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ASSESSMENT OF STRUCTURAL ENCROACHMENT WITHIN THE STATUTORY RIGHT-OF-WAY OF 33KV POWER DISTRIBUTION LINES IN DAMATURU METROPOLIS, YOBE STATE, NIGERIA

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Abstract
Encroachment on electricity transmission and distribution rights-of-way (RoW) constitutes a growing challenge in Nigerian urban centres, contributing substantially to electrocutions, wildfires, and power supply disruptions. The statutory setback for 33kV distribution lines in Nigeria is 11 metres as stipulated by the Nigerian Electricity Regulatory Commission (NERC). This study assessed the nature, extent, and drivers of structural encroachment within the 33kV RoW in Damaturu Metropolis, Yobe State, Nigeria. A mixed-methods research design was employed, combining quantitative physical measurements with qualitative inquiry. Using purposive sampling, all structures situated within 11 metres of selected 33kV feeder lines were identified. Distances from structures to conductor centre-lines were measured using a 50-metre measuring tape. A structured questionnaire was administered to 120 property owners/occupants, and key informant interviews were conducted with officials from Yola Electricity Distribution Company (YEDC) and the Yobe State Ministry of Lands and Urban Development. A total of 347 encroaching structures were identified along 6.4 km of surveyed feeder lines. Of these, 42% (n=146) lay within the high-risk zone (<3 metres), 33% (n=115) within the medium-risk zone (3–6 metres), and 25% (n=86) within the low-risk zone (6–11 metres). Commercial structures accounted for 58% of all encroachments identified. Alarmingly, only 22% of respondents were aware of the statutory 11-metre RoW requirement, while merely 8% knew the correct setback distance. Primary drivers of encroachment included land scarcity (48%), ignorance of regulations (31%), and economic pressure (15%). The study reveals widespread, high-risk encroachment on Damaturu's 33kV distribution network, posing significant public safety hazards. Urgent policy interventions are recommended, including selective relocation of high-risk structures, comprehensive public awareness campaigns, strengthened enforcement mechanisms, and institutional capacity building for regulatory agencies.

Keywords: Right-of-way, distribution line, structural encroachment, electrical safety, urban planning.

Introduction
The reliable distribution of electrical energy is fundamental to urban economic development, social well-being, and quality of life in contemporary societies. In Nigeria, the Transmission Company of Nigeria (TCN) and electricity distribution companies (DisCos) are statutorily responsible for delivering power to end-users across the federation (Hamidu, El-Jummah, & Shuwa, 2025). However, the integrity and safety of electricity distribution infrastructure are increasingly threatened by unauthorised development activities within designated rights-of-way (RoW) a phenomenon known as structural encroachment.

According to Harvey and Jowsey (2019), encroachment refers to the unauthorised or gradual intrusion of a structure, object, or activity onto another person's land, property, or public space. It often involves violations of property boundaries, zoning regulations, and land-use policies.

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Encroachments can be intentional or unintentional and may include building extensions, fences, driveways, or businesses extending beyond legal limits (Merriam, 2020). In the context of electricity infrastructure, encroachment poses serious safety risks, including electrocution, fire hazards, and service disruptions (Okafor, 2020; Adebayo & Ogunjuyigbe, 2021).

A critical, yet often overlooked, component of distribution infrastructure is the statutory right-of-way, a designated buffer zone designed to ensure safe operation, maintenance access, and public safety (Adebayo & Ogunjuyigbe, 2021). The Nigerian Electricity Regulatory Commission (NERC) and the Transmission Company of Nigeria (TCN) have established minimum setback distances to mitigate these risks. Specifically, the required minimum distances for construction near power lines are: 5.5 metres by 5.5 metres from 11/33kV lines, 15 metres from 132kV lines, and 25 metres from 330kV lines respectively. For 33kV distribution lines, the statutory setback is 11 metres measured horizontally from the conductor centre-line.

