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RESEARCH ARTICLE

GEOMETRIC AND SPATIAL ASSESSMENT OF URBAN ROAD POTHOLES IN YENAGOA, BAYELSA STATE, NIGERIA

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ABSTRACT

The study was initiated to address the need for accessible spatial data on pothole locations, which is crucial for road maintenance efforts aimed at reducing accidents, preventing loss of life, and protecting property. Its goal was to conduct a spatial analysis of pothole locations and their geometrical features, providing essential information for policymakers, road construction companies, and road users in Yenagoa City Local Government Area, Bayelsa State. The research objectives included identifying the spatial locations of potholes, analyzing their geometrical characteristics, calculating the total volume of potholes on the roads, and producing a geospatial map of potholes in the study area. The study examined twenty internal roads, including Opolo Road, Ebi's Mechanic Road, Amarata, Goodnews Road, and Azikoro. A combination of ground survey methods, remote sensing, and geospatial information systems was used. Data were collected using a Differential Global Positioning System with Real-Time Kinematics and drone technology, which provided both three-dimensional and aerial views of the potholes. Data processing was conducted using ArcGIS 10 and Drone-Deploy software. The findings included the coordinates, surface areas, volumes, imagery, and digitized maps of the potholes in the study area. A total of 239 potholes were identified, with varying surface areas and volumes across the roads. Ebi's Mechanic Road in Amarata had the highest percentage of potholes, accounting for 21% of the total with 51 potholes covering 11,958.901m2. Azikoro Road was found to be the longest and widest road, while Nepa Road was the shortest. Notably, Opolo Road, which is the only interlocked road, had the fewest potholes and the smallest surface area affected by them. The deployment of Geospatial techniques in this study underscored the capability of the approach to delineate and generate the geometrical attributes of these potholes in the study area.

KEYWORDS

Spatial Data, Potholes, Map, DGPS, GIS

1. INTRODUCTION

Road pavement can deteriorate over time due to human and biological processes, requiring immediate maintenance. The local ecosystem affects how long road pavement lasts in different states and nations. Different types of roads and their respective locations have different requirements. Nevertheless, when these requirements are not met during the construction process, road segments collapse, resulting in potholes in the paved surface. Yenagoa's roadways are divided into three categories: Trunk A, Trunk B, and Trunk C. The national grid is built upon trunk 'A' routes. Through the Federal Ministry of Works (FMW), the Federal Road Maintenance Agency (FERMA), and the Niger Delta Development Commission (NDDC), the Federal Government develops and finances them. This category of roads includes both motorways and highways. State highways known as "Trunk B" routes connect the state's cities and communities. They are built, funded, and maintained by the state government via the Ministry of Works. They include roads and driveways. Unpaved "Trunk 'C' roads are found inside metropolitan areas. They are financed and built by the Local Government Authorities (Olubomehin, 2013; Yusuf, 2020). Potholes are a type of road pavement imperfection that negatively impacts a variety of social functions within the society, state, or nation, including agriculture, education, emergency medical care, traffic, economic advancement, and regional development (Ndefo, 2012; Yusuf, 2020).

One common type of pavement deterioration is potholes, which reveal structural vulnerabilities in an asphalt road. Repairing pavement requires data collection and analysis, determining the shape of potholes, and quantifying them. Low-severity potholes with a depth of 0.0254 meters and a width of 0.0254 meters are present, and the depth and width of moderately severe potholes range from 0.0254 to 0.0508 meters, whereas high-severity potholes are distinguished by a notable impact brought on by increased vehicle acceleration, which causes degradation and depreciation.

The unchecked proliferation of potholes poses a significant hazard to neighbourhood safety and urban mobility (Musa et al., 2025). Severe potholes in the study area exhibit depths and widths exceeding 0.508 m, a threshold commonly associated with advanced pavement failure and elevated accident risk (Patrick et al., 2012). Plate 1 illustrates representative pothole categories identified within the study area. The occurrence and severity of these potholes reflect the combined influence of geological conditions, hydrological processes, marshy subsurface

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characteristics, and substandard construction specifications, all of which contribute to progressive pavement structural collapse. In the Niger Delta region of Nigeria, pavement failures have been widely linked to adverse geological and hydrological conditions, particularly the presence of weak, waterlogged subsoils and inadequate drainage systems that accelerate material degradation (Jegede, 2005).

