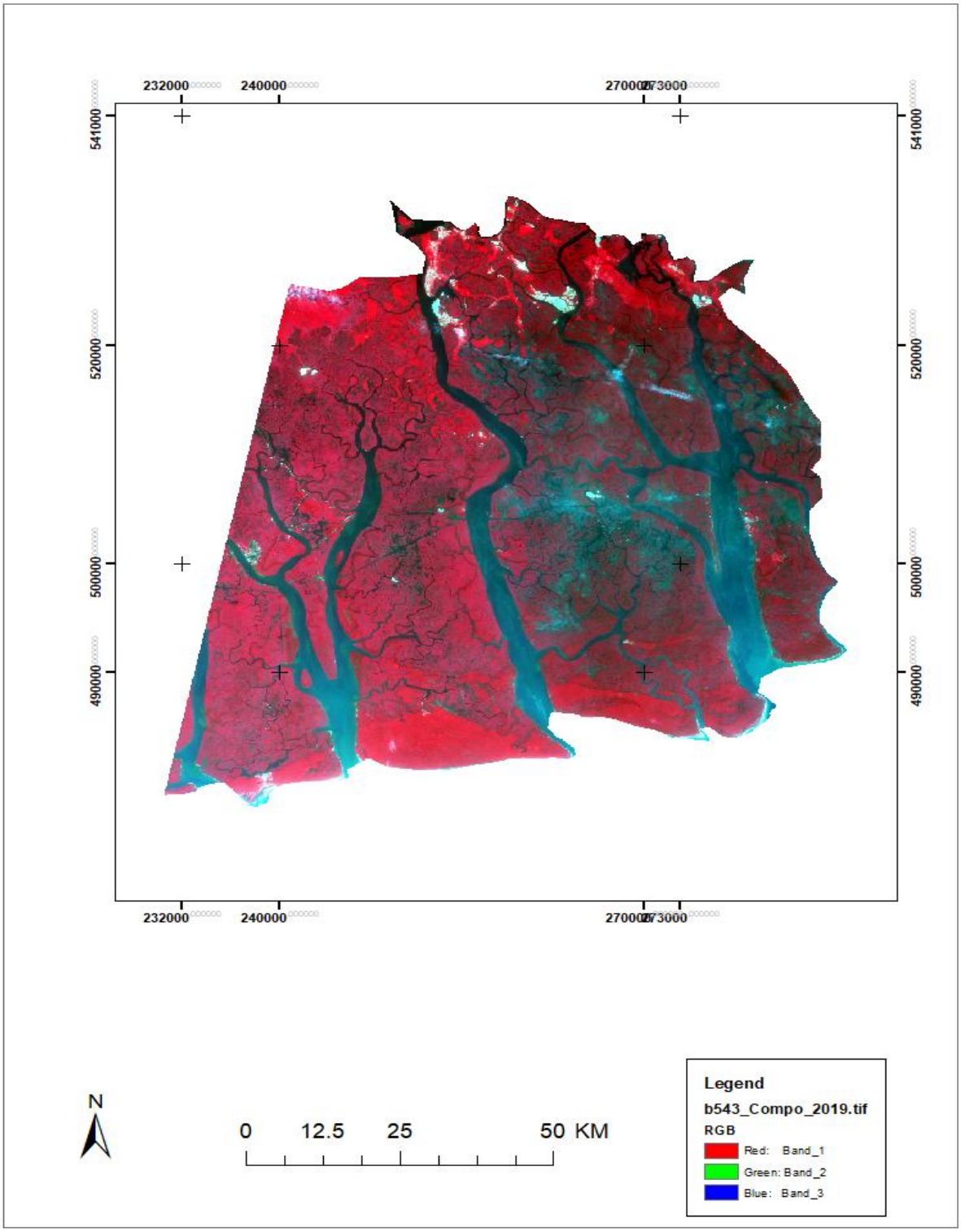

Figure 2: Composite image for Landsat 2019

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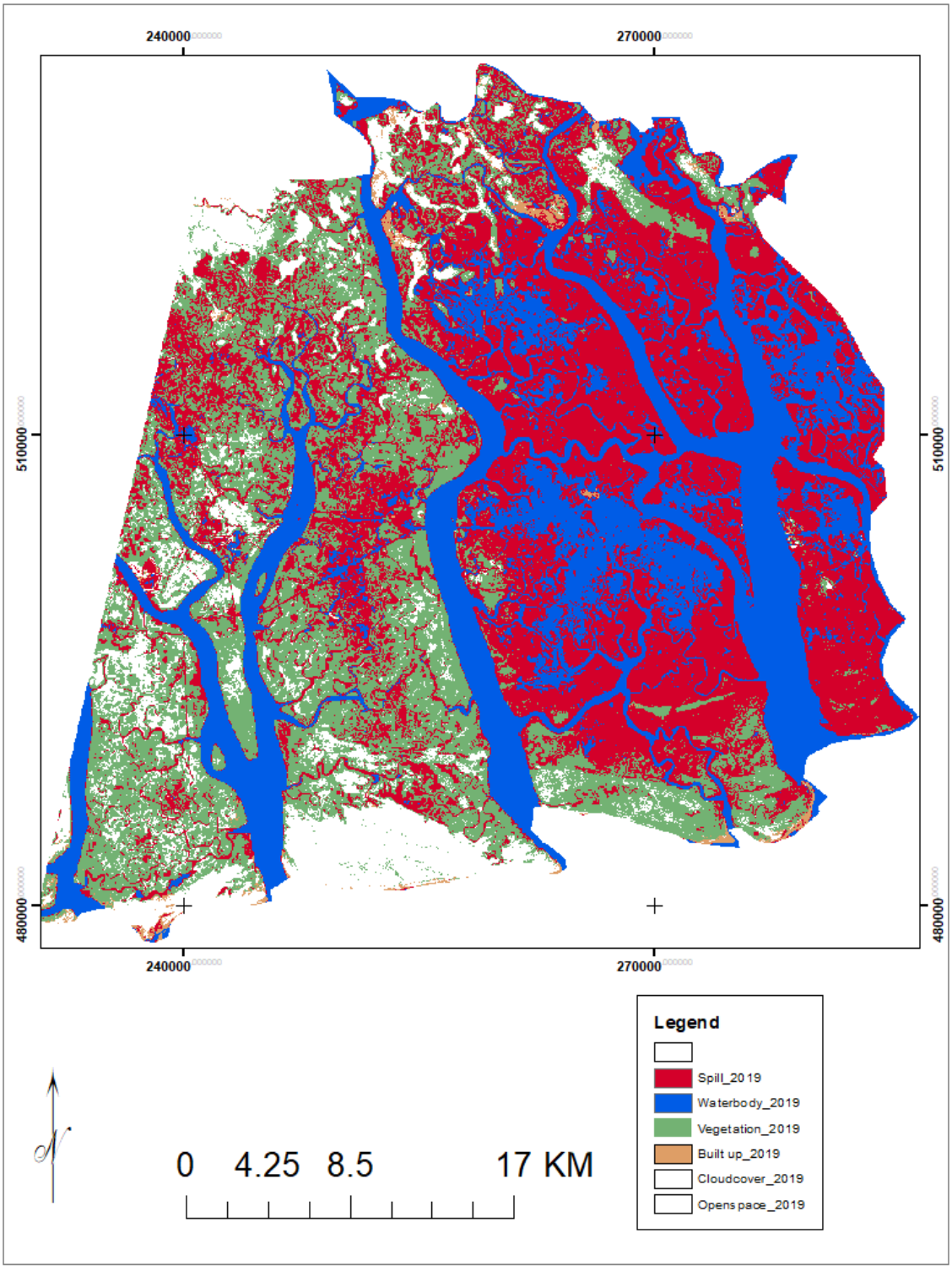

Figure 3: Classified map for Landsat 2019

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4.1 Confusion Matrix for 2019 Classification

