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Investigating the Environmental Hazards in the Rural-Urban Transition Zones in Delta State, Nigeria

[1]Ochokwu, N. U., [2]Alazigha, N & [1]Dollah, O. C
[1]Institute of Geosciences and Environmental Management, Rivers State University Nkpolu-Oroworukwo **Port** *Harcourt, Rivers State, Nigeria.*
[2]Department of Surgery, Faculty of Medical Sciences, Rivers State University Nkpolu-Oroworukwo Port Harcourt, Rivers State, Nigeria.
Corresponding Email: osademe.dollah@ust.edu.ng / ndomadu.ochokwu@ust.edu.ng

Abstract
The study investigated the spatial distribution of environmental hazards in the rural-urban transition zones of Delta State, Nigeria. A cross sectional research design was used and both primary and secondary data were used. The structured questionnaires were administered to 400 respondents, using random sampling from which 399 were retrieved. Frequencies, percentages, weighted mean, charts and one way Analysis of Variance (ANOVA) were used to analyse data at 0.05 level of significance. It was found that oil spill, petroleum pollution (WM = 4.09), environmental degradation (WM = 4.08), open garbage dumps (WM = 4.07), blocked drainage (WM = 4.05), contaminated water sources (WM = 4.02), air pollution due to burning of garbage (WM = 4.00), flooding (WM = 3.98), water logging (WM = 3.93), erosion (WM = 3.88), noise pollution (WM = 3.87) were the major environmental hazards in the study area. The results of ANOVA showed that there were significant differences in spatial hazards such as flooding ($F = 8.534$, $p < 0.001$), oil pollution ($F = 14.637$, $p < 0.001$), contaminated water sources ($F = 8.146$, $p < 0.001$) and worsening environmental conditions ($F = 6.084$, $p < 0.003$). Healthcare accessibility ($F = 5.874$, $p = 0.003$), road conditions ($F = 8.937$, $p < 0.001$), emergency medical services ($F = 9.451$, $p < 0.001$) and environmental hazards which limit accessibility to healthcare ($F = 10.628$, $p < 0.001$) also varied significantly, while there was no significant variation in healthcare affordability ($F = 2.316$, $p = 0.100$). The study concluded that environmental hazards are widespread and multifaceted within the rural-urban transition zones of Delta State; whereby communities are exposed to a combination of hydrological, ecological, pollution-related, and infrastructural hazards, including flooding, erosion, open refuse dumping, blocked drainage channels, waterlogging, air pollution, oil pollution, noise pollution, contaminated water sources, and general environmental deterioration. Among these hazards, petroleum pollution, declining environmental conditions, improper waste disposal, and drainage-related challenges emerged as the most critical concerns, reflecting the complex environmental pressures associated with rapid settlement transformation and resource exploitation. The study therefore recommended that the implementation of zone-specific environmental management strategies to address the major hazards identified, particularly flooding, oil pollution, erosion, and waste-related problems.

Keywords: Environmental, Hazards, Rural-urban, Transition zones, Management

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I. Introduction

The peri-urban interface is characterized as the transitional zone between urban and rural areas. The peri-urban zone has become a focal point for research and policy discussions globally (Rajendra, 2024). This region typically experiences rapid land use changes due to urbanization, which profoundly impacts rural livelihoods, social structures, and environmental sustainability (Ameye & De-Weerdt, 2020). As cities expand outward to accommodate growing populations, peri-urban areas face unique challenges and opportunities that differ from those in core urban or purely rural settings (Akoyeyon & Abidemi, 2025). The rapid development in the peri-urban landscape has been linked to population increase and urban expansion. The increasing demand for land for housing, location of industries and other land uses has manifested in land use and land cover changes in the transition zones between the urban and rural area. Rajendra et al., (2024) reported that this transition from rural to peri-urban and ultimately to urban space has induced plethora of environmental and economic consequences.

The peri-urban landscape is replete with indiscriminate dumping of dangerous waste that induces the concentration of heavy metals, soil and water pollution, exposure to illegal mining sites, mass wasting, flooding and gully erosion. Adewoyin (2025) posited that the waste heap in the transition zones could induce

mobilization of carcinogenic heavy metals. Weiss and McMichael (2020) reported gully erosion, flooding, air pollution, water pollution and pollution of ground water as some of the environmental hazards that characterizes the rural urban transition zones. The exposure of residents in the peri-urban space to these hazards has been reported to induce different public health ailments. Adewoyin (2025) argued that the majority of the residents in this zone are low income segment of the population. They live in low grade housing where access to clean water is difficult. Also, the limited access to healthcare services in the peri urban space has manifested in medical poverty. The implication is that residents are forced to resort to herbal remedies that could not provide the needed intervention for the ailments. Rolli (2019) reported poor access to primary health care (PHCs) in rural communities in Delta state. He reported that beyond the inadequacy of the PHCs in Ughelli north local government area, there is the problem of health care affordability. To this end, the problems bedeviling the rural urban transition zones are not entirely of accessibility, but also of affordability. Mack (2025) posited that the poor delivery of PHCs to the peri urban space has resulted to the domination of privately owned and operated health care centres where the needed expertise to delivery healthcare services is lacking. Given the low income status of the population in the rural urban transition zone, only few of the residents have been reported to have the financial wherewithal to afford healthcare services. Implication is that infant and maternal mortality is becoming higher, life expectancy is becoming a c concern, more patronage for herbal medicine that is not regulated to provide the right dosage have proliferated the peri-urban space.