Problem Statement

Despite the existence of these regulatory provisions, enforcement in Nigeria remains notably weak, leading to widespread cases where buildings, markets, and other structures encroach upon the prescribed setbacks of transmission and distribution lines (Ajayi & Akinyemi, 2019). Studies have demonstrated that such encroachments can lead to electric shocks, electrocution, and fires, particularly during storms or equipment failures (Ogunleye & Adebayo, 2022). For instance, Oyedepo (2020) reported that population growth, poor enforcement of planning laws, and inadequate public awareness have resulted in illegal structures proliferating within restricted zones, thereby increasing the risk of accidents and service disruptions.

Building encroachments on electricity transmission lines have become a growing concern due to their potential to disrupt the stability and functionality of electrical infrastructure (Gonçalves *et al.*, 2020). The development of residential, commercial, and industrial structures near transmission corridors presents various risks, including safety hazards, interference with electrical operations, and increased costs of maintenance and repairs (Adebayo, 2022).

Damaturu, the capital of Yobe State in northeastern Nigeria, has experienced rapid population growth and physical expansion over the past decade. The town is served by several 33kV feeders emanating from the Potiskum 132/33kV Substation. Preliminary observations reveal that markets, car parks, and residential buildings have been constructed within metres of these distribution lines, often with rooftop structures passing dangerously close to live conductors. However, no systematic study has documented the nature, extent, or drivers of this encroachment. Without baseline data, effective mitigation remains impossible.

Literature Review

Concept of Right-of-Way and Encroachment

The concept of right-of-way (RoW) in the context of electricity infrastructure refers to a legally defined corridor or strip of land that encompasses transmission and distribution lines, providing safe clearance for the conductors and access for maintenance and emergency operations (Adebayo & Ogunjuyigbe, 2021). The RoW serves multiple critical functions, ensuring public safety by maintaining adequate distance between live conductors and human activities, facilitating access for inspection, maintenance, and repair works, preventing interference with electrical operations from adjacent structures or activities, and providing a buffer zone for potential conductor sag or sway due to environmental conditions (NERC, 2023).

Encroachment, conversely, represents any unauthorised intrusion onto this designated corridor. It may take various forms, including permanent structures (buildings, walls, fences), temporary

structures (market stalls, awnings, car parks), or activities (storage, farming, trading) that violate the prescribed setback requirements (Harvey & Jowsey, 2019).

Regulatory Framework for Electricity Infrastructure in Nigeria

The Nigerian electricity sector operates within a comprehensive regulatory framework established through several legislative instruments. The Electric Power Sector Reform (EPSR) Act of 2005 created the Nigerian Electricity Regulatory Commission (NERC) as the primary regulatory authority, with powers to establish and enforce technical standards, safety regulations, and operational guidelines (Federal Republic of Nigeria, 2005).

Under the EPSR Act and subsequent regulations, NERC has established minimum clearance distances for various voltage levels. For 33kV distribution lines, the statutory setback is 11 metres measured horizontally from the conductor centre-line. This requirement is codified in the Nigerian Electricity Distribution Code and the Safety, Health, and Environment (SHE) Guidelines for the Electricity Industry (NERC, 2018).

The Transmission Company of Nigeria (TCN) is responsible for high-voltage transmission infrastructure (132kV and above), while Distribution Companies (DisCos) manage the 33kV and 11kV networks. However, the enforcement of RoW regulations has proven challenging due to overlapping jurisdictional responsibilities between DisCos, state governments, local authorities, and federal agencies (Ajayi & Akinyemi, 2019).

Drivers of Structural Encroachment

Several interrelated factors drive structural encroachment on electricity RoWs in Nigerian urban centres. These include;

Rapid Urbanisation and Population Growth; Nigerian cities have experienced unprecedented population growth, with urban expansion often outpacing planning and regulatory frameworks (Kasim, 2014). This demographic pressure creates intense competition for land, particularly in prime locations such as market areas and commercial corridors.

Land Scarcity and Affordability; In many urban areas, land is scarce and expensive, leading property owners and developers to exploit any available space, including RoW corridors (Oyedepo, 2020). The economic logic of encroachment is often compelling from an individual perspective, even though it imposes collective costs in terms of safety risks and service reliability.

Inadequate Public Awareness; A significant proportion of the population is unaware of statutory RoW requirements or the associated safety risks (Ogunleye & Adebayo, 2022). This ignorance is particularly pronounced for medium-voltage distribution lines (33kV and 11kV), which are often perceived as "ordinary poles and wires" rather than potentially lethal infrastructure.