Accuracy may be a theoretical frame that's spoken in many alternative contexts within the context of image interpretation, accuracy assessment determines the standard information of knowledge, derived from remotely perceived data. Assessment is often either qualitative or quantitative. In qualitative assessment, you establish if a map 'looks right' by comparison of what you see within the map or image with what you see on the bottom. However, quantitative assessments conceive to establish and live remote sensing-based mostly on map errors. In such assessments, you compare map knowledge with ground truth knowledge, which is assumed to be 100 percent correct. The foremost normally used methodology of representing the degree of accuracy of classification is to make a k×k array, wherever k represents the number of classes. The values within the matrix indicate the numbers of pixels. This arrangement establishes a regular type that helps to search out site-specific error within the consequence and is understood as an error matrix. Table 2 demonstrates error analysis for the different land use land cover such as spill indicating 670 pixels in the 2019 classification, waterbody contains (10493 pixels), vegetation is 1176 pixels, built-up (2372 pixels) and cloud cover (2336 pixels) which are correctly classified.

The gain in the land use and land cover is called the error of commission where the spill exhibits 0.7617 pixels in Table 3. The Waterbody also gain 0.0009 pixels, other leads are vegetation which recorded 0.3531pixels and built –up successfully betokens 0.0215 pixels and 0.5387 pixels of gain also are presented in cloud cover, and the total error of omission- (loss of pixels' value) in the classification is 0.0363. Secondly, the Kappa index for the classification is 86.40% where the number system represents the individual features of the classification using the classified map (Table 4) as a reference while (Table 5) as ground truth specification.

Table 2: Error Matrix analysis for 2019 classification

Category	**Spill**	**Waterbody**	**Vegetation**	**Built-up**	**Cloud Cover**	
Spill	670	0	1108	1030	3	0.7617
Waterbody	2	10493	5	2	0	0.0009
Vegetation	348	0	1176	252	42	0.3531
Built -up	0	0	0	2372	52	0.0215
Cloud Cover	0	0	678	2050	2336	0.5387
Strip Line	0	0	0	0	0	0.0000
Total	**1024**	**10493**	**2967**	**5706**	**2433**	
Error of omission(O)	*0.3431*	*0.0000*	*0.6036*	*0.5843*	*0.0399*	

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Table 3: Error of omission and commission 2019

Category	LULC (6)	Total	Error of commission (C)
Spill	0	2811	0.7617
Waterbody	0	10502	0.0009
Vegetation	0	1818	0.3531
Built- up	0	2424	0.0215
Cloud Cover	0	5064	0.5387
Strip Line	130972	130972	0.0000
Total	**130972**	**153591**	
Error (O)	*0.0000*		*0.0363*

Table 4: Referenced classified image 2019

Category	KIA
1	0.2333
2	0.9991
3	0.6399
4	0.9777
5	0.4526
6	1.0000

Table 5: Training site 2019

Category	KIA
1	0.6505
2	1.0000
3	0.3891
4	0.4063
5	0.9588
6	1.0000

4.2 The Causes and Sources of Oil Spill

A pipeline is a network of line that is passing from one point to another through a concentric consecutive pipe. These pipes vary in size as regards the transportation of crude oil to the fractionating column, and variability is measured in 2-inches- (5-centimetre-) diameter lines used

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in oil-well gathering systems, high-volume water and sewage networks possibility, do measure 30 feet which is nine (9) meters in specification regulating oil and gas industries. Pipes of these exercises are metallic-coated to prevent rust or uneven breakdown to cause environmental issues. The catholic protection of pipes is a product of steel, cast iron and aluminum that is made up of concrete, clay products and sometimes plastic. The benefits of Pipeline transportation are of eminent importance to the society at large when compared to rail and truck system of transportation which are less destructive to the environment, less vulnerable to theft, and more economical, safe, convenient, and reliable. Several pipes are connected to the flow station (separation facilities-also called gathering centres which separate natural gas and water from the crude oil extracted from the production wells) in the area of study and the dimensions of the pipe are ten (10) and twenty (20) inches. Table 6 present a list of all the flow station with their respective location coordinates, Ruairi is located on the land while the rest are in the swamp environment and they are owned by Shell Petroleum Development Company (SPDC) of Nigeria.