The case of Delta is not different because of the multiplicity of urban areas in the state. The rate of urban expansion has manifested in the emergence of peri-urban spaces where low income population resides. However, with the pressure on land in the urban core and intermediate zones, many industries and residencies owned by the middle and high income population have been located in the peri urban space. The implication for the environment and public health have remained problematic and under researched. Bloch et al. (2015) have reported that spatial expansion is a threat to biodiversity in the urban fringe, the land available for food production and urban ecology. Many rural communities close to the cities could lose their rural and cultural characteristics if the rate of urban expansion subsists. The rapid development in the peri-urban zone has increased the rate of deforestation, land degradation, loss of agricultural land due to sprawl, heat wave and heat island.

Rural urban transition is a dynamic process where rural areas located in the fringes of urban areas transmute to become more urban in character. This transformation can be adduced to occur in physical, economic, and social factors. Rural urban transition and peri-urban development are used interchangeably in the literature, Farrell (2018).have reported that rapid social and structural changes in the peri-urban landscape is caused by population and economic pressure. Aliyu and Amadu (2017) argued that changes are recorded in the manner the rural populace is forced to adapt to emerging reality through adaptation, shift to new sources of livelihood while coping with the hazards induced by the rapidity of development and the poor delivery of health care facilities. Rapid environmental deterioration and infrastructure backlogs are usually another characteristic of the peri-urban landscape. Typically, peri-urbanization is stimulated by an infusion of new investment, generally from outside, including foreign direct investment (FDI).

Although many studies have been conducted to examine the rural and urban landscape in Delta state, conspicuous research and policy gaps still exists in the peri-urban literature. Studies conducted have reported that the rate of urbanization in Delta state could induce rapid shift from rurality to urbanity, but there is no attempt to find out if the development taking place in the rural urban transition zones is matched with delivery of healthcare services. Also evident is that the attendant hazards that characterized the peri-urban space have not been investigated. It is on the basis of the foregoing gaps that this study sought to examine the environmental hazards in the peri urban space in Delta state. Attempt would be made to examine access to healthcare services and implication for quality of life in the rural urban transition zone.

II. Material and Methods

The study was carried out in Delta State. Delta State lies approximately between Latitude $5^{0}0^{1}$N and $6^{0}30^{1}$N, & Longitude $5^{0}00^{1}$E and $6^{0}45^{1}$E. The State is bounded in the North by Edo state, to the east by Anambra State, and on the Southeast by Bayelsa State, and on the southern flank by the Atlantic Ocean (see Figure 1.1). Delta State is generally low-lying without remarkable hills, and covers a landmass of about 18,050km2 of which more than 60% is land. The state has a wide coastal belt inter-laced with rivulets and streams, which form part of the Niger-Delta (Efe, 2010).

The River Niger drains the eastern flank of the state and discharges into the sea through its several distributaries such as the Forcados, Escravos and Warri Rivers and Creeks such as the Bomadi creeks, amongst others (Eze et al., 2021). Delta State is situated in the tropics based on *AF-AM* Koppen's classification. The area experiences abundant rainfall amount annually. The annual rainfall is about 2673.8mm in the coastal areas and 1905mm in the extreme north section (Efe, 2002). The vegetation in Delta State varies from the mangrove swamp along the coast, to the evergreen forest in the middle, and the fresh water in the South-Eastern part of

Delta State. The availability of abundant mineral resources in the state makes the area an ideal home for many viable industries. The survey research design was adopted for this study. This study utilized both primary and secondary data to achieve the aim of conducting a spatial analysis of environmental hazards and access to healthcare services in the rural urban transition zones in Delta State. The data to be generated were structured to address the objectives of identifying environmental hazards, determining their causes, assessing variations across the three senatorial zones, and evaluating the availability and accessibility of healthcare services within the study area. Direct field observation was also conducted to identify and document physical indicators of environmental hazards across selected rural urban transition communities. The observation exercise focused on visible hazards such as flooding, erosion, waste accumulation, blocked drainage, stagnant water, water pollution, air pollution sources, and other forms of environmental deterioration. Observations were recorded using a structured checklist, supported with photographic evidence where necessary, to ensure consistency in the documentation of hazards across the study locations. Healthcare facility assessment was carried out to generate direct data on the availability, condition, and service capacity of healthcare facilities serving the transition zones. Information was collected on the types of facilities available, the range of services provided, staffing levels, availability of essential drugs, adequacy of equipment, facility operating hours, and general infrastructure condition. This provided an objective basis for evaluating healthcare availability and service readiness, complementing the perceptions obtained from household respondents. Secondary data was sourced from relevant government institutions and official records to support and validate the primary data. Such information was obtained from the Delta State Ministry of Health, Local Government health departments, and other related agencies for healthcare facility records, service coverage information, and health planning documents. Environmental related secondary data was also obtained from state and local government environmental agencies, including reports on flooding, erosion, waste management, and pollution issues within the study area. In addition, published academic journals, textbooks, conference papers, and official reports were consulted to provide theoretical and empirical background for the study. The population of Delta State in Table 1 according to 2006 National Population Census was 4,112,445. When projected to 2025 using the current growth rate of 2.87% provided by the National Population Census Bureau (National Population Commission, 2010), the population of Delta State is currently 5,834,453. To determine the sample size for questionnaire administration, the Taro Yamane's (1967) sample determination formula was employed.

