

# Spatial Temporal Patterns of Bayelsa State Spdc Related oil Spill from 2011 to 2019

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**Abstract:** An Oil spill is a global issue which causes serious pollution to the environment. In this study, spatio-temporal models of the distribution of oil spills in Bayelsa State, Nigeria, from 2011 to 2019, were analyzed using ARCGIS software based on available data from the SPDC JIV report. The results showed a total of 234 spills in Bayelsa State from 2011 to 2019. The estimated spill volume is 25,501.30 barrels, with 2015 having the highest spill volume of 22% and 2019 the lowest spill volume of 3%. The spill affected an area of 14,789,570.02 m<sup>2</sup>, with the year 2012 having the most affected area (65.5%) and 2017 the lowest (1%). Swamp recorded the most spill incidents at 67% followed by land at 29%, water 3% and land / swamp at 1%. The main causes of the spills are sabotage (66.5%), operational failures (30.7%), others (2.3%) and the mysterious spill 0.5% (spills whose cause is not established). The main oil spill facilities such as oil pipelines, flow lines, well head, delivery line, flow station, manifold, trunk line, and buckline, accounted for 60% of the spill and other facilities accounted for 40% of spills. The main oil spill leak points are hack saw cut 35%, crude oil theft, 16%, corrosion 9%, well head tampering 6% and the rest (points leakages) 34%. This study presents a spatio-temporal map of the distribution of oil spills in Bayelsa State from 2011 to 2019 on the basis of oil spills related to SPDC.

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

## I. INTRODUCTION

### Background

Since the discovery of crude oil in 1956 by Shell British Petroleum known now as Royal Dutch Shell in Bayelsa State at Oloibiri village (Anifowose 2008, Onuoha 2008) there has been enormous issues regarding oil spillage, which has improved the discuss on how to tackle oil spills. The role of SPDC in Shell Nigeria's oil/gas family is usually limited to physical production and crude oil extraction/natural gas: oil spills in the Niger Delta wetlands and marine ecosystems during SPDC's E and P activities in Nigeria. The incident has been reported in the public oil spill documents since 2010, which is the main cause of the oil spill. According to reports, these leaks were caused by theft (refuelling), operational failures, and equipment at wellheads, pipelines and other facilities. As many as 400,000 barrels of oil are spilled every day, and more than 1,010 barrels of oil are spilled, of which 110,535 barrels of oil are equivalent to SPDC, which is said to have lost 17.5 million litres. Since 2011, this continuous environmental degradation has led to the establishment of the National Office of Oil Spill Detection and Response

(NOSDRA) in 2006. This study aims to analyse Bayelsa State oil spill related to the 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, spill leak points, spilled volume and area impacted by spill.

## II. LITERATURE REVIEW

Many scholars have conducted research on various aspects of Bayelsa State oil spills and its impacts on the environment. Some of the highlights of these researches include: Luiselli & Akani 2002 assessed oil pollution, diversity and the functioning of turtles in the Niger Delta, Nigeria. The study found a significant reduction in the specific variability of the turtles with 50% loss after oil spill, with a reduced number of turtle that were able to survive the oil spill. Ordinioha & Sawyer 2008 investigated Food Insecurity, Malnutrition and Crude Oil Spillage in a Rural Community in Bayelsa State, South-South Nigeria. The results show that the crude oil spill may exacerbate household food insecurity and child malnutrition. Ordinioha & Sawyer 2010 probed the acute health effects of a crude oil spill in a rural community in Bayelsa State, Nigeria. The results confirmed that exposure to the fog and fumes caused by the crude oil spill has had some health effects, although they are mild and temporary.

SPDC Geomatics 2012 mapping spill incidents in the Niger Delta. The findings suggest that oil spills around the Kolo Creek area are due to corrosion of pipelines and tankers (accounting for 50% of all spills), sabotage (28%), oil production operations (21%), with a 1% leakage for inadequate or impractical production equipment. The International Union for Conservation of Nature (IUCN) Kolo Creek Biophysical Report 2013 shows that Kolo Creek in Bayelsa's Ogbia Local Government Area (LGA) in southern Nigeria's Niger Delta is experiencing stress, which is likely to occur from the regular oil spill in the area. It could also be viewed as an indication that the environment and ecosystems are not fully recovered and it may take some time to fully recover. kabiamawei et; al 2017 examined the impact of oil operations in the Epebu community. Results, found that oil operations had negative effects on the environment and on the lives of host communities, such as: oil spills, water contamination, crises between communities and within the community, reducing economic activities, etc.

