

## LOCATIONAL IMPLICATIONS OF LIQUEFIED PETROLEUM GAS SELLING POINTS IN KANO METROPOLIS, NIGERIA

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### ABSTRACT

*This study assesses the locational implications of Liquefied Petroleum Gas selling points in Kano Metropolis, with a view to mapping and determining their locational compliance with regulatory guidelines. GPS was employed to record the coordinates of the selling points. ArcGIS 10.1 was used to map the spatial location of the selling points. A spatial statistical tool was used to analyze their spatial distribution patterns. In contrast, the z-ratio analytical technique was used to examine their compliance with the NMDPRA requirement to be 10m away from the road. The findings reveal that retail shops/outlets are predominantly located in densely populated areas, in proximity to one another, indicating a high level of vulnerability and exposure for residents to a likely LPG disaster. The buffer analysis shows that about 57% of retail shops and 64% of plants are located within 10m and 20m of the road, violating NMDPRA standards and guidelines. The NNI ratio is 0.39, which is  $>1$  and closer to zero, indicating that the points are closer to each other and clearly indicating that the LPG selling points are statistically clustered. It was concluded that the location of the LPGSPs in the area exposes community members and the environment to LPG-related risks and hazards. The study recommends that KUNPDA introduce zoning regulations to address the rapid proliferation of LPGSPs in residential areas.*

**Keywords:** Location, Implications, Spatial, Risk vulnerability, Distribution pattern, Metropolis

### INTRODUCTION

Liquefied Petroleum Gas (LPG) is generally recognized as a clean cooking fuel for urban households and is currently gaining popularity and wider acceptance across all levels of use. Hriday and Anonya (2025) noted that LPG is one of the clean cooking fuels gaining high usage as a domestic fuel worldwide. The transition to clean cooking fuels is part of the global agenda and is currently making waves. Abhishek *et al.* (2024) noted that clean-cooking transitions have the potential to generate large public health, environmental and societal gains for 2.6 billion people in the Global South. However, rapid urbanization and rising demand for clean cooking fuel have spurred the proliferation of LPG retail shops/outlets along major Nigerian streets and roads, improving household access. Bukar (2024) noted that in Nigeria, most petrol and gas stations are located along roads, often too close to one another and to residential buildings, places of worship, schools, hospitals, and markets. This situation presents significant risks and safety challenges. Originally, the siting of LPGSPs and Petroleum Filling Stations should be well regulated by the concerned authority in accordance with safety regulations. Bukar (2024) noted



that all facilities related to flammable products should be cited in accordance with the guidelines provided by the Nigeria Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) and fire service safety rules to minimize risk and avoid potential hazards and disasters associated with LPG. Unfortunately, the regulatory guidelines and conditions governing the establishment of these high-risk businesses are routinely and grossly violated by most retail shops/outlets.

The proliferation of LPGSPs/PFSs in Kano Metropolis is associated with regulatory challenges, given the pattern of their spatial distribution, which threatens communities and the physical environment. The residents where these LPGSPs are located are living in vulnerable conditions associated with LPG hazards and disasters. Substantiating this assertion, a 2023 survey by NMDPRA revealed that out of about 500 LPG retail shops/outlets, only 5% were registered with the organization. This poses a constraint on effective regulation, as NMDPRA can regulate only licensed operators by law. One of the biggest challenges of regulations concerns retailers situated in high-density residential areas, as they are difficult to manage and control given their dispersed locations across the city. Mapping the spatial location and distribution patterns of LPGSPs has policy implications in the state. It will help to provide details of their number and the community where they are located for easy regulation by the concerned authority.

Thus, limited studies have been conducted on locational implications of PFSs, and from the empirical review show that notable studies include that of Oyinloye & Abiola (2021) on the locational impact of petrol filling stations (PFS) close to residential buildings in Ife Central, Nigeria, Olokoba *et al.* (2020) which assessed the locational suitability, health and safety practices in PFSs, Ilorin, Nigeria. Also, Akinsulire & Fadare (2020) assessed the locational pattern of PFSs along the Lasu-Isheri Road Corridor. Abubakar, Okere & Akpu (2019) conducted a study analyzing the distribution patterns of PFSs and their implications in Kaduna Metropolis, and Yunus (2019) conducted a study analyzing locational compliance and fire safety preparedness among PFSs in Dutse, Jigawa.

