

ASSESSMENT OF DRAINAGE INFRASTRUCTURE DEFICIENCIES AND THE ASSOCIATED PERCEIVED PUBLIC HEALTH IMPACT IN OTA, SOUTHWEST NIGERIA

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ABSTRACT

Drainage infrastructure constitutes an essential component of the built environment and plays a vital role in the disposal of wastewater and storm runoff. This study examined drainage infrastructure deficiencies and their perceived public health impact on the sustainable environment with the aim of contributing to the achievement of 2030 Sustainable Development Goals (SDGs) in Ota community, Southwest Nigeria. The study adopted a cross-sectional quantitative survey method, while stratified and systematic sampling techniques were employed to select residential sectors, buildings and respondents for questionnaire administration. A total of 280 questionnaires were administered. The findings revealed that 53.1% of respondents reported inadequacy and absence of drainage infrastructure with associated problems in the form of standing water, slow flow, blockages, stormwater overflow, erosion, and flooding. Findings also identified the perceived health hazards caused by drainage deficiencies. The health challenges analysed ranged from low to high prevalence. Similarly, Pearson chi-square values of 85.3, 49.47 and 79.80 exceeded the critical value (24.996), indicating a statistically significant relationship in each of the residential zones. The p-value in the three residential zones (which is less than 0.05) further confirms the statistical relationship between the prevalence of public health impacts and drainage deficiencies. This study contributes to the expanding body of knowledge on the relationship between urban drainage infrastructure and public health, as well as the critical need for improved drainage planning, funding, and proper maintenance to reduce the public health risk associated with inadequate drainage infrastructure. These strategies are expected to enhance public health outcomes and also promote Sustainable Cities and Communities in line with the SDG (Goal-11), specifically Target 11.5, which seeks to improve resilient infrastructure and help mitigate the negative impact of disasters, including urban flooding.

Keywords: Water, Public Health, SDGs, Environment, Urban Planning and Infrastructure.

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INTRODUCTION

Infrastructural facilities are fundamental components needed in human society. They are essential to enhancing the existence of life and sustenance.¹ The development and growth of an area would remain difficult to attain if the infrastructural facilities needed are not in place.² It can be likened to a very rare commodity that requires substantial investment to procure and maintain. These infrastructures are classified into physical, social and economic infrastructure that support society for continuous operation and survival of a nation.³ Economic infrastructures include public essential requirements such as electricity generation, communication systems, and potable water. Environmental infrastructure includes sewage and waste management facilities⁴, others include road networks, drainage facilities, and canal projects for irrigation of farmlands. Transportation infrastructures such as urban mass transit, suburban railways, traffic equipment, seaports, waterways and airports. The usefulness of infrastructure is evidenced in providing further social amenities needed in the activity package and the growth of communities.⁴ Drainage facilities are also noted as a type of public essential infrastructure needed for