The Bayelsa State Oil & Environmental Commission Interim Report 2019 shows that over 50 years oil company activities and the associated impacts have caused endless disasters in the Bayelsa State. Umar et; al 2019 has developed a spatial database for oil spill pollution affecting the water quality system in the Niger Delta. The results of the study found that the three states of the Niger Delta (Bayelsa Rivers and Delta) were the ones where oil spills and distribution were the most, and were confirmed with ER charts showing correlations between sources of pollution pathway and receptors.

2.1 Study Area

The study area is located within Latitude 04°15' North, 05°23' South and longitude 05°22' West and 06° 45' East, sharing its territory with Delta state in the north, the Rivers state in the east and the Atlantic ocean in the west, and South (figure 1). It is politically divided into 8 local government areas (LGA) namely: Brass, Ekeremor, Kolokuma/Opokuma, Nembe, Ogbia, Sagbama, Southern Ijaw, and Yenagoa (state capital). Bayelsa State is located within the lower delta plain believed to have been formed during the Holocene of the quaternary period by the accumulation of sedimentary deposits. The main geological feature of Bayelsa state is alluvium sediments. The entire state is made up of abandoned beach ridges, and because of the many tributaries of the Niger River in the plains. Bayelsa State is a tropical rainforest, with more than three quarters of the state covered by water, with a network of meandering creek, mangrove swamps and rivers flowing into the Atlantic Ocean.

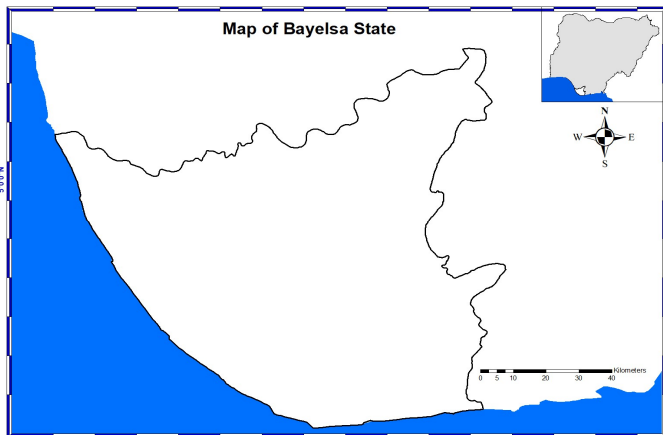


Fig 1: Map of Bayelsa State

III. MATERIALS AND METHODS

This study used the data provided in the SPDC 2011-2019 JIV report. The subsequent method was published by Apata et al. 2019.

IV. RESULTS AND DISCUSSION

A total of 234 SPDC related oil spill incidents occurred in Bayelsa State from 2011- 2019 across 6 local Government Areas of the state. The analysis of the spill is presented in tables, charts and maps.

Volume of SPDC related Oil Spill from 2011-2019 in Bayelsa state

It is estimated that a total of 25,501.30Bbl oil was spilled in Bayelsa State from 2011 to 2019 at a rate of 9,054.44Bbl per year. The lowest volume of oil spill was recorded in 2019 (3%) and the highest volume recorded in 2015 (22%). A gradual increase in the rate of oil spill from 2011 (11%) to 2015 (22%) was noticed which reduced in 2016 to 6% and increased to 15% in 2018 before reducing in 2019 to 3%. It is expected that this new trend in reduction will be sustained going forward. Fig. 2 shows percentage change in spill volume.

