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Spatial Temporal Patterns of Rivers State Spdc Relatedoil Spill From 2010 To 2019

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ABSTRACT
Oil spills poses serious threats to the ecosystem and inhabitants of any given environment. In this study, the spatial temporal patterns of oil spill distribution in Rivers State, Nigeria from 2011-2019 wasanalysed using ARCGIS software based on available data from SPDC JIV report. The results showed that in Rivers state from 2011 - 2019 a total of 715 spills.The estimated spill volumeis 72435.54Bbl with 2013 having the highest spill volume of 20% and 2011 having the lowest spill volume of 4%. The spill impacted an area of 146360428.32m^2 with 2017 having the highest impacted area of 88% and 2014 having the lowest impacted area of 2%. The terrain having the highest spill incidents is land at 66% followed by swamp at 31%, water 2% and land/swamp at 1 %. The major causes of oil spill are Sabotage (79.4%), operational failures (19.8%) others (36%) and mystery spill 2% (spills whose cause cannot be ascertained).The major oil spilling facilities accounting for 73% of the spill are oil pipelines, flowlines, well head, trunk line, compressor unit, terminals, manifold delivery line and flow station with other facilities accounting for 27% of the spills. The major oil spill leak points are Crude oil theft at 44%, hack saw cut at 15%, bunkering at 10%, drilled hole at 9 %, corrosion at 9% and the rest (minor leak points) at 12 %.This study presents a spatial temporal map of oil spill distribution across Rivers State from 2011 to 2019 based on SPDC related oil spills covering the spill terrains, volume, impact area, leak points, spilling facilities and causative factors.

Keywords*: Rivers State, oil spills, impact area, causative factors, leak point, terrain, facilities, and volume.*

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I. INTRODUCTION

Background

Oil spills a major threat to the environment (oceans,seas,river and land) occurs when crude oil or its refined products are discharged by accident, or with intent over a period of time into the surrounding environment. It is a global issue that has been occurring since the discovery of crude oil causing severe destruction of ecosystems.The discovery of crude oil in Nigeria in 1956 by Shell British Petroleum (now Royal Dutch Shell) the forerunners of Shell Petroleum Development Company of Nigeria (SPDC) at Olobiri in Bayelsa State located within the Niger Delta of Nigeria (Anifowose, 2008, Onuoha, 2008) and its commercial production in 1958 marked the beginning of crude oil and it's by product flow by pipelines and flowlines and other moving land vehicles. SPDC's role in the shell Nigeria oil/gas family is typically confined to the physical production and extraction of crude oil/natural gas. Over the course of SPDC's exploration and production activities in Nigeria, there has been reports of oil spill across the Niger Delta wetland and marine ecosystem with available public spill documentation starting from 2010. The major causes of these spills have been reported to be theft (oil bunkering), operational and equipment failures of well heads, pipelines, and other facilities. Oil spill is estimated to cost Nigeria as much as 400,000 barrels of crude per day with over 1,010 oil spills amounting to 110,535 barrels equivalent of 17.5 million litters of oil reported as lost by SPDC since 2011. This continuous degradation of the environment lead to the establishment of National Oil Spill Detection and Response Agency (NOSDRA) in 2006. This study is aimed at examining the trending patterns of oil spills in RiversState with respect to SPDC JIV report from 2011 to 2019 using Geographic Information System (GIS) to map the spatiotemporal nature of the spill across the state as it relates to causative factors, spilling facility, spill terrain, spillleak points, spilled volume and area impacted by spill.

II. LITERATURE REVIEW

A number of scholars have researched on the different aspects of oil spill in rivers state. Notable among such researches are: Ojimba (2012) who estimated the impact of oil pollution on crop production in Rivers State, Nigeria, using a random log production function in a multi-stage sampling technique to conduct a survey of 296 people from 17 out of 23 local government areas. The research results show that the impact of crude oil pollution on farms significantly reduces the planting area by 1%, reduces the marginal product (MPP),

and increases the output of pollution-free farms.Bahaa et al. (2016) analyzed 163 recorded oil spills in River State, Nigeria between 2011 and 2012. The study found that 73% of the areas affected by the oil spill caused crop losses due to the oil spill. The study also concluded that the size of the affected area, the amount of oil spilled, the amount of residual oil in the area, the environment of the affected area, and the recovery response and cleaning time are the key factors affecting the impact of oil spills on the Niger Delta vegetation. Agunobi et al. (2014) investigated the pattern and environmental impact of oil spills in the local government area of Eche, He State, Nigeria. The results showed that during the study period (2001-2007), there were approximately 29 oil spills, and the cumulative oil spill reached 4,270 barrels, the highest in 2003 (4171.5 barrels) and the highest in 2005. Lowest (0.1 barrel)

Oteiva and Ndokiari (2018) studied the impact of crude oil spills on the surface of the lower Niger delta. (Sombro River) The results of chemical, physical and heavy metal concentration studies show that the crude oil has an impact on the river due to corrosion and damage of crude oil pipelines. (Illegal distillation) The processing of oil in the Jerry tanks with wooden barrels in the local area to produce and transport crude oil products. Because some parameters are higher than the initial state of the river, the ship is sailing along the coastal river.Abii and Nwosu, (2009) conducted a study on the impact of the Eleme oil spill on the soils of Eleme in the River State of the Niger-Nigerian delta. The effects of oil adversely affect the nutrient levels and fertility status of Eleme soils, which Eleme needed to be included in the continuous correction technique for soil cleaning in the Rivers State.Bahaa(2015). Evaluation of the impact of oil spills on Nigerian rivers plants using GIS and remote sensing techniques. The results showed that the oil spill could affect plants approximately 2.5 kilometers from the spill point in a wet environment controlled by open water as a diffuser.Umar et al. (2019) developed a spatial database to deal with oil spill pollution affecting the water quality system of the Niger Delta. The results showed that the water surface in the Delta and Rivers State was more polluted than in Bayelsa State. This was due to increased metal concentrations, which affected the salinity and pH of the water, which were found in all three states. Lindén and Pålsson (2013) evaluated the oil pollution of small rivers, rivers and groundwater in Ogoniland, Nigeria. Sample analysis showed that the extracted petroleum hydrocarbons had a high proportion. Yes (EPH) in most water

Chima (2011) believes that arbitration is a solution to the conflict of compensation for oil spills in Nigerian river producer communities. The author concludes that due to the obvious advantages of litigation, arbitration is the best way to resolve the deadlock between oil companies and oil producing countries and host countries, and suggests direct and indirect methods to solve this problem. Resolve the ongoing conflicts between oil and gas, oil and gas companies and their communities.Nkechi et al. (2017) studied the impact of crude oil spills on surface water in the Niger Delta in Nigeria. The results of the study can be concluded that the Obunkun River of the Oyigbo local government in the River State of Nigeria is pollution related to pH, total suspended solids, total dissolved solids and total petroleum hydrocarbons. The pollution is caused by the leakage of oil and ions in the solution (NO3-, NH4 +, Ca2 +, K +, Na + and Mg2 +) and decreases as the distance from the pollution source decreases.Sanusi et al., (2016) examined the environmental impact of pipe destruction - a challenge to biodiversity in the Port Harcourt area of River State, Nigeria. The results show that the constant oil spills from these pipes pose a health hazard to both people and the environment.

STUDY AREA

The study area is River State, Nigeria (Figure 1), and is named after the various rivers in it. Rivers State is located at latitude 4°44’59’’north and longitude 6°49’39’’east. There are 23 local government areas within it. It is bordered by the Atlantic Ocean, states of Imo, Abia,Akwa-Ibom Delta respectively.