These conditions promote moisture retention within pavement layers, reduce bearing capacity, and intensify deformation under traffic loading. Given the persistent recurrence of potholes and the resulting deterioration of road surfaces in Yenagoa, this study undertook a systematic analysis of pothole geometry and spatial distribution to support effective mitigation strategies. Consistent with the findings which emphasize the role of intelligent road defect monitoring in infrastructure management, this research applies geospatial techniques to delineate pothole locations and quantify their geometric characteristics (Kamalesh et al., 2020). The results provide decision-support information for road construction firms and maintenance agencies, including the State Ministry of Works, the Niger Delta Development Commission (NDDC), and the State Employment and Expenditure for Results Project (SEEFOR), to enhance planning, prioritization, and cost-effective intervention. Poor road conditions impose substantial economic and safety burdens. Studies estimate that the Nigerian automotive sector incurs annual losses exceeding ₦133.8 billion due to increased vehicle maintenance costs and damage attributable to deteriorated road infrastructure (Enwerem and Ali, 2016; Yusuf, 2020).

Beyond financial losses, potholes elevate the risk of vehicle failure and traffic accidents. The widespread susceptibility of roads in Yenagoa to pothole formation underscores the urgency for data-driven pavement monitoring and geotechnically informed maintenance strategies. Road condition monitoring systems are systems that detect the presence of road anomalies (Bello-Salau et al., 2019). Several reviewed works on road deformation used image processing for the detection of road anomalies and recorded reasonably high efficiency (Anaissi et al., 2019; Bansal et al., 2020; Chen et al., 2020; Kamalesh et al., 2021 in Ahmed et al., 2025; Zang et al., 2023). However, most of these works did not appraise the geometrical properties of potholes using geospatial analysis techniques. This is the focus of this work to address the seeming gap in the characteristics of potholes in a deforming road condition.

Plate 1: Specimen of a typical pothole on some of the Roads within the Study Area

2. Study Area

The research site is situated in the Yenagoa Local Government Area of Bayelsa State, bordered by Winner's Chapel Road, Swali, and Opolo Market Road, Yenagoa. This territory, encompassing both the Epie and Atissa clans, is acknowledged as the Central Business District of Yenagoa City. There are twenty (20) internal roads, which constitute a portion of the seventy-seven (77) roads included in the infrastructure enhancement initiated in 2011 by Chief Timipre Sylva, the former governor of the state. All of them are classified as "B" trunk highways. The study area is situated between latitudes 04º 55' 09" N and 04º 56' 51" N, and longitudes 006º 16' 04" E and 006º 19' 59" E as shown in Figure 1. The soil in the research region is categorized as rainforest, comprising over 90% of the soils categorized as Entisols, Oxisols, and Alfisols. The soil texture of the research region consists of an alternating sequence of sand and clay, with a predominance of clay.

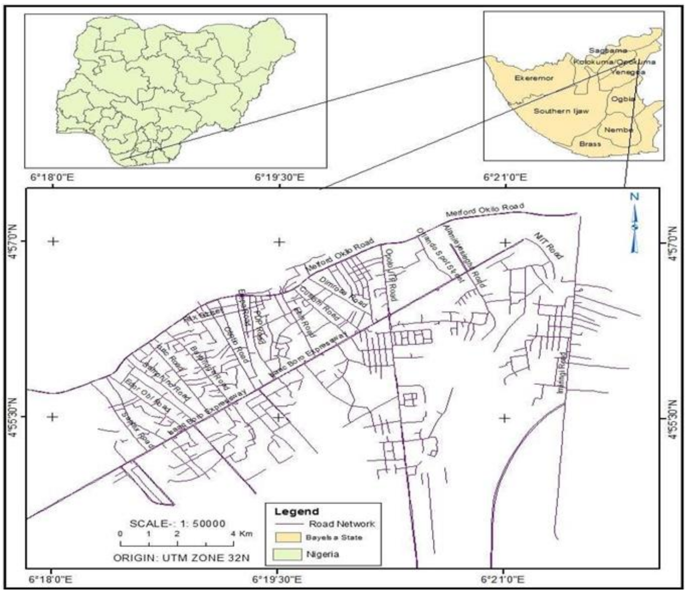

Figure 1: Map of Nigeria, Map of Bayelsa State, and Map of Yenagoa.