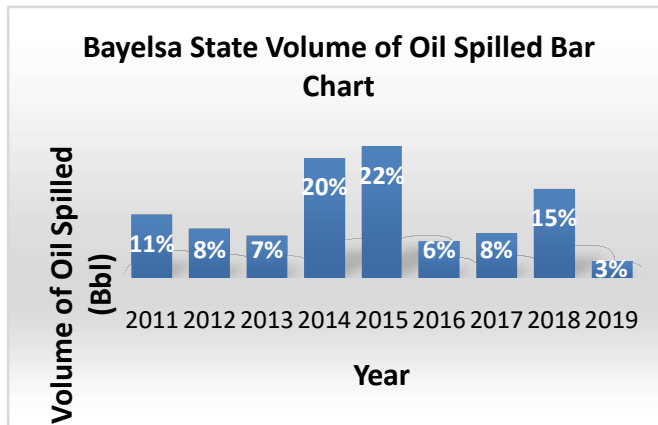


Figure 2: Histogram showing spill volume change for Bayelsa State from 2011-2019

Impacted Area of Oil Spill from 2011-2019 in Rivers state

It is estimated that an area of 14,789,570.02m<sup>2</sup> was impacted by oil spill in Bayelsa State from 2011 to 2019 at a rate of 1,643,286 m<sup>2</sup>per year. The lowest area impacted by oil spill was recorded in 2017 (1%) and the highest area impacted by oil spill was recorded in 2012 (65.5%). A sever decrease in the rate of area impacted by oil spill from 2012 (65.5%) to 2019 (2.6%) was noticed, signifying a reduction in spill area of impact. Fig. 2 shows percentage area Impact of oil spill.

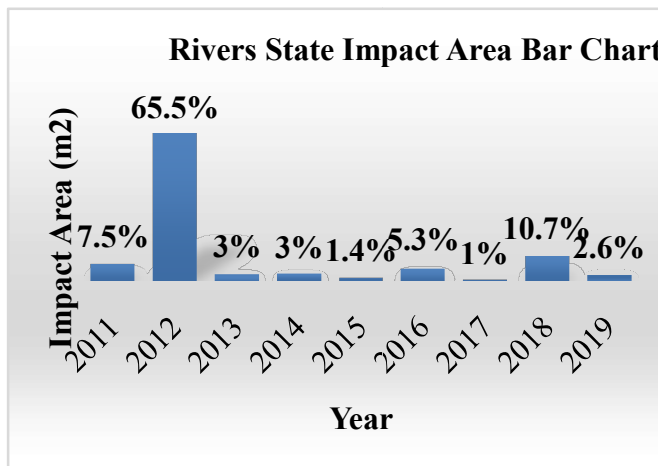


Figure 3: Histogram showing Impact Area change for Bayelsa State from 2011-2019

*Terrain affected by Oil spill from 2011-2019 in Bayelsa state*

Land, swam, water and land/swamp terrains were affected by oil was spill in Bayelsa State from 2011 to 2019. Swamp was

the most affected terrain with 67% of the spill followed by land at 29%, water 3% 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	20	4	13	8	8	3	1	6	4	29
Swamp	11	19	11	38	25	11	8	21	12	67
Water	2	1	0	1	2	1	1		0	3
Land/Swamp	0	1	1						1	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 Bayelsa State from 2011 to 2019.

Sabotage was responsible for 66.5% of the oil spills, followed by operational failures at 30.7%, others 2.5% and mystery spills at 0.5%. 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	23	12	13	31	12	14	7	18	15	66.5
Operational	10	13	12	13	6	1	3	7	2	30.7
Others				3	1			1		2.3
Mystery								1		0.5

*Spilling facilities of SPDC related Oil spill from 2011-2019 in Rivers state*

Oil pipelines, flowlines, well head, delivery line, flow station, manifold, trunk line, and buckline are the major oil spilling

facilities in Bayelsa State from 2011 to 2019. Pipelines were the most affected spilling facilities with 60% with the rest accounting for 40%. 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	9	5	4	13	19	6	3	19	13	91	38
Pipeline	11	12	9	19	1					52	22
Flow line	10	6	1	3	4	2	1	4		31	13
Oil Flowline	1		4	3	1	2			2	13	5
Well head	1		1	1	7	4	6	3		23	10
Trunk line		1		2						3	1
Compressor Station/Unit		1								1	0
Delivery line		7	1	1						9	4
Flow station	1		1	2	2					6	3
Manifold			3		1					4	2
Condensate pipeline		1								1	0
Riser Pipeline			1							1	0
Gas Line		1								1	0
Buck line						1		1		2	1
Others				1						1	0

