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ABSTRACT

Open defecation remains a pressing public health and environmental challenge, particularly within urban centers like Lokoja Metropolis. This paper assessed the spatial distribution of public toilets as a viable solution to combat open defecation in the Lokoja metropolis using Euclidean distance measurement and Nearest Neighbor Analysis (NNA). Through a comprehensive review of existing literature and spatial analysis, this study investigates the current status of the existing public toilets, their accessibility, and their impact on open defecation practices. Furthermore, the paper explores the socio-economic factors influencing the availability and usage of public toilets. The findings suggested about twenty-four (24) locations of public toilets which are strategic distribution of public toilets and can significantly mitigate open defecation within the Lokoja metropolis. This research provides valuable insights for policymakers, urban planners, and sanitation authorities to implement targeted interventions and achieve sustainable sanitation goals within urban areas. The study recommended that the government, non-governmental organizations, and communities should provide initiatives to provide adequate public toilets at strategic locations as shown in this study as well as homes, and school environments (in hostels and school premises). The study further recommended that there should be Public awareness as regards the locations and usage of these public toilets within the metropolis.

***Keywords*:** spatial distribution, open defecation, metropolis, public convenience, health, interventions

1.0 Introduction

Comprehensive environmental sanitation encompasses a range of practices, including human waste management, pest and vector control, and the proper disposal of both gaseous, liquids and solid waste. (Abdulkadir et al., 2023). Outdoor defecation refers to the practice of individuals or groups defecating in public areas, including water bodies, bushes, or other public spaces, rather than using a toilet, resulting in the unhygienic mixing of human waste and the environment, with severe consequences for public health (Center for Legislative and Research and Advocacy, 2013; Coffey, 2015; Saleem et al., 2019; Onyemaechi et al., 2022).

The practice of Open defecation is a pervasive global issue that has a significant health concern, particularly in developing countries like Nigeria. This practice can be attributed to various factors, including harmful cultural beliefs, superstitions, and poor personal hygiene habits. Additionally, limited access to modern toilet facilities can also contribute to open defecation (Lugaka, 2012). Global data from the World Health Organization (2022) reveals that about 2.4 billion people globally are denied access to fundamental sanitation infrastructure, resulting in approximately 946 million individuals being forced to engage in open defecation, often in public areas, water bodies, or other unsanitary environments. The unsanitary practice of open defecation has sparked a significant increase in the spread of infectious diseases, including cholera, diarrhea, dysentery, hepatitis A, typhoid fever, and polio. Furthermore, it has fostered an environment that facilitates the transmission of the following diseases, such as intestinal worms, schistosomiasis, and trachoma, posing a significant threat to public health

In Nigeria, open defecation is a widespread practice, leading to significant health challenges. According to a report by Punch on October 3, 2023, global rankings, Nigeria overtook India in 2019 as the nation with the most widespread practice of open defecation, now holding the unenviable position of having the highest number of people without access to proper sanitation facilities. Approximately 50m individuals, equivalent to 10m households, engage in open defecation, primarily in rural areas where low-income earners lack access to modern toilet facilities. This practice is also prevalent among students in public tertiary institutions, as well as in business and residential areas of low-income earners in urban centers. To combat the issue of

public defecation, Nigeria's President issued Executive Order 009 in 2019, aiming for its complete eradication by 2025. The same year saw the launch of the "Nigeria Open Defecation Free by 2025" initiative by the Ministry of Water Resources, in tandem with UNICEF and other vital stakeholders, accompanied by a detailed National Roadmap to guide the country's efforts towards achieving this critical sanitation goal. This roadmap outlines a strategic plan to eradicate open defecation in Nigeria by 2025, through the execution of multiple approaches and interventions.

It is in this regard that it has become imperative to spatially map and distribute locations of public convenience (toilets) within the Lokoja metropolis as a panacea for open defecation. Although Kogi State Government alongside other private sectors has provided few of these public conveniences which are highly inadequate and poorly situated. Public convenience in contemporary terms, refer to public facilities that offer sanitation services to the general public and transient populations in high-traffic areas such as markets, transportation hubs (train stations, bus terminals), highways, tourist attractions, office complexes, and other public spaces, with a fee charged for each use (Federal Ministry of Health, 2017).