Table 6: List of flow station

Station	Name of flow station	Eastings (m)	Northings (m)	Location	Division
1	Adobe	259164.3636	501955.8770	Swamp	SPDC
2	Belem	239081.7075	486958.5337	Swamp	SPDC
3	Buguma Creek	266933.3628	524308.4756	Swamp	SPDC
4	Caw throne Channel 1	283329.4689	503329.5156	Swamp	SPDC
5	Caw throne Channel 2	278288.7010	503921.1879	Swamp	SPDC
6	Caw throne Channel 3	275587.6761	504164.0313	Swamp	SPDC
7	Kalama 1 East	246129.4249	504349.8001	Swamp	SPDC
8	Kalama 2 West	240780.5250	503120.6930	Swamp	SPDC
9	Krakrama	266942.3759	503574.4688	Swamp	SPDC
10	Odeama Creek	224672.0112	488994.9954	Swamp	SPDC
11	Orubiri	278677.4107	519661.0869	Land	SPDC
12	Soku	275587.6761	504164.0313	Swamp	SPDC

Source: SPDC (2021)

The spill event happens some distance away from the oil installation that is described to be pipeline, flow station and manifolds. Irate youths from oil-bearing communities organize themselves to be engaged in illegal refinery method as a source of livelihood to meet up in the face of unemployment. The illegal refinery industry is a fictitious way of assembling six (6) by five (5) metres metal long, constructed and fixed to the metal height of four (4) metres with a long pipe connected to the valve point where the crude is tapped. The science of discovery is the basis of invention, this theory is formulated to weld metal pipes and drums together to carry boiled crude oil, cool and store in a tank for commercial distribution such as energy, lighting and used for transportation. This local refining in most case leads to incomplete combustion and the

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hydrocarbon particles always seepage into the soil to damage the microbial stage of developmental structure in the vicinity of the study.

Sometimes, the illegal refining process does burn down the local habitat thereby putting the vegetation and the mangrove at risk. The bunkering activity is a major cause of the oil spill that is flowing from the production point to the aquatic environment and it is transported along the new Calabar River to the sombrero river due to the tidal nature of the river (Figure 6). Oil sheen is seen by the side of the shoreline or shore as a proven decimal which floats few centimetres above the water level because it is less dense than water. Fishes like tilapia killed from the river do smell fuel on their body, will be processed and consumed as a means of food. The aquatic foods consumed is becoming a threat to life as the quality-of-life span reduces. For example, the researcher visited some of these unlawful bunkering sites and took a view of the reality of the environment, nine (9) spill points were discovered during the ground truth survey to make a real-time study. These places are located along the seawater and others in the swamp environment, all the places integrate boys of different categories to do this act, thereby spilling the ecological terrain. The prime cause of the pollution in the neighbourhood is called illegal bunkering. In Degema Local Government Area, the study observed five spill sites, Asalga reports three and Akulga shows one site with location as shown in figure 7.

In the central point of discussion, the sources of the spill are from a pipeline owned by Shell Production Development Company of Nigeria commissioned between the 1970s and 1994 (Figure 8). Specifically, the thickness of the pipe connecting Krakrama (ML) to Buguma City is ten (10) inches truck line while from Buguma (major flow line -ML) to Alakiri is twenty (20) inches truck line (TL) and the spill at George –Ama is from the flow line (ML). This range of scenario is applicable to others within the dominance of spill. The coordinates of the spill environment and the affected communities ranging from very high impacted to least impacted are presented in Table 7. The study evaluated the impact level against thirty-four communities, Buguma, Tombia, Sama, Krakrama, Idama and Bille are placed under very high impacted state from ($0.111m^2$ - $0.133m^2$). Following the stratification of impact, Ido, Abalama, Opurobokokiri, Ifoko and Sangama are recorded against high area ($0.083m^2$ -$0.111m^2$). The results show Abonnena, Tumkiri, Orukiri, and Oluwaeoku as moderately impacted from ($0.0611m^2$ - $0.0833m^2$) while Kala-Owoma and Okpo are least impacted from ($0.0125m^2$ - $0.0611m^2$) to mention but a few as shown in figure 9.