Source: Bayelsa Geographic Information System (BGIS), 2021.

The flora of the study region is the tropical rainforest (Udo, 1981; Amadi, 2012). They were categorized into two primary groups: the tropical rainforest and the swamp forest. The predominant natural vegetation is the rainforest, characterized by evergreen trees and palms, Arboreal and shrubby vegetation. The clay located 8m beneath the ground surface, together with other intrinsic elements, contributes to the failure of civil engineering projects (Amadi, 2012; Youdeowei and Nwankwoala, 2013).

3. Materials And Methods

Both spatial and non-spatial data were used in the study, premised on the descriptive research methodology. The Differential Global Positioning System (DGPS) Real Time Kinematic (RTK) and close-range photogrammetry approach (Drone Technology) were utilized in this study, and the conventional survey techniques for positioning were used to gather critical primary datasets. The latter method will help determine the geometrical characteristics of the potholes. Table 1 shows the control stations, which are secondary data that served both the instrument calibration control station to the project. Another secondary data source used for the project was the map of the road network that was sourced from the Bayelsa Geographic Information System (BGIS). This enabled the digitizing of the primary data of the potholes in producing a geospatial map of the study area.

Table 1: List of Coordinates WGS 84 UTM Zone 32

S/No	Station ID	Eastings (m)	Northings (m)	Height (m)
1	BGIS 014	435303.041	105224.492	4.636
2	BGIS 016	431011.335	103060.488	5.564
3	BGIS 017	428443.551	103909.498	5.213

Source: Bayelsa State Geographic Information System, Yenagoa, (2023).

The DGPS (RTK) Kolida K9T GNSS was calibrated using two control points, BGIS 016 and BGIS 017. This was achieved by comparing the already determined coordinates of the control point with the observation obtained by the DGPS. The DGPS, after calibration, was set up on the control station

BGIS016, and the rover was used to navigate the potholes. The pseudo ranges were corrected at the reference station, and the spatial data of that pothole were broadcast to the receivers. The processing approach employed both quantitative and qualitative classification of data. Quantitative classification is based on variables; it involves grouping the variables and quantifying them in groups for seamless data integration and manipulation. The processed data was transported to an ArcGIS environment.

Figure 2: A Specimen of Flight Path Starting from North to South of Ebis Mechanic Road in the Study Area.

The shapefiles were used to calculate the area also volume of the potholes. Hence, with the analysis tools in ArcGIS, running multiple cropping was used to perform the analyses of the potholes. In another vein, the DJI Mavic 2 pocket drone was employed in acquiring the aerial photographs of the potholes of the study area. Both IMU and GNSS navigation systems allow it to perform automated aerial survey with sufficient accuracy, as determined by the flight mission plan, as shown in Figure 2. The drone compass was calibrated in a square motion. Batteries and propellers were all confirmed to be in good condition before the drone started the mission strip.

4. Results And Discussion On Findings

4.1 Azikoro Road, Ekeki and Alamieyeseigha Road, Opolo-Epie

This road connects from the Sani-Abacha Express from the South to the North at the Mbiama/Yenagoa Road with 2.1km in total length. It is a paved road with 0.5m drainage at both ends. It is an access to Residents, Ekeki Police Station, Public and Private Schools, Churches, Supermarket, Eateries, and Hotels. The Alamieyeseigha road has a large surface area of potholes of 2.805m² and the least surface area of 0.751m2. The road had three (3) identified potholes.