It's crucial to recognize that public convenience is a universal concern, transcending age, social class, ethnicity, gender, mental ability, and physical ability. Public facilities are expected to meet certain standards, being sufficient, accessible, secure, clean, culturally sensitive, and inclusive (catering to diverse genders and people with disabilities) (Federal Ministry of Health, 2017). To enhance access to public convenience, eradicate open defecation, and protect people's health and dignity, the Ministry of Health employs community-led total sanitation and hygiene (CLTSH) and sanitation marketing strategies.

Public convenience facilities are crucial for various reasons. Their absence can lead to filthy and disgusting conditions in many street areas, severely impacting nearby residences. To address the global and Nigerian issue of open defecation, numerous researchers have employed diverse approaches and methodologies, as seen in the works of Abdulkadir et al. (2023), Ukpabi (2023), Mukhtar et al. (2023), Olu et al. (2022), Charles et al. (2020), Sawyerr and Adepoju (2019), and Karanja (2018). However, there is a notable research gap in the Lokoja metropolis, where little to no studies has been conducted on this topic. This study seeks to address this knowledge gap by

spatially mapping and identifying optimal locations for public convenience facilities within the Lokoja and its environs.

2.0 Materials and Methods

2.1 The Research location

The Geographic area of interest is situated within the Lokoja Metropolis, bounded by latitudes 7° 45' and 7° 51' North, and longitudes 6° 41' and 6° 45' East, in the lower Niger-Benue trough of Central Nigeria (refer to Fig.1). With a legacy rooted in its history as the former capital of the British Northern Nigeria Protectorate, Lokoja, the capital of Kogi State, maintained its importance as a key administrative hub following the unification of Northern and Southern Nigeria in 1914, remaining a crucial center of colonial governance (Kogi State Government, 2013).

Lokoja serves as the administrative hub of a Local Government Area in Kogi State. With a total area of 63.82 km² (Adeoye, 2012) and a population of 195,261 according to the 2006 Census (National Population Commission), Lokoja is a thriving trade center, strategically located at the confluence of the Niger and Benue Rivers. This advantageous position facilitates the trade of agricultural products, such as rice. The local economy is diverse, with inhabitants engaged in various activities like fishing, farming, lumbering, trading, boat-making, and public sector employment, including civil service. However, the growing population in Lokoja has led to increased pressure on wood resources for cooking and other essential amenities (Johnson et al., 2024).

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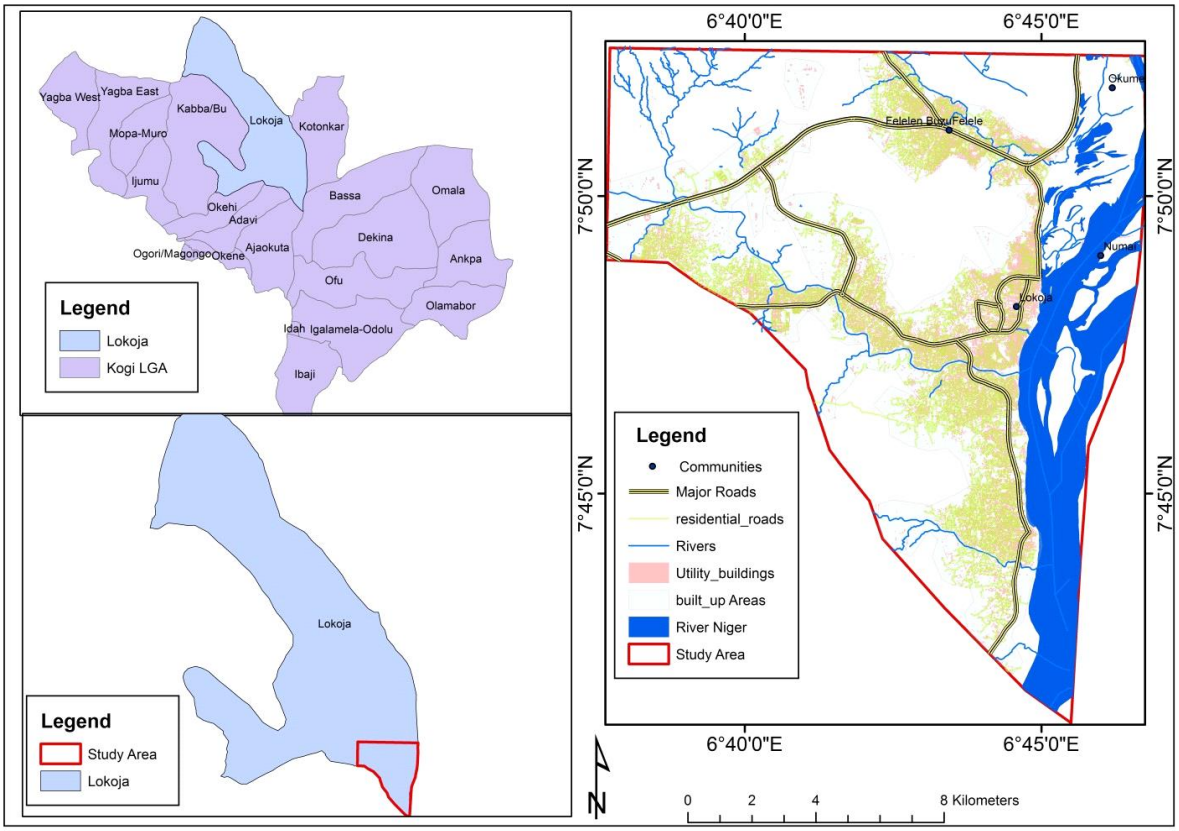