Table 7: Spill impacted communities

S/N	Spill impacted community	Ratio of 1km	Impact level
1	Buguma	5>2	Very High
2	Ido	4>3	High
3	Abalama	4>1	High
4	Tombia	5>3>1	Very High
5	Sama	5>3>1	Very High
6	Krakrama	5>3	Very High
7	Idama	5>3>1	Very High

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8	Bille	5>2>1	Very High
9	Orukiri	3≥2>5	Moderate
10	Kala-owoma	1	Least Impacted
11	Obonoma	5>2>1	Very High
12	Soku	5>1	Very High
13	Ngozikiri	5>2	Very High
14	Kula	5>3	Very High
15	Elizekiri	5>3>1	Very High
16	Degema	5>3>1	Very High
17	Abonnema	3	Moderate
18	Opurobokokiri	4>1	High
19	Oluwaeoku	3≥1	Moderate
20	Abissa	5>1	Very High
21	Tingibibikiri	1	Least Impacted
22	Akokokiri	5<4>1	Very High
23	Ifoko	4>1	High
24	Tema	3>1	Moderately Impacted
25	Bakana	5>1	Very High
26	Old Bakana	5>3>1	Very High
27	Fouche (Ifoko)	5>1	Very High
28	Angulama	4	High
29	Tumkiri	3	Moderate
30	Elem-Ifoko	5>3	Very High
31	Okpo	1<3<5	Least Impacted
32	Usokun	5>1	Very High
33	Obuama	5>4>1	Very High
34	Oporoama	5>3	Very High
35	Sangama	4>1	High

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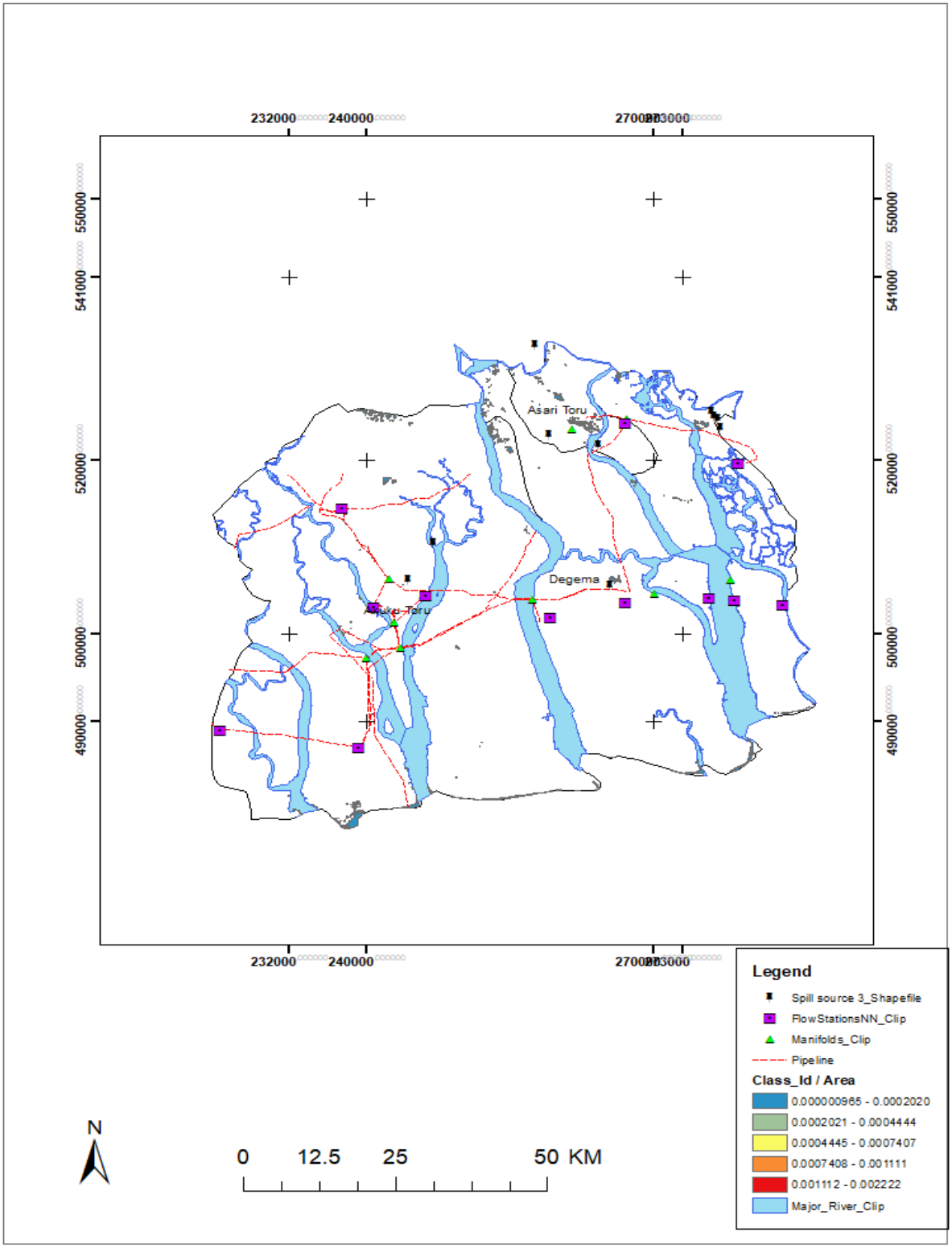