4.2 Babridge Road and Captain Ayeni's Road

This road connects the Sani-Abacha Express to the Mbiama/ Yenagoa Road with an 8m width and 1.390km length. A paved road with no drainage at both ends. It is access to schools, churches, and Helen's Plaza. A total of 10 potholes were identified on this road. Similarly, Captain Ayeni Road connects the Sani-Abacha Express to the Mbiama/Yenagoa Road with an 8m width and 1.274k km length. A paved road with no drainage at both ends. It is an access to Residents, schools, churches, and hotels. A total of 36 potholes were identified on this road.

4.3 Dimrose Road, Opolo-Epie, and Ebi's Biogbolo Road

This road connects the Sani-Abacha Express to the Mbiama/Yenagoa Road with an 8m width and a 1.9km length. A paved road with no drainage at both ends. It has access to schools, churches, Guest House. A total of 6 potholes were found on this road. In the same vein, Ebi Biogbolo road connects the Sani-Abacha Express to the Mbiama/ Yenagoa Road with a 7m width and 1.357km length. A paved road with 0.6 drainage. It has access to both residential houses, Schools, Churches, and Ebi's Hotel. A total of 9 potholes were found on this road.

4.4 Ebi's Mechanic Road

This road connects from the Sani-Abacha Expressway to the Mbiama/Yenagoa Road with a 7m width and a 1.38 km length. A paved road with drainage at both ends. It is an access to Residents, the Army checkpoint, private schools, churches, and Residents. A total of 51 potholes were identified, as shown in Table 2.

Table 2: Shows the Spatial Location of Potholes on Ebi's Mechanic Road

ID	Potholes Location		Pothole Area (m^2)	Average Pothole Depth (m)	Volume of Potholes (m^3)
	Eastings (m)	Northings (m)			
EB01	198964.746	544671.424	27.727	0.215	5.961
EB02	198997.020	544744.982	94.790	0.499	47.300
EB03	198998.489	544759.014	36.645	0.341	12.496
EB04	199020.737	544809.756	38.264	0.188	7.194
EB05	199031.313	544821.654	10.318	0.421	4.344
EB06	199035.632	544840.988	28.400	0.292	8.293
EB07	199040.142	544850.997	11.287	0.457	5.158
EB08	199044.677	544857.249	5.306	0.139	0.738
EB09	199047.898	544866.018	8.189	0.482	3.947
EB10	199053.361	544869.197	28.122	0.263	7.396
EB11	199055.654	544879.750	21.035	0.535	11.254
EB12	199059.356	544895.427	23.354	0.201	4.694
EB13	199065.647	544902.244	10.181	0.445	4.531
EB14	199073.019	544919.715	38.996	0.278	10.841
EB15	199091.768	544943.137	238.897	0.316	75.492
EB16	199112.175	544975.274	22.113	0.409	9.044
EB17	199120.179	544992.315	116.937	0.192	22.452

Table 2 (cont): Shows the Spatial Location of Potholes on Ebi's Mechanic Road

EB18	199136.903	545018.137	210.406	0.467	98.260
EB19	199156.856	545046.457	8.362	0.253	2.115
EB20	199164.226	545058.139	2.049	0.529	1.084
EB21	199172.497	545073.596	129.987	0.187	24.308
EB22	199191.025	545098.614	4.562	0.442	2.017
EB23	199193.437	545104.612	11.053	0.308	3.404
EB24	199198.293	545112.074	4.303	0.491	2.113
EB25	199204.642	545119.095	8.967	0.225	2.018
EB26	199205.491	545124.345	3.426	0.514	1.761
EB27	199213.153	545134.022	52.108	0.169	8.806
EB28	199216.19	545149.197	5.967	0.386	2.303
EB29	199229.434	545160.257	22.159	0.244	5.407
EB30	199236.232	545171.328	36.852	0.521	19.200
EB31	199242.079	545180.141	6.194	0.181	1.121
EB32	199242.644	545184.210	3.836	0.219	0.840
EB33	199248.295	545191.515	10.889	0.468	5.096
EB34	199254.587	545202.524	5.759	0.342	1.970
EB35	199267.748	545222.635	82.817	0.191	15.818
EB36	199303.321	545275.358	6.647	0.421	2.798
EB37	199321.269	545303.665	6.309	0.265	1.672
EB38	199327.716	545313.457	13.380	0.398	5.325
EB39	199332.535	545322.544	11.593	0.185	2.145
EB40	199338.359	545334.531	4.386	0.170	0.746
EB41	199341.085	545340.962	11.790	0.251	2.959
EB42	199346.863	545350.345	14.592	0.437	6.377
EB43	199348.086	545358.967	11.141	0.204	2.273
EB44	199356.585	545367.898	11.008	0.189	2.080
EB45	199354.547	545369.493	7.904	0.119	0.941
EB46	199368.924	545389.295	28.569	0.304	8.685
EB47	199377.744	545411.734	73.748	0.411	30.310
EB48	199391.354	545454.067	52.035	0.376	19.565
EB49	199400.466	545485.283	217.981	0.492	107.246
EB50	199418.988	545512.372	69.666	0.340	23.686
EB51	199414.000	545511.631	47.894	0.302	14.464
	Aggregate Pothole Area (m^2)				**1958.901**
	Aggregate Volume (m^3)				**670.047**
	Road Distance				**1139.98**
	Road Area (m^2)				**9290.29**
	Pothole Percentage %				**21.09**