Figure 1: Research Location.
Source: Adopted from Johnson et al., (2024)

2.2 Data Requirements and Collection

The following data and materials were utilized for this research:

i. Landsat ETM+ satellite imagery with a 30m spatial resolution, encompassing the entire study area.

ii. A map of Lokoja Local Government Area, obtained from the Bureau of Lands, Housing, and Urban Development in Lokoja.

iii. Digital vector layers comprising road networks, built-up areas, and streams were sourced from geofabrik's online repository, offering a detailed spatial dataset for analysis and mapping purposes.

iv. Spatial reference points, which provide the geodetic positions of existing as well as proposed public convenience locations.

This study utilized datasets from diverse sources, each with unique formats, coordinate systems, and projections. To facilitate integration and analysis, the input data was unified within the Universal Transverse Mercator (UTM) coordinate system, anchored to the Minna Datum, with its central point at the Minna L40 base station. This standardization process not only resolved measurement inconsistencies but also preserved the spatial relationships and geometric properties of the features, guaranteeing accurate and reliable results.

The study employed the Federal Ministry of Health criteria for the location of public convenience with an emphasis on traffic of people and ideal distance norms for locating public convenience within a walkable distance.

The geographic positions of existing public conveniences within the study area were determined through a field survey using a Global Navigation Satellite System (GNSS) receiver. During the fieldwork, geographical coordinates (latitude and longitude) of the existing public conveniences were collected. Additionally, shapefiles comprising road networks, buildings, and rivers were downloaded from the website http://www.geofabrik.de). These data were then imported into ArcGIS 10.5 as a text file and converted to a shapefile, allowing for the visualization of public convenience locations on satellite imagery. This process enabled the analysis of the distribution pattern and extent of existing public conveniences.

Twenty-four (24) new public convenience sites were determined in this study. The geographical coordinates were also obtained using the same device as mentioned above. Based on the Federal Ministry of Health criteria for siting public convenience, public conveniences are expected to be sufficient, accessible, secure, clean, culturally appropriate, and all-inclusive, the study emphasizes more on the accessibility of these locations to the various and varied users. To optimize accessibility by the users, the study further carried out Distance Metric calculations to determine the accessibility and viability of these proposed sites.

In Nigeria, the approved walking distance guidelines for public convenience facilities are not explicitly stated in a single national document. However, there are some guidelines and regulations that provide insight into the recommended walking distances:

The Nigerian Building Code (2016) recommends the following walking distances to public convenience facilities:

(a). 100-150 meters (0.1-0.15 kilometers km) for residential areas

(b). 150-200 meters (0.15-0.2 km) for commercial areas

(c). 200-300 meters (0.2-0.3 km) for industrial areas

The Federal Ministry of Works and Housing's "Manual of Standards for Road and Bridge Design" (2012) suggests a walking distance of 200-400 meters (0.2-0.4 km) to public facilities, including restrooms. The Lagos State Government's "Lagos State Physical Planning and Development Regulations" (2019) recommends a walking distance of 100-200 meters (0.1-0.2 km) to public convenience facilities in residential areas.