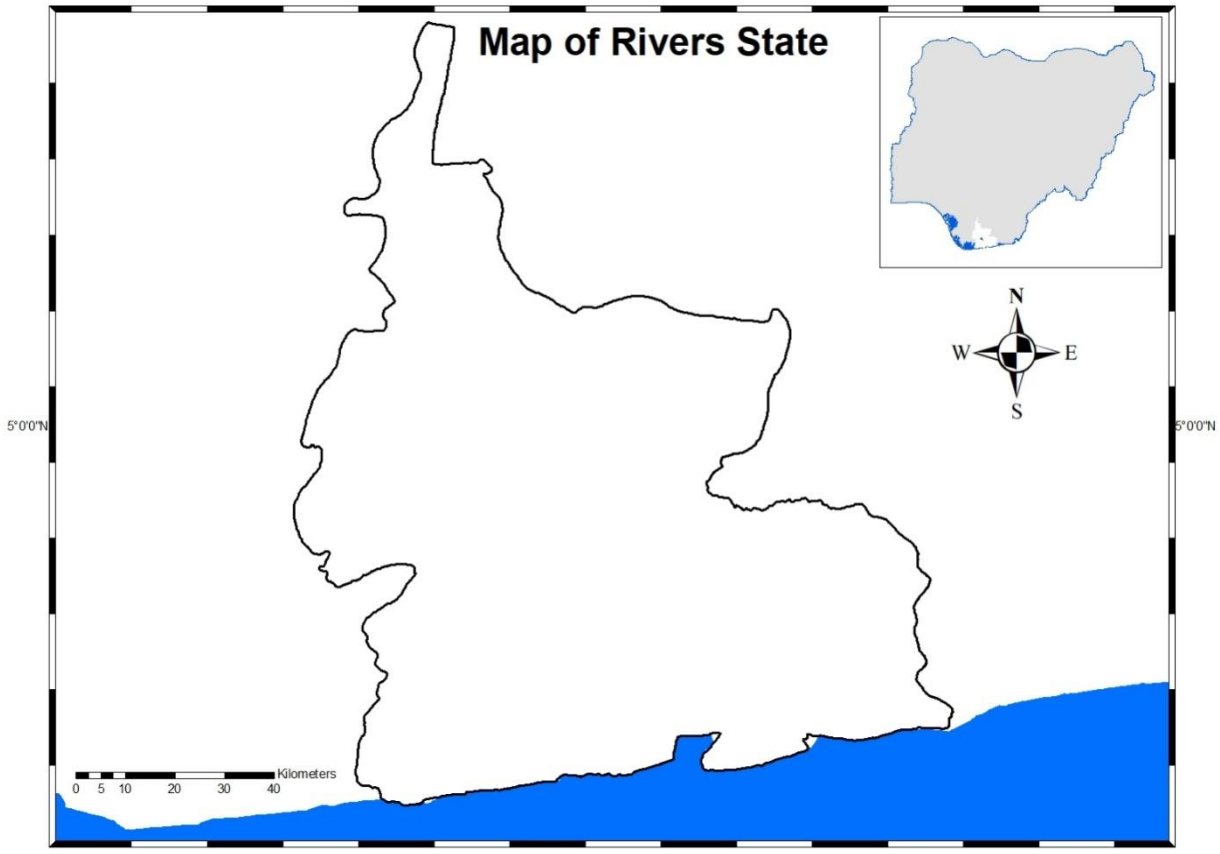

Fig 1: Map of Rivers state

III. MATERIALS AND METHODS

Available data from SPDC JIV report from 2011-2019 was used in this study. The method followed is that published by Apata et al 2019.

IV. RESULTSANDDISCUSSION

A total of 715 SPDCrelated oil spill incidents occurred in Rivers State from 2011- 2019 across 17 local Government Areas of the state as shown in figure 1. The analysis of the spill is presented in tables, charts and maps.

Volume of SPDC relatedOil Spill from 2011-2019 in Rivers state

It is estimated that a total of 72435.54Bbl oil was spilled in Rivers State from 2011 to 2019 at a rate of 9054.44Bbl per year. The lowest volume of oil spill was recorded in 2011 (4%) and the highest volume recorded in 2013 20%).A gradual increase in the rate of oil spill from 2016 (5%) to 2019 (11%) was noticed. If this trend is allowed to continue, the nation will be losing a lot of revenue and lives in the associated fire explosions as a result of most oil spill events.Fig. 2 shows percentage change in spill volume.

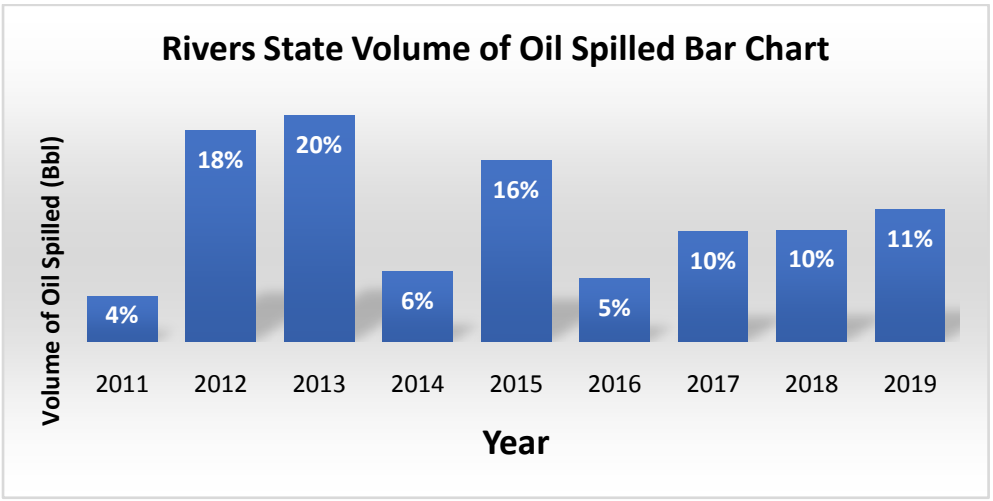

Figure 2: Histogram showing spill volume change for Rivers State from 2011-2019

Impacted Area of SPDC relatedOil Spill from 2011-2019 in Rivers state

It is estimated that an area of146,360,428.32 m^2 was impacted by oil spill in Rivers State from 2011 to 2019 at a rate of 18295053.54 m^2per year. The lowest area impacted by oil spill was recorded in 2014 (02%) and the highest area impacted by oil spill was recorded in 2017(88%). A sever increase in the rate of area impacted by oil spill from 2011 (3%) to 2017 (88%) was noticed with a sharp decrease to 0.4% in 2019, signifying a reduction in spill trend and activities. Fig. 2 shows percentage area Impact of oil spill.