Arising from the foregoing, this study aims to assess the locational implications of LPGSPs, with a view to examining the compliance status of the LPG retail shops/outlets with safety regulations and how nearby communities and built-up areas might be exposed to risk from LPG operations. Understanding where these retail shops and outlets are located and how close they are to essential facilities such as roads, hospitals, schools, and residential neighborhoods is crucial. Yet, in Kano Metropolis, there is currently no comprehensive spatial data available on the distribution patterns of LPGSPs. This information gap makes it difficult to carry out effective urban planning, enforce regulations, or properly assess potential risks. Without a clear picture of the spatial layout and proximity of these outlets to critical infrastructure, it becomes challenging to ensure public safety or guide informed decision-making.

## LITERATURE REVIEW

To study spatial phenomena on Earth, the theory of spatial location is among the oldest and most widely used theories. The Central Place Theory (CPT) is one such theory in studying spatial patterns and the distribution of any geographic features. Since LPGSPs are predominantly found in high-density residential areas with high thresholds or marketability due to high demand, this greatly minimizes transportation costs and increases households' access in the city. Hence, the



CPT applies to this study and is considered the underpinning theory. Berliant (2005) noted that the CPT is a collection of loosely related, informal, descriptive models of city size, location, and market area, based on the trade-off between increasing returns to scale in production and the cost of transporting goods from firms to homes. Land markets are often absent. At its core, central place theory is an empirically motivated description of production in Southern Germany. It is a remarkable empirical regularity in search of a formal theory; a better name would be central place regularity.

The origin of the CPT is attributed to the foundational work of Walter Christaller, a German scholar, who first made detailed observations of urban hierarchies and later attempted to model them in his 1933 book. The basic ideas put forward are that the consumer population is distributed uniformly, while farms are located in cities. Cities form a hierarchy, in that cities higher in the hierarchy produce all the goods that cities one level lower in the hierarchy produce, and one more. The ratio of market areas of a commodity produced only at a given level of the hierarchy (and above) to the market area of a commodity produced at the next lower level of the hierarchy (and above) is assumed to be constant, independent of the level in the hierarchy considered. Thus, the cities in a given area form a hierarchy where the size of a city's market area and the variety of commodities it offers are perfectly correlated. In graphical terms, the results present a hierarchical ordering of cities, such that market areas overlap between cities at different levels of hierarchy but are disjoint among cities at the same level. Commodities characterized by low transport cost but high returns to scale are provided by a few cities high in the hierarchy. Most cities provide commodities characterized by high transport costs but low returns to scale (Berliant, 2005).

In a similar perspective, Terfruchte & Flex (2018) posited that the term 'central place' was coined by Christaller as part of his central place theory. Christaller defined central places as location clusters of goods (goods and services) that are characteristic of central places. In spatial planning practice, the municipality, as the addressee of the legal norm that allocates the central place function, is often equated with the central place. He derives optimal locations for goods and services aimed at consumers from the restrictive premises of a homogeneous space (e.g., with an even spread of population and income) and the notion of *homo-economicus* to offer a solution for the actual key question of his work on the principles of the dimension, number, and spatial distribution of urban functions.

## **MATERIAL AND METHODS**

This study employed a quantitative research method to obtain the primary data; GPS was employed to record the coordinates of the LPGSPs. ArcGIS 10.1 was used to map the spatial locations, determine the distances of LPGSPs from the road, and conduct buffer analysis. The Z-ratio analytical technique was used to examine the conformity of LPGSPs to the required distances of 10m (retail shops) and 20m (Plants) as specified in NMDPRA Guide 0019 – 2020. Spatial statistical tools were used to analyze the spatial distribution patterns.

### **Data Types and Sources**

The study used primary and secondary data. The primary data consist of spatial point data, namely the coordinates of latitude and longitude of the LPG selling points, as well as attribute data for each LPGSP, such as name. Secondary data consist of the shape file of the network of



roads from the Kano State Urban Planning and Development Authority (KNUPDA), Open Street Map (OSM), while a regulations document on stipulated setbacks for LPG facilities (e.g., distance from roads, buildings, source of ignition) from the Nigerian Midstream and Downstream Regulation Authority is essential for the study.