Table 1: The rural urban transition zones in Delta State

Delta Zone	Metropolitan Transition Area	Rural Urban Transition Communities (Selected)	Estimated population	Taro Yamane Sample
Delta Central	**Ughelli Zones**	Ughelli, Evwreni, Orogun, Otujeremi, Agbarho, Oteri, Ovwian, Ekakpamre, Olomu, Eku, Orerokpe, Jeremi, Okpare, Uduere, Ofagbe	1434521	98
Delta North	**Asaba Zones**	Asaba, Okpanam, Ibusa, Oko, Ogwashi-Uku, Issele-Uku, Issele-Azagba, Issele-Mkpitime, Ubulu-Uku, Ubulu-Unor, Illah, Ebu, Akwukwu-Igbo, Onicha-Ugbo, Anwai	1976211	135
Delta South	**Warri Zones**	Warri, Effurun, Uvwie, Enerhen, Ekpan, Jeddo, Osubi, Okpe, Sapele, Amukpe, Orhuwhorun, Ugborikoko, Ubeji, Ogunu, Aladja	2423721	166

Source: Delta State Ministry of Housing

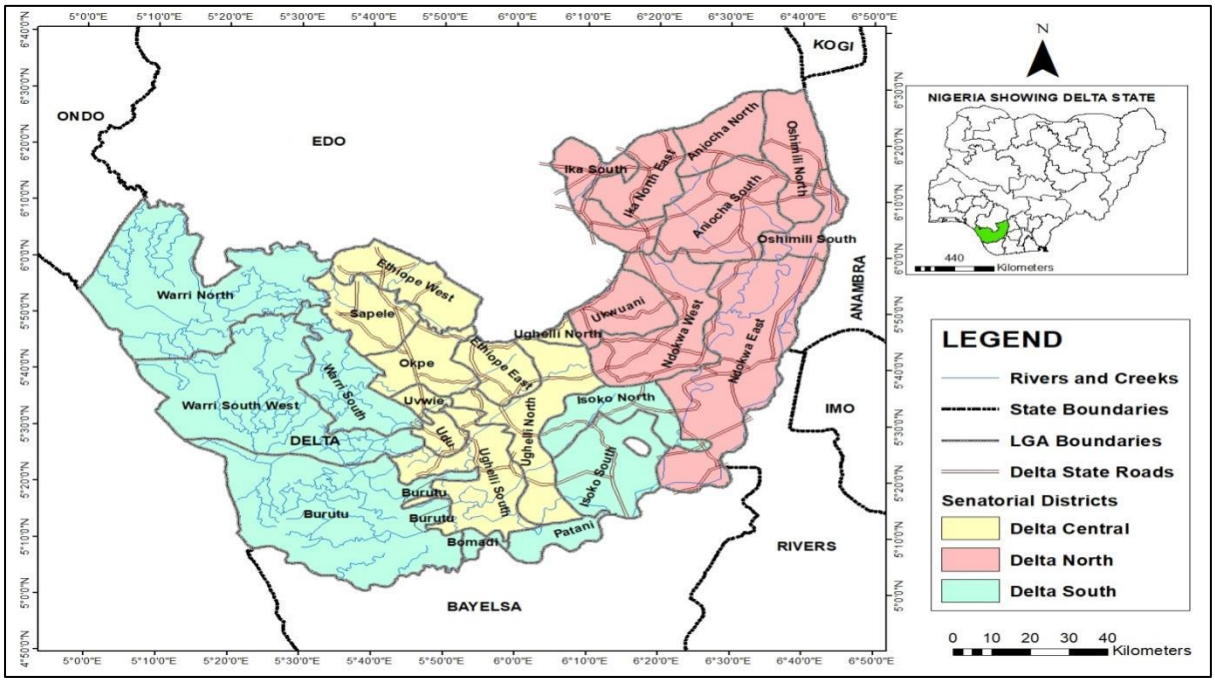

Figure 1: Delta State showing Senatorial Zones

The systematic sampling technique was used for this study and the combination of questionnaire administration and systematic field observation provided comprehensive primary data required to evaluate environmental hazards and healthcare accessibility in the rural urban transition zones of Delta State. The population of Delta state according to 2006 National Population Census was 4,112,445. When projected to 2025 using the current growth rate of 2.87% provided by the National Population Census Bureau (National Population Commission, 2010), the population of Delta State is currently 5,834,453. To determine the sample size for questionnaire administration, the Taro Yamane's (1967) sample determination formula was employed. The formula is stated as follows:

$$\boldsymbol{S} = \frac{\mathrm{N}}{1 + \mathrm{N(e)}^2}$$

Where:
S = Sample size
e = Margin of error assumed (0.05)
1= Theoretical constant
N = No of population

$$\mathrm{S} = \frac{5{,}834{,}453}{1 + 5{,}834{,}453(0.05)^2}$$

$$\mathrm{S} = \frac{5{,}834{,}453}{1+5{,}834{,}453(0.0025)}$$

$$\mathrm{s} = \frac{5{,}834{,}453}{301.315}$$

S= 400
The sample size for the study is 400.
A total of 400 questionnaires would be administered in the three senatorial zones. Descriptive statistics were used to analyse the data and presented in tables.

III. Results and Discussions

Demographic characteristics of the Respondents

The demographic characteristics of the respondents presented in Table 2 provide an overview of the socioeconomic composition of the study participants. A total of 399 respondents participated in the study, providing a broad representation of residents across the selected communities in Delta State. With respect to sex, the findings revealed that 231 respondents, representing 57.9%, were male, while 168 respondents, accounting for 42.1%, were female. This indicates that male respondents constituted the majority of the study population, although females also formed a substantial proportion of the respondents. The age distribution showed that respondents aged 36 to 50 years constituted the largest age group, with 149 respondents or 37.3%

of the sample. This was followed by those aged 21 to 35 years, who accounted for 131 respondents or 32.8%. Respondents within the age bracket of 51 to 65 years comprised 71 respondents or 17.8%, while those younger than 20 years represented 28 respondents or 7.0%. The least represented age category was 66 years and above, with 20 respondents or 5.0%. Overall, the data indicate that the majority of respondents were adults within the economically active age groups. Regarding occupation, trading and business emerged as the most common occupation among the respondents, accounting for 118 respondents or 29.6%. Civil servants constituted the second largest occupational group with 84 respondents or 21.1%, followed by artisans with 69 respondents or 17.3%. Students represented 52 respondents or 13.0%, while farming and other occupations each accounted for 38 respondents or 9.5% of the study population. The educational qualifications of the respondents revealed that those with a Bachelor's degree constituted the largest educational category, representing 98 respondents or 24.6%. Respondents with Senior Secondary School Certificate qualifications closely followed, with 97 respondents or 24.3%. Those possessing OND or Diploma qualifications accounted for 72 respondents or 18.0%, while HND holders represented 63 respondents or 15.8%. Respondents with postgraduate qualifications comprised 35 respondents or 8.8%, whereas those with only primary school education constituted the smallest group with 34 respondents or 8.5%. The findings generally indicate that a considerable proportion of the respondents possessed at least secondary or tertiary education. The distribution of respondents according to years of residence showed that 136 respondents, representing 34.1%, had resided in their communities for more than 20 years, making this the largest category. Respondents who had lived in their communities for 11 to 15 years accounted for 81 respondents or 20.3%, while those with 16 to 20 years of residence comprised 72 respondents or 18.0%. A total of 69 respondents or 17.3% had resided in their communities for 6 to 10 years, whereas respondents with less than five years of residence accounted for 41 respondents or 10.3%. These findings suggest that a substantial proportion of the respondents had lived in their respective communities for relatively long periods and were therefore likely to possess adequate knowledge of the environmental and healthcare conditions within their localities.

Table 2: Demography data of the respondents

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	231	57.9
	Female	168	42.1
	Total	**399**	**100**
Age (Years)	Less than 20	28	7
	21–35	131	32.8
	36–50	149	37.3
	51–65	71	17.8
	66 years and above	20	5
	Total	**399**	**100**
Occupation	Civil Servant	84	21.1
	Trading/Business	118	29.6
	Artisan	69	17.3
	Student	52	13
	Farming	38	9.5
	Others	38	9.5
	Total	**399**	**100**
Educational Qualification	Primary School	34	8.5
	SSCE	97	24.3
	OND/Diploma	72	18
	HND	63	15.8
	B.Sc.	98	24.6

	Postgraduate Degree	35	8.8
	Total	**399**	**100**
Years of Residence	Less than 5 years	41	10.3
	6–10 years	69	17.3
	11–15 years	81	20.3
	16–20 years	72	18
	Above 20 years	136	34.1
	Total	**399**	**100**

Environmental Hazards in the Rural-Urban Transition Zones

Table 3 presents the respondents' perception of environmental hazards affecting communities within the rural-urban transition zones of the study area. The findings revealed that all the identified environmental hazard indicators recorded weighted mean scores above the decision benchmark, indicating general agreement among respondents that these environmental challenges are prevalent within their communities.