Weak Enforcement and Institutional Capacity; Enforcement agencies including state urban planning authorities, building control agencies, and DisCos often lack the resources, political will, or statutory authority to effectively address RoW violations (Ajayi & Akinyemi, 2019). The Lagos State Building Control Agency's demolition of structures within RoWs following public notices and compensation negotiations provides a notable exception (Lagos State Government, 2021).

Economic Pressure and Livelihood Considerations; In many cases, encroachment is driven by economic necessity, with small-scale traders and entrepreneurs establishing businesses in RoW corridors due to limited alternatives (Nwosu & Okeke, 2022).

Consequences of RoW Encroachment

The consequences of structural encroachment on electricity RoWs are multifaceted and severe these include;

Safety Hazards. The most immediate and serious consequence is the risk of electrocution and fire. At distances of less than 3 metres from live 33kV conductors, the risk of electrical flashover where electricity arcs through the air without physical contact becomes significant, particularly during conditions of high humidity, rainfall, or dust storms common in the Sahel region (Ibrahim & Suleiman, 2020).
Service Disruptions. Encroaching structures can interfere with maintenance activities, making it difficult or dangerous for utility workers to access and service lines. Additionally, structures that come into contact with conductors can cause faults, leading to power outages that affect entire neighbourhoods (Abubakar, Idoniboyeobu, & Braide, 2020).
Economic Costs. Power outages caused by RoW encroachments impose substantial economic costs on businesses, households, and the economy at large. Additionally, utility companies incur significant expenses in repairing damaged infrastructure and responding to fault events.
Legal and Liability Issues. RoW encroachment creates complex legal issues, particularly when accidents occur. Property owners, developers, and utility companies may all bear liability for damages resulting from encroachment-related incidents.

Several studies have documented RoW encroachment in various Nigerian urban centres. Ogunyemi *et al*. (2021) conducted a study on 33kV RoW encroachment in Ado-Ekiti, Ekiti State, reported that commercial encroachment accounted for 54% of surveyed sites, with 38% of structures located within 5 metres of conductor centre-lines. Similarly, Nwosu and Okeke (2022) found that 67% of RoW violations in Enugu were driven by market expansion and commercial activities. A study by Adebayo and Ogunjuyigbe (2021) in Ibadan, Oyo State, documented extensive encroachment on 33kV and 11kV distribution lines, with over 45% of structures located within high-risk zones. The study identified ignorance of regulations and economic pressure as the primary drivers.
Also, a study by Ibrahim and Suleiman (2020) assessed RoW encroachment in Kano metropolis, reveal that 52% of encroached structures were within the high-risk zone (<3 metres). The study highlighted the particular vulnerability of the Sahel region to electrical incidents due to climatic conditions.
However, no previous study has systematically assessed RoW encroachment in Damaturu or Yobe State more broadly. This gap represents a significant knowledge deficit, particularly given the region's rapid urbanisation and the presence of critical distribution infrastructure serving the state capital.

Materials and Methods

Study Area

The study was conducted in Damaturu Metropolis, the state capital of Yobe State in northeastern Nigeria. Damaturu is located at latitude 11.7470°N and longitude 11.9662°E. The state is bordered by Borno State to the east, Gombe State to the south, Bauchi State to the west, and Jigawa State to the northwest, to the north, the state shares an international boundary with the Republic of Niger, its strategic location has historically encouraged trade and cultural interactions between Nigeria and neighbouring countries, particularly through trans-Saharan trade routes (Babangida, 2020).
Damaturu has experienced rapid population growth and physical expansion over the past decade, driven by its status as the state capital, the presence of educational institutions including Yobe State University, and its role as a commercial hub for the surrounding agricultural region. The town's urban core is characterised by a mix of residential, commercial, and institutional land uses, with the central market area (Bayan Tasha) representing the primary commercial centre.