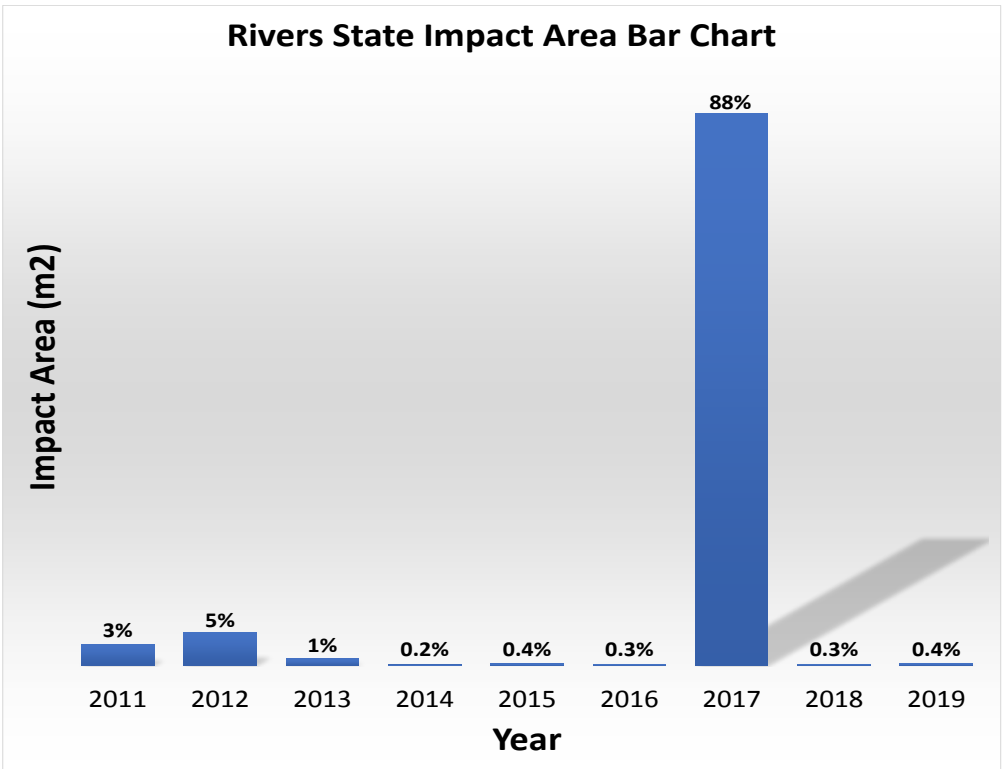

Figure 3: **Histogram showing Impact Area change for Rivers State from 2011-2019**

Terrain affected by SPDC relatedOil spill from 2011-2019 in Rivers state

Land, swam, water and land/swamp terrains were affected by oil was spill in Rivers State from 2011 to 2019. Land was the most affected terrain with 66% of the spill followed by swamp at 31%, water 2% and land/swamp at 1 %. Table 1 shows the terrains affected by oil spill.

Table 1: Showing terrain affected by oil spills from 2011-2019

Terrain	2011	2012	2013	2014	2015	2016	2017	2018	2019	% Change
Land	44	77	67	62	41	25	32	56	62	**66**
Swamp	40	18	38	24	27	13	9	23	29	**31**
Water	3	0	0	2	5	1	2	0	0	**2**
Land/Swamp	0	3	0	0	0			2	0	**1**

Causative factors of Oil spill from 2011-2019 in Rivers state

Sabotage, operational, others and mystery, were the major causes of the oil spill in Rivers State from 2011 to 2019. Sabotage was responsible for 79.4% of the oil spills, followed by operational failures at 19.8%, others 036% and mystery spills at 0.2%.Table 2 shows the causative factors of the oil spill.

Table 2: Showing Causative factors from 2011-2019

Causative factor	2011	2012	2013	2014	2015	2016	2017	2018	2019	% Change
Sabotage	58	73	76	28	62	32	37	71	91	**79.4**
Operational	29	25	29	20	8	6	5	10	0	**19.8**
Others	0	0	0	1	1	1	1	0	0	**0.6**
Mystery					1			0	0	**0.2**

Spilling facilities of SPDC relatedOil spill from 2011-2019 in Rivers state

Oil pipelines, flowlines, well head, trunk line, compressor unit, terminals, manifold delivery line and flow station are the major oil spilling facilities in Rivers State from 2011 to 2019. Pipelines was the most affected spilling facilities with 73% with the rest accounting for 27 %. Table 3 shows the spilling facilities of the oil spill and their respective percentages.

Table 3: Showing spilling facilities from 2011-2019

Spilling facilities	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total	% Change
Oil pipeline	54	25	24	15	44	23	28	64	90		**52**
Pipeline		44	46	53	6						**21**
Flow line	24	16	12	5	3	5	2	9	1		**11**
Oil Flowline		2	5	2	6	3	7	2			**4**
Well head	4	2	1	0	9	3	1	4			**3**
Trunk line		3	4	4							**2**
Compressor Station/Unit		**1**	1	1		1					**1**
Oil/Gas Terminal					2	1	1				**1**
Delivery line	1	2	3	4							**1**
Flow station	2	1	2	0		1	1	1			**1**
Manifold	1	2	1	2		1		1			**1**
Condensate pipeline	1	0	1	0							**0**
Riser Pipeline		1	1	1							**0**
Gas Line			1	1	1						**0**
Gas Plant											**0**
GeePee / Oil Tank					1		2				**0**
Buck line						1					**0**
B O G T							1				**0**
Others					1						**0**

Leak Points of SPDC relatedOil spill from 2011-2019 in Rivers state

Crude oil theft, hack saw cut, bunkering, drilled hole and corrosion were the major oil spill leak points in Rivers State from 2011 to 2019. Crude oil theft was the most affected leak point with 44% of the spill followed by hack saw cut at 15%, bunkering 10%, drilled hole at 9 %, corrosion at 9% and the rest at 12 %. Table 4 shows the leak points of the oil spill.

Table 4: Showing leak points from 2011-2019

Leak points	2011	2012	2013	2014	2015	2016	2017	2018	2019	% Change
Crude oil theft	19	41		48	38	17	20	47	72	**44**
Hack saw cut	23	20	18	14	6		3	7	12	**15**
Failed weld-on illegal hot top valve (Bunkering)	3	5	55	0	0		4			**10**
Drilled Hole	3	6	7	9	8	3	4	14	6	**9**
Corrosion	8	7		5	1	1		6		**4**
Others		4	2	5	11	4	2	1		**4**
Failed clamp	5	2	2	2	3	1				**2**
Missing pipeline/Flowline	3	3	2	0	1		4	2		**2**
Well head tampering	1			3	2	2	1	1		**1**

Internal corrosion	3	2			0					**1**
External corrosion	3	1		0	0					**1**
Third party tampering with Valve Settings		1	1	0	0			2	1	**1**
Tear					2		2			**1**
Explosive tear	1				0					**0**
Saver pit overflow	2				0					**0**
External grind out	1				0					**0**
Third party tampering with clamp	1	1			1					**0**
Inward dent	2	0	0	0	0					**0**
Punched hole	1			0	0					**0**
Structural failure	1			0	0					**0**
Failed welded joint	1			0	0					**0**
Krotex valve removal	1			0	0					**0**
Pinhole and slight	1			0	0					**0**
External tear due to construction damage	1			0	0					**0**
Equipment damage/failure	1	1		0	0					**0**
Bean box failure	1			0	0					**0**
Containment	1			0	0					**0**
Failed barrel door seal	1			0	0					**0**
Sectional rupture	1			0	0					**0**
Explosive tear		1		0	0					**0**
Third party interference		1		0	0	1				**0**
Saver Pit overflow		1		0	0					**0**
Well head failure		1		0	0					**0**
Complete Rupture			1	0	2					**0**
Valve failure			1	0	0					**0**
Failed New Manifold Tank Drain			1	0	0					**0**
Rupture						1				**0**
Flare System								1		**0**

Analysis of SPDC relatedoil spill for 2011

A total of 86 oil spills occurred in Rivers State between January and December 2011 with spill volume of 2832.79Bbl, and 5116651.96m^{2}area of impact spreading across 14 L.G.As (Etche, Oyigbo, Ahoada-East, Akuku-Toru,Gokana, Bonny, Degema, Obia/Akpor, Ikwerre, Port Harcourt, Emohua, Eleme, Ogba/Egbema/Ndoni,Asari-Toru).Figure 4 shows a spatial temporal map of 2011 oil spill sites, leak points and terrain.