Straight-line Euclidean, Manhattan, and Minkowski distances were adopted in this study to determine the optimal distance of each facility or residence to the public convenience sites proposed. For distance computations, the road network is projected onto a planar surface using an equidistant projection system, chosen for its ability to maintain accurate distance relationships and ensure consistent measurement results

The geographic coordinates were transformed into a Cartesian system, with Easting and Northing values represented as x and y coordinates in kilometers. This enables the calculation of Euclidean, Manhattan, and Minkowski distances using standard geometric formulas:

$$d = [(x_i - x_j)^p + (y_i - y_j)^p]^{1/p}$$

For this application:

d is the distance between a particular facility or residence and the public convenience site;

$x_i\, y_i$ are the geographical coordinates of the centre points of the facilities or residential units;

$x_j\, y_j$ are the geographical coordinates of the centroid of the public convenience sites.

The generic p in the parameter in the equation can be replaced by 2 to yield the well-known Euclidean distance, the value of 1 would yield the Manhattan distance, and all the intermediates values in the interval yield an array of Minkowski distance.

The calculation of road distance networks, to determine the shortest path between two locations along the route, was performed using the ArcGIS software. The Network Analyst tool within ArcGIS toolbox facilitates the analysis of spatial networks and provides the necessary tools for computing road distances.

3.0 Results and Discussions

3.1 Spatial Distribution of Public Convenience

Table 1.

Existing Public Convenience

N	E	Location	Ownership	No of Toilets	No of Bathrooms
7.851044	6.729645	Wada Park Felele	Government	5	5
7.842715	6.746787	Sarikin Numa I	Private	5	6
7.843474	6.746208	Sarikin Numa II	Private	2	2
7.84108	6.74381	New Market	Government	6	6
7.840628	6.747293	Ibro Park	Government	4	0
7.820832	6.74583	Kabawa	Sure-P	5	0
7.815073	6.747928	Old Market	Government	2	2
7.808098	6.746397	Kogi Travellers	Government	2	0
7.802094	6.699673	Lokogoma Phase2	Government		

Source: Authors fieldwork, (2024)

Table 1 presents the geospatial and attributes data of public conveniences within the research area. The research findings reveal that public conveniences within Lokoja and its environs were predominantly situated around markets and motor parks, catering for casual users who are short-term or long-term migrants. Additionally, high-demand areas like Kabawa axis, Sariki Numa, and Phase 2 also have public conveniences. A total of nine public conveniences were identified in the study area, exhibiting a dispersed distribution pattern (Fig. 3) influenced by commercial factors. The coordinates of these public conveniences were used to create the map shown in Fig. 2.

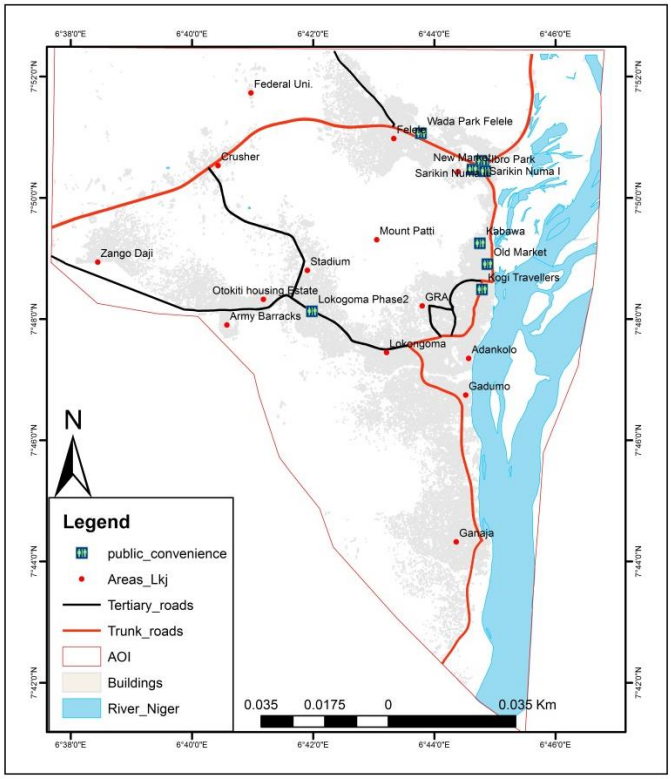

Fig. 2. Spatial locations of the existing public convenience
Source: Authors lab work, (2024).