### **Data Collection Procedure**

A preliminary visit was conducted to identify LPG selling points and familiarize ourselves with the study area. Five research assistants were trained to assist with recording coordinates, given the number of retail selling points in the city. A high-precision handheld GPS, the Garmin eTrex 10, was used to record coordinates of the LPGSPs after ensuring a strong satellite signal at a 5-meter elevation to improve accuracy. The attribute data, such as the name and address of each LPGSP, was recorded using structured observation. Regulatory documents on guidelines for the establishment of LPG refilling facilities and retailers' outlets in Nigeria (NMDPRA Guide 0019-2020) were obtained directly from the NMDPRA, given the ethical issues under consideration. Relevant shapefiles of the road networks in the Kano Metropolis were obtained from the OSM data source of the Kano Urban Planning Development Authority (KNUPDA).

### **Techniques for Data Analysis**

The GPS coordinates were imported into ArcGIS and converted into a point shapefile, while the attribute data from the structured observation recorded was joined to the point shapefile. The point shapefile was overlaid on the base map of Kano Metropolis to create a spatial distribution map of the LPG selling points. Buffers of 10m and 20m were created around the road network shapefile to facilitate the analysis of the buffer zone. The Spatial Join or Select by Location tool was used to determine the number and percentage of LPG points located within each buffer zone.

## **RESULTS AND DISCUSSION**

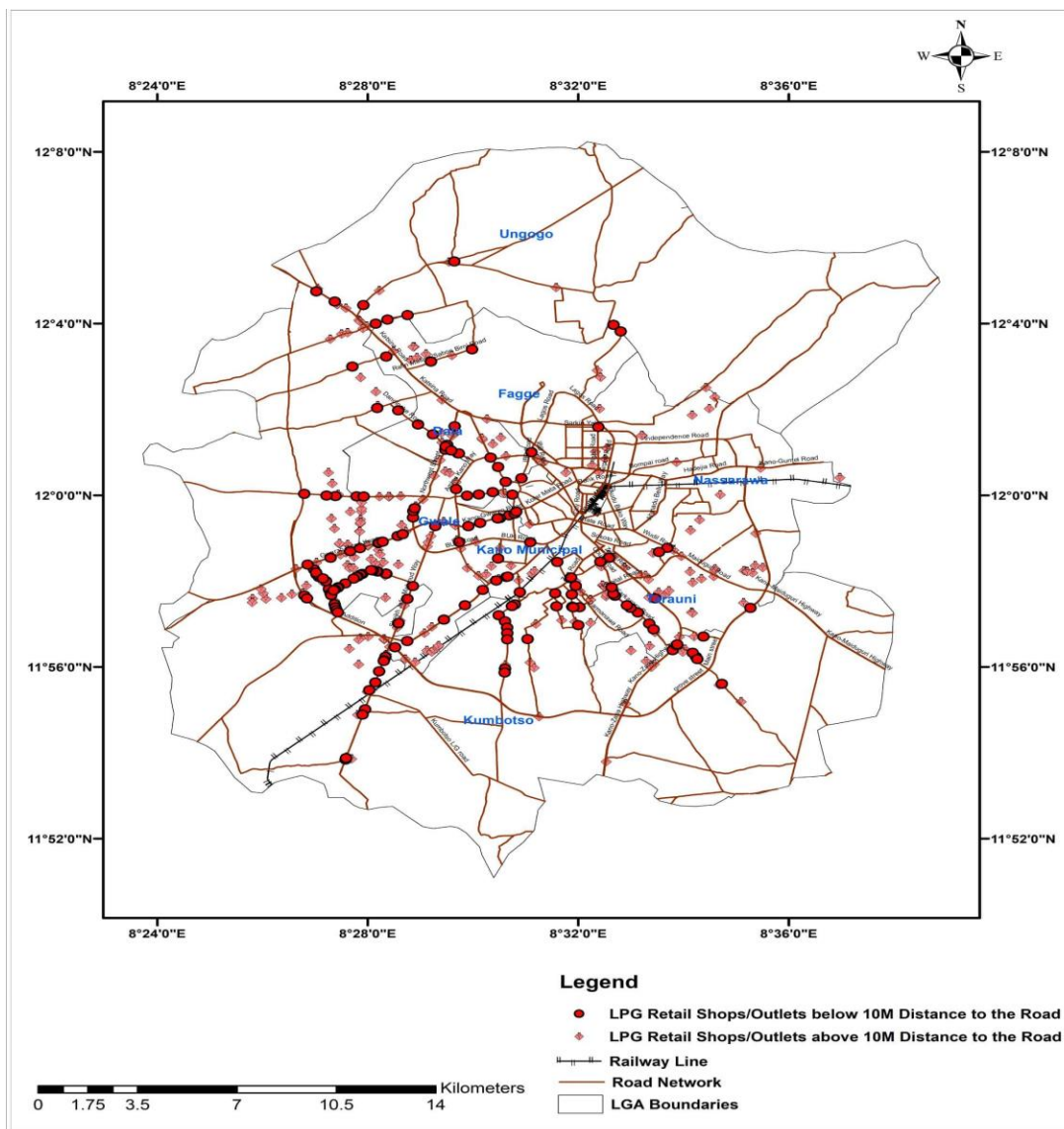
Several factors, including available space, regulatory enforcement procedures, socio-economic conditions, capital resources for business operations, and the size and capacity of LPG facilities, greatly influence the spatial pattern and distribution of LPG retail shops and outlets. Based on space availability, retail shops and outlets are predominantly located in densely populated residential areas with high commercial activity and customer demand. The settlements in this location are mostly informal, and shops are rented at lower prices due to their availability. In most of these locations, one could observe more than two or three retail shops in proximity to one another. Examples of these areas include Yamadawa in Gwale; Panshekara, Sheka, and Sabuwar Gandu in Kumbotso; Riziyar Zaki in Ungogo; Gwammaja in Dala; and Darmanawa and Sallari in Tarauni. These areas have high demand for cooking gas and, hence, a high prevalence of indiscriminate siting of LPG selling points almost everywhere, regardless of the associated risk and safety concerns (Appendix I).