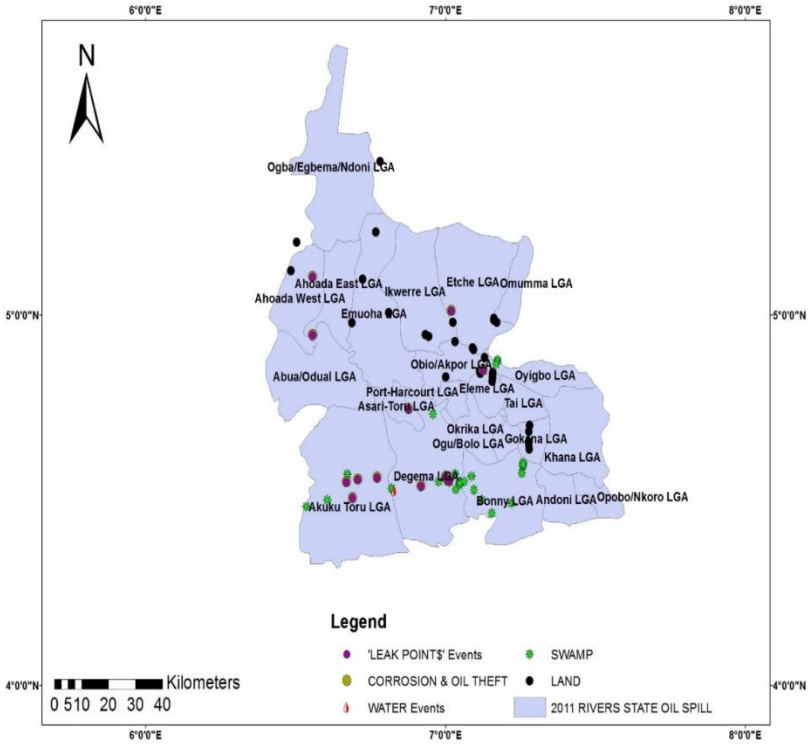

Figure 4: A trend map showing oil spill sites, leak points, causative factors and terrains in Rivers State for 2011

Analysis of SPDC relatedoil spill for 2012

A total of 98 oil spills occurred in Rivers State between January and December 2012 with spill volume of13330.25Bbl, and 7885633.65m^{2}area of impact spreading across 13 L.G.As (Obia/Akpor, Degema, Ikwerre, Ahoada-West, Eleme, Akuku-Toru, Gokana, Oyigbo, Bonny, Etche, Emohua, Tai, Andoni). Figure 5 shows a spatial temporal map of 2012 oil spill sites, leak points and terrain.

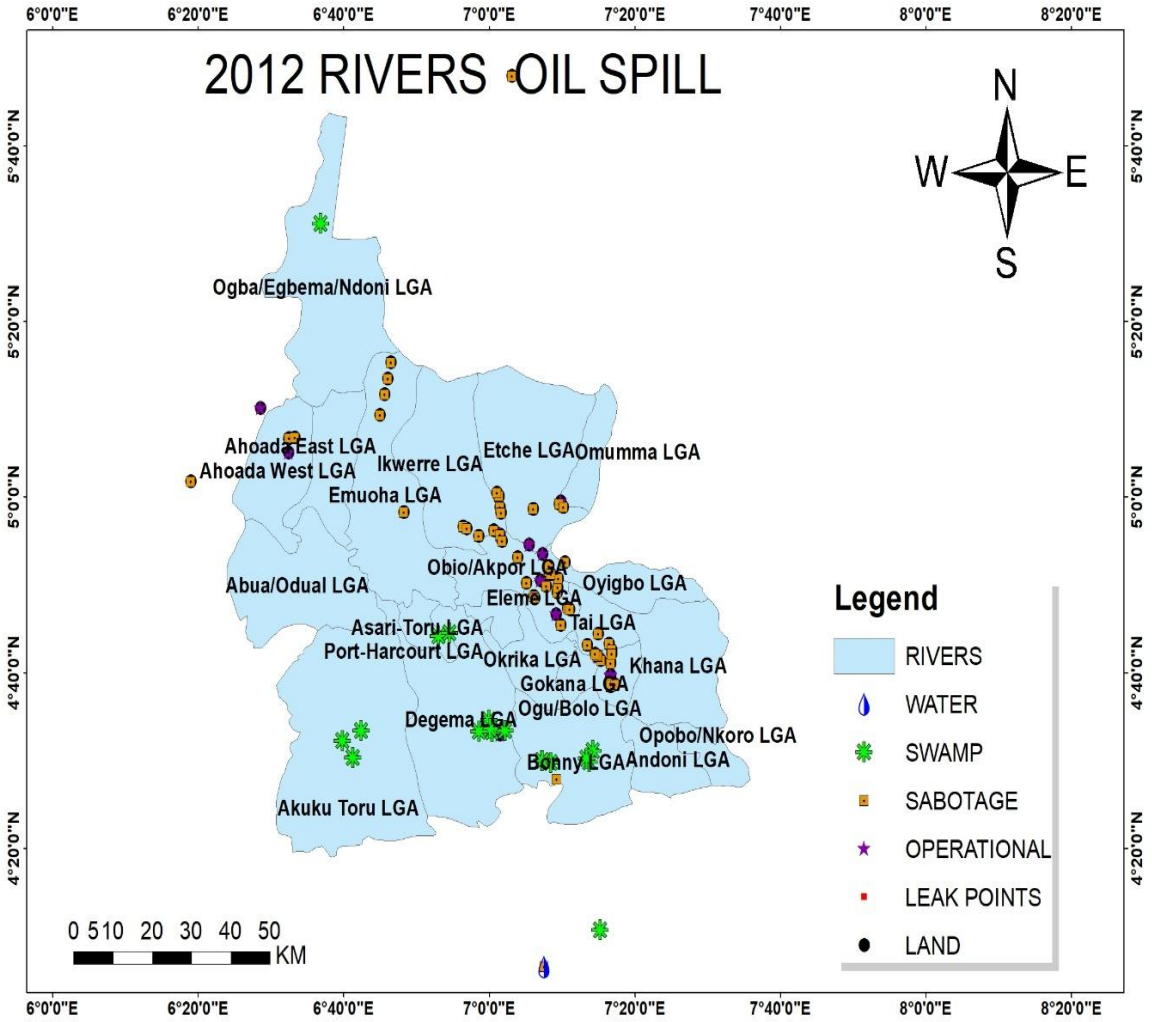

Figure 5: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Rivers State for 2012

Analysis of SPDC relatedspill for 2013

A total of 105 oil spills occurred in Rivers State between January and December 2013 with spill volume of14244.10Bbl, and 1646094.92m^{2}area of impact spreading across 13 L.G.As (Tai, Gokana, Degema, Ikwerre, Akuku-Toru, Etche, Emohua, Ahoada- West, Eleme, Oyigbo, Obia/Akpor, Bonny, Andoni). Figure 6 shows a spatial temporal map of 2013 oil spill sites, leak points and terrain.

