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SPATIAL PATTERNS AND WELLNESS IMPACTS OF LPG STATIONS IN EGOR LGA, NIGERIA

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ABSTRACT: This study investigates the spatial distribution of Liquefied Petroleum Gas (LPG) stations in Egor Local Government Area (LGA) and examines their perceived implications on residents' health and well-being. A multi-stage sampling design was employed. Buffers of 100m, 200m, 300m, 400m, and 500m were created around each LPG station, and 100m, 200m, and 300m buffers were made around each LPG retail shop. Residential buildings within these buffers were identified, numbered, and randomly selected using a table of random numbers. A questionnaire was administered to one adult resident in each selected building, resulting in a total of 325 questionnaires, which constituted the study's sample size. By analysing spatial patterns, the research identifies areas of high concentration of LPG facilities and assesses the environmental stressors related to their presence. Residents' perceptions, including anxiety, sleep disturbances, and feelings of helplessness to change location, are explored to understand how proximity to LPG outlets impacts their psychological and physical wellness. This study uniquely combines geospatial analysis with psychological assessments to examine the impact of LPG proximity on well-being within the context of rapid urbanisation in Nigeria. The findings reveal significant links between the location of LPG stations and increased anxiety and sleep disturbance levels among residents, particularly in areas with higher concentrations of LPG outlets. These insights contribute to urban planning by highlighting the need for stricter regulations and safety measures to mitigate the negative impacts of LPG stations on residential areas, offering valuable information for policymakers and stakeholders in community health and urban facility management.

Keywords: LPG Stations, Environmental Stressors, Public Health and Safety, Urban Planning and Well-being, Anxiety

INTRODUCTION

Liquefied Petroleum Gas (LPG) is a widely used source of energy in urban and semi-urban areas, providing a cleaner and more efficient alternative to other fossil fuels. It is a mixture of commercial propane and butane gases obtained from crude oil in petroleum processing plants, liquefied by pressurising and cooling (Murugkar et al., 2006), and for safety purposes, contains a sulphur-based odorising agent to allow leaks to be more easily detected (Sirdah et al., 2013). The increasing reliance on Liquefied Petroleum Gas (LPG) as a primary energy source for domestic and commercial use in Nigeria has made the establishment of LPG stations a common sight in urban areas. As a cleaner and more efficient alternative to traditional fuels like wood and kerosene, LPG

plays a vital role in reducing indoor air pollution and advancing the country's shift towards cleaner energy solutions (Imelda, 2020; Roche et al., 2024).

The importance of LPG is widely acknowledged, particularly in its contribution to advancing goals like SDG7, "ensuring access to affordable, reliable, sustainable and modern energy for all" by 2030 (Gan et al., 2019), as it is commonly used as a household cooking fuel in both developed and developing nations. However, this represents only a small aspect of its broader significance. The rapid proliferation of LPG stations, particularly in densely populated areas, has sparked growing concerns about the spatial arrangement of these facilities and their potential impact on public wellness (Gan et al., 2019). In areas like Egor Local Government Area (LGA) in Edo State, where urbanisation is fast-paced and regulatory oversight may be inadequate (see Ulasi et al., 2020; Akpi et al., 2023; Antwi et al., 2024), the clustering of LPG stations raises questions about safety, environmental sustainability, and residents' wellness. In this research, the concept of wellness encompasses both the physical health and psychological wellbeing of the population.

The spatial distribution of LPG stations is a critical urban planning issue, particularly in relation to the risks associated with gas leaks, explosions, and air pollution. When LPG stations are poorly sited, such risks can have devastating consequences, not only in terms of immediate safety but also in long-term health outcomes for nearby residents (Clean Cooking Alliance, 2021; Kukfisz et al., 2022). In many cases, the siting of LPG stations in close proximity to residential neighbourhoods exposes the population to environmental stressors such as noise, air pollution, and the psychological burden of living near potentially hazardous facilities (see Mshelia et al., 2015; Akote et al., 2021; Mäkká et al., 2024). This study seeks to explore these risks by analysing the spatial patterns of LPG stations in Egor LGA and examining the perceived impacts on residents' wellness, which encompasses both physical health and psychological wellbeing.

The relevance of studying the spatial distribution of LPG stations goes beyond the immediate implications for public safety (Adedeji et al., 2022). It also touches on broader issues of urban inequality and environmental justice. In many urban settings, low-income and densely populated neighbourhoods are more likely to house hazardous facilities such as LPG stations, further compounding the risks faced by already vulnerable populations (Akote et al., 2021). This spatial imbalance of LPG not only affects the health and psychological wellbeing of residents but also raises concerns about equitable access to safe living environments (Aayushi et al., 2024). As such, understanding how LPG stations are distributed within Egor LGA, with a population density of 5,707/km^2 and average income level of ₦96,062.78 ($124.68) in Egharevba (2024) can provide insights into the extent of environmental risks faced by different communities and offer guidance for more sustainable and equitable urban development practices.

This study addresses this gap by examining how spatial clustering of LPG stations in Egor LGA influences residents' anxiety, sleep quality, and perceived helplessness by integrating geospatial and survey data.

Theoretical Framework

This study is anchored on the Environmental Stress Theory and Urban Planning Theory.

The Environmental Stress Theory (EST) emerged from the field of environmental psychology, which seeks to understand how the physical environment affects human behaviours and wellbeing (Lazarus & Cohen, 1977; Schertz et al., 2022; Reuben, 2022). The theory was initially developed in the 1960s by psychologists such as Gary W. Evans, who emphasised that prolonged exposure to environmental stressors, which are defined as elements in the physical environment that threaten the wellbeing of individuals, can have detrimental effects on both mental and physical health (Evans, 2001). The theory builds upon earlier psychological models of stress, like Hans Selye's General Adaptation Syndrome (GAS), which describes how organisms respond to stressors but focuses specifically on how aspects of the environment contribute to chronic stress and its associated health impacts (McCarthy, 2020).

The core principle of EST is that certain environmental conditions, known as stressors, can impose strain on individuals, triggering a stress response. These stressors can be physical (e.g., pollution, noise, extreme temperatures), social (e.g., overcrowding, social isolation), or perceptual (e.g., the perceived threat of an accident) (Kapur, 2021). The theory suggests that the body's response to stress, originally adaptive for short-term survival, becomes harmful when exposure to stressors is sustained over a long period. Chronic exposure to stressors results in adverse psychological outcomes, such as anxiety, depression, and cognitive impairment, as well as physical consequences, such as cardiovascular diseases, respiratory problems, and weakened immune systems. One of the fundamental aspects of this theory is the individual's perception of the stressor. It posits that the degree of impact depends not only on the objective nature of the environmental stressor but also on how it is perceived by individuals (Nesma et al., 2023). A constant sense of danger or threat, even without the actual occurrence of a hazardous event, can still cause significant psychological distress.

Evans and Cohen (2004) emphasized that chronic stress arises from prolonged exposure to environmental stressors, which can overwhelm an individual's ability to adapt, leading to cumulative psychological and physiological strain. Their work reinforces the Environmental Stress Theory (EST) by highlighting how persistent exposure to adverse environmental conditions such as pollution, noise, overcrowding, or perceived threats can result in sustained stress responses, negatively impacting mental and physical health. This perspective strengthens EST's foundation by underscoring the role of environmental factors in shaping long-term well-being, particularly in urban settings where individuals are continuously subjected to multiple stressors. The relevance of this framework is evident in the study of LPG stations, as their presence can generate chronic stress among nearby residents due to ongoing fears of accidents and exposure to pollutants, ultimately affecting their overall health and quality of life.

Liquefied Petroleum Gas (LPG) stations, with their associated risks of gas leaks, explosions, fires, and air pollution, fall well within the framework of environmental stressors described by the Environmental Stress Theory. LPG stations represent both real and perceived dangers, as residents living in proximity to these facilities may experience stress due to the constant fear of accidents or health risks from exposure to pollutants. In line with the EST, even the mere presence of LPG stations, without any actual disaster, can heighten stress levels among residents, leading to increased anxiety, disrupted sleep patterns, and a reduced sense of wellbeing.