*Leak Points of Oil spill from 2011-2019 in Bayelsa state*

Crude oil theft, hack saw cut corrosion, and Well head tampering were the major oil spill leak points in Bayelsa State

from 2011 to 2019. Hack saw cut was the most affected leak point with 35% of the spill followed by Crude oil theft 16%, corrosion 9%, well head tampering at 6 %, and the rest at 34 %. 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	2	2	3	16	6	3	1	2	2	16
Hack saw cut	20	7	9	12	11	5		11	6	35
Failed weld-on illegal hot top valve (Bunkering)		1					2			1
Drilled Hole	3			1				1		2
Corrosion		4	5	3	2		2	4	1	9
Others	2		1	1	7			3	1	6
Failed clamp	2		1	1					1	2
Missing pipeline/Flowline				1	1				4	3
Well head tampering		1		2	1	3	3	3		6
Internal corrosion	2	3								2
Third party tampering with Valve Settings		1		3	1		1	1		3
Tear				3	2			2		3
Saver pit overflow						1				0
Third party tampering with clamp		1	3		1					2
Inward dent		1		1		1			2	2
Failed welded joint		1	1							1
Cork valve gauge removal					1					0
Pinhole and slight	1	1	1	2	1		1			3
Equipment damage/failure						1				0
Sectional rupture	1									0
Saver Pit overflow				1						0
Complete Rupture / Broken Pipeline		1				1				1
Failed Gasket at Flanged Joint			1							0
Failed Injection hose					1					0
Deep cut		1								0

*Analysis of Oil spill for 2011*

The year 2011 recorded 33 oil spills in Bayelsa State with 2,719.19Bbl volume spilled over 1,111,759.59m<sup>2</sup> area across 6 L.G.As (Ogbia, Ekeremor, Yenegoa, Nembe, Brass and

Southern Ijaw). The spatial map of the oil spill for 2011 is shown in Figure 4.

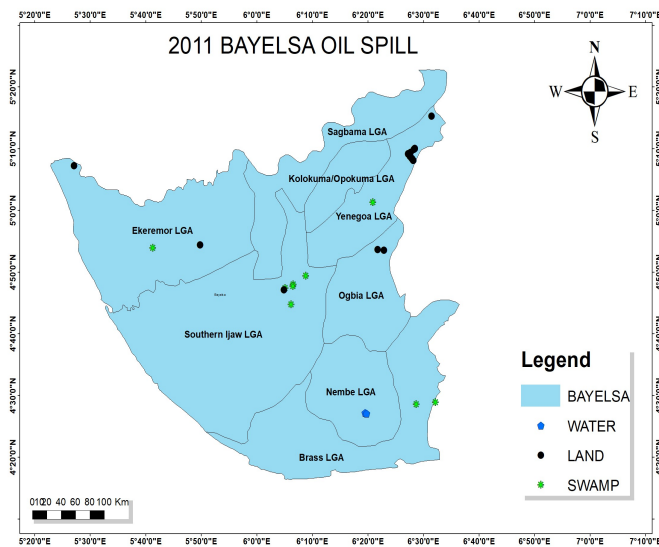


Figure 4: A trend map showing spill sites, causative factors, and leak points, spilling facilities and terrain in Bayelsa state for 2011

*Analysis of Oil Spill for 2012*

The year 2012 recorded 25 oil spills in Bayelsa State with 2,112.06Bbl, volume spilled over 9,688,514.20m<sup>2</sup> area across 4 LGA's (Southern Ijaw Yenegoa, Ekeremor and Brass). The spatial map of the oil spill for 2012 is shown in Figure 5.

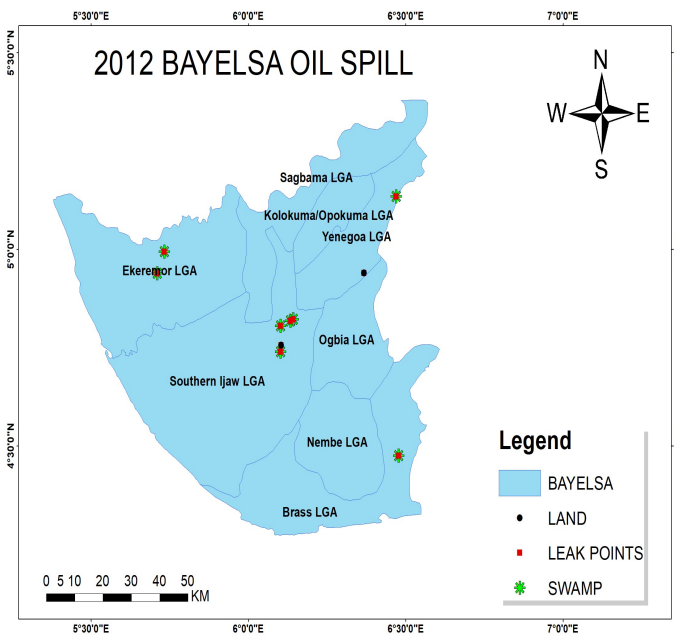


Figure 5: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Bayelsa for 2012.