4.5 Goodnews Road, Azikoro-Epie and Erepa Road, Yenezuegene-Epie

This road connects the Sani-Abacha Expressway, Bayelsa Balm from the East to the West at Azikoro town road. It is a paved road with an 8m width and 1.765km length. It is an access to the House of Assembly quarters, Private Schools, Churches, Hospital, Market, and Residents. A total of 26 potholes were observed on this road, as shown in Table 3. Similarly, the Erepa Road has a total of 11 potholes with the largest surface area of 2.580m^2 and the smallest area of 0.574m^2. Also, the deepest pothole was 1.935m, with the least depth of 0.609m. The largest volume was 4.149m^3, as against the smallest volume of 0.531m^3.

Table 3: Showing Spatial Location of Potholes on Goodnews Road, Azikoro-Epie

ID	Potholes Location		Pothole Area (m^2)	Average Pothole Depth (m)	Volume of Potholes (m^3)
	Eastings (m)	Northings (m)			
GN01	199874.5255	541521.9336	18.885	0.143	2.701
GN02	199850.3955	541506.9476	21.243	0.219	4.652
GN03	199989.0903	541562.4784	26.496	0.468	12.400
GN04	199992.9003	541564.7009	17.774	0.342	6.079
GN05	200007.1244	541569.3364	45.680	0.191	8.725
GN06	200011.1249	541571.1144	58.167	0.421	24.488
GN07	200030.6829	541578.3535	3.369	0.265	0.893
GN08	200051.7015	541582.8626	30.268	0.398	12.047
GN09	200068.6878	541589.2437	18.755	0.185	3.470
GN10	200081.0068	541592.6304	8.684	0.439	3.812
GN11	200108.9362	541601.8168	16.934	0.306	5.182
GN12	200138.5696	541612.9293	5.076	0.492	2.497
GN13	200121.9538	541605.6268	7.629	0.229	1.747
GN14	200286.3556	541676.0907	4.605	0.518	2.385
GN15	200335.6317	541689.1294	11.870	0.275	3.264
GN16	200347.7391	541694.3788	20.975	0.454	9.523
GN17	200374.0175	541706.3803	15.174	0.138	2.094
GN18	200381.3835	541707.1423	11.768	0.482	5.672
GN19	200459.6585	541721.4514	8.087	0.211	1.706
GN20	200482.1688	541721.5357	4.161	0.549	2.285
GN21	200541.4356	541723.9698	46.352	0.295	13.674
GN22	200581.6524	541719.4139	160.976	0.436	70.185
GN23	200796.3675	541715.9477	13.108	0.251	3.290
GN24	200825.6833	541710.3385	14.093	0.513	7.230
GN25	200857.2217	541711.1851	4.329	0.168	0.727
GN26	201237.2277	541716.4557	11.806	0.384	4.534
	Aggregate Pothole Area (m^2)				**606.265**
	Aggregate Volume (m^3)				**215.262**
	Road Distance				**1765.57**
	Road Area (m^2)				**12027.91**
	Pothole Percentage %				**5.04**