For instance, noise from delivery trucks, the potential for gas leaks, and the visibility of the station itself may serve as daily reminders of the potential dangers. Over time, this exposure can result in chronic stress, manifesting in both psychological symptoms (e.g., heightened anxiety, sleep disturbances) and physical health issues (e.g., respiratory problems, hypertension). The theory helps explain why residents near LPG stations often report higher levels of anxiety and stress, as they are subjected to continuous exposure to these environmental stressors, whether or not an actual hazard occurs. This aligns with findings from numerous studies on the health and psychological impacts of living near hazardous facilities, reinforcing the need for careful spatial planning and risk mitigation strategies.

Urban Planning Theory emerged in the late 19th and early 20th centuries in response to rapid urbanisation and industrialisation in Europe and North America. Thinkers like Ebenezer Howard, with his "Garden City" concept, and Le Corbusier, through his "Radiant City" model, laid the foundation for structuring cities to meet both functional and human needs. The theory evolved to address the growing complexities of urban life, focusing on how cities can balance population demands with sustainable and equitable land use. It advocates for efficient spatial arrangements that enhance the quality of life for urban dwellers by promoting safe, accessible, and organised infrastructure (Zulfiqar, 2023).

The core principles of Urban Planning Theory (UPT) emphasise zoning, accessibility, sustainability, and equity. Zoning ensures that different land uses, such as residential, commercial, and industrial, are strategically located to minimise conflict and maximise public safety (Fainstein, 2024). Accessibility ensures that all urban residents can easily access essential services like transportation, schools, and healthcare (Egharevba & Asikhia, 2018). Sustainability highlights the integration of green spaces and environmental considerations to promote liveable and environmentally friendly cities (Nebo & Ndukwe, 2023; Mani, 2024). Equity, a key element of the theory, ensures that all residents benefit from urban development without any group disproportionately suffering from negative externalities such as pollution or noise (see Lemaire & Kerr, 2017).

A central aspect of UPT is its focus on equity in infrastructure development, particularly in the placement of potentially hazardous facilities like LPG stations. Unequal access to urban amenities or a higher concentration of hazardous infrastructures in low-income or marginalised areas can lead to environmental injustice (Fernández et al., 2024). Ensuring fair access to safe and clean environments requires policies that prevent certain groups from bearing the brunt of urban development risks (James, 2023; Chaudhry, 2024). This principle is essential in ensuring that urban growth benefits all without disproportionately affecting vulnerable communities.

When applied to the spatial distribution of LPG stations, Urban Planning Theory underscores the importance of thoughtful placement to balance safety, accessibility, and equity. While LPG stations are essential for energy supply, they also pose risks such as air pollution, noise, and fire hazards. Therefore, their location must minimize these risks while ensuring equitable access for residents. By incorporating buffer zones and placing LPG stations in commercial or industrial zones rather than densely populated residential areas, urban planners can safeguard community wellness while maintaining accessibility to energy resources.

Interplay between Environmental Stress and Urban Planning Theories

The integration of both theories offers a more comprehensive understanding of the perceived impact of LPG stations on wellness. Environmental Stress Theory provides insight into how the presence of LPG stations contributes to individual stress and health issues. At the same time, Urban Planning Theory addresses the broader, systemic issues related to spatial distribution, safety, and equity. Together, these theories highlight the dual nature of the problem: on the one hand, there is the immediate environmental and psychological stress caused by the proximity to potentially hazardous infrastructure, and on the other, there are long-term systemic issues arising from poor urban planning decisions.

For example, if LPG stations are concentrated in certain neighbourhoods, those residents are not only more exposed to environmental stressors (as per Environmental Stress Theory) but are also victims of inequitable land-use practices (as per Urban Planning Theory). This dual exposure exacerbates the wellness impact, making it more urgent for urban planners and policymakers to address the clustering of such hazardous facilities through proper zoning, stricter environmental regulations, and a focus on sustainability and equity.

Understanding the perceived impact of LPG stations through the combined lenses of Environmental Stress Theory and Urban Planning Theory provides an all-inclusive view of how these facilities affect wellness. It underscores the need for more thoughtful urban planning practices that prioritise both physical safety and mental wellbeing and calls for a balanced approach to infrastructure development that protects vulnerable communities from the environmental stressors associated with LPG stations.

LITERATURE REVIEW

The environmental and health risks of LPG stations emerge as a significant theme in the literature, with multiple studies highlighting the potential dangers posed by these facilities. Mäkká et al. (2024) assess the environmental risks associated with gas stations, focusing on hazardous material spills, especially in sensitive areas like the High Tatras National Park. The study calls for risk assessments beyond legislative frameworks to better safeguard public health and the environment. Similarly, Adedeji et al. (2022) examine the indiscriminate establishment of petrol stations in Abeokuta, Nigeria, which results in significant fire risks and environmental hazards such as soil and groundwater contamination. In a similar vein, Douti et al. (2019) explore the spatial distribution of petrol stations in the Kassena-Nankana district of Ghana. The study reveals that most stations fail to adhere to siting regulations, posing serious health and safety risks to residents living in close proximity to these facilities. van Kamp et al. (2020) established that environmental noise, which is an environmental stressor, can lead to sleep disturbance

Another critical issue is the spatial distribution and regulatory compliance of these stations, focusing on how these facilities are sited relative to public buildings and residential areas. Kukfisz et al. (2022) investigate the spatial arrangement of LPG filling stations, challenging the need for a 60-meter safety distance between LPG stations and public buildings. Their findings suggest that mandatory distances may not be necessary if appropriate safeguards are in place. Similarly,

Adewuyi et al. (2021) and Kelechi et al. (2024) both highlight the lack of compliance with planning standards in Nigeria. In Awka, Anambra State, they found that many stations are located closer to roads and other sensitive areas than permitted by regulations, while Adewuyi et al. reveal that a significant proportion of gas stations in Ibadan do not comply with standards set by the Energy Regulation Board, contributing to increased environmental and health risks.

The health impacts of LPG stations and workers is another important theme in the literature. Sirdah et al. (2013) explore the health risks faced by LPG workers in Gaza, reporting significantly higher levels of red blood cells, kidney function abnormalities, and liver enzyme activity among workers compared to control groups. This suggests that long-term exposure to LPG may have serious health consequences. Olanrewaju et al. (2020) investigated the perceived environmental health impact of gas stations in Ede, Osun State and found that the respondents' perception of the impact of petroleum gas stations was low. Similarly, Akpi et al. (2023) investigate disaster preparedness at LPG stations in Port Harcourt, Nigeria. Although many stations are equipped with safety devices and emergency plans, significant gaps remain in staff training and preparedness for potential disasters, raising concerns about the overall safety of these facilities for both workers and nearby residents.

Another theme of growing importance is the transition towards clean energy and its implications for LPG use. Roche et al. (2024) project various clean cooking energy scenarios for Nigeria, emphasizing the health and environmental benefits of moving away from wood fuel reliance. Their study highlights how a shift towards LPG and other cleaner energy sources can reduce premature deaths and significantly decrease carbon emissions. This research underscores the need for immediate action to promote cleaner cooking alternatives, particularly in developing countries where reliance on polluting energy sources remains high.

While the existing literature addresses the spatial distribution, environmental risks, and health impacts of petrol and LPG stations, particularly in relation to improper siting and regulatory non-compliance, there is a gap in understanding the specific wellness implications for residents in Egor Local Government Area. Most studies either focus on the spatial clustering of stations, the occupational health risks to LPG workers, or the broader environmental impacts. However, little attention has been paid to how the proximity of LPG stations directly influences the psychological wellbeing and perceptions of safety among cities' residents. This research aims to fill that gap by exploring how the spatial arrangement of LPG stations impacts the wellness perceptions of residents. By focusing on this underexplored aspect, this study will offer an understanding of the spatial and wellness challenges associated with LPG stations, contributing to both urban planning literature and policy interventions aimed at improving safety and wellbeing in cities.