*Analysis of Oil Spill for 2013*

The year 2013 recorded 25 oil spills in Bayelsa State with 1,814.60Bbl, volume spilled over 449,584.74m<sup>2</sup> area across 5 L.G.As (Ekeremor, Yenagoa, Southern Ijaw, Brass and Nembe). The spatial map of the oil spill for 2013 is shown in Figure 6.

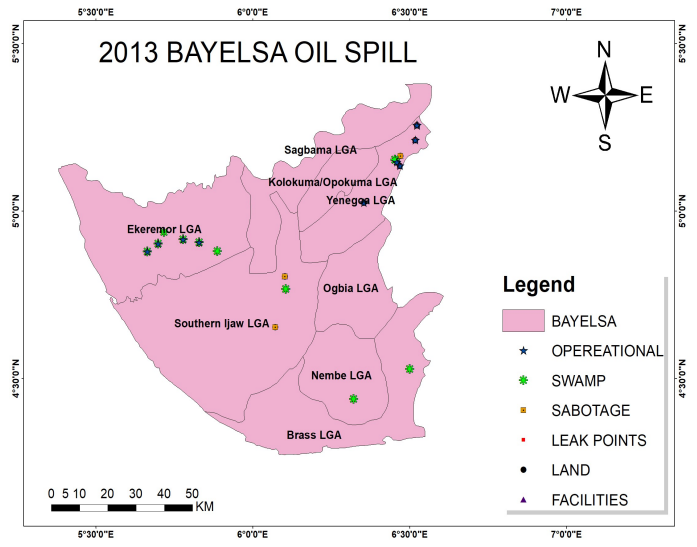


Figure 6: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Bayelsa State for 2013.

*Analysis of Oil Spill for 2014*

The year 2014 recorded 47 oil spills in Bayelsa State with 5,144.90Bbl, volume spilled over 480,516.87m<sup>2</sup> area across 6 L.G.As (Ogbia, Ekeremor, Yenegoa, Nembe, Brass and Southern Ijaw). The spatial map of the oil spill for 2014 is shown in Figure 7.

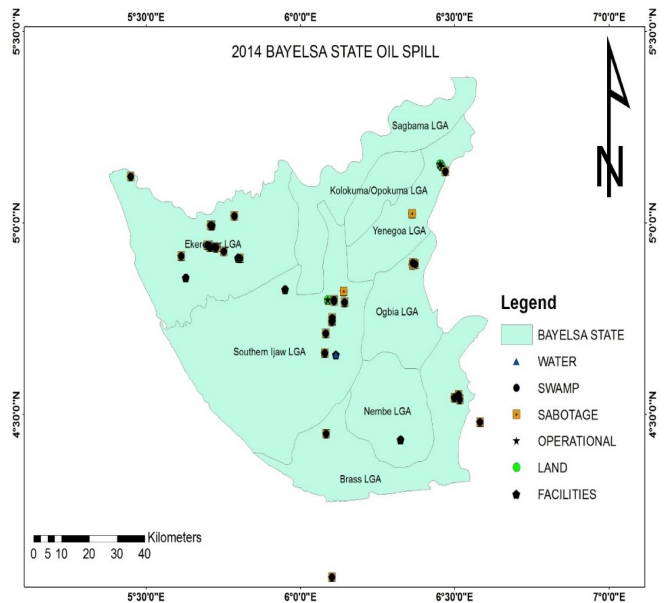


Figure 7: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Bayelsa for 2014

*Analysis of Oil Spill for 2015*

The year 2015 recorded 35 oil spills in Bayelsa State with 5,657.24Bbl, volume spilled over 214,126.96m<sup>2</sup> area across 6 L.G.As (Ogbia, Ekeremor, Yenegoa, Nembe, Brass and Southern Ijaw). The spatial map of the oil spill for 2015 is shown in Figure 8.