Figure 6: Transportation of oil spill

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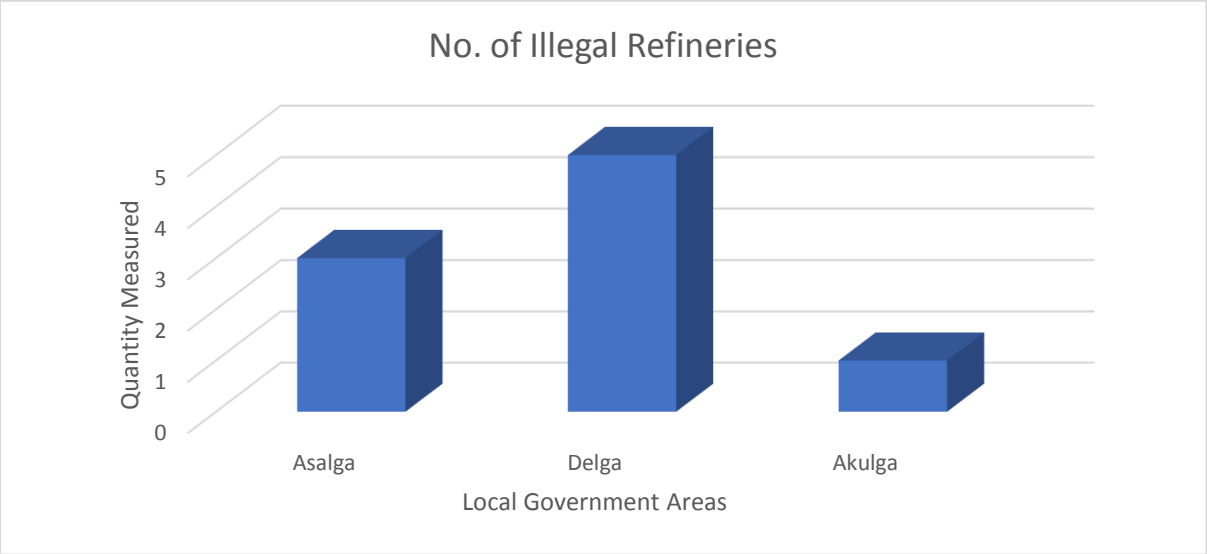