The Study area

Egor Local Government Area (LGA) is situated in Edo State, southern Nigeria, and forms part of the rapidly expanding urban landscape of Benin Metropolis (Egharevba & Atewe, 2024; Egharevba & Osakue, 2024). It is made up of ten (10) wards, and the area hosts a diverse mix of residential, commercial, and industrial activities, making it a significant hub within the city's economy and serving as a major transit point. Neighbourhoods such as Uselu, Ugbowo, Evbareke,

Use, Uwelu, Okhoro, Ogida, Useh, and Egor have experienced substantial growth in commercial enterprises, including an increasing number of Liquefied Petroleum Gas (LPG) stations (see Figure 1). This proliferation, particularly in or near residential zones, has sparked concerns regarding public safety, environmental health, and overall air quality. Egor LGA was chosen for this study due to its high population density, diverse land use patterns, and growing reliance on LPG as a primary source of domestic energy and power, making it a critical area for assessing the spatial and perceived wellness implications of LPG stations and retails on local residents.

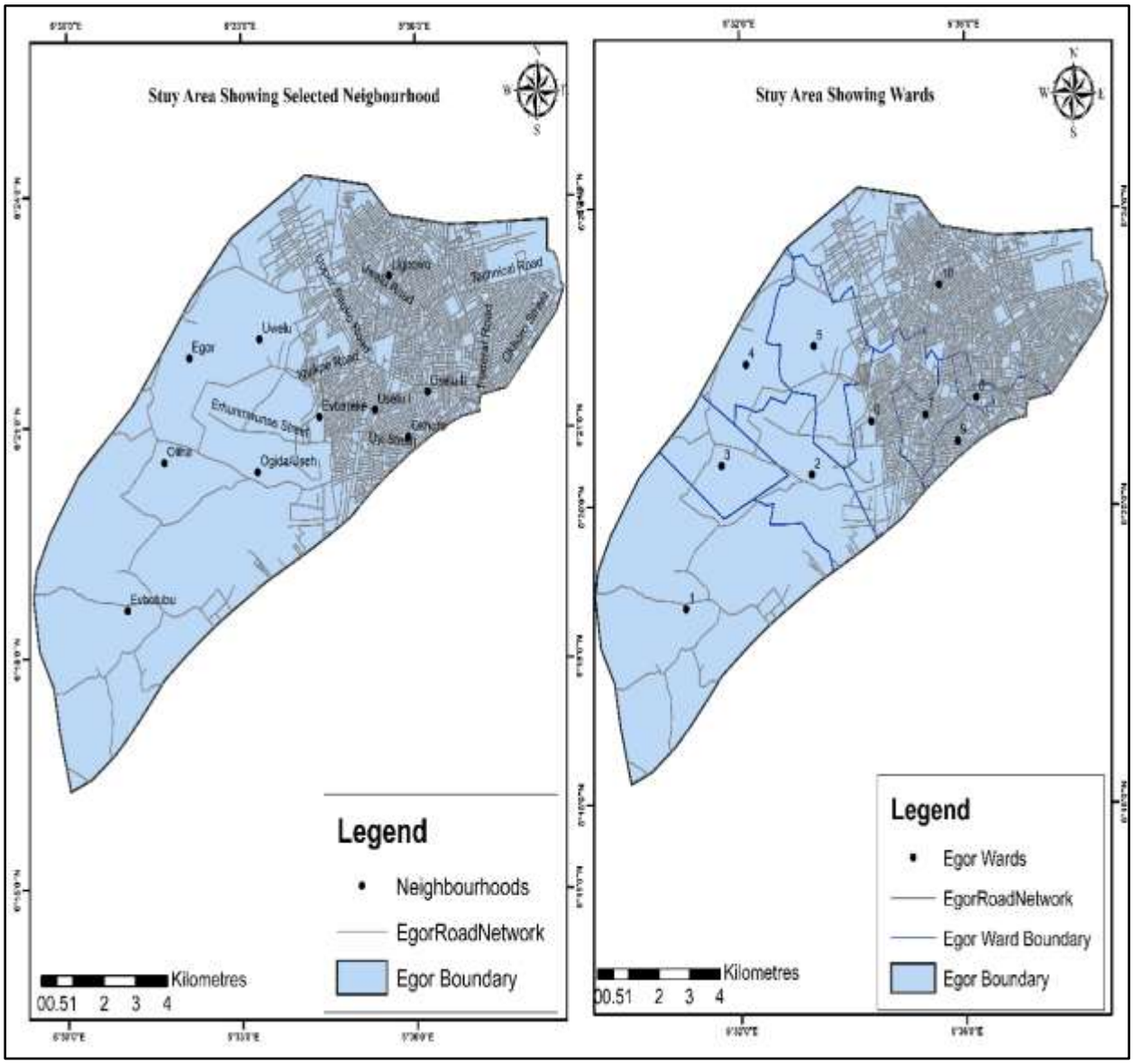

Figure 1: Study Area Showing the Neighbourhoods and Wards

History of the Utilisation of Liquefied Petroleum Gas in the Study Area

In Nigeria, the use of LPG was once regarded as a luxury, primarily seen as a cooking and lighting utility accessible only to wealthy households residing in affluent neighbourhoods (Alozie et al., 2007; Adeola, 2021). The use of LPG in the study area has gradually increased over the past few decades, driven by urbanisation, economic growth, and shifts in energy consumption patterns. Historically, cooking fuels in the study area were dominated by firewood and kerosene, particularly in lower-income and rural households (see Akomolafe & Ogunleye, 2017). The shift towards LPG began in the late 1990s and early 2000s, as the government and various energy stakeholders promoted it as a cleaner, more efficient alternative to traditional cooking fuels (World Bank/Energy Sector Management Assistance Programme ESMAP, 2004).

By the mid-2000s, LPG usage began to gain traction in middle-class households in Benin Metropolis, particularly in more affluent neighbourhoods, where access to modern amenities and infrastructure was improving. Government policies promoting cleaner energy and subsidies on LPG cylinders also contributed to its growing adoption. Previously, the major location for refill of LPG cylinders was in the Agbado market, which is located in the core of the city, where there was a cluster of retail LPG sellers. The first LPG station in the study area was at Uselu Shell beside Okundaye Street. Over time, as access to LPG distribution networks expanded, more residents in the urban and peri-urban areas of the Egor began to embrace LPG for domestic use, especially for cooking. In the study area, there are three major sources that residents utilised to fill the LPG cylinders, these are LPG stations, LPG retail-shops and mobile LPG retail-vehicles.

LPG stations can be categorised into two main types: stand-alone LPG stations and multi-product fuel stations that offer a range of petroleum products, including Premium Motor Spirit (PMS), diesel, kerosene, and LPG. Stand-alone LPG stations are dedicated solely to the storage and sale of LPG, typically focusing on residential and commercial customers who rely on LPG for cooking, heating, or small-scale industrial uses. In contrast, multi-product fuel stations house a variety of fuels, making them one-stop facilities for customers seeking not only LPG but also petrol, diesel, and kerosene for their vehicles, generators, or other fuel needs. These stations often operate in busy urban areas or along major roads, providing convenience to both motorists and local residents. In the study area, the multi-product fuel station is the more common type, reflecting the growing demand for diverse fuel options in a single location, driven by the mix of residential, commercial, and industrial activities. This setup also helps optimise land use in densely populated urban areas, where space for infrastructure is limited, while catering to the diverse energy needs of the community. See Plate 1.

LPG retail-shops consist of small-scale outlets, typically stores or caravans, where LPG is sold to end users in smaller, portable cylinders. These shops serve as key points of access for consumers who do not have large storage tanks at home or prefer to purchase LPG in manageable quantities. The primary function of these retail shops is to supply LPG for domestic uses such as cooking, heating, and sometimes for small-scale commercial purposes. See Plate 2.

Mobile LPG retail vehicles are an increasingly popular mode of LPG distribution, particularly in areas where access to traditional LPG stations or retail shops may be limited. These retailers

operate using various types of vehicles such as buses, tricycles (locally known as "keke"), vans, and trucks, to transport and sell LPG directly to consumers. This form of distribution offers significant convenience by providing door-to-door services, allowing customers to purchase LPG cylinders or refills without having to travel to a station or retail outlet. The mobile LPG retailers often serve urban and peri-urban areas where demand for cooking gas is high, and they cater to both residential and small-scale commercial users. The flexibility of the mobile retail model also allows these vendors to reach customers in more remote or densely populated areas, where fixed LPG infrastructure may be inadequate or non-existent. This system not only increases accessibility but also helps to meet the growing energy needs of consumers in a convenient, flexible, and often timely manner. However, it also raises concerns regarding safety and regulation, as these mobile units must adhere to stringent safety standards to prevent accidents, such as leaks or explosions while operating in close proximity to residential neighbourhoods.