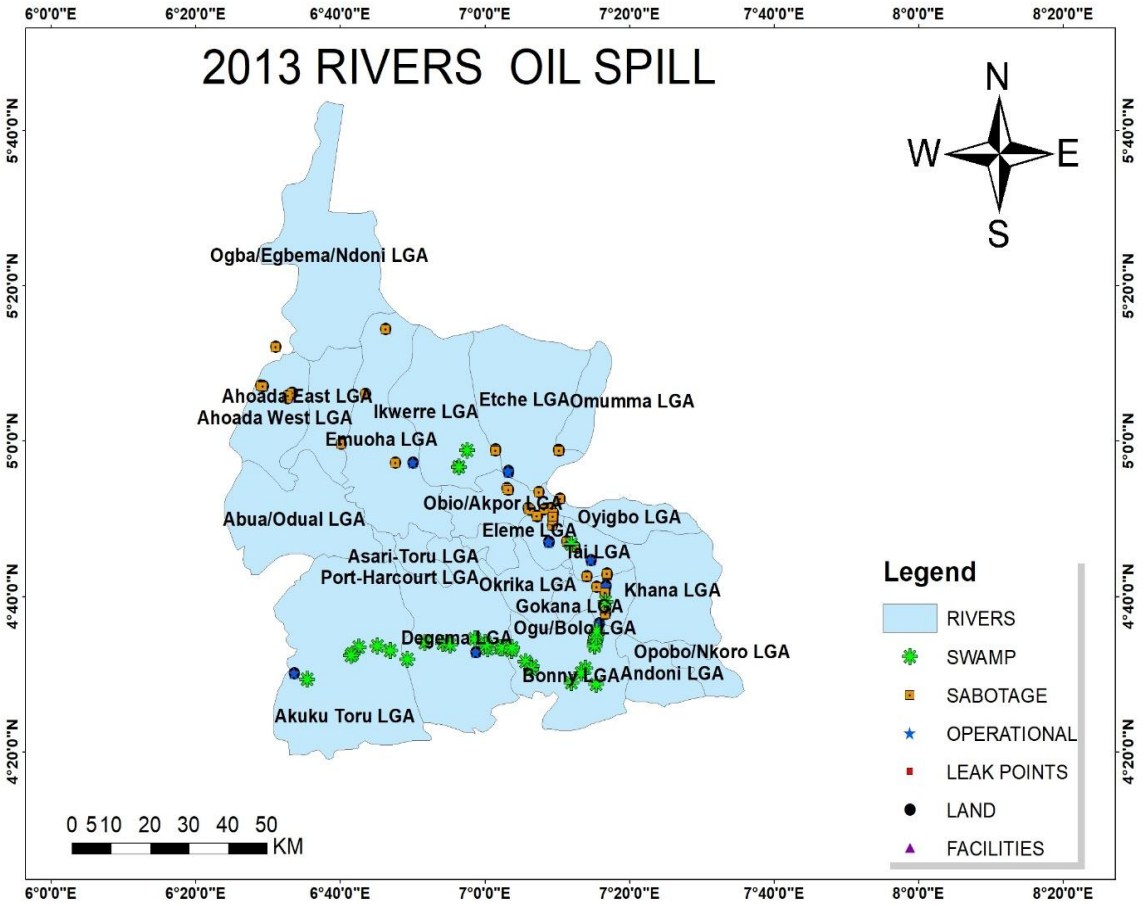

Figure 6: A trend map showing spill sites, causative factors, spilling facilities, leak points and terrains in Rivers state for 2013

Analysis of SPDC relatedspill for 2014

A total of 88 oil spills occurred in Rivers State between January and December 2014 with spill volume totalling 4404.60Bbl, and 292827.40m^{2}area of impact spreading across 14 L.G.As (Gokana, Eleme, Tai, Degema, Etche, Emohua, Andoni, Akuku-Toru, Oyigbo, Ahoada-West, Abua/Odual, Obia/Akpor, Ikwerre, and Bonny). Figure 7 shows a spatial temporal map of 2014 oil spill sites, leak points and terrain.

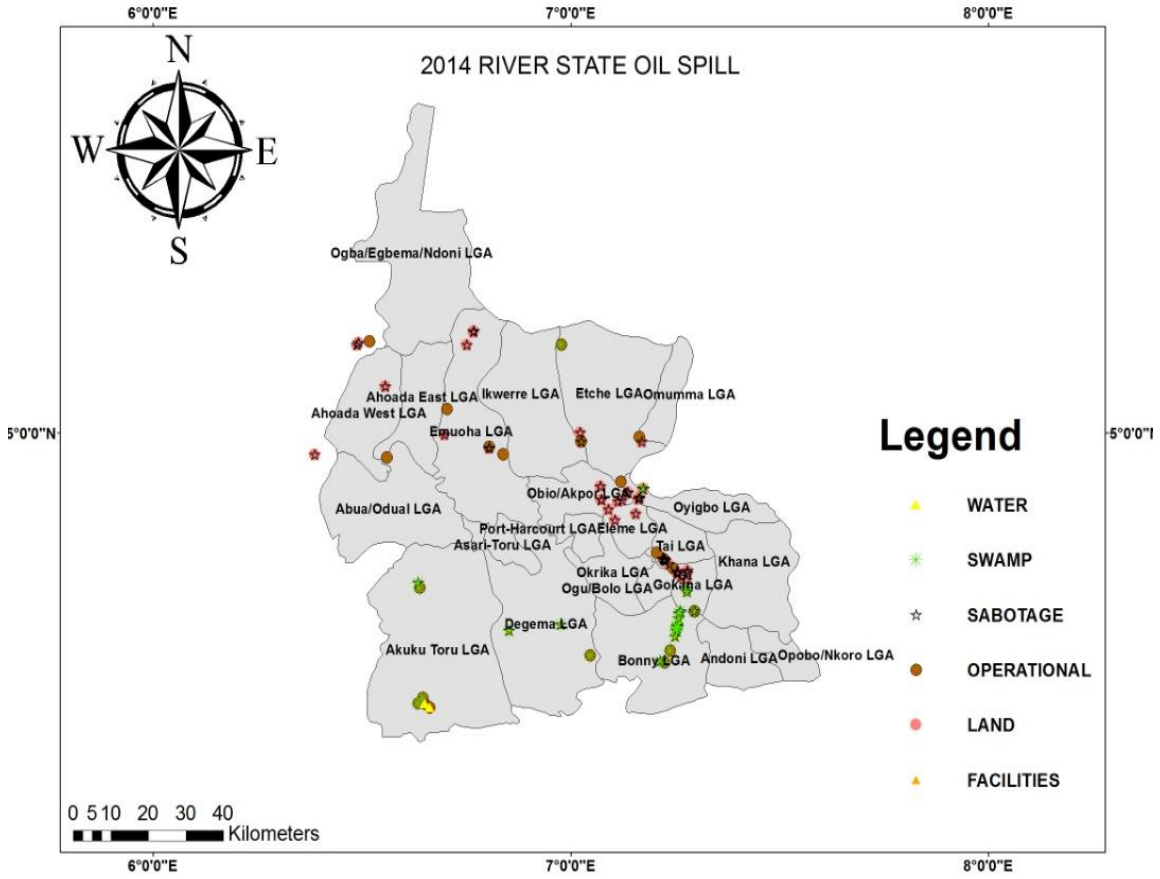

Figure 7: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Rivers State for 2014.