It is pertinent to acknowledge that the location of LPGSPs in high-density residential areas has many locational implications. The positive implication is that it offers high accessibility and convenience for households, as most find it easy to refill their cylinders at zero transportation cost because LPG is readily available at their doorstep. This brought a significant change to the local energy market by removing accessibility barriers, thereby promoting greater use among residents. On the other hand, the negative implication concerns safety, as high residential density increases vulnerability to fire and explosion hazards. Besides, locating LPGSPs in proximity to

sensitive environmental features at risk poses a significant threat to retailers and residents. This requires adherence to zoning, safety, and environmental regulations to protect residents.

### Location of LPG Retail Shops and Outlets to the Road Based on 10M Buffer Zone

Location of the LPG retail shops and outlets based on a 10M buffer zone shows that 222 (57%) are below 10M distance from the road; this violates the standards and guidelines for the establishment of LPG refilling facilities and retailers' outlets in Nigeria, as contained in the NMDPRA Guide 0019 – 2020. Only 166 (43%) fall within 10M of the road and meet the regulatory authority's standards (Figure I). This finding corroborates that of Olokoba et al. (2020), who reported in their study that the PFSs were indiscriminately sited in violation of NMDPRA standard criteria, thereby exposing many innocent city residents to danger. Olufayo *et al.* (2017) reveal that about 85% of the PFSs in Akure were not in compliance with the 1800 m<sup>2</sup> siting standard recommended by the NMDPRA regulations.



### Figure 1: LPG Retail Shops/Outlets Proximity to the Road Based on 10M Buffer Zone

However, those located below the minimum distance required by regulations are the shops/outlets posing the highest threat to the communities where they are located. Substantiating this assertion, Monney (2015) noted that in most Nigerian cities, PPSs and LPG stations are sited without complying with regulatory standards, causing traffic obstructions and posing potential dangers to people's lives, property, and the environment. Bukar (2025) added that in most Nigerian cities, PFSs and LPGSs are located along roads, often too close to each other and to residential buildings, places of worship, schools, hospitals, and markets. Moreover, inappropriate handling of petroleum products poses a potential danger, such as the risk of fire, which can destroy lives and property.

In addition, most of the retailer's operating shops/outlets usually assemble cylinders of different sizes along the roadside, some directly by the road and others on pedestrian sidewalks (Plate 1).