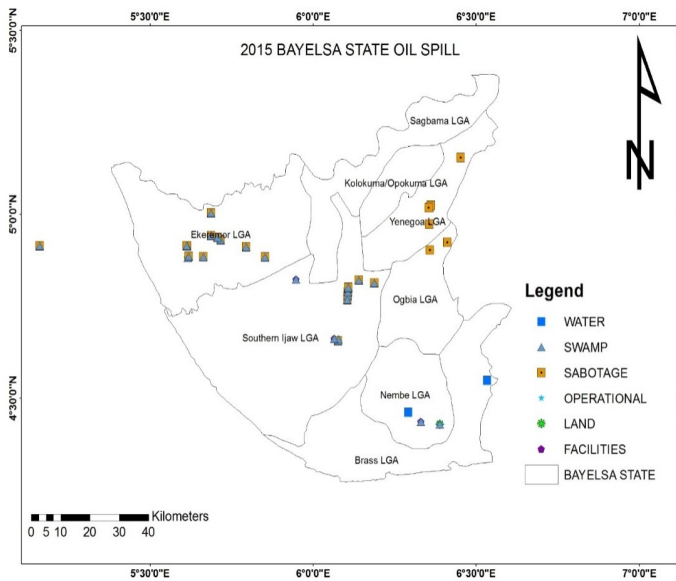


Figure 8: A trend map showing spill sites, causative factors, leak points, spilling facilities and terrain in Bayelsa state for 2015

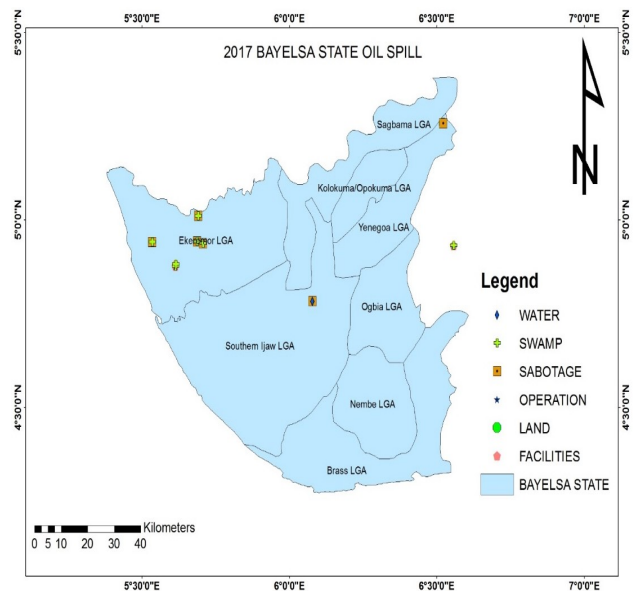


Figure 10: A trend map showing spill sites, causative factors, leak points, spilling facilities and terrain in Bayelsa for 2017

*Analysis of Oil Spill for 2016*

The year 2016 recorded 15 oil spills in Bayelsa State with 1,583.30Bbl, volume spilled over 785,279.00m<sup>2</sup> area across 4 LGA's (Southern Ijaw Yenegoa Ekeremor and Ogbia). The spatial map of the oil spill for 2016 is shown in Figure 9.

*Analysis of Oil Spill for 2018*

The year 2018 recorded 27 oil spills in Bayelsa State with 3,827.61Bbl, volume spilled over 1,586,939.60m<sup>2</sup> area across 4 LGA's (Southern Ijaw, Yenegoa, Ekeremor and Ogbia). The spatial map of the oil spill for 2018 is shown in Figure 11.

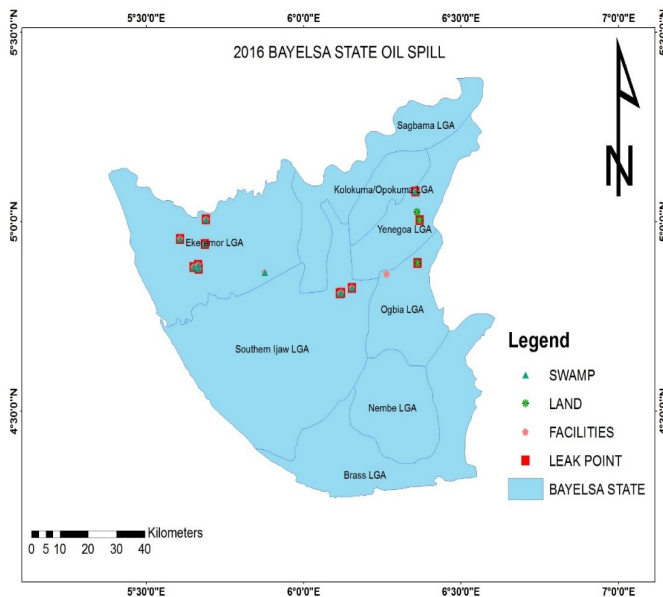


Figure 9: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Bayelsa State for 2016