Plate 1: LPG Station

Plate 2: LPG Retail-shop

In recent years, the rising costs of kerosene and wood for cooking, as well as petrol (PMS) and diesel as fuel sources for generators, compared to the relatively more affordable price of LPG for similar purposes, have contributed to a significant increase in the adoption and use of LPG (Ogundari, 2018; Ibiamagabara, 2020; Jimoh, 2024). However, affordability and accessibility remain challenges for many lower-income households, leading to the continued use of alternative fuels in some areas (see Ye & Koch, 2023). Despite these challenges, LPG has become an integral part of urban energy consumption in Benin City, with increasing commercial activities and the proliferation of LPG stations facilitating broader adoption across the city.

METHODOLOGY

The study employed a cross-sectional survey research design method using diverse data sourcing tools which included personal observation and questionnaire (primary source). Personal observation was conducted by using GPS receiver to take geospatial coordinates of the LPG stations, LPG retail shops, and selected residential houses for the survey. The questionnaire included questions about the respondents' social, demographic, and economic attributes, as well as their levels of anxiety, sleep disturbances, and feelings of helplessness regarding their ability to relocate.

The multi-stage sample design was adopted. A buffer of 100m, 200m, 300m, 400m, and 500m was made independently around each LPG stations while 100m, 200m, and 300m was made independently around each LPG retail-shops. According to the Department of Petroleum Resources (DPR, 2018), the proposed location for an LPG storage tank must be at least 15 meters from any adjacent property that may be developed and a minimum of 50 meters from public buildings, including hospitals, schools, parks, train or metro stations, mosques, and churches. From within each buffer, the identified residential buildings were numbered, and a table of random numbers was used to select from the numbered buildings within each buffer. A residential building was selected from each buffer zone (100m to 500m) around LPG stations and from each buffer zone (100m to 300m) around LPG retail shops, resulting in a total of 325 buildings selected for the study. The spatial unit for analysis in the study was the wards in the study area. The software used for the analysis was ArcGIS 10.8

RESULTS AND DISCUSSION

Distribution Pattern of LPG Stations and Retail-shops

Analysing the distribution pattern of LPG stations and retail shops in LGA is crucial for understanding the implications of energy access and public safety in the study area. As LPG continues to replace traditional fuels like firewood and kerosene, it has become essential to assess how evenly these stations and retail shops are distributed across the study area, especially in relation to wards in the study area. Such an analysis is necessary for identifying potential risks associated with the proximity of LPG facilities to homes and public spaces, particularly in densely populated neighbourhoods. Moreover, it highlights the accessibility of clean energy sources to different socio-economic groups, ensuring that the benefits of LPG are equitably distributed. By evaluating these patterns, policymakers and urban planners can address gaps in service coverage, improve regulatory frameworks for safer siting of LPG stations, and contribute to sustainable energy planning in the study area.

Table 1: Distribution of Liquefied Petroleum Gas Stations and Retail-shops in Egor LGA

Name of Wards	Ward Code	LPG Stations		LPG Retail-shops	
		Frequency	Percentage	Frequency	Percentage
Evbotubu	01	0	0.0	9	16.1
Ogida/Useh	02	7	20.6	8	14.3
Oliha	03	0	0.0	4	7.1
Egor	04	4	11.8	5	8.9
Uwelu	05	3	8.8	6	10.7
Evbareke	06	3	8.8	4	7.1
Uselu I	07	2	5.9	5	8.9
Uselu II	08	6	17.6	4	7.1
Okhoro	09	4	11.8	5	8.9
Ugbowo	10	5	14.7	6	10.7
Total		34	100%	56	100%

Source: Field Survey, 2024.

The distribution of LPG stations and retail-shops across Egor LGA revealed significant variation among the different wards. As shown in Table 1, LPG stations are unevenly distributed, with the highest concentration in Ward 02, which is primarily residential with limited industrial activity. Ward 08 follows closely behind in terms of LPG station density. Interestingly, despite Ward 10 having a higher concentration of commercial and industrial land uses than Ward 04, which is more residential, Ward 10 has more LPG stations. This discrepancy could be attributed to the socio-economic characteristics of the residents in Ward 10, which houses staff and students from the University of Benin and the University of Benin Teaching Hospital, leading to higher LPG demand because of proximity to their place of work and school. In contrast, Ward 01 and Ward 03 have no LPG stations, likely due to their lack of major road networks. A detailed analysis of the site locations shows that most LPG stations are located along arterial or major roads, improving accessibility and distribution. This observation is consistent with the findings of Kelechi et al. (2024), who also noted that the stations were primarily positioned along main roads.

The distribution of LPG retail shops in Egor LGA is uneven but show a wider spread across the wards compared to LPG stations. Ward 01 has the highest concentration of retail shops, likely due to the absence of LPG stations, as the predominantly residential area depends on the products and services provided by these smaller-scale outlets. This is followed by Ward 02, which also has a significant number of LPG retail shops. Wards 04, 05, and 10 exhibit relatively balanced access to LPG retail shop services, ensuring availability across these areas. Notably, Ward 1, despite having no LPG stations, has the highest number of retail shops, underscoring the ward's reliance on smaller-scale LPG distribution to meet local demand.

In order to make a general statement on the pattern distribution of LPG stations and retail shops in the study area, Nearest Neighbour Analysis NNA was carried out. The NNA helps determine whether the locations of these facilities are randomly distributed, dispersed, or clustered, providing insights into accessibility, potential risks, and service gaps in Egor LGA. See Figures 2 and 3.