Analysis of SPDC relatedspill for 2015

A total of 73 oil spills occurred in Rivers State between January and December 2015 with spill volume of 11,403.50Bbl, and 531,816.02m^2area of impacted spreading across 12 L.G.As (Degema, Gokana, Tai, Akuku-Toru, Ahoada-West, Andoni, Ikwerre, Oyigbo, Eleme, Abua/Odual, Obia/Akpor, Ogba/Egbema/Ndoni). Figure 8 shows a spatial temporal map of 2015 oil spill sites, leak points and terrain.

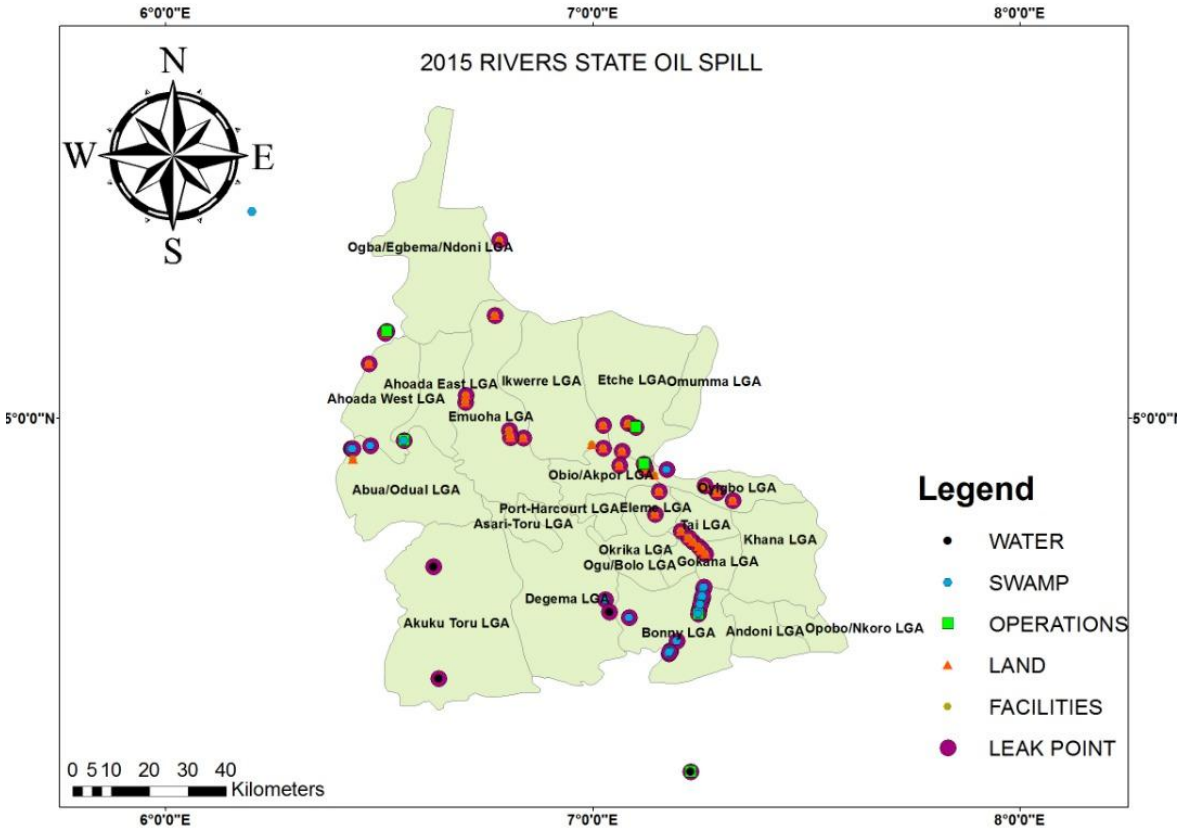

Figure 8: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Rivers State for 2015.

Analysis of SPDC relatedspill for 2016

A total of 39 oil spills occurred in Rivers State between January and December 2016 with spill volume of 3948.70Bbl, and 412956.57m^2area of impact spreading across 14 L.G.As (Andoni, Etche, Gokana, Emohua, Tai, Bonny, Akuku-Toru, Eleme, Obia/Akpor, Abua/Odual, Ikwerre, Oyigbo, Ahoada-West). Figure 9 shows a spatial temporal map of 2016 oil spill sites, leak points and terrain.

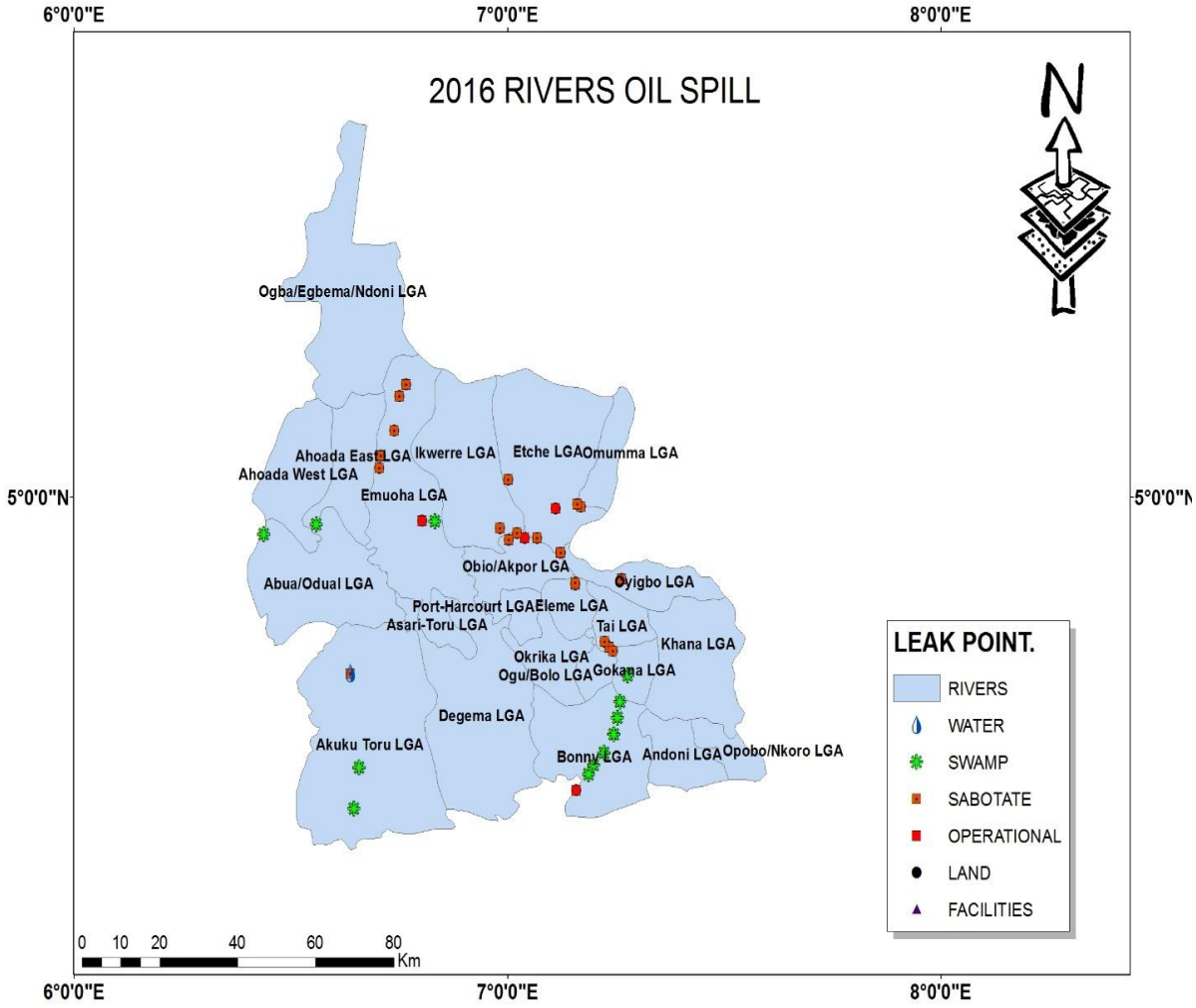

Figure9: A trend map showing spill sites, causative factors, leak points, spilling facilities and terrain in River State for 2016