urban stormwater runoff and removal of other wastewater within the environment.^{5,6} Major cities will be susceptible to floods and general environmental degradation if drainage facilities are not in place.⁷ Absence of drainage infrastructure in a community will contribute to environmental debasement that could result in health issues and more disruption to human activities.⁸ A well-designed drainage system is essential for the removal of excess water from both major roads and inner streets. It is useful in preventing water-related damage to road facilities and buildings.⁹ Most road channels in the South-west region of Nigeria are faced with inefficient drainage systems. This is essentially connected with poor maintenance, indiscriminate dumping of refuse and littering in drains.^{10,11} Stagnant water frequently accumulates in the streets, leading to pothole formation and waterlogging, particularly during rainy seasons, causing overflowing water that spreads over the ground, resulting in localised flooding.^{12,7} This issue poses a significant risk to motorists and pedestrians, such as weakening road foundations and causing the road surface to crack. Likewise, such an environment does not align with the 2030 Sustainable Development Goals (SDGs). Achieving an environmentally sustainable agenda of SDGs for 2030 will necessitate an environment where everyone can enjoy a healthy, productive, and pleasant life.¹³ This will also require having the basic infrastructural facilities, such as drainage facilities, needed for a healthy environment and public safety. The word sustainability has become a central concept in modern international development theory and practice, emerging as a focal point of development discourse since the United Nations (UN) adopted the Sustainable Development Goals (SDGs) 2030 target.⁹ However, the eleventh target of the Sustainable Development Goal (SDG) for 2030 is to make cities and human settlements safe, resilient, inclusive, and sustainable.¹³ The reality is that the majority of the fundamental infrastructure required to sustain cities is either insufficient, unavailable, or poorly maintained. Therefore, achieving Sustainable Development Goal (SDG)-11 in most communities will remain abstract unless appropriate actions are taken. Several studies have examined urban drainage systems focusing on hydrology, engineering and policy perspectives. However, there remains a lack of empirical evidence on community-level perceptions concerning drainage deficiencies as well as the associated environmental and public health impacts. This study addresses this knowledge gap and provides empirical insights relevant to sustainable urban development and the achievement of Sustainable Development Goal (SDGs) target 11. This study examined drainage infrastructure deficiencies and the associated perceived public health implications in Ota community, Southwestern Nigeria. The objectives evaluated the condition and functionality of the existing drainage infrastructure based on field observations and residents' perceptions.

EXPERIMENTAL

Ota is a rapidly growing city in the Southwestern Nigeria, situated between longitudes 3°41'E and 3°68'E and latitudes 6°41'N and 6°68'N, covering a total land area of approximately 878 km²¹¹, Ota community experiences considerable annual rainfall ranging from 1,200–1,800 mm, which is predominantly convective and varies considerably in frequency and intensity. As a result, heavy rainfall during the peak seasons can occasionally cause floods, resulting in waterlogging, especially in areas without adequate drainage facilities.¹¹ Therefore, for excess stormwater to be removed from both major roads and residential streets, a well-designed drainage system is essential for conveying excess stormwater in the environment. It will help shield buildings and road infrastructure from water-related damage.^{10,14} Ota community is one of the largest industrial hubs in Ogun State, which generates the largest share of Internally Generated Revenue (IGR) for the State, and is expected to have adequate infrastructure, including drainage facilities with accessible road networks. However, the opposite is the case, coupled with the rapid and unplanned urban expansion without drainage facilities in most of the access roads. Figure-1 displayed the study area location.

The study population of 300 respondents was determined using a sample size calculation displayed in Eqn.-1. The respondents consist of Ota, the Southwestern region of Nigeria, who are directly affected by inadequate drainage challenges. A cross-sectional quantitative survey method was adopted, while a stratified random sampling technique was used to enhance the study's internal validity, ensuring adequate coverage of the study area. The sampling frame was created through a pilot study that used a population planning pattern such as the core residential zone, the transition zone and the planning scheme zone to stratify the study area into sectoral groups, which covered the entire study area.¹⁴ A random selection of

neighbourhoods was made from each residential zone. The study aimed to reach 100 households per residential zone due to high population density. This resulted in 300 questionnaires distributed among the chosen neighbourhoods.