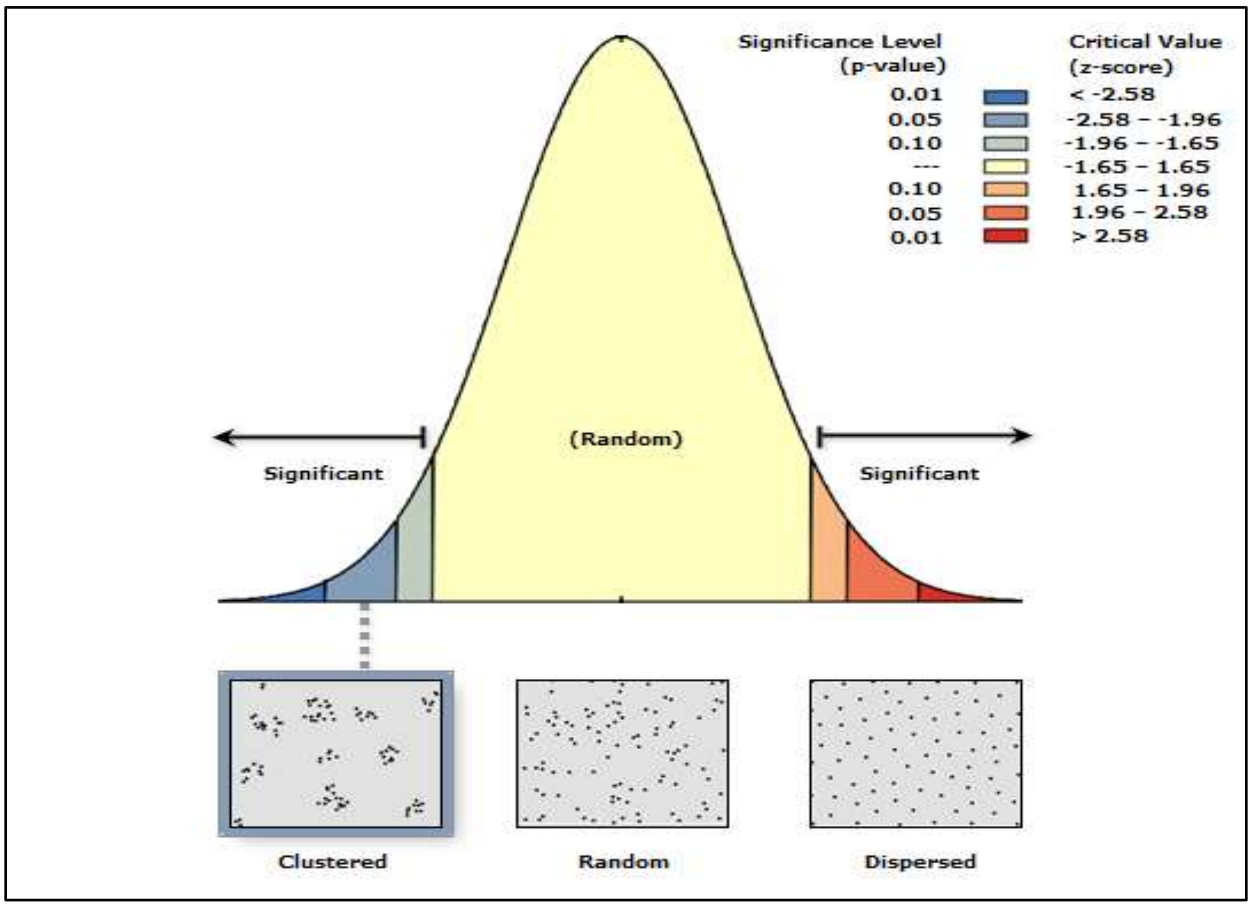

Figure 2: Nearest Neighbour Summary for LPG Stations in Egor LGA

Source: Author's Computation, 2024.

Nearest Neighbour Ratio:	0.787413
z-score:	-2.371412
p-value:	0.017720

Average Nearest Neighbour Summary

Observed Mean Distance: 339.6096 Meters

Expected Mean Distance: 431.2979 Meters

The Nearest Neighbour Analysis (NNA) for LPG stations in Egor LGA reveals significant insights into the spatial distribution pattern of these facilities. The Nearest Neighbour Ratio (NNR) of 0.787 suggests that the LPG stations in the area are not randomly distributed but tend to exhibit a clustered pattern. An NNR less than 1 indicates clustering, which in this case is statistically

significant, as shown by the z-score of -2.37 and a corresponding p-value of 0.0177. The negative z-score further supports this clustering tendency, while the p-value, being less than 0.05, confirms that the observed clustering is unlikely to have occurred by chance.

The observed mean distance between LPG stations is 339.61 meters, which is notably smaller than the expected mean distance of 431.30 meters if the distribution were random. This deviation reinforces the clustering pattern, as the LPG stations are located closer to each other than would be expected in a random distribution.

This clustering has important implications for urban planning and safety in Egor LGA. The concentration of LPG stations in certain areas could increase competition and service efficiency in those zones. Still, it may also elevate risks, such as fire hazards, environmental concerns, and exposure to potential accidents. Furthermore, this pattern could highlight service gaps in less dense areas where access to LPG may be limited. Addressing these spatial inequalities is crucial to ensuring that the distribution of LPG stations supports both accessibility and public safety across the LGA.

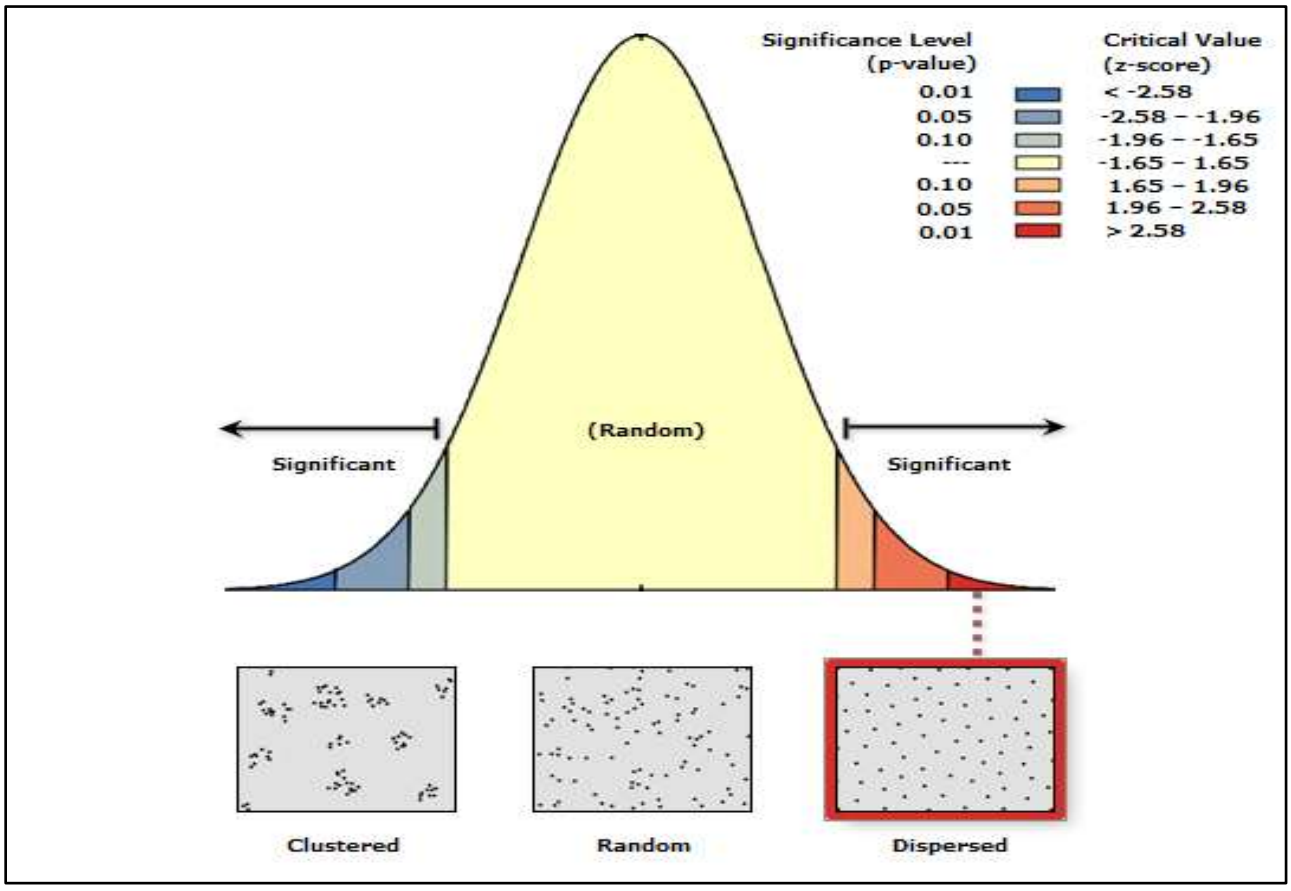

Figure 3: Nearest Neighbour Summary for LPG Retail-shops in Egor LGA

Source: Author's Computation, 2024.

Nearest Neighbour Ratio:	1.401404
z-score:	5.797628
p-value:	0.000000

Average Nearest Neighbour Summary

Observed Mean Distance: 1012.5350 Meters

Expected Mean Distance: 722.5146 Meters

The NNA for LPG retail shops in Egor LGA indicated a distribution pattern that is statistically significant and distinct from that of the LPG stations. The NNR of 1.401 indicates a tendency toward dispersion rather than clustering. An NNR greater than 1 suggests that the retail shops are spread out more than would be expected in a random distribution. The z-score of 5.80 further supports this finding, with a very low p-value of 0.000000, which confirms the statistical significance of the result. This means the dispersed pattern is highly unlikely to be due to random chance.

The observed mean distance between LPG retail shops is 1,012.54 meters, which is significantly larger than the expected mean distance of 722.51 meters if the distribution were random. This dispersed distribution could have several implications for accessibility and service delivery in Egor LGA. The wider spacing between LPG retail shops could mean that residents in some areas might have limited access to LPG retail services, necessitating longer travel distances to purchase LPG.