3.2 Nearest Neighbor Ratio (NNR)

To determine how clustered or dispersed the facilities are, an average nearest-neighbor analysis was carried out. The NNR value of 1.300916 suggests that the average distance between points and their nearest neighbors is about 30% greater than expected under a completely random spatial distribution. Since NNR > 1, it indicates some level of dispersion, meaning points are farther apart on average compared to a random spatial distribution. The result of the breakdown therefore shows that all the distribution of public conveniences is dispersed as shown in Figure 3.

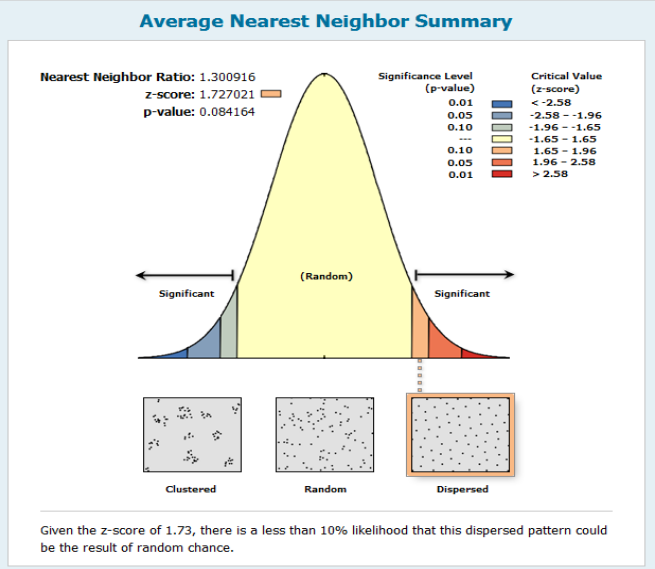

Fig. 3 Average Nearest Neighbor Analysis
Source: Authors lab work, (2024)

3.3 Maximum Walking Distance Analysis

Maximum Walking Distance refers to the farthest distance a person is willing or able to walk to reach a destination. This is a critical parameter in urban design, public health, and transportation planning. In this study, Euclidean distance analysis was performed to determine the travel distance between the location of the public conveniences and the users. The result of the Euclidean distance analysis shows that people within the first circle (1.5km) (figure 4.) can conveniently access the facilities while it will be difficult for those outside the range to access.

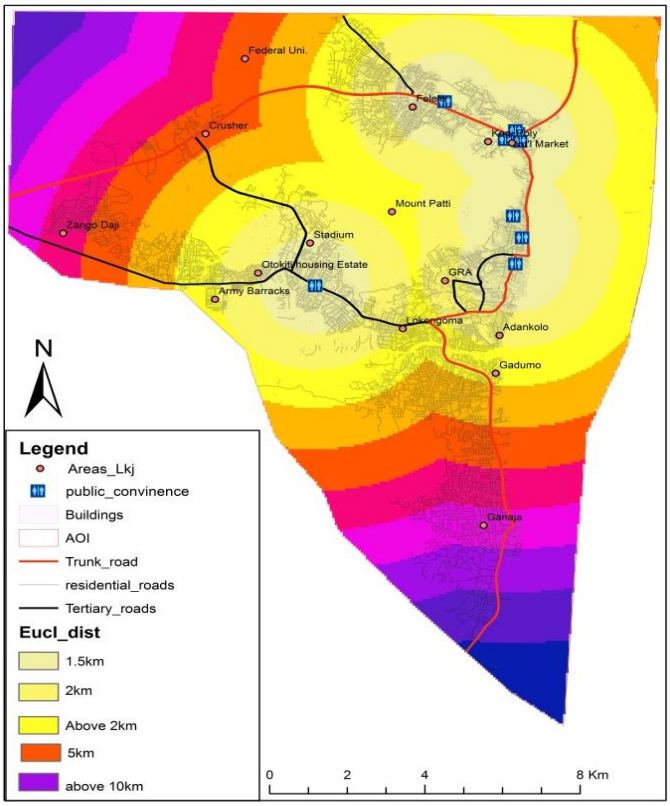

Figure 4. Minimum walking distance using Euclidean distance
Source: Authors lab work, (2024)

3.4 Proposed Locations for Public Convenience

Table2. Shows the geospatial information on the proposed location of the public convenience, about twenty (24) locations were strategically selected, and several factors were also considered during the process of selecting the sites, including population, concentration of migrants, road junctions and accessibility, this agrees with the study of Auwal et al, (2020). Figure 5 illustrates the proposed public conveniences in the study area, with their spatial locations and distribution highlighted in red.