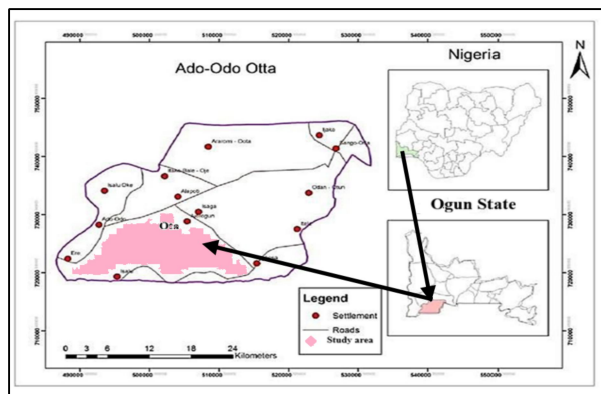


Fig.-1: Study Area Location

A structured questionnaire was used to collect data through a face-to-face survey method that was carried out using systematic sampling that involved the selection of every fifth household in each residential zone. Simple, non-technical language was used in the questionnaire's design to ensure that respondents understood the purpose of each item. Similarly, questionnaires were administered through qualified field assistants who verbally explained each question to ensure appropriate interpretation without influencing responses from respondents. This method enhanced the quality and reliability of data collected. The Face-to-face survey method aligns with contemporary, cost-effective, timely data collection techniques, enabling automatic data validation and lowering the possibility of human error.^{15,16} Health indicators linked to damp and contaminated environments, as well as stress-related issues concerning flooding events, such as psychological stress, anxiety, and fear, were investigated. Descriptive statistics, including frequency distribution, bar charts, frequency tables, and percentages, were used in the data analyses. Pearson's chi-square was used to examine the association between the drainage problem and perceived associated health hazards.

$$N = \frac{X^2 np(1-p)}{d^2(n-1) + X^2 p(1-p)} \quad (1)$$

Where:

n = sample size required

X^2 = the degree of freedom at the desired confidence level (3.841)

N = population size

P = population proportion (assumed to be .05).

d^2 the degree of accuracy expressed as a proportion (.05).

RESULTS AND DISCUSSION

Table-1 displays the geographical distribution and response rate of the questionnaires distributed across the residential zones. Out of 300 questionnaires distributed, 280 copies representing 93.3% were completed and recovered; therefore, validating the response rate for survey-based research that is statistically acceptable.¹⁷ The core and transition residential zones had the most completed responses, while the planning scheme zone recorded a lower response. This poor performance may be attributed to the available drainage infrastructure, higher educational attainment, and a comparatively higher number of employed individuals in the planning scheme zone.

Socioeconomic Characteristics of Respondents

The breakdown of the 280 survey participants presented in Table-2 reveals respondents' socioeconomic and demographic characteristics, providing crucial background information for understanding how

drainage infrastructure deficiencies are perceived and their implications for public health. Male respondents constitute the majority of the sample (51.2%), while female respondents account for only 48.6%. The gender disparity supports the assertion that men play a greater role in housing and infrastructure decisions, possibly as a result of social systems that assign men to handle property infrastructure-related duties.¹⁸ Most respondents fall within the 31–40 age range (41.0%), followed by those aged 18–30 years (37.85%), suggesting.

Table-1: Questionnaire Distribution and Responses

Residential zone	No of questionnaires distributed	No retrieved	Response rate
Core residential zone	100	100	100%
Transition residential zone	100	100	100%
Planning scheme zone	100	80	80%
Total	300	280	93.3%

The majority of participants appear to be actively involved in everyday activities that increase exposure to environmental conditions such as flooding, stagnant water, and inadequate sanitation, based on the predominance of respondents in the economically active age groups (18–40 years). This age structure, however, improves the validity of perception-based assessments because these people are more likely to experience the effects of drainage failure on mobility, livelihood, and health. In terms of educational attainment, the respondents recorded very low educational status, with 36.02% holding secondary education, followed by primary education, 28.92% and no formal education, 18.21%. Low levels of education are linked to heightened susceptibility to environmental risks, less access to health information, and a lack of environmental awareness.¹⁹ Consequently, perceptions obtained from this group represent the lived experiences of communities most affected by drainage deficits. Occupational distribution of respondents reveals factory workers with 32.5% and petty traders (27.3%) dominated other occupations, reflecting the industrial nature of the study area. Similarly, civil servants accounted for a very low number, 13.57%, due to a low level of educational background, indicating the predominance of low-income households / economic disadvantage individuals. Artisans and the unemployed accounted for 10.71% and 11.4% respectively.