Spatial Distribution of Anxiety, Sleep Disturbance, and Helplessness Levels Regarding Relocation Among Respondents

Studying the spatial distribution of perceived anxiety, sleep disturbance, and feelings of helplessness regarding relocation among respondents is crucial for understanding how environmental stressors and proximity to hazards (urban planning) affect the wellness of the people. By analysing the spatial patterns of these wellness indicators, it becomes possible to identify areas where residents may be disproportionately affected by such stressors. Understanding these spatial patterns also provides insight into how environmental and social factors intertwine, influencing individuals' wellness and their perceived helplessness in controlling their living conditions. To do this, inverse distance weight interpolation analysis was carried out to show the surface spread of the perceived level of anxiety, sleep disturbance, and feeling helpless in changing one’s proximity to LPG stations and retail-shops. Also, linear regression was carried out to establish distance significantly predicts the dependent variables.

Anxiety Level

Figure 4 shows the spatial distribution of anxiety levels among residents in Egor LGA, overlaid with the locations of LPG stations and retail shops. The perceived anxiety levels are colour-coded, ranging from lower levels (blue) to higher levels (red), indicating varying degrees of stress across different wards.

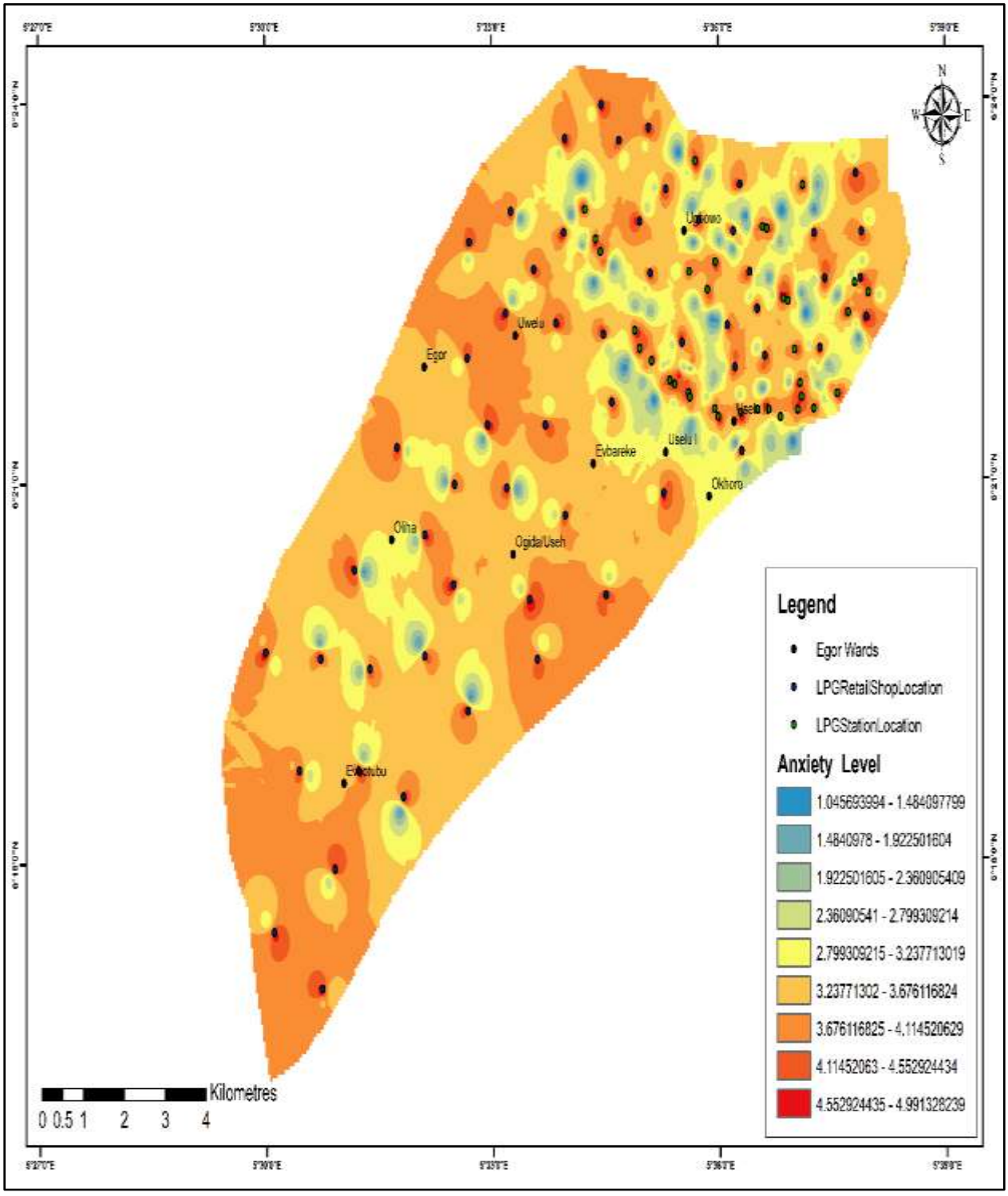

Figure 4: Spatial Distribution of Anxiety Level Among Residents in Egor LGA

Source: Author's Computation, 2024.

From an environmental stress perspective, the map reveals significant clusters of high anxiety (orange to red) in areas with a high concentration of LPG retail shops and stations. This is particularly noticeable in regions such as Ward 7, Ward 5, and Ward 2, where residents experienced heightened levels of environmental stress due to the proximity of LPG facilities. The presence of these stations near residential zones could contribute to concerns about safety, air quality, and potential hazards, leading to increased stress and anxiety.

In contrast, areas with fewer or no LPG stations, such as Ward 1 and Ward 3, show comparatively lower anxiety levels (yellow to light orange), suggesting that the absence of LPG stations may be linked to reduced environmental stress. However, the reliance on retail LPG outlets in these areas also shows that they may still play a role in local anxiety levels.

From an urban planning standpoint, the spatial distribution of anxiety reflects potential conflicts in land use planning, where industrial or commercial activities, such as the placement of LPG stations, may not be adequately separated from residential areas. This imbalance could exacerbate health and safety concerns among residents, as well as reduce overall quality of life. Proper zoning regulations, environmental impact assessments, and buffer zones between industrial facilities and residential areas are essential for mitigating the psychological and physical stressors associated with urban living. This finding aligns with Adedeji et al. (2022), which revealed that filling stations pose significant risks and may contribute to elevated anxiety levels among residents living nearby.

Sleep Disturbance Level

Figure 5 illustrates the spatial distribution of sleep disturbance levels in Egor LGA, overlaid with the locations of LPG stations and retail shops. The colour gradient represents varying levels of perceived sleep disturbance, ranging from low (green) to high (red). By analysing the map through the lens of environmental stress and urban planning theory, we can infer the impacts of LPG facilities on the well-being of residents.