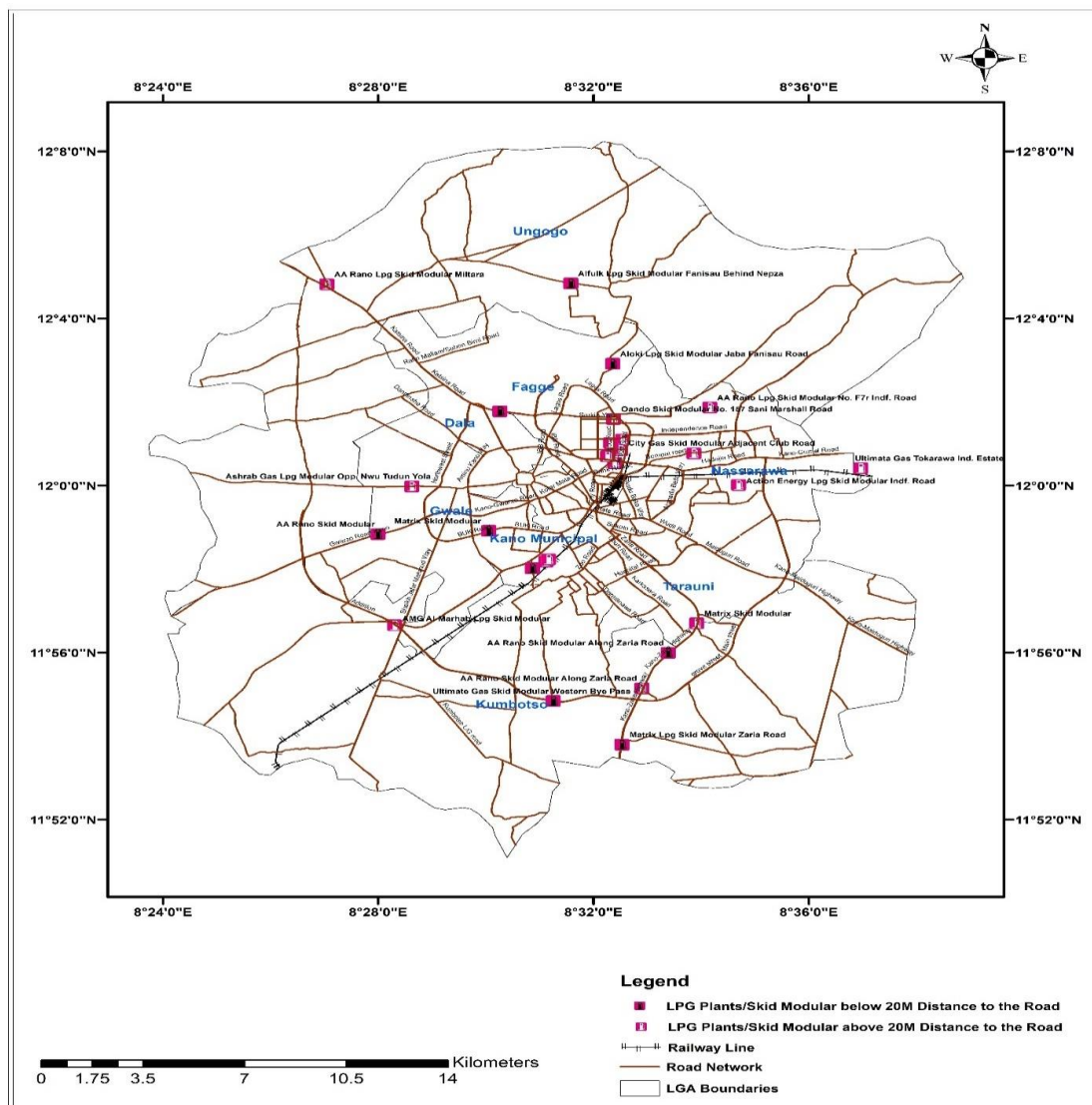
**Plate 1:** LPG Cylinders Assembled on Pedestrian Sidewalk at Tudun Yola

It is pertinent to acknowledge that assembling large cylinders containing the LPG product by the roadside poses serious safety risks to the people and community in the area. For example, the LPGSP's proximity to pedestrians and vehicles increases disaster risk vulnerability, including injury or death in the event of road crashes, which may eventually trigger a fire or explosion, as vehicles serve as potential sources of ignition. In addition, most retailers used faulty equipment, such as expired cylinders, worn-out hoses, and valves, which may cause leaks. In some cases, exposing such worn-out LPG cylinders to direct sunlight is more hazardous. It could lead to accidental removal of the cylinder valve, which may eventually result in an explosion.

### LPG Plants and Skids Modular Proximity to the Road Based on a 20M Buffer Zone

The LPGSPs proximity analysis was also determined based on 20M buffer zone, the result shows that majority 17 (65%) are below 20M distance away from the road, and they did not meet

up with the requirement of the regulatory authority, while, only 9 (35%) are within 20M distance from the road, and are in compliance with NMDPRAs regulations (Figure 2).