Flooding was identified as a major environmental hazard, with 176 respondents (44.1%) strongly agreeing and 128 respondents (32.1%) agreeing that flooding is frequent in their communities. Only 37 respondents (9.3%) disagreed, while 24 respondents (6.0%) strongly disagreed and 34 respondents (8.5%) were undecided. The weighted mean score of 3.98 indicates that respondents generally agreed that flooding is a recurring environmental challenge in the study area.

Similarly, erosion was perceived as a significant environmental problem, with 159 respondents (39.8%) strongly agreeing and 134 respondents (33.6%) agreeing that erosion has caused noticeable damage to roads, houses, and farmlands. The weighted mean score of 3.88 further confirms that respondents acknowledged erosion as an important environmental concern affecting community infrastructure and livelihoods.

The prevalence of open refuse dumps received one of the highest levels of agreement among the identified hazards. A total of 183 respondents (45.9%) strongly agreed, while 139 respondents (34.8%) agreed that open refuse dumps are common in their communities. With a weighted mean score of 4.07, the result indicates that indiscriminate waste disposal remains a prominent environmental challenge within the rural-urban transition zones.

The issue of blocked drainage channels was also highly recognized by respondents. About 187 respondents (46.9%) strongly agreed and 133 respondents (33.3%) agreed that blocked drainage channels contribute to environmental problems in the area. The weighted mean score of 4.05 suggests that inadequate drainage management is considered an important factor contributing to environmental degradation and related hazards.

Regarding waterlogging during the rainy season, 165 respondents (41.4%) strongly agreed and 136 respondents (34.1%) agreed that waterlogging is common within their communities. The weighted mean score of 3.93 indicates that seasonal water accumulation remains a noticeable environmental challenge, particularly during periods of intense rainfall.

The perception of air pollution resulting from refuse burning showed that 172 respondents (43.1%) strongly agreed and 138 respondents (34.6%) agreed that open burning of waste constitutes a serious environmental problem. The weighted mean score of 4.00 demonstrates that respondents recognized refuse burning as an important source of environmental pollution within the study area.

Oil spills and petroleum pollution recorded the highest weighted mean score among the environmental hazards assessed, with a value of 4.09. The results showed that 191 respondents (47.9%) strongly agreed and 132 respondents (33.1%) agreed that oil spills or petroleum pollution have affected the environment in their communities. This highlights the perceived influence of petroleum-related activities on environmental quality within the study area.

Noise pollution from traffic and commercial activities was also identified as an increasing environmental concern. A total of 151 respondents (37.8%) strongly agreed and 145 respondents (36.3%) agreed with the statement, while the weighted mean score of 3.87 indicates general agreement that noise pollution is becoming more noticeable in the area.

Furthermore, contaminated water sources were perceived as a major environmental concern by the respondents. About 180 respondents (45.1%) strongly agreed and 133 respondents (33.3%) agreed that

contaminated water sources constitute an environmental challenge. The weighted mean score of 4.02 confirms that water quality concerns are significant within the communities studied.

Finally, respondents' perception of the overall environmental condition of their communities revealed that 186 respondents (46.6%) strongly agreed and 136 respondents (34.1%) agreed that environmental conditions have worsened in recent years. The weighted mean score of 4.08 indicates that most respondents perceived a decline in environmental quality over time.

Overall, the findings show that environmental hazards are widespread within the rural-urban transition zones, with all assessed indicators receiving an agreement decision. The highest perceived challenges were oil spills or petroleum pollution (WM = 4.09), worsening environmental conditions (WM = 4.08), open refuse dumps (WM = 4.07), and blocked drainage channels (WM = 4.05), while noise pollution (WM = 3.87) and erosion (WM = 3.88) recorded the lowest but still significant perceptions. The results demonstrate that communities within the study area are experiencing multiple and interconnected environmental challenges, including flooding, waste management problems, pollution, and inadequate environmental infrastructure.

Table 3: Respondents perception of the environmental hazards in the rural-urban transition zones in the study area