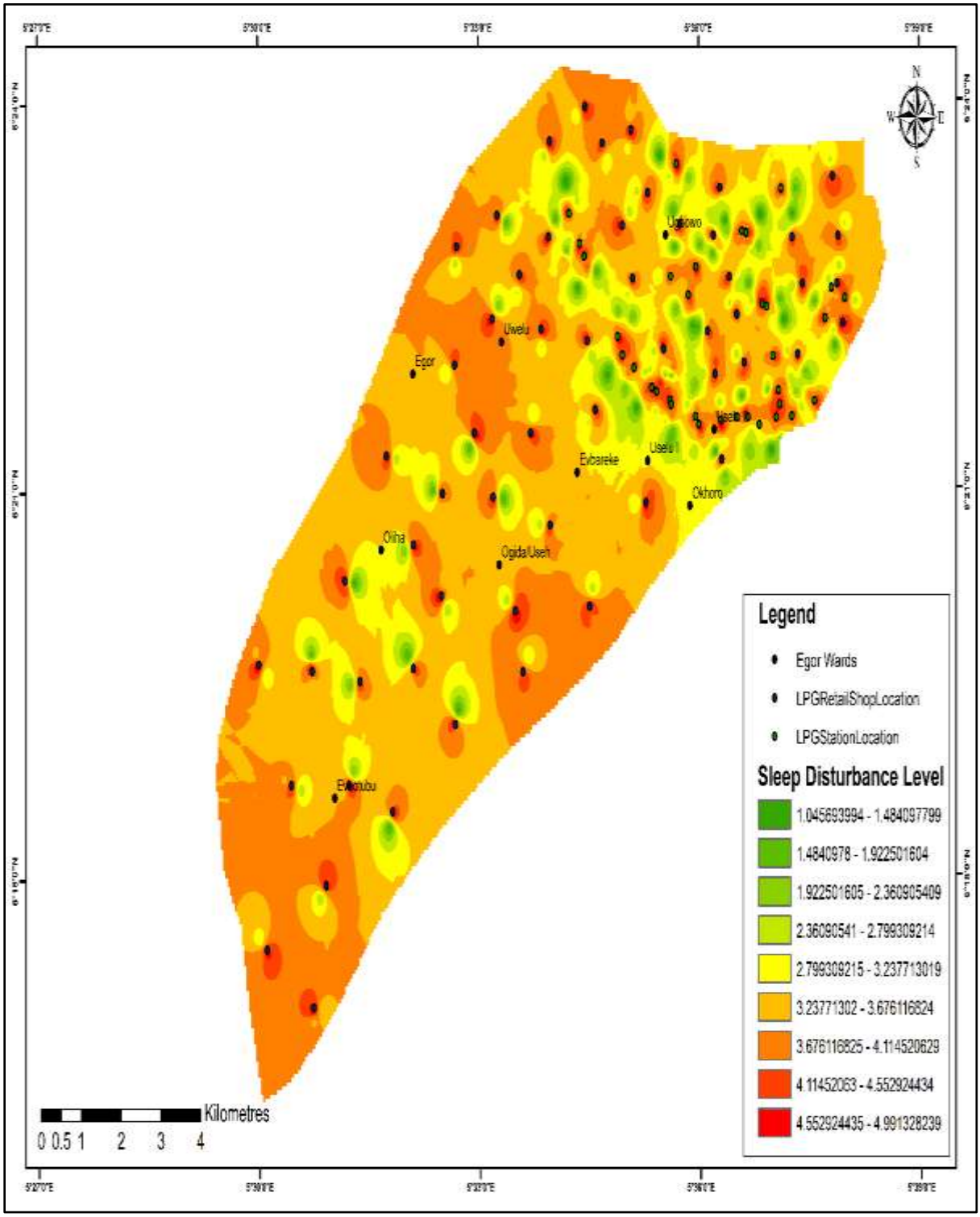

Figure 5: Spatial Distribution of Sleep Disturbance Among Residents in Egor LGA

Source: Author's Computation, 2024.

High sleep disturbance levels, particularly in areas shaded red and orange, suggest that environmental stressors may be more prevalent in those regions. These stressors could include noise, air pollution, and safety concerns linked to the presence of LPG stations and retail shops. The proximity of industrial or commercial activities to residential areas is a known contributor to heightened stress levels, which can, in turn, lead to poor sleep quality. Notably, areas like Ward 7, Ward 10, and Ward 2 show significant levels of sleep disturbance and also feature a higher concentration of LPG stations and retail shops. This correlation indicated that the presence of these facilities disrupted the residents' sleep.

In contrast, areas with fewer LPG stations and retail shops, such as Ward 1 and Ward 2, show relatively lower sleep disturbance levels (green and yellow). This suggested that the absence of industrial or commercial activities close to residential areas may contribute to reduced environmental stress, allowing for better sleep quality. This finding aligns with the research of van Kamp et al. (2020), which revealed that environmental noise significantly contributes to sleeplessness and other disruptions to residents' sleep patterns. Their study established that prolonged exposure to such noise, particularly in urban areas, can increase stress and lead to chronic sleep disturbances.

From an urban planning perspective, the map highlights potential issues related to land use and zoning regulations. The presence of LPG stations and retail shops in close proximity to residential zones indicates poor land use planning. Proper zoning laws should ensure a clear separation between residential, commercial, and industrial activities to reduce the negative impact of environmental stressors on the community. In Egor LGA, the distribution of LPG stations along major roads, often near residential areas, likely exacerbates the problem. The lack of adequate buffer zones or green spaces between these commercial entities and homes may be contributing to sleep disturbances.

Effective urban planning that considers residents' health and well-being should incorporate strategies to minimize environmental stressors. This can include relocating LPG stations farther from residential areas, implementing noise control measures, and introducing green spaces as buffers. Additionally, public health policies addressing the hazards associated with the operation of LPG facilities near homes can help mitigate the negative impact on residents' sleep and overall quality of life.

Feeling Helpless to Change my Proximity to the LPG Station

Figure 6 depicts the spatial distribution of perceived helplessness levels across the Egor Local Government Area (LGA), overlaying the locations of LPG stations and retail shops. The colour gradient represents varying levels of helplessness, with lighter shades indicating lower levels (yellow) and darker shades representing higher levels of helplessness (red). Analysing Figure 7 through the lens of environmental stress theory and urban planning principles provides insight into the relationship between LPG infrastructure and residents’ psychological responses.

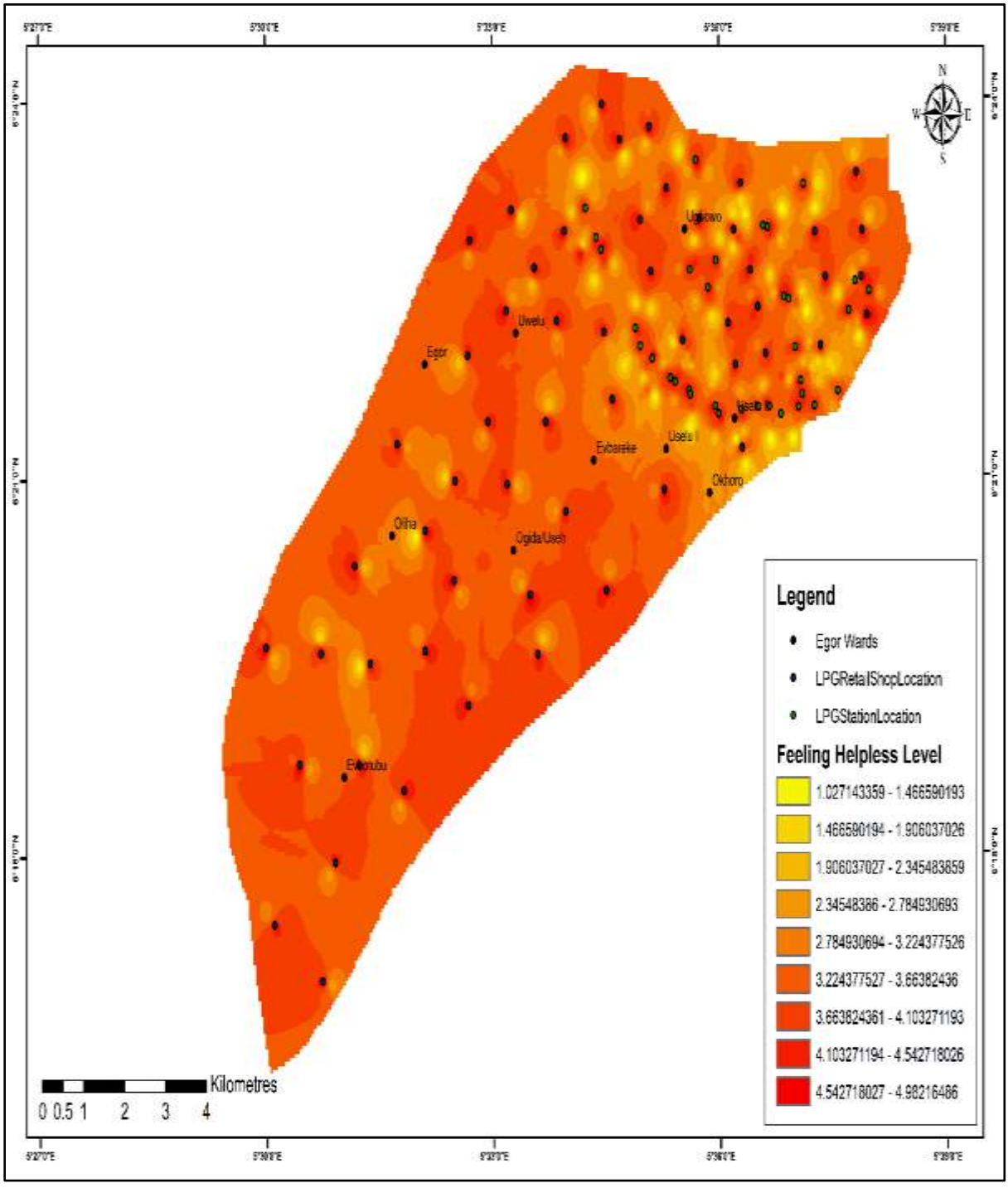

Figure 6: Spatial Distribution of Feeling Helpless to Change Locational Proximity Close to LPG Point Among Residents in Egor LGA

Source: Author's Computation, 2024.