**Figure 2:** LPG Plants and Skids Modular Proximity to the Road Based on 20M Buffer Zone

However, the major concern is the siting of Skid Modular at PFSs, which presents a series of technical, environmental, and social vulnerabilities due to the presence of Petroleum motor spirit spouts, which increase the risk of fire hazards (Plate 2). One observable challenge with some of these SMs (dispensing sheds) is that they are not widely separated from PMS pumps, and sometimes the minimum separation distance between the LPG shed and the parking lot is not properly maintained. In some circumstances, customers don't observe and comply with the safety rules during periods of high patronage, and sometimes during festive periods or periods of



high LPG scarcity. It is pertinent to note that the lack of strict compliance by customers with maintaining safe distances from dispensing sheds, using clear, marked routes, and parking in designated spaces exposes them to a high risk of LPG-related hazards and disasters.



**Plate 2:** Add-on Skid Modular at A.A. Rano Filling Station at 3<sup>rd</sup> Gate along Gwarzo Road

Thus, to ensure precision in explaining the spatial pattern and distribution of the LPGSPs, a spatial statistical technique was used to determine the spatial distribution of the phenomenon under study. The results show that the observed average distance from each point to its nearest neighbour in the data set is approximately 220.48 meters, whereas the expected distance is 552.39 meters. Since the observed distance is significantly less than the expected mean distance, this suggests that the LPGSPs are spatially clustered rather than randomly distributed across the study area. The NNI ratio is 0.39, which is  $\leq 1$  and closer to 0, indicating that the points are clustered and clearly supporting the conclusion that the LPGSPs are statistically clustered. In addition, the z-score is -24.25, indicating an extremely strong clustering effect based on the observed and expected mean value differences. The p-value is very small (0.000), suggesting that the observed spatial pattern is statistically significant. Moreover, it provides strong evidence that the points are significantly clustered rather than randomly distributed (Appendix).

### **Accident Recorded at the LPGSPs in Kano Metropolis**

It is widely recognized that LPG has gained acceptance and use among households with varying socio-demographic characteristics across most cities. This situation led to the emergence of a new local energy market dominated by LPG. This rapid adoption of LPG has not been matched with adequate systems for managing the risk, safety, distribution, and lifecycle of cylinders. This is why the incidents of gas-related accidents have been reported in both urban and rural communities, resulting in the loss of lives and property. These accidents are frequently linked to the use of expired and uncertified cylinders, accidental cylinder falls, valve removal, and other causes (Okechukwu, Ogbonna, & Reginald, 2025). It is pertinent to acknowledge that LPG is essentially associated with high-level risks. That is why safety is of paramount importance given the product's flammable nature. Despite the associated threats, most retail shop and outlet operators do not place much emphasis on their safety, as the majority believe that whatever happens to them is a normal tragedy from their creator. This is a general misconception of reality.

Understanding the basic principles of LPG safety practices promotes a culture of adoption, which will reduce vulnerability and minimize uncertainty. However, disparities exist in the level of risk prevention among LPG retailers in the city; for example, retailers operating Plant, Skid, and Add-on Modular appear to have the best safety practices, which is why they have few accidents. At the same time, those operating shops and outlets accounted for the highest number, 64 (98%), of all accidents recorded, clearly indicating a high level of negligence among them. Also, the level of vulnerability to accidents at most of these selling points is more apparent, given how they mishandle the flammable product without proper safety practices and, most importantly, their storage and refilling facilities are not fit for the business.

**Table 1:** Types of Accident Recorded and Causes at the Various Locations of LPGSPs

S/No.	Accident Type	Causes	Frequency	Percentage
1	Fire explosion Hazards	Accidental cylinder fall and collision, ignition from charcoal burning, motorcycle due to overheating, lighter ignition, and electric spark due to high current.	26	39
2	Cylinder Breakage	Expired cylinder	03	05
3	Valve Removal	Valve malfunction and cylinder malfunction due to pressure, poor valve tightening, and accidental cylinder falls.	20	30
4	Horse cliff Removal	Valve and cylinder malfunction, accidental cylinder fall.	07	11
5	Cold burns	Accidental horse removal, valve malfunction, horse removal due to cliff malfunction, horse breakage, and uncontrolled leakages from the valve.	10	15
6	<b>Total</b>		<b>66</b>	<b>100</b>

**Source:** Authors' Analyzed Data (2025)

Table 1 shows the number of accidents, their types, and causes across the LPGSPs. There is a clear disparity in accident cases across facility types. For instance, retailers operating LPGSPs and LPGSMs appear to follow best safety practices. As a result, they have recorded very few accidents. In contrast, those operating LPGRSOs recorded the highest number, 64 cases, which account for 98% of all accidents. This figure clearly indicates a high level of negligence among LPGRSO operators. In addition, the level of vulnerability to accidents at most of these selling points is more apparent, given

how they handled the flammable LPG without adequate safety measures or PPE. Most importantly, their storage and refilling facilities are not fit for the business.