Items	SA n (%)	A n (%)	D n (%)	SD n (%)	U n (%)	Total n (%)	WM	Decision
Flooding is a frequent environmental hazard in my community.	176 (44.1)	128 (32.1)	37 (9.3)	24 (6.0)	34 (8.5)	399 (100)	3.98	Agreed
Erosion has caused noticeable damage to roads, houses, or farmlands in this area.	159 (39.8)	134 (33.6)	42 (10.5)	28 (7.0)	36 (9.0)	399 (100)	3.88	Agreed
Open refuse dumps are common in my community.	183 (45.9)	139 (34.8)	28 (7.0)	19 (4.8)	30 (7.5)	399 (100)	4.07	Agreed
Blocked drainage channels contribute to environmental problems in this area.	187 (46.9)	133 (33.3)	27 (6.8)	21 (5.3)	31 (7.8)	399 (100)	4.05	Agreed
Waterlogging is common during the rainy season in this community.	165 (41.4)	136 (34.1)	39 (9.8)	25 (6.3)	34 (8.5)	399 (100)	3.93	Agreed
Air pollution from burning refuse is a serious problem in my area.	172 (43.1)	138 (34.6)	33 (8.3)	24 (6.0)	32 (8.0)	399 (100)	4.0	Agreed
Oil spills or petroleum pollution have affected the environment in this community.	191 (47.9)	132 (33.1)	25 (6.3)	19 (4.8)	32 (8.0)	399 (100)	4.09	Agreed
Noise pollution from traffic and commercial activities is increasing in this area.	151 (37.8)	145 (36.3)	43 (10.8)	24 (6.0)	36 (9.0)	399 (100)	3.87	Agreed
Contaminated water sources are a major environmental concern in this community.	180 (45.1)	133 (33.3)	31 (7.8)	21 (5.3)	34 (8.5)	399 (100)	4.02	Agreed
The general environmental condition of this community has worsened in recent years.	186 (46.6)	136 (34.1)	25 (6.3)	20 (5.0)	32 (8.0)	399 (100)	4.08	Agreed

Table 4 presents the ANOVA results examining whether significant variations exist in the perception of environmental hazards among the three senatorial zones (Delta Central, Delta North, and Delta South) in the study area. The hypothesis tested states that there is no statistically significant variation in environmental hazards across the three senatorial zones. The analysis was conducted at a 0.05 significance level using one-way ANOVA, followed by Duncan Multiple Range Test (DMRT) to determine the direction of significant differences among the zones.

The results revealed that significant variations existed for most of the environmental hazard indicators across the three senatorial zones. Flooding showed a statistically significant variation among the zones ($F = 8.534$, $p < 0.001$). The Duncan Multiple Range Test indicated that Delta South recorded significantly higher perceptions of flooding challenges compared with Delta Central and Delta North. This suggests that communities in Delta South experience greater exposure to flooding, which may be associated with its low-lying coastal environment and vulnerability to rainfall-related hazards.

Similarly, erosion showed significant spatial variation across the zones ($F = 6.721$, $p = 0.001$). The DMRT revealed that Delta South recorded significantly higher perceptions of erosion impacts than Delta Central and Delta North, while Delta Central and Delta North showed similar responses. This indicates that

erosion-related challenges are more pronounced in Delta South, potentially due to environmental conditions that increase susceptibility to land degradation.

The perception of open refuse dumps, however, showed no statistically significant variation among the three zones ($F = 2.114$, $p = 0.122$). This implies that the prevalence of open refuse disposal is relatively similar across Delta Central, Delta North, and Delta South. The absence of significant variation suggests that poor waste management practices represent a widespread environmental challenge affecting communities throughout the study area rather than being restricted to a particular zone. Blocked drainage channels recorded significant differences among the zones ($F = 7.483$, $p = 0.001$). The Duncan grouping showed that Delta South had significantly higher perceptions of blocked drainage problems compared with Delta Central and Delta North. This finding suggests that inadequate drainage systems and poor maintenance may contribute considerably to environmental problems, particularly in areas where flooding and water accumulation are common. Waterlogging also varied significantly across the senatorial zones ($F = 5.296$, $p = 0.005$). The DMRT revealed that Delta South recorded higher perceptions of waterlogging compared with Delta Central and Delta North, while the latter two zones showed similar responses. This pattern indicates that seasonal water accumulation remains a more prominent environmental concern in Delta South.

Air pollution resulting from refuse burning demonstrated significant variation among the zones ($F = 9.218$, $p < 0.001$). Unlike most other hazards, Delta Central recorded the highest perception of refuse burning-related air pollution, followed by Delta South and Delta North. This may reflect differences in settlement density, waste disposal practices, and human activities that influence air quality within the respective zones. Oil spills and petroleum pollution recorded the highest level of spatial variation among all assessed environmental hazards ($F = 14.637$, $p < 0.001$). The Duncan test revealed that Delta South had significantly higher perceptions of petroleum pollution impacts than Delta Central and Delta North. This finding reflects the strong influence of oil exploration and related activities in the southern part of the state, where communities are more directly exposed to petroleum-related environmental challenges. Noise pollution also showed significant variation across the zones ($F = 3.928$, $p = 0.020$). The DMRT indicated that Delta Central recorded significantly higher perceptions of increasing noise pollution compared with Delta North and Delta South, which showed similar responses. This variation may be linked to differences in commercial activities, urbanization levels, and transportation intensity across the zones. Contaminated water sources showed significant differences among the three zones ($F = 8.146$, $p < 0.001$). The Duncan test indicated that Delta South recorded significantly higher concerns regarding water contamination compared with Delta Central and Delta North. This suggests that communities within Delta South may face greater challenges associated with water quality, possibly due to increased vulnerability to pollution sources and environmental degradation. The perception that the general environmental condition of communities has worsened in recent years also varied significantly among the zones ($F = 6.084$, $p = 0.003$). The DMRT revealed that Delta South recorded the highest perception of declining environmental conditions, followed by Delta Central and Delta North. This indicates that residents in Delta South perceive more severe environmental deterioration compared with other parts of the state.