In environmental psychology, stressors such as proximity to industrial or commercial activities can significantly influence residents' feelings of helplessness. Higher levels of helplessness, as indicated by the red areas, appear concentrated around certain wards, particularly Ward 10, Ward 7, and War 5, where LPG stations and retail shops are densely located. The presence of LPG facilities, which may be associated with perceived risks such as potential explosions, noise pollution, or environmental hazards, could contribute to a heightened sense of insecurity and helplessness among residents. This can result from the inability to relocate or reduce their exposure to these stressors.

The areas with high levels of helplessness reflected communities where socio-economic factors limit mobility or resilience, increasing the residents' susceptibility to environmental stressors. Such neighbourhoods feel "trapped" in their current living conditions due to limited financial resources or lack of housing options. This perception of being unable to control or change one's environment is a hallmark of environmental stress and helplessness. This finding is supported by Egharevba (2024), who reported that the mean income of residents in Benin Metropolis is ₦96,062.78 ($124.68). With this income level, relocating to a new apartment is perceived as financially burdensome.

From an urban planning standpoint, the clustering of LPG stations and retail shops in certain wards suggests an uneven distribution of services, which can contribute to disparities in environmental quality and perceived safety across the LGA. Wards with higher concentrations of LPG facilities (e.g., Ward 10, Ward 5, and Ward 7) experience greater exposure to these potentially hazardous sites, which could intensify feelings of helplessness among residents. Proper planning would involve creating buffer zones between residential areas and such infrastructure to mitigate these effects.

Conversely, areas with fewer LPG stations or retail shops, indicated by the yellow shades, have lower perceived helplessness due to less environmental stress from these facilities. This distribution calls for planners to consider more equitable infrastructure placement to balance access to essential services without overburdening specific neighbourhoods with associated risks.

Residents' Perception of the Effect of the Presence of LPG Outlets on the Health, Psychological Wellbeing and Environment

The use of the Relative Importance Index (RII) is vital in evaluating residents' perceptions of the impact of LPG outlets on their health, psychological well-being, and environment. By quantifying concerns, the RII helps to identify and prioritise key issues such as health risks, psychological effects like anxiety, and environmental problems. This method provides valuable insights for policymakers and urban planners, enabling them to make informed decisions about regulations, safety measures, and resource allocation to minimize negative effects on the community. See Appendix 1 for the formula.

From Appendix 1, several concerns related to the presence of LPG outlets in Egor LGA. The most significant issue is the heightened anxiety and stress among residents stemming from the potential dangers of gas leaks, explosions, and fires. Many believe that these risks also lead to a decline in

property values near LPG outlets, making homes less desirable. Noise pollution is another prominent issue, as residents experience disturbances from the operation of LPG outlets, including delivery trucks and refilling activities, which affect their daily lives. This is closely linked to reports of sleep disturbances, where constant noise and worries about safety prevent residents from achieving restful sleep.

Environmental impacts are also a concern, with noticeable changes in local vegetation and perceived threats to water sources due to the presence of LPG outlets. Residents express worries about the potential harm to the local environment and the sustainability of natural resources in the area. Additionally, traffic congestion has increased around LPG facilities, causing frustration among locals, while some also report concerns about possible health risks associated with the outlets. Feelings of helplessness are evident as many residents feel powerless to change their proximity to the LPG outlets or to mitigate the perceived dangers, which leads to frustration and dissatisfaction with their living conditions. Thus, the safety, health, environmental, and economic impacts of LPG facilities on the local community underscore the need for better planning and management to address these issues. Contrary to the findings of Olanrewaju et al. (2020), which indicated a low public perception of LPG's impact, this study revealed that residents of Egor exhibited a High-Medium perception of its effects.

Conclusion

The study on the spatial distribution and wellness impacts of LPG outlets in Egor LGA provides empirical evidence on how the location of these outlets affects residents' health, psychological well-being, and environmental quality. The analysis of spatial patterns and resident responses confirms that proximity to LPG stations is linked to environmental stress, noise pollution, increased anxiety, and sleep disturbances. Findings demonstrate that the clustering of LPG outlets in residential areas correlates with heightened wellness challenges, underscoring the importance of strategic urban planning and environmental health policies. The study establishes the necessity of implementing regulatory measures, such as 200-meter buffer zones between LPG stations and residences, in alignment with WHO guidelines to mitigate these adverse effects and ensure a safer living environment.

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Appendix 1

Residents Perception of the Effect of the Presence of LPG Outlets on the Health, Psychological Wellbeing and Environment.

Statements	SA	A	N	D	SD	Total	Mean Rank Weight	RII (%)
The availability of LPG facilities poses a threat to local water sources in Egor Local Government Area	85 26%	131 40.4%	78 24%	26 8%	4 1.1%	325 100%	**3.82**	**76.4%**
Noticeable changes in local vegetation are observed due to the presence of LPG facilities in Egor Local Government Area	98 30.1%	185 57%	31 9.4%	7 2.2%	3 0.8%	325 100%	**3.88**	**77.6%**
The presence of LPG facilities has led to an increase in noise pollution in residential areas of Egor Local Government Area	85 26%	205 63%	29 9%	3 1%	3 1%	325 100%	**4.12**	**82.4%**
The presence of LPG facilities has led to a decrease in property values in proximity to these facilities in Egor Local Government Area	123 38%	172 53%	14 4.4%	13 4.1%	2 0.5%	325 100%	**4.24**	**84.8%**
The presence of LPG facilities has led to an increase in traffic congestion in Egor Local Government Area	76 23.5%	125 38.5%	55 17%	49 15.2%	17 5.3%	325 100%	**3.59**	**71.8%**
The presence of LPG facilities can lead to health challenges in Egor Local Government Area	46 14%	145 44.5%	8 26.5%	37 11.5%	11 3.5%	325 100%	**3.56**	**71.2%**
The possibility of gas leaks, explosions, or fires induces anxiety and stress in you. (Increased Anxiety and Stress Level)	114 35%	65 20%	78 24%	52 16%	16 5%	325 100%	**4.31**	**86.2|%**
Knowing that LPG is highly flammable creates a	125	89	49	37	24	325	**3.68**	**73.6%**

constant sense of danger, leading to heightened vigilance and worry about potential disasters. (Increased Anxiety and Stress Level)	38.5%	27.5%	15%	11.5%	7.5%	100%		
Persistent concerns about safety have resulted in difficulty falling asleep or maintaining restful sleep. (Sleep Disturbance)	73 22.5%	119 36.5%	81 25%	44 13.5%	8 2.5%	325 100%	**4.02**	**80.4%**
70.8 %The operations of an LPG 66 station involve noise (from the delivery trucks and refilling of cylinders), contributing to sleep disturbances, particularly for those living very close. (Sleep Disturbance)	50 15.5%	99 30.5%	81 25%	57 17.5%	37 11.5%	325 100%	**3.54**	**70.8%**
I feel helpless due to my inability to change my proximity to the LPG station or mitigate the perceived dangers, which foster feelings of frustration, powerlessness, or even resentment. (Feelings of Helplessness)	86 26.5%	65 20%	55 17%	60 18.5%	59 18%	325 100%	**3.34**	**66.8%**
Total Mean							**3.85**	
$$RII = \frac{weighted\ mean}{maximum\ possible\ weight} X \frac{100}{1}$$								

Source: Author's Computation, 2024

Importance Level from RII

High (H) 80% < RII < 100%

High-Medium (H-M) 60% < RII < 80%

Medium (M) 40% < RII < 60%

Medium-Low (M-L) 20% < RII < 40%

Low (L) 0% < RII < 20%