Furthermore, field evidence revealed that 66 accident cases were recorded, of which fire and explosion hazards accounted for 26 (39%), the highest among all hazards recorded across the various LPGP locations (Plate 3).



**Plate 3:** Fire Explosion Hazard Scene During the incident on 20<sup>th</sup> April 2025, at Rahama Gulu Gas along Gwarzo Road opposite Dorawar Yankifi Rijiyar Zaki

Plate 3 shows an LPG fire explosion hazard at Rahama Gulu Gas Dorayi Babba, along Gwarzo Road, which was caused by an accidental cylinder collision while refilling for customers, resulting in one injury and loss of property worth millions of naira (Plate 4).



**Plate 4:** Fire Explosion Hazard Scene after the incident at Gulu Gas along Gwarzo Road, Opposite Dorawar Yankifi Rijiyar Zaki

Plate 4 shows fire-ravaged property worth millions of Naira due to poor safety management practices. In this particular selling point, no single PPE was found, which worsened the situation, as indicated in

plate 4. Another case of fire explosion hazard was recorded as a result of accidental cylinder collision during unloading of filled cylinders by a retailer from a loaded vehicle on the 27<sup>th</sup> August, 2025 in one LPGRS at Ibrahim Khalil Street, along Gwarzo Road in Ungogo LGA, which caused massive destruction of property even though no injury or death was recorded (Plate 5).



**Plate 5:** Fire Explosion Hazard Scene at Unidentified Retail Shop at Ibrahim Khalil Street, Rijiyar Zaki, on Wednesday, 27th, 2025

Cylinder valve removal or breakage was responsible for 20 cases, accounting for 30% of the total incidents. This type of accident is attributed to factors such as valve or cylinder malfunctions, loose connections, high liquefied petroleum gas (LPG) pressure, and accidental cylinder drops. Ensuring the availability of high-quality cylinder valves is a key safety measure that helps prevent vulnerable conditions from developing at the selling points. Despite the importance of such safety practices, most retail shops/outlets continue to use faulty equipment, including expired cylinders, worn-out hoses, and valves, which can cause gas leaks. Moreover, exposing this deteriorated equipment to direct sunlight is particularly hazardous, as the intense heat can cause cylinder valve failure, potentially leading to a fire or explosion. Such incidents not only increase the vulnerability of at-risk communities but also pose significant threats to valuable built environmental features.

Additionally, cold burns accounted for 10 (15%) cases. This type of accident is associated with poor safety practices among retail shop/outlet operators, resulting from accidental hose removal during high-pressure cylinder refills, valve malfunctions, hose removal due to cylinder malfunctions, and hose breakage. This type of accident is common among retail shops/outlets with poor compliance with basic LPG safety principles. Horse cliff removal constituted 7 (11%) cases. This type of accident is mostly caused by cylinder valve malfunction and accidental cylinder fall. Whenever a full cylinder falls, there is a strong tendency for the valve to break, especially if the metal valve is cast and prone to breaking. The least common accident type is cylinder breakage, which accounted for 3 (5%) of the total cases and is attributed to cylinder expiration. This is where the application of pre-refill checks is fundamental, as it helps minimize the risk of cylinder breakage and potential explosion hazards.



## CONCLUSION AND RECOMMENDATIONS

In conclusion, the locational pattern and distribution of LPGSPs in Kano Metropolis pose significant risks that remain among the major threats to public health and safety. Poor compliance with guidelines and regulations for LPG retail operations indicates weak regulatory enforcement and systemic failure by the authority concerned. This clearly reveals a potential lack of awareness among the communities that housed those illegal retail selling points, as well as a deliberate disregard for safety standards. Poor urban development control and a lack of zoning regulations create a significant policy gap that allows the proliferation of LPGSPs in Kano Metropolis. Furthermore, it should be noted that these unsuitable locations pose a high risk and increase vulnerability for most homes, schools, markets, and other places of public gathering. In the event of an accidental cylinder fall, a fire or explosion may occur, with catastrophic consequences, including high casualties, extensive property damage, and severe social and economic disruptions.