Overall, the ANOVA results demonstrate that significant spatial variations exist in the distribution and perception of environmental hazards across the three senatorial zones. Since most of the environmental hazard indicators recorded significant p-values below 0.05, the null hypothesis stating that there is no statistically significant variation in environmental hazards across the three zones is rejected. The findings indicate that Delta South generally experiences higher levels of environmental challenges, particularly flooding, erosion, waterlogging, oil pollution, and contaminated water sources, while Delta Central shows greater concerns relating to air pollution from refuse burning and noise pollution. However, open refuse dumping remains a common environmental challenge across all three zones, with no significant spatial difference observed.

Table 4: ANOVA summary testing the hypothesis 'there is no statistically significant variation in the environmental hazards in the three senatorial zones in the study area'

Items	N	df	F	p-Value	Duncan MRT
Flooding is a frequent environmental hazard in my community.	399	2,396	8.534	<0.001	Delta South > Delta Central > Delta North
Erosion has caused noticeable damage to roads, houses, or farmlands in this area.	399	2,396	6.721	0.001	Delta South > Delta Central = Delta North
Open refuse dumps are common in my community.	399	2,396	2.114	0.122	NS
Blocked drainage channels contribute to environmental problems in this area.	399	2,396	7.483	0.001	Delta South > Delta Central > Delta North
Waterlogging is common during the rainy season in this community.	399	2,396	5.296	0.005	Delta South > Delta Central = Delta North

Air pollution from burning refuse is a serious problem in my area.	399	2,396	9.218	<0.001	Delta Central > Delta South > Delta North
Oil spills or petroleum pollution have affected the environment in this community.	399	2,396	14.637	<0.001	Delta South > Delta Central > Delta North
Noise pollution from traffic and commercial activities is increasing in this area.	399	2,396	3.928	0.02	Delta Central > Delta North = Delta South
Contaminated water sources are a major environmental concern in this community.	399	2,396	8.146	<0.001	Delta South > Delta Central > Delta North
The general environmental condition of this community has worsened in recent years.	399	2,396	6.084	0.003	Delta South > Delta Central > Delta North

IV. Discussions

The findings of this study revealed that environmental hazards are widespread within the rural-urban transition zones of Delta State, as all assessed hazard indicators recorded weighted mean scores above the decision benchmark. The results indicate that flooding (WM = 3.98), erosion (WM = 3.88), open refuse dumping (WM = 4.07), blocked drainage channels (WM = 4.05), waterlogging (WM = 3.93), air pollution from refuse burning (WM = 4.00), oil spills and petroleum pollution (WM = 4.09), noise pollution (WM = 3.87), contaminated water sources (WM = 4.02), and general environmental deterioration (WM = 4.08) are significant environmental concerns within the study area. This finding agrees with the observations of Douglas et al. (2019), who noted that rural-urban transition areas in developing countries are increasingly exposed to environmental hazards due to rapid land-use transformation, inadequate infrastructure, and weak environmental governance. The authors emphasized that these transitional landscapes often become hotspots of environmental vulnerability because development occurs faster than planning and infrastructure provision.

The high perception of flooding as a major environmental hazard in the study area is consistent with previous studies conducted in the Niger Delta region. For instance, Aderogba (2012) reported that flooding remains one of the most persistent environmental challenges in Nigerian urban and peri-urban communities due to poor drainage systems, increased impervious surfaces, and uncontrolled settlement development. Similarly, Adelekan (2016) observed that coastal Nigerian communities are highly vulnerable to flooding because of their low elevation, proximity to water bodies, and increasing exposure to extreme rainfall events. The current study extends these observations by demonstrating that flooding remains a dominant concern specifically within the rural-urban transition zones of Delta State, where increasing settlement expansion interacts with natural environmental limitations. The significant perception of erosion impacts (WM = 3.88) agrees with findings by Nwankwoala (2018), who identified land degradation and erosion as major environmental challenges affecting communities in the Niger Delta. The author attributed these problems to vegetation removal, construction activities, sand extraction, and poor land management practices. The present finding that erosion affects roads, houses, and farmlands suggests that environmental degradation within the study area has both ecological and socioeconomic consequences. This supports the argument by Egbueri et al. (2020) that land degradation in developing regions threatens infrastructure stability and livelihood sustainability.