Analysis of SPDC relatedspill for 2017

A total of 42 oil spills occurred in Rivers State between January and December 2017, with spill volume of6936.20Bbl, and 129400930.50m^{2}area of impact spreading across 12 L.G.As (Gokana, Emohua, Oyigbo, Ikwerre, Abua/Odual, Etche, Obia/Akpor, Andoni, Bonny, Eleme, Ahoada-East, and Tai). Figure 10 shows a spatial temporal map of 2017 oil spill sites, leak points and terrain.

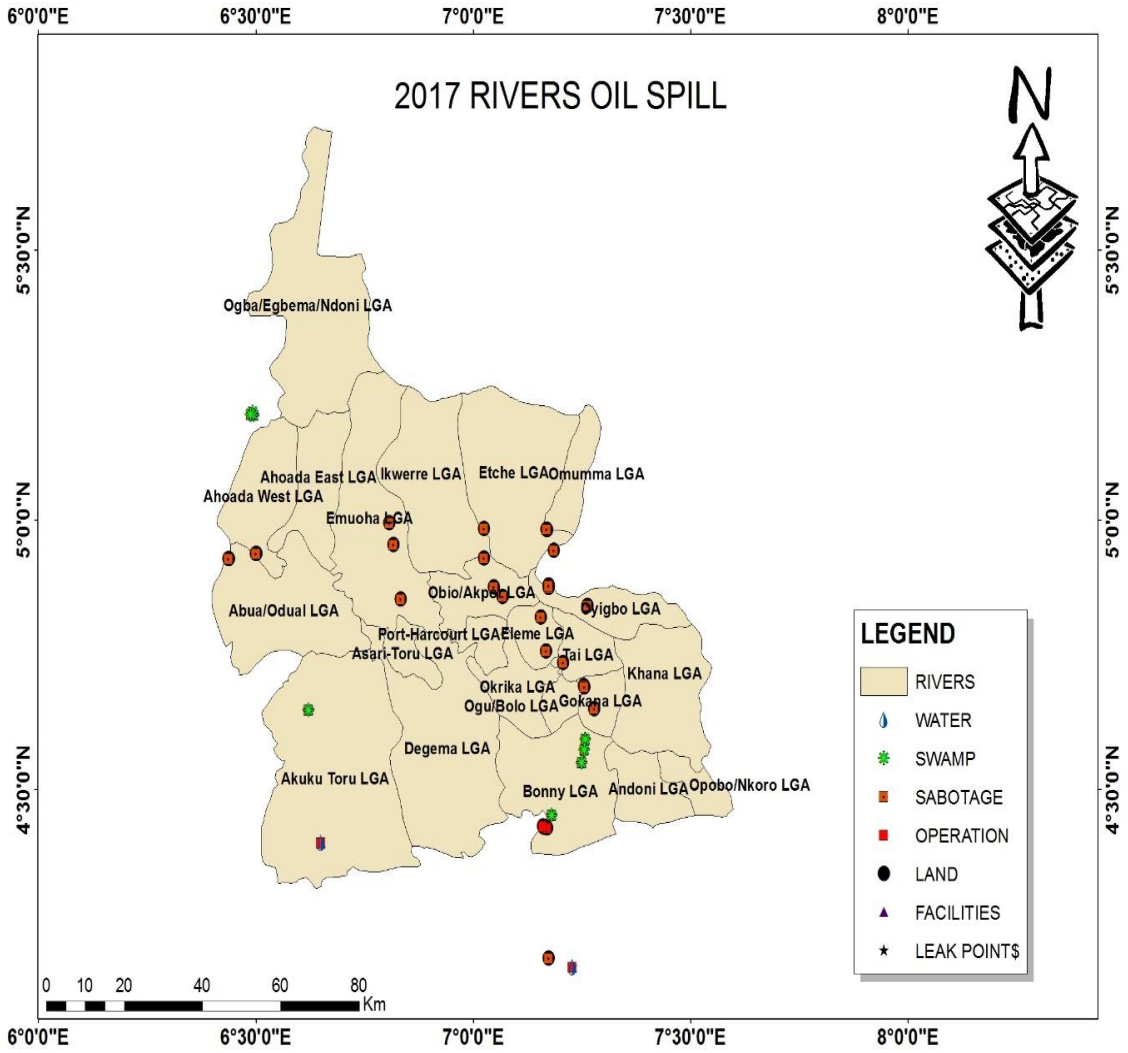

Fig 10: *A* trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Rivers state for 2017.

Analysis of SPDC relatedspill for 2018

A total of 81 oil spills occurred in Rivers State between January and December 2018 with spill volume of7029.00Bbl, and 423176.00m^{2}area of impact spreading across 14 L.G.As (Eleme, Ahoada-West, Ikwerre, Gokana, Etche, Akuku-Toru, Tai, Oyigbo, Bonny, Andoni, Abua/Odual, Emohua, Obia/Akpor). Figure 11 shows a spatial temporal map of 2018 oil spill sites, leak points and terrain.