Table-2: Socioeconomic Characteristics of Respondents

Marital status	Frequency	%	Age	Frequency	%
Single	135	48.21	18-30	106	37.85
Married	124	44.28	31-40	115	41.07
Divorced	17	6.07	41- 50	53	18.92
Widowed	2	0.71	51- 60	4	1.42
Separated	2	0.71	Above 60	2	0.71
Total	280	100	Total	280	100

Educational qua	Frequency	%	Occupation	Frequency	%
Non-formal education	51	18.21	Civil Servant	38	13.57
Primary education	81	28.92	Traders	77	27.5
Secondary education	109	38.92	Factory workers	91	32.5
First degree	26	9.28	Unemployed	32	11.4
Post graduate	13	4.64	Artisan	30	10.71
			Others	12	4.28
Total	280	100	Total	280	100

Gender	Frequency	%	Monthly income	Frequency	%
Male	144	51.2	Less than ₦80,000	157	56.07
Female	136	48.6	₦80,000– ₦100,000	104	37.14
			₦100,000– ₦150,000	16	5.71
			₦150,000– ₦200,000	2	0.71
			Above ₦200,000	1	0.35
Total	280	100	Total	280	100

The remaining 4.28% comprises private parastatals, professionals and the retirees. Similarly, monthly income indicates that 56.07% of respondents earn below N80,000, 37.14% earn between N80,000 and N100,000, categorizing them as very low-income earners. Only 0.71% and 0.35% earn between 100,000 and N200,000, suggesting a population that is not economically disadvantaged and vulnerable to environmental challenges. Household size is predominantly 1-5 persons in all the residential zones, accounting for 59.64%. followed by 5-10 persons with 32.85% of the sample.

Drainage Condition and Availability

Information on drainage availability revealed that 53.1% of the respondents indicated that drainage facilities were unavailable compared to 45.1% of respondents who responded positively, Fig.-2a. The core residential zone recorded a higher frequency of drainage deficiency, accounting for 27% of the responses. The core residential zone also reports a significant number of buildings constructed along drainage channels, which will further make the provision more difficult to execute. The transition and the planning scheme residential zones reported a lower frequency of drainage deficiency, accounting for 15.3% and 10.7% respectively. Similarly, the predominant type of drainage available in the area is open drainage, with a high frequency of 47.8%; subsurface drainage is reported at 6.1%, and combined drainage has 2.8% Fig.-2b. Open surface drains, according to studies in the literature, are the most common type of drainage available in most urban areas in Nigeria.

For instance, studies^{20,21,22} reported similar findings, highlighting the prevalence of surface drainage in Ogun State, including the study area. Previous studies have commented repeatedly on the need for improvement in the poor state of the available surface drainage system in Nigeria's urban area^{3,23,20,24}. The major drainage problems assessed include issues of standing water, slow flow, blockages, stormwater overflow, erosion, flooding and odour challenges. Figure-2c shows blockages as the major problem with 44.2%, followed by standing water at 23.2%, slow drainage at 18.1%, while odour, erosion and overflow recorded notable frequencies.

The challenges associated with open surface drainage systems have remained an issue of debate among several scholars who have openly confirmed the consequences, such as blockages, standing water, odour, and slow drainage, among others.^{15,24} The findings of this study further confirm these assertions reported in the literature. Figure-3a presents the condition of the available drainage, while Fig.-3b illustrates disruption of economic activities and accessibility issues as having the major impact from drainage deficiency in all the residential zones.