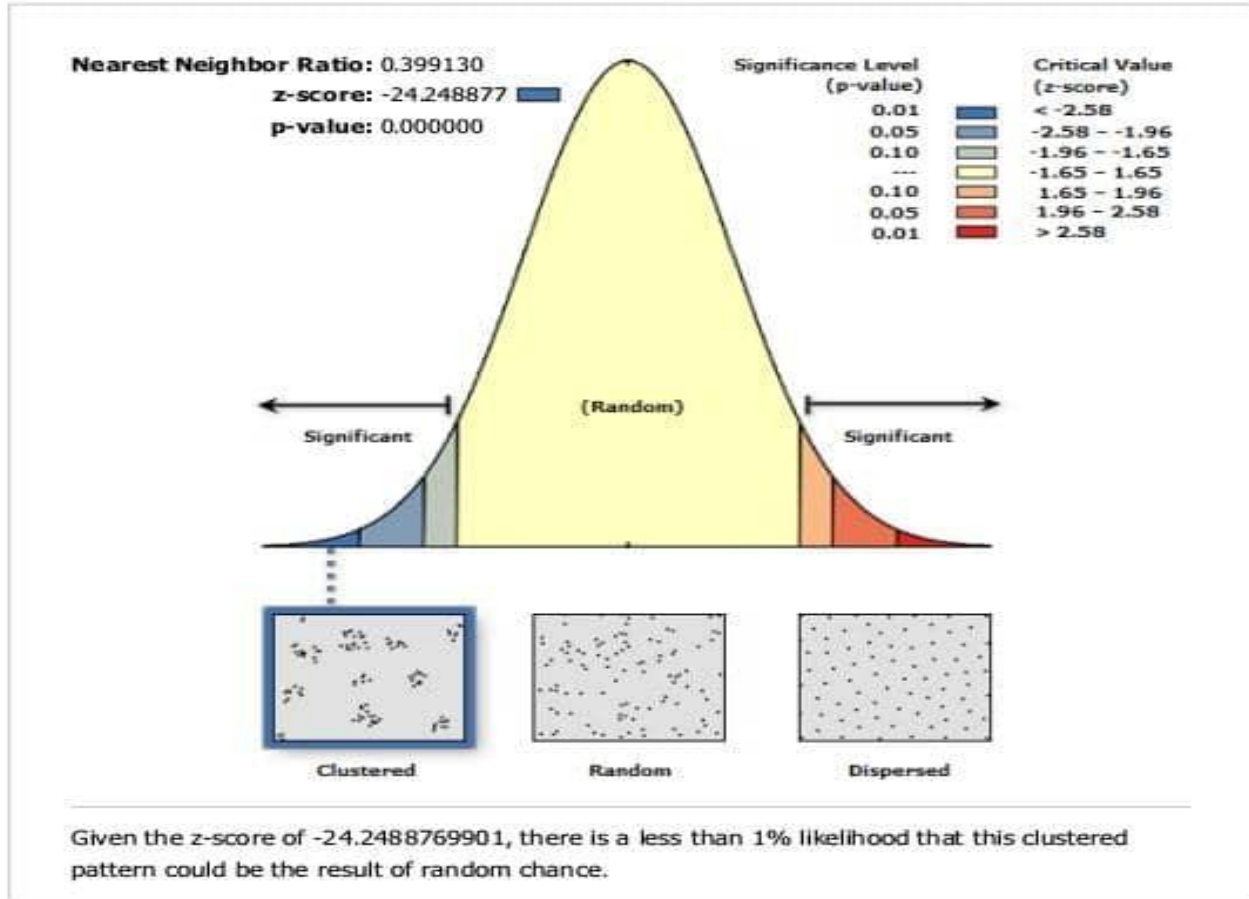
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### APPENDIX 1



### Average Nearest Neighbor Summary

<b>Observed Mean Distance:</b>	220.4752 Meters
<b>Expected Mean Distance:</b>	552.3898 Meters
<b>Nearest Neighbor Ratio:</b>	0.399130
<b>z-score:</b>	-24.248877
<b>p-value:</b>	0.000000

### Dataset Information

<b>Input Feature Class:</b>	Export_Output_2_Merge4
<b>Distance Method:</b>	EUCLIDEAN
<b>Study Area:</b>	543139326.171288

Pattern of the Distribution of the LPGSPs Based on the Nearest Neighbour Index