The prominence of open refuse dumps (WM = 4.07) and blocked drainage channels (WM = 4.05) observed in this study agrees with the findings of Nzeadibe et al. (2018), who reported that inadequate waste management remains a major urban environmental challenge in Nigeria. According to the authors, rapid population growth, insufficient waste collection systems, and weak institutional capacity encourage indiscriminate dumping practices. The current study further demonstrates that waste management challenges are not limited to urban centres but extend into rural-urban transition zones where settlements are expanding without corresponding improvements in environmental services. The absence of significant spatial variation in open refuse dumping across Delta Central, Delta North, and Delta South also supports this argument, indicating that poor waste management is a widespread challenge throughout the state.

The finding that oil spills and petroleum pollution recorded the highest weighted mean score (WM = 4.09) is consistent with extensive literature on environmental degradation in the Niger Delta. Nwilo and Badejo (2018) reported that petroleum exploration activities have significantly altered terrestrial and aquatic ecosystems in the Niger Delta through oil contamination, habitat destruction, and reduced environmental quality. Similarly, Kadafa (2012) noted that oil pollution has negatively affected soil productivity, water resources, and community livelihoods in oil-producing areas. The current study agrees with these studies by confirming that residents perceive petroleum-related pollution as one of the most serious environmental challenges affecting their communities.

The perception of contaminated water sources as a major environmental concern (WM = 4.02) also agrees with previous studies highlighting the vulnerability of water resources in oil-producing regions. According to Obeta and Nwankwo (2015), contamination from industrial activities, poor sanitation systems, and

improper waste disposal has contributed to declining water quality in many Nigerian communities. The current finding supports this argument by showing that environmental degradation has implications not only for ecological systems but also for public health and domestic water security.

The ANOVA results further revealed significant spatial differences in environmental hazards across the three senatorial zones. Delta South consistently recorded higher perceptions of flooding, erosion, waterlogging, oil pollution, and contaminated water sources. This finding agrees with the work of Ibaba (2017), who identified coastal Niger Delta communities as particularly vulnerable due to their exposure to sea-level influences, tidal flooding, petroleum activities, and fragile ecosystems. The higher environmental vulnerability of Delta South may therefore be explained by its coastal location and greater concentration of petroleum-related activities.

The significant variation in oil pollution perception among the zones ($F = 14.637$, $p < 0.001$) particularly supports previous studies that have identified spatial differences in environmental impacts associated with oil exploration. Owoyemi et al. (2021) argued that communities located closer to oil-producing areas often experience greater environmental risks due to frequent exposure to oil spills, gas flaring, and industrial pollution. Therefore, the higher perception recorded in Delta South reflects the environmental realities associated with petroleum activities within the zone.

However, the finding that Delta Central recorded higher perceptions of air pollution from refuse burning and noise pollution differs slightly from the pattern observed for other hazards. This may be associated with higher levels of commercial activities, transportation intensity, and population concentration in some Delta Central communities. This interpretation agrees with Owoade et al. (2020), who reported that urban growth and increased economic activities contribute significantly to air and noise pollution in Nigerian cities and rapidly developing settlements.

The overall perception that environmental conditions have worsened in recent years (WM = 4.08) agrees with the broader environmental change literature. The United Nations Human Settlements Programme (UN-Habitat, 2022) reported that rapid urban expansion without adequate planning has intensified environmental pressures in developing regions, resulting in increased waste generation, flooding risks, and infrastructure deficiencies. The present study confirms this pattern within Delta State by demonstrating that residents perceive continuous environmental decline across the rural-urban transition zones.

The rejection of the null hypothesis due to significant spatial variation in most environmental hazard indicators highlights the importance of location-specific environmental management strategies. Similar conclusions were reached by Douglas et al. (2019), who argued that environmental hazards are spatially uneven because vulnerability is influenced by physical geography, socioeconomic conditions, infrastructure availability, and governance structures. Therefore, environmental interventions within Delta State should consider the distinct vulnerabilities of each senatorial zone rather than adopting a uniform management approach.

V. Conclusion and Recommendations

The study concluded that environmental hazards are widespread and multifaceted within the rural-urban transition zones of Delta State; whereby communities are exposed to a combination of hydrological, ecological, pollution-related, and infrastructural hazards, including flooding, erosion, open refuse dumping, blocked drainage channels, waterlogging, air pollution, oil pollution, noise pollution, contaminated water sources, and general environmental deterioration. Among these hazards, petroleum pollution, declining environmental conditions, improper waste disposal, and drainage-related challenges emerged as the most critical concerns, reflecting the complex environmental pressures associated with rapid settlement transformation and resource exploitation. The study further concluded that environmental hazards are not uniformly distributed across the three senatorial zones; thus, Delta South exhibited greater vulnerability to flooding, erosion, waterlogging, petroleum pollution, and contaminated water sources due to its coastal setting, exposure to oil exploration activities, and fragile environmental characteristics. The study therefore recommended that the implementation of zone-specific environmental management strategies to address the major hazards identified, particularly flooding, oil pollution, erosion, and waste-related problems. The Delta State Ministry of Environment should strengthen environmental monitoring and enforcement, while the state government should invest in flood control, pollution remediation, and ecological restoration. Local governments and community leaders should promote proper waste disposal and environmental awareness among residents.

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