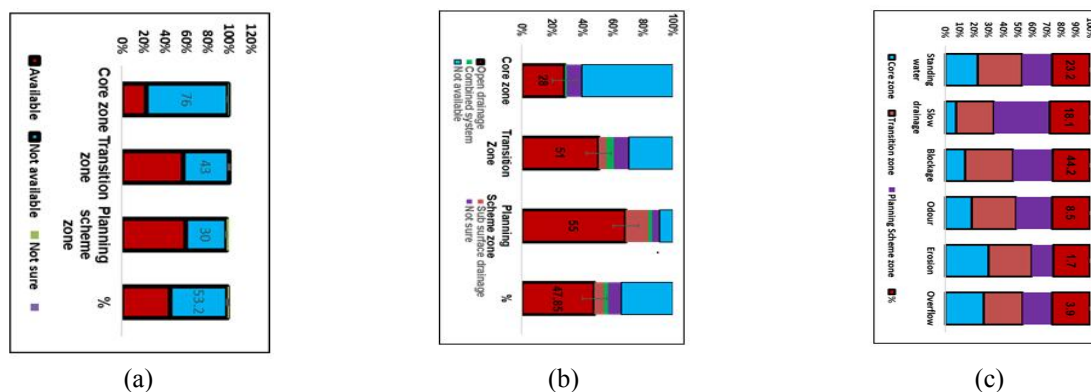


Fig.-2: (a) Drainage Availability, (b) Drainage Type, (c) Drainage Challenges

Perceived Environmental and Health Impact of Drainage Deficiency

The perceived health risks associated with the absence of drainage infrastructure were also investigated Table-3. The results showed that 48.9% of respondents agreed with the statement, confirming that inadequate drainage has a substantial influence on residents' well-being. Nevertheless, 20.1% of respondents disagreed with these assertions, and 16.78% were uncertain of the effect of drainage deficiencies on health, while 8.2% were neutral. Table-5 shows the distribution of the perceived prevalence of health issues across residential zones. The results indicate that the respondents rated

diarrhoea, cholera, irritations and psychological disturbances as the most prevalent perceived health problems associated with environmental pollution and drainage deficiency as affirmed by.²⁵

Table-3: Existence of Perceived Health Impact

Options	Core zone	Transition zone	Planning scheme	Total	Percentage
There is a perceived health impact	34	55	48	137	48.92
There is no perceived health impact	23	28	22	73	26.07%
I'm not sure	32	5	10	47	16.78%
Neutral	11	12	-	23	8.21%
Total	100	100	80	280	100%



Fig.-3: (a) Existing Drainage Condition (b) Impact of Drainage Deficiencies in the Environment

Table-4: Percentage of Perceived Prevalence of Health Hazards in Residential Zones

Perceived health issues	Core Zone				Transition Zone				Planning Zone			
	none	low	MD	high	none	low	MD	high	none	low	MD	high
Respiratory diseases	7%	4%	10%	14%	5%	12%	7%	10%	7%	4%	7%	11%
Skin infections	4%	5%	15%	10%	2%	8%	7%	18%	4%	6%	5%	13%
Diarrhoea	9%	4%	7%	16%	2%	5%	11%	17%	6%	5%	2%	15%
Dysentery	2%	10%	8%	12%	1%	12%	14%	7%	2%	5%	11%	10%
Cholera	1%	5%	11%	18%	2%	7%	7%	19%	0.7%	3%	8%	16%
Cough	2%	9%	14%	10%	8%	6%	10%	11%	8%	12%	6%	2%
Typhoid fever	7%	7%	9%	13%	0%	7%	10%	17%	6%	3%	9%	11%
Chest pain	0.7%	16%	5%	10%	13%	4%	4%	14%	2%	6%	11%	9%
Wheezing	2%	10%	17%	7%	5%	4%	13%	12%	2%	7%	9%	11%
Escherichia Coli	8%	17%	7%	6%	17%	11%	4%	3%	8%	6%	5%	7%
Malaria	-	7%	15%	14%	0.7%	3%	12%	21%	2%	3%	8%	15%
Headache	4%	6%	11%	14%	2%	4%	13%	17%	3%	6%	13%	7%
Irritations	-	7%	7%	21%	-	-	17%	22%	-	1%	6%	21%
Psychological disturbances	2%	7%	11%	15%	-	7%	16%	20.7%	-	4%	6%	18%
Anxiety	0.7%	9%	15%	11%	2%	4%	10%	19%	2%	5%	12%	12%
Fear	4%	7%	12%	13%	-	-	11%	21%	0.7%	4%	7%	17%