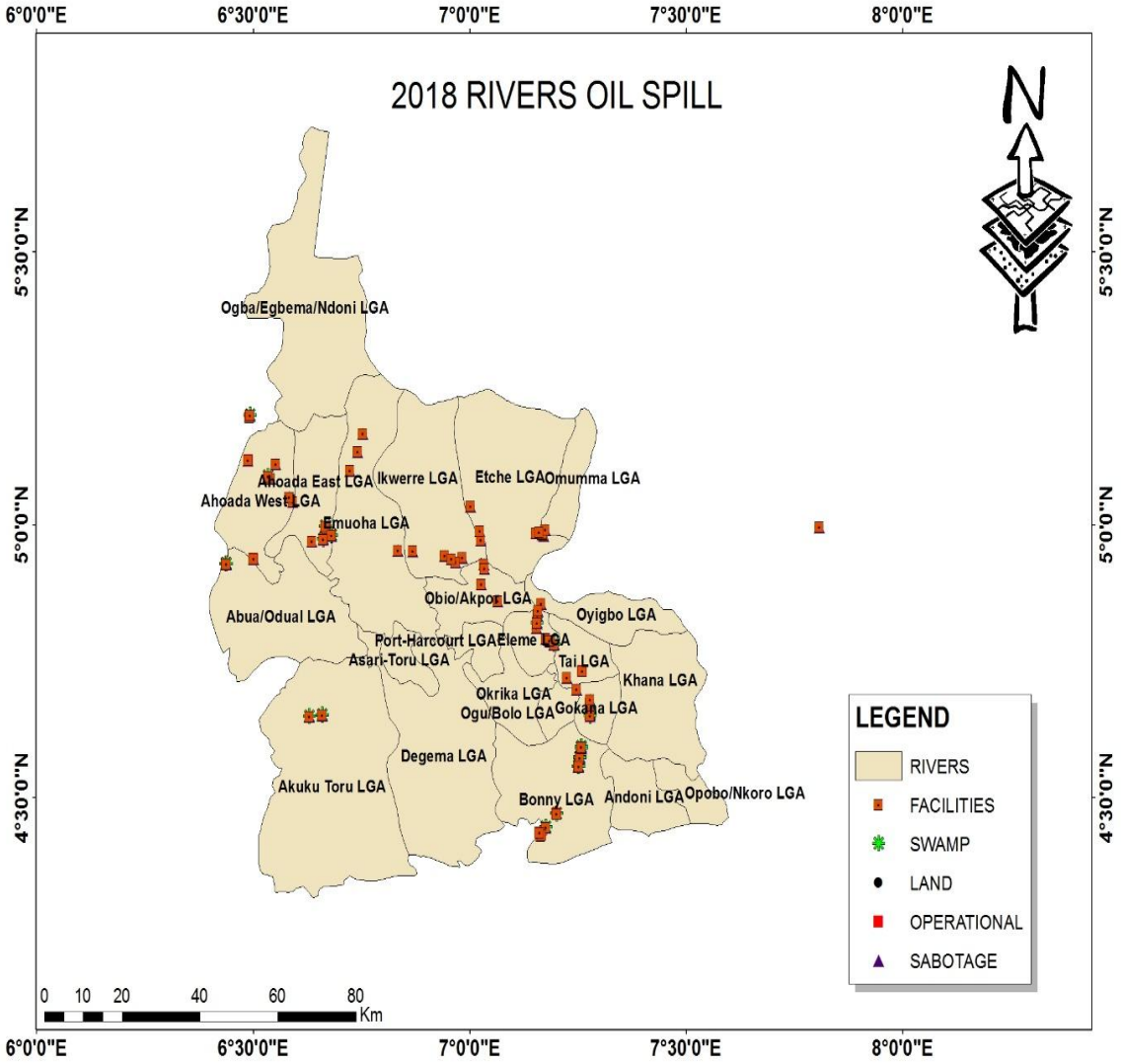

Figure 11: A map showing spill sites, leak points, causative factors, spilling facilities and terrain in Rivers State for 2018

AnalysisSPDC relatedof spill for 2019

A total of 103 oil spills occurred in Rivers State between January and December 2019 with spill volume of8306.40Bbl, and 650341.29m^{2}area of impact spreading across 14 L.G.As (Ahoada-West, Gokana, Eleme, Emohua, Akuku-Toru, Andoni, Oyigbo, Abua/Odual, Etche, Tai, Obia/Akpor, Ahoada-East, Ikwerre, Ahoada). Figure 12 shows a spatial temporal map of 2019 oil spill sites, leak points and terrain.

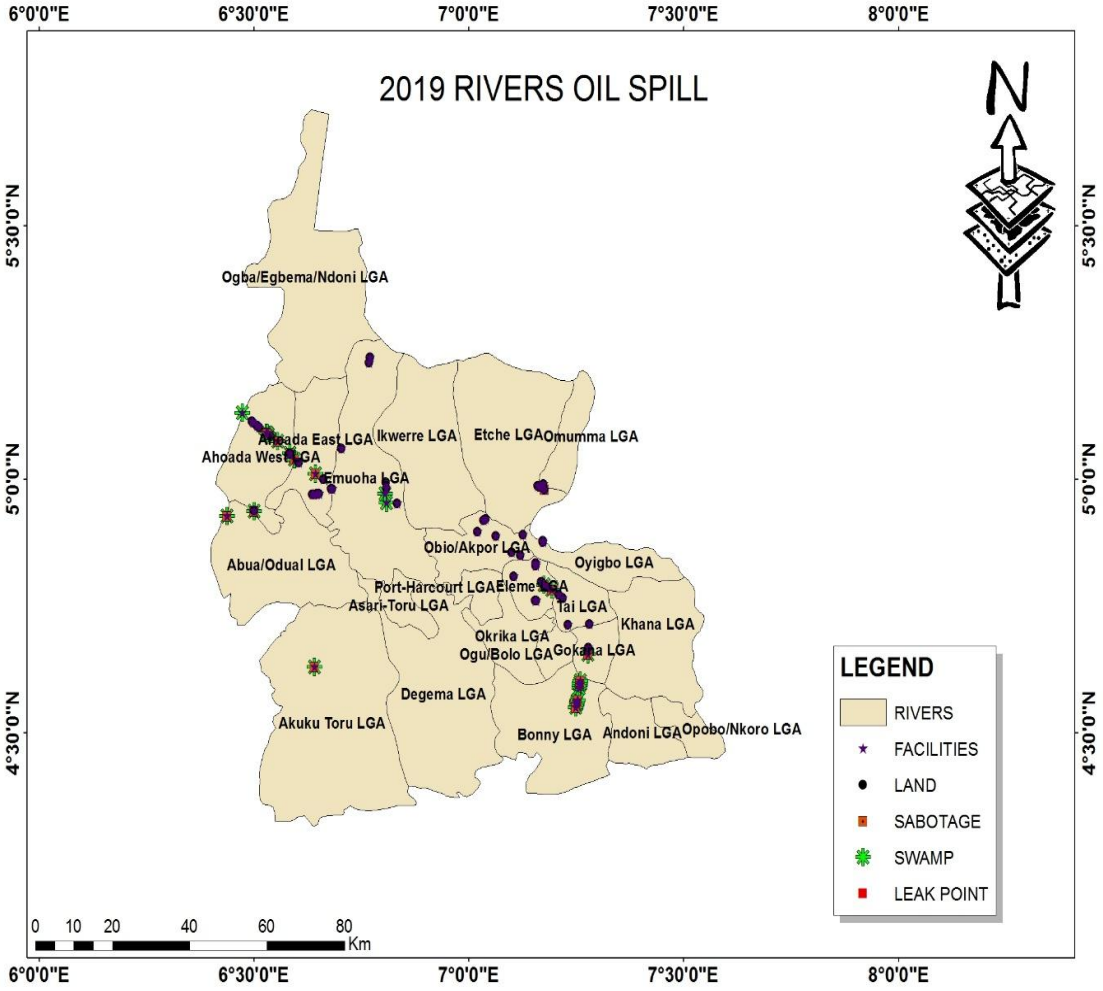

Figure 12: A map showing spill sites, leak points, causative factors, spilling facilities and terrain in Rivers State for 2019

V. CONCLUSIONS

This study investigates oil spillincidents in Rivers State from 2011 to 2019 by looking at its trends and patterns, using data from SPDC JIV report and ARCGIS software. The results showeda trending pattern of clustering in an area, in a linear form, withLand as the major terrain of spill, sabotage the major cause of spill, oil pipeline the major spilling facility, crude oil theft the major leak point, 2017 the year of highest area impacted by the spill and 2013 the year of highest volume of oil spilled. This study has shown that geo-spatial technology can be used to map oil spill trendpatterns and provide a veritable tool for which oil spill assessments can be made. There is an urgent need for improved GNP per capital, living index, security, welfare and economicdevelopment of the society especially oil producing communities to act as a stop gapto pipelines vandalizationand sabotage of oil facilities in Rivers state (Iyayi 2004, Etiosa and Matthew 2007)

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