4.6 INEC Road, Market Square Road, and Nepa Road, Opolo-Epie

This road connects the Sani-Abacha Express to the Mbiama/ Yenagoa Road with an 8m width and 1.365km length. A paved road with no drainage at both ends. It is an access to private schools, churches, Kpansia market, and hotels. A total of 35 potholes were seen on this road. In this same vein. Market Square Road connects the Sani-Abacha Express to Market Square at Mbiama/Yenagoa Road with a 7m width and 8m length. A paved road with no drainage at both ends. It is an access to residents, schools, shopping mall. A total of 17 potholes were seen on this road. Similarly, the Nepa Road connects the Mbiama/Yenagoa Road with a 6m width and 437m length. A paved road with no drainage system. It is an access to residents, schools, and a total of 4 potholes were found on this road.

4.7 Okaka Road, Kpansia-Epie

This road connects from the Sani-Abacha Express to the Mbiama/Yenagoa Road with an 8m width and 1.387k km length. A paved road with no drainage at both ends. It is an access to Residents, schools, churches, filling stations, and the Okaka correctional center. A total of 13 potholes were observed on this road. The road has a pothole with the largest surface area of 2.961m^2 and the smallest area of 0.491m^2. Also, the deepest pothole was 1.859m, with the least depth of 0.657m. The largest volume was 4.149m^3 m^3, as against the smallest volume of 0.472m^3.

4.8 Opolo Market Road, Custom Road, Yenezuegene-Epie, and Otiotio Road, Kpansia-Epie

This road connects the Sani-Abacha Express to the Mbiama/Yenagoa Road with an 8m width and 1.29km length. This is an interlocked road with no drainage at both ends. It is an access to the Opolo market, Public Schools, Churches, Mosque, and the Diete Koki Memorial Hospital Residents. A total of 3 potholes were observed on this road. Custom Road has a total of five (5) potholes with the largest surface area of 2.395m^2, the deepest pothole of 1.469m, and 2.181m^3 as the largest volume. In another vein, Otiotio Road connects the Sani-Abacha Express to the Mbiama/ Yenagoa Road with a 7m width and 1.469k km length. A paved road with no drainage at both ends. It has access to both public and private schools, churches, and business centers. A total of 11 potholes were observed on this road. It has an average deepest pothole of 1.961m, the largest surface area of 5.128m^2, with the highest volume of 7.431m^3.

4.9 Osiri Road and Samphino Road

This road connects the Sani-Abacha Express to the Mbiama/Yenagoa Road, with an 8m width and a length of 1.880km. A paved road with 0.5m drainage at both ends. It is an access to residents, the Event center, Emmanuel's hall, schools, churches, Army Base, Maternity Clinic, Osiri hotels. A total of 43 potholes were observed on this road. The Samphino road connects the Sani-Abacha Express to the Mbiama/ Yenagoa Road with an 8m width and 1.340km length. It is named after a hotel known as the Samphino Hotel. A paved road with 0.6m wide drainage at both ends. It has access to schools, churches, the Kpansia market, and hotels. A total of 11 potholes were identified on this road. It has an average deepest pothole of 3.840m, the largest surface area of 3.291m^2, with the highest volume of 2.229m^3.

4.10 Saptex Road, Yenizuegene

This road connects the Sani-Abacha Express to the Mbiama/Yenagoa Road with an 8m width and 1.285km length. A paved road with no drainage at both ends. It is access to schools, churches, and the Guest House. A total of 39 potholes were observed on this road, as shown in Table 4.