Table-5a presents the results of the chi-square test. The likelihood ratio and Pearson chi-square tests both indicate a statistically significant association between drainage challenges and the types of perceived health concerns. Similarly, the Pearson chi-square value exceeded the critical value, confirming the statistical significance in each of the residential zones. Furthermore, the P-value in the three residential zones (which is less than 0.05) further supports the statistical relationship. Table-5b presents actions taken by the respondents to address the identified drainage challenges. The majority of respondents chose to live with the challenges rather than take any action, such as 43% in the core zone, 35% in the transition zone and 42% in the planning scheme zone. Similarly, 12% and 18% in the core and transition zones, respectively, indicated they address the problem through community participation by constructing and

maintaining drainage facilities, whereas 6% of respondents in the transition zone reported taking the same action. A relatively small proportion of respondents resolved to maintain the existing drainage and also submitted a formal complaint to local government and public health officials.

Table-5a: Chi-Square Test Value

Residential zone		Critical value (0.05)	D	P. value
Core residential zone				
Pearson chi-square	85.3	24.996	15	0.0000001 (highly significant)
Likelihood ratio	82.1			
Transition residential zone				
Pearson chi-square	49.47	24.996	15	0.0000149 (highly significant)
Likelihood ratio	49.68			
Planning scheme residential zone		24.996	15	0.0000175 (highly significant)
Pearson chi-square	79.80			
Likelihood ratio	73.59			

Table-5b: Analysis of Actions Taken by Individuals

Actions taken by the community	Core zone	%	T. Z	%	PS zone	%	Total
The community resolves to provide the drainage	12	12%	18	18%	5	6%	35
Community resolves to maintain the available ones	15	15%	5	5%	16	20%	36
Made a formal complaint to the local government	10	10%	12	12%	6	7%	28
Made a formal complaint to public health officials	10	10%	21	21%	5	6%	36
No effort was made	10	10%	9	9%	15	18%	34
Live with the problem	43	43%	35	35%	33	42%	111
Total	100	100%	100	100%	80	100%	280

The outcome of this study offers valued insights on the perceived health challenges arising from inadequate and deficient drainage infrastructure. These findings are essential for informing effective public health intervention and urban planning strategies. Similarly, promoting sustainable, safe and livable cities for human settlements remains one of the central objectives for Sustainable Development Goal (SDG)11 objectives 13.¹² Achieving this goal will require addressing numerous environmental and infrastructural challenges confronting communities in the region.¹³ Subsequently, greater efforts should be channelled towards providing adequate drainage infrastructure, especially for the most vulnerable communities, as well as ensuring safety, resilience and sustainability.

CONCLUSION

This study investigated the prevalence of inadequate drainage infrastructure and the perceived public health risk associated with drainage deficiencies. This study was undertaken in recognition of the need to contribute to the achievement of Sustainable Development Goal (SDG) 11, which seeks the promotion of inclusive, safe, and sustainable cities for human settlements by 2030. The study establishes that there are perceived health constraints associated with drainage infrastructure deficiencies in the Ota community, with varying levels of prevalence. Additionally, the statistical likelihood ratio and Pearson chi-square analysis demonstrated a significant relationship between drainage deficiencies and perceived public health issues across the residential zones.

This study therefore highlights the importance of providing drainage infrastructure in residential environments through effective urban planning and proper funding. Regular maintenance of the existing drainage infrastructure also remains critical to environmental sustainability. The limitation of this perception-based study is the absence of real-time medical records and clinical health assessment records to validate individual perceptions. A future study is proposed to integrate hospital records, public health surveillance data, and expert medical assessments to provide a more comprehensive assessment.

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CONFLICT OF INTERESTS

The concept was agreed upon as no conflict of interest was recorded.

AUTHOR CONTRIBUTIONS

The present work is related to *SDG-11: Sustainable Cities and Communities*. All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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