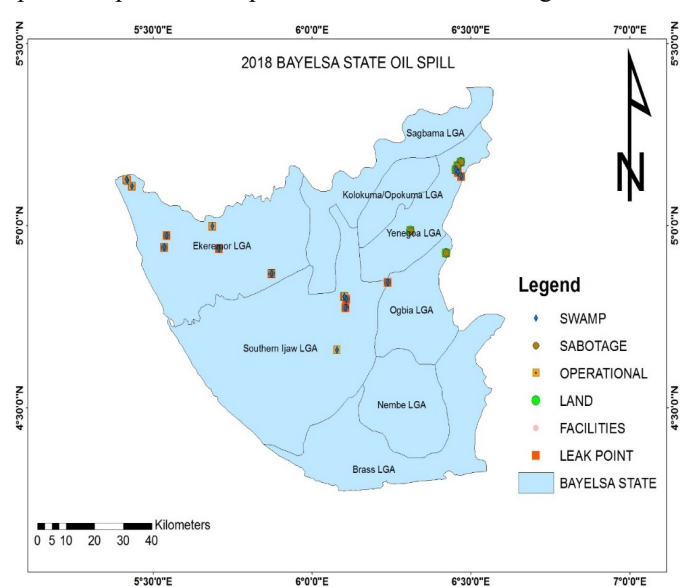


Figure 11: A trendmap showing spill sites, leak points, causative factors, spilling facilities and terrain in Bayelsa State for 2018

*Analysis of Oil Spill for 2017*

The year 2017 recorded 10 oil spills in Bayelsa State with 1,918.10Bbl, volume spilled over 82,806.00m<sup>2</sup> area across 3 L.G.As (Ekeremor, Yenegoa, and Southern Ijaw). The spatial map of the oil spill for 2017 is shown in Figure 10.

*Analysis of Oil Spill for 2019*

The year 2019 recorded 17 oil spills in Bayelsa State with 724.30Bbl, volume spilled over 390,043.06m<sup>2</sup> area across 4 LGA's (Southern Ijaw, Yenegoa, Ekeremor and Ogbia). The spatial map of the oil spill for 2019 is shown in Figure 12.

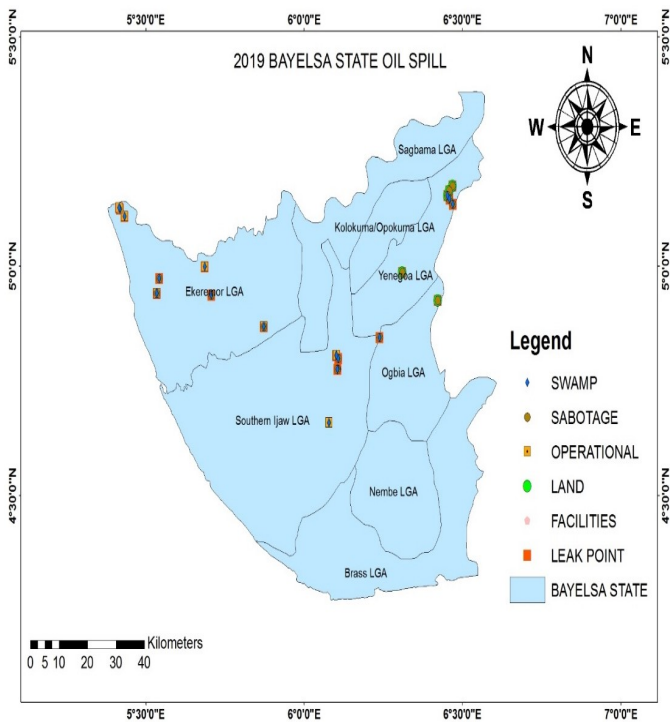


Figure 12: A trend map showing spill sites, leak points, causative factors, spilling facilities and terrain in Bayelsa for 2019

### V. CONCLUSIONS

This study used data from the SPDC JIV report and ARCGIS software to study the trends and patterns of Bayelsa State oil spill from 2011 to 2019. The results showed a trendy pattern of clusters in the study area, in linear form, with Swamp as the main terrain for spills, sabotage the main cause of spills, oil pipeline the main spilling facility, Hack saw cut the biggest leak point, while the highest oil spilled and area impact occurred in 2012 and 2015 respectively. This study shows that geospatial technology can be used to map oil spill trends and provide tools that can be used to assess oil spills.

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