Table 4: Showing Spatial Location of Potholes on Saptex Road, Yenezuegene-Epie

ID	Eastings (m)	Northings (m)	Pothole Area	Average Pothole Depth	Volume
SP01	201129.853	545380.872	8.435	0.328	2.767
SP02	201141.368	545366.140	12.963	0.294	3.811
SP03	201145.683	545362.384	11.693	0.401	4.689
SP04	201154.576	545352.932	13.410	0.525	7.040
SP05	201162.111	545341.587	12.086	0.299	3.614
SP06	201236.787	545247.691	50.747	0.432	21.923
SP07	201260.071	545209.253	38.112	0.289	11.014
SP08	201270.823	545187.917	124.382	0.392	48.758
SP09	201294.530	545143.890	9.890	0.302	2.987
SP10	201296.308	545126.618	11.478	0.275	3.157
SP11	201302.065	545115.611	48.742	0.301	14.671
SP12	201306.807	545112.732	18.018	0.524	9.441
SP13	201309.552	545104.094	3.662	0.301	1.102
SP14	201311.870	545096.471	6.797	0.191	1.298
SP15	201313.775	545085.803	12.358	0.169	2.089
SP16	201318.643	545087.369	47.855	0.459	21.966
SP17	201317.923	545073.187	31.591	0.654	20.660
SP18	201332.190	545055.111	38.674	0.388	15.005
SP19	201343.408	545038.559	213.164	0.277	59.046
SP20	201339.979	545029.457	5.150	0.318	1.639
SP21	201346.541	545028.145	16.818	0.543	9.127
SP22	201348.911	545012.524	23.939	0.337	8.059
SP23	201357.378	545006.047	7.652	0.428	3.275
SP24	201369.655	544976.837	9.794	3.191	31.252
SP25	201372.830	544979.631	4.329	0.383	1.659

Table 4 (cont): Showing Spatial Location of Potholes on Saptex Road, Yenezuegene-Epie

SP26	201381.593	544958.549	11.806	0.329	3.884
SP27	201388.112	544954.739	33.974	0.502	17.039
SP28	201386.250	544951.733	7.073	0.293	2.070
SP29	201386.419	544948.473	2.136	0.120	0.256
SP30	201388.578	544950.717	8.039	0.443	3.561
SP31	201398.907	544934.037	3.158	0.201	0.635
SP32	201409.956	544915.326	343.536	0.306	105.122
SP33	201434.044	544874.277	2.334	0.170	0.397
SP34	201468.175	544819.720	10.873	0.251	2.729
SP35	201518.732	544742.507	396.393	0.437	173.224
SP36	201548.232	544698.916	2.591	0.204	0.528
SP37	201551.058	544696.218	2.823	0.189	0.534
SP38	201552.709	544692.852	1.840	0.119	0.219
SP39	201555.630	544689.169	5.022	0.304	1.527
	Aggregate Pothole Area (m^2)				**1613.337**
	Aggregate Volume (m^3)				**621.774**
	Road Distance (m)				**1274.673**
	Road Area (m^2)				**13688.44**
	Pothole Percentage %				**11.791**

The results further showed that several other feeder roads to the main road had potholes, viz. PDP road had six (6) potholes with the highest depth of 1.785m, 3.365m^2 surface area, and 5.258m3 volume. Similarly, Mr.Biggs Road, Opolo-Epie, had a total of 12 potholes with the highest depth of 1.942m, 2.977m^2 surface area, and 4.534m^3 volume. In the same vein, Green Villa Road in Yenezuegene-Epie had 8 potholes with the highest depth of 1.961m, 4.721m^2 surface area, and 6.171m^3 volume.

Figure 4: Orthophoto Map of the Section of the GoodNews and Saptex Road in Yenagoa City

Figure 5: Orthophoto Map of the Section of Ebi's Mechanic Road in Yenagoa City

The analysis identified a total of 239 potholes across the study area, exhibiting pronounced variability in geometry, surface extent, and depth. The results demonstrate a positive relationship between pothole depth and mean surface area, suggesting that pothole evolution in the study area follows a progressive enlargement mechanism driven by subsurface weakening and surface material fatigue. This relationship reflects a common geomorphological process in which initial surface defects expand laterally and vertically under repeated hydrological loading and traffic-induced stress. According to a study, there is a need for an intelligent road anomaly identification and monitoring mechanism to be put in place to minimize the consequences of the effect of potholes (Fan et al., 2020). The orthophotography interpretation (Figures 4–5) reveals that pothole distribution is not uniform across the road network but is strongly controlled by surface material type, traffic intensity, and localized drainage conditions.