Figure 7: Number of illegal refinery in different regions

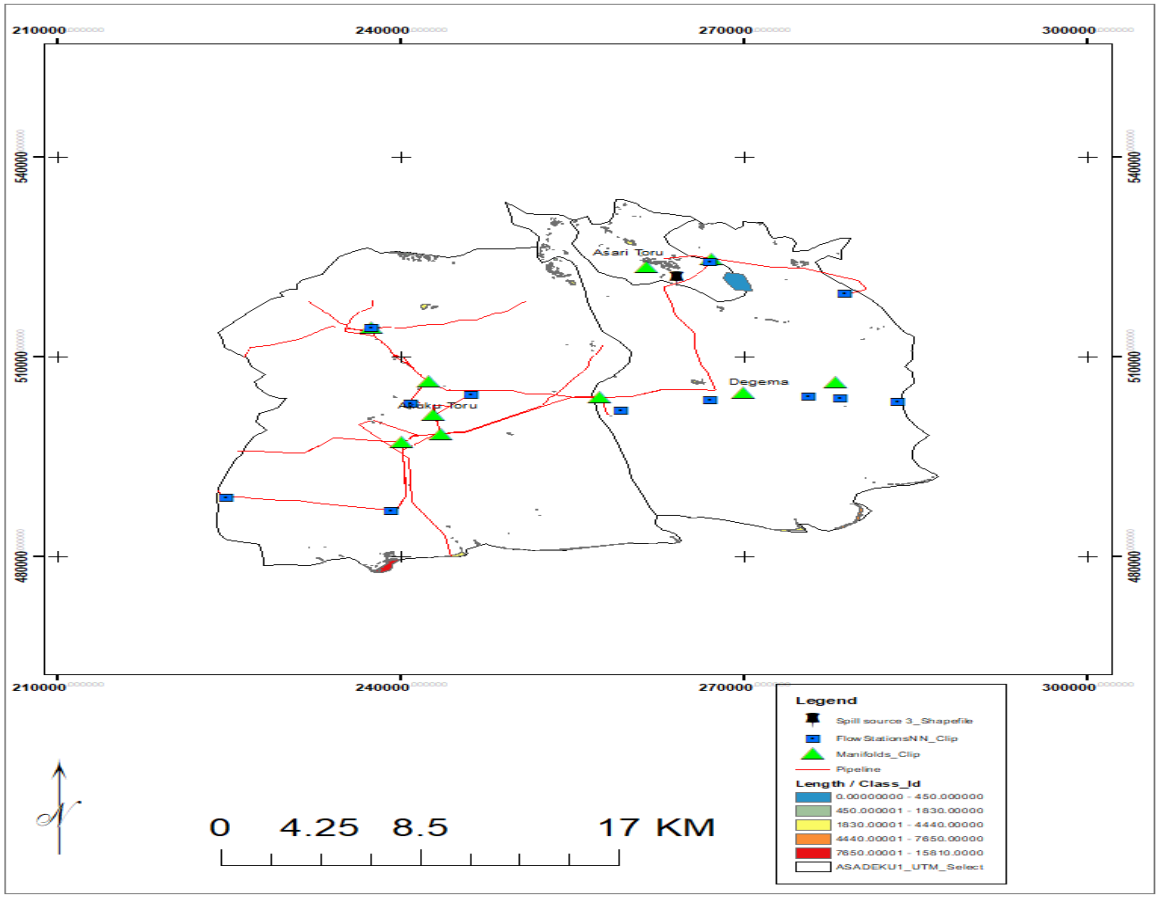

Figure 8: Sources of oil spill

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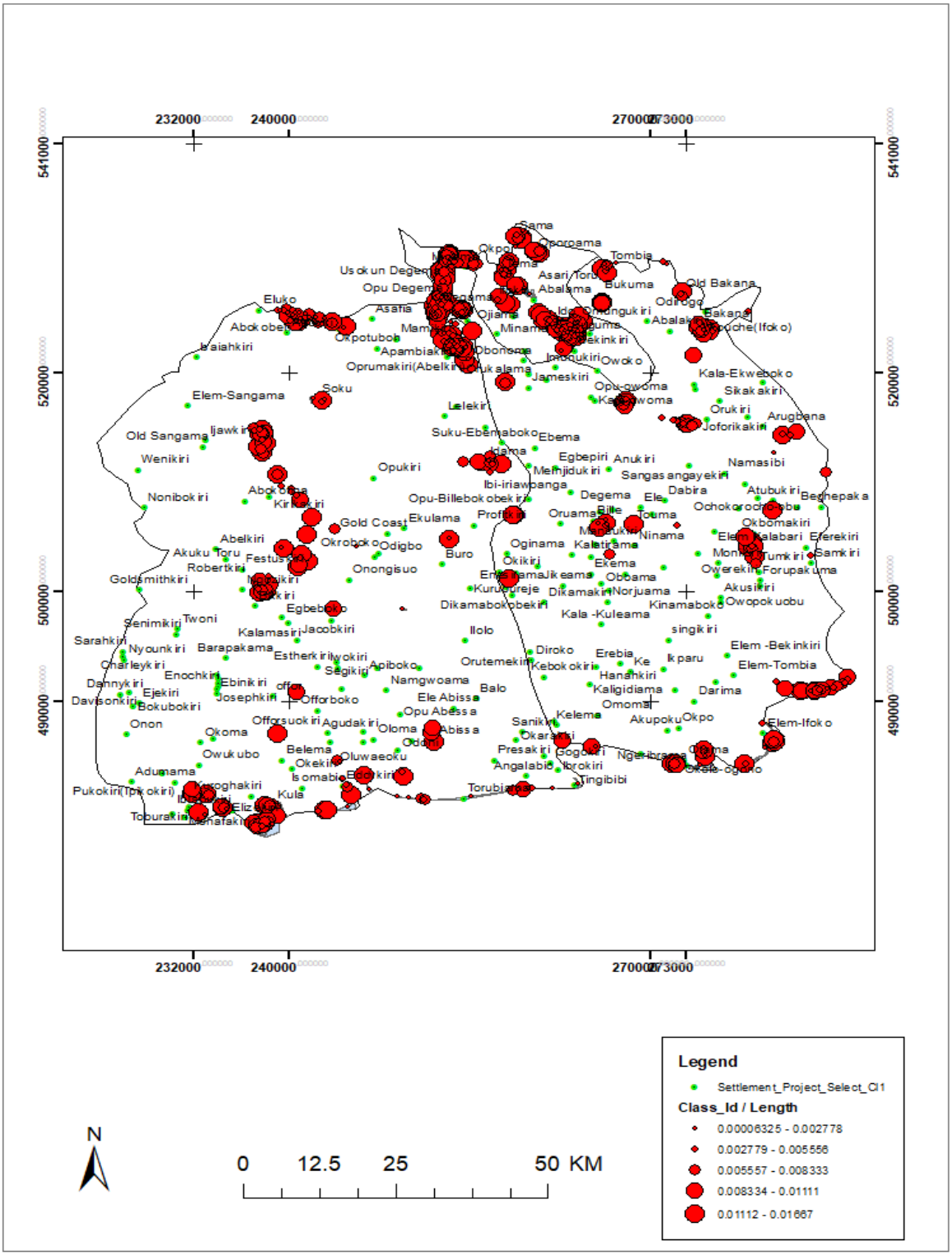

Figure 9: Settlement impacted map

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5.0 CONCLUSION

The use of satellite imagery has demonstrated the effectiveness of satellite-based mapping over the earth activity, especially oil pollution in the selected Local Government Area of Rivers State, Nigeria. The mapping showed that the spread of oil spill cover 79416.180ha against 24.976% from the classification scheme. Consequently, the study revealed that 17.79% of water body and vegetation 17.62% were affected as a result of oil pollution in the study area.

6.0 RECOMMENDATION

The following recommendations are derived from the study:

1. Oil bunkers should stop the bunkering
2. Oil companies should set up vigilante group to monitoring the network of pipelines
3. Proper education is needed to educate the oil-bearing communities the danger of oil spill in the environment
4. The study was funded by the researcher independently without any grant from corporate organization
5. The results of the study are in agreement with others scholars stated in the literature

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