Table2.
Proposed Sites for Public Convenience

S/N	Y	N	Location
1	7.843676	6.741698	Front of KSp
2	7.852198	6.684959	FUL permanent site

3	7.841285	6.671582	Crusher junction
4	7.808982	6.695387	State Secretariat
5	7.805634	6.693921	Zone 8 junction
6	7.809752	6.641979	Zango (okanda junction)
7	7.798007	6.707496	Phase2 1st gate
8	7.801028	6.702557	Phase2 2nd gate
9	7.791965	6.727466	Ganaja junction
10	7.781969	6.732288	1st 200 housing Unit junction
11	7.751358	7.743843	500 housing Unit
12	7.737649	6.744766	Nyamanyama Junction
13	7.814743	6.74947	Old market
14	7.821152	6.749268	Kabawa
15	7.842843	6.747295	Sarkin Noma
16	7.809765	6.749644	Kpata
17	7.7775	6.740154	Gadumo
18	7.788722	6.730223	FUL junction (around Dunamis)
19	7.794202	6.732251	FUL junction (around specialist hospital)
20	7.791857	6.720816	Lokongoma market area
21	7.802337	6.673067	Barracks
22	7.802192	6.670646	Shetima junction
23	7.840047	6.747076	New ***market***
24	7.852864	6.722112	Felele bus-stop

Source: Authors fieldwork, (2024)

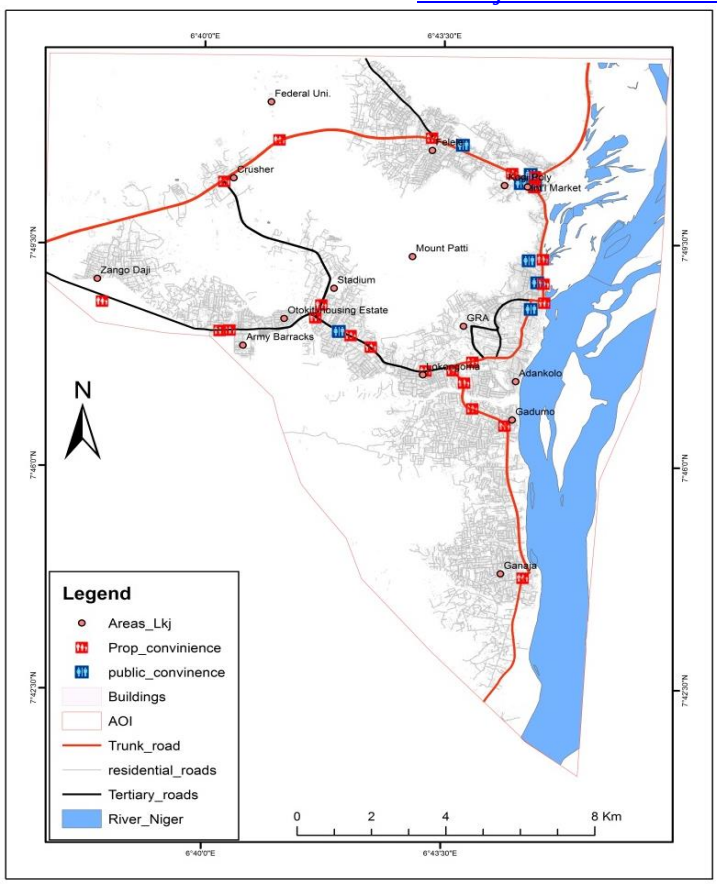

Figure 5. Proposed convenience locations
Source: Authors lab work, (2024)

4.0 Conclusion

Open defecation, the act of defecating outside of a designated public toilet, poses significant health risks by exposing individuals to direct contact with feces, thereby facilitating the spread of diseases. When people engage in open defecation, they release millions of microorganisms into the environment, which can then be ingested, leading to the transmission of various diseases and health issues, including polio, cataracts, typhoid, cholera, hepatitis, malnutrition, and others.

Consequently, it is essential to spatially distribute and strategically locate public conveniences in areas that will be accessible to varied users. The study highlighted the disparity between existing public conveniences and the expected users. The study recommended that the government, nongovernmental organizations, and communities should provide initiatives to provide adequate public convenience at strategic locations as shown in this study as well as Private and public

institutions (including homes and schools). This study further recommended that there should be Public awareness as regards the locations and usage of these public conveniences within the metropolis.

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