The Ebis–Mechanic Road, Amarata, recorded the highest pothole density, with 51 potholes covering approximately 21.09% of the road surface (11,958.90 m^2). The significantly larger surface area and volume of potholes along this corridor indicate advanced material degradation, likely associated with persistent water infiltration, poor subgrade compaction, and repeated mechanical loading. From a geological perspective, such conditions promote the loss of fine-grained sub-base materials through erosion and pumping, accelerating surface collapse. In contrast, Goodnews Road exhibits a relatively low pothole coverage (5.04%) despite observable surface defects. This suggests comparatively improved subsurface stability or reduced exposure to moisture ingress. Saptex Road, with 39 potholes affecting 11.79% of its surface area, represents an intermediate condition, where localized failure zones dominate over systemic structural breakdown. These spatial variations underscore the influence of heterogeneous subsurface conditions and differential stress distribution across the road network. Azikoro Road, despite being the longest and widest road, does not exhibit the highest pothole density, indicating that geometric road dimensions alone do not govern pothole formation.

Instead, geological factors such as subgrade lithology, drainage efficiency, and pavement structure play dominant roles. Neppa Road, the shortest segment, similarly reflects limited spatial exposure to the processes driving pothole development. Notably, Opolo Road recorded the fewest and smallest potholes, a condition attributed to its interlocked pavement surface rather than asphalt. Interlocking pavements enhance load distribution and limit water infiltration into the subgrade, thereby reducing the susceptibility of underlying materials to erosion and mechanical failure. This observation reinforces the role of surface material engineering in mitigating geomorphologically driven pavement degradation. Overall, the findings indicate that pothole development in the study area reflects the interaction of geological behavior, particularly subsurface erosion, moisture dynamics, and material fatigue, with anthropogenic loading. These results highlight the importance of geospatial analysis to underscore perennial geological and geotechnical defects on roads and assist in optimizing road design, maintenance planning, and urban infrastructure management. Ultimately, spatially explicit pothole data serve as both a diagnostic and predictive tool for managing road deformation, enhancing infrastructure resilience, and improving socio-economic outcomes (Musa et al., 2025).

5. Conclusion And Recommendations

Potholes represent not only a spatially and temporally evolving surface deformation phenomenon but also a critical manifestation of pavement structural failure with significant socio-economic and environmental consequences. In deformational terms, potholes emerge from the progressive interaction between surface fatigue, subsurface material weakening, moisture infiltration, and repeated traffic loading, ultimately leading to localized collapse of the pavement structure. This study demonstrates that geospatial techniques provide a robust framework for capturing the spatial distribution, geometry, and volumetric characteristics of potholes, thereby enabling a quantitative understanding of road deformation processes.

The derived geometric attributes, surface area, depth, and volume, offer direct indicators of pavement distress severity and deformation stage. These metrics support evidence-based decision-making for the Yenagoa Development Agency by enabling accurate estimation of repair materials, prioritization of intervention zones, and cost-effective maintenance scheduling. Beyond financial considerations, potholes pose substantial risks to road safety, increase vehicle operating costs, exacerbate localized flooding through disrupted drainage, and negatively affect urban environmental quality and community well-being. In view of the findings of this study, the following recommendations are hereby proposed:

- Adopt Geospatial-Based Pavement Monitoring: Routine UAV and GIS-based surveys should be institutionalized to monitor pothole evolution and broader pavement deformation patterns.
- Integrate Deformation Metrics into Maintenance Planning: Volumetric and areal pothole parameters should guide repair prioritization rather than reactive visual inspections.
- Improve Drainage and Subgrade Design: Addressing moisture-driven deformation through improved drainage systems and stabilized subgrades will reduce pothole recurrence.
- Develop a Decision-Support System: A spatial pothole database should inform route planning, public safety advisories, and predictive maintenance models.
- Policy Alignment: Road maintenance strategies should align with sustainable urban infrastructure goals, emphasizing resilience and lifecycle cost reduction.

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