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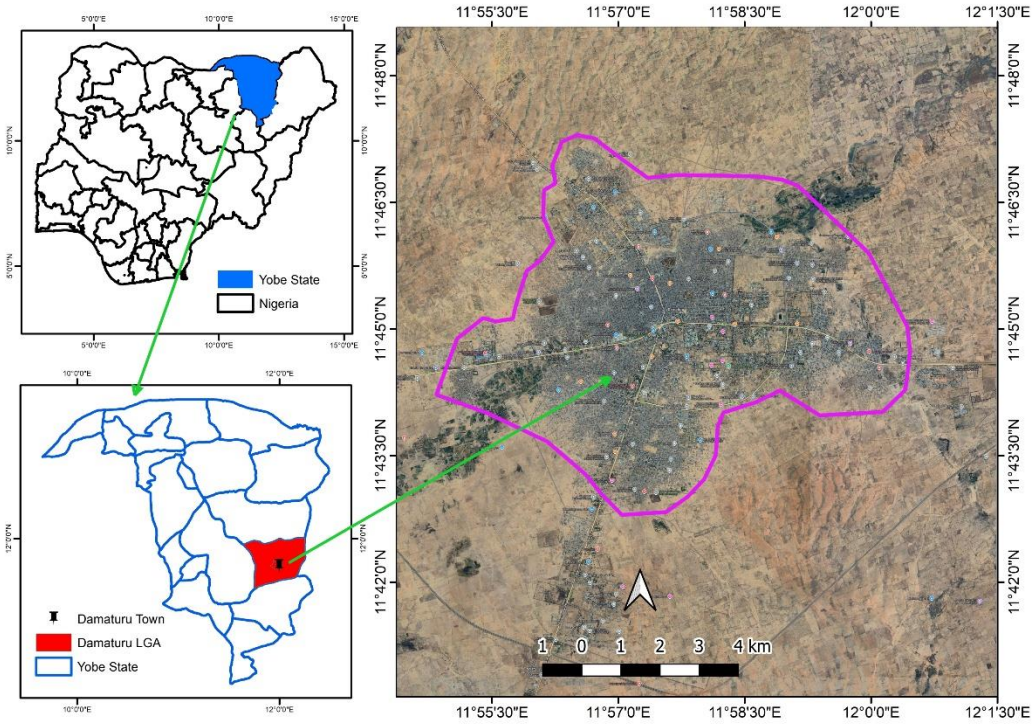

Figure 1: Map of the Study area
Source: Field survey, 2026

The primary 33kV feeders serving the town originate from the Potiskum 132/33kV Substation and include the University feeder (serving Yobe State University and environs) and the Campus feeder (serving the government reserved area and central market). These feeders form the backbone of the town's electricity distribution network.

Methodology

A mixed-methods research design was employed, combining quantitative physical measurements and questionnaire surveys with qualitative key informant interviews. This approach was chosen to provide both breadth and depth of understanding, enabling documentation of the extent and nature of encroachment while also exploring the social, economic, and institutional factors that drive and perpetuate it (Denscombe, 2004). All visibly identifiable 33kV distribution lines within the Damaturu urban core were traced on foot during reconnaissance surveys conducted from an estimated total route length of 12 km, a purposive sample of 6.4 km was selected, comprising two distinct urban typologies that is, Central market corridor (3.3 km). This segment includes the Bayan Tasha market area and Sabon Pegi opposite Pom-Pamari commercial streets. This segment includes areas of mixed land use, combining residential properties with small-scale commercial enterprises, workshops, and services, high-density commercial activity and significant pedestrian and vehicular traffic corridor (3.1 km**)**. Purposive sampling strategy was designed to capture the range of urban typologies and encroachment patterns present in the metropolis, while ensuring accessibility and safety for the research team.

Every structure whose foundation lay within 11 metres (measured horizontally) of the conductor centre-line was included in the survey, irrespective of building type, use, or condition. Structures were defined as any permanent or semi-permanent construction, including buildings, walls, fences, market stalls, awnings, and car parks.

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For each identified structure, the horizontal distance from the nearest point of the structure to the conductor centre-line was measured. Semi-structured interviews were conducted with five key informants. Three maintenance engineers from Yola Electricity Distribution Company (YEDC), the utility responsible for distribution services in Yobe State and two officials from the Yobe State Ministry of Lands and Urban Development, responsible for urban planning and land administration. Interviews explored institutional perspectives on RoW encroachment.

Results

Extent of Structural Encroachment

A total of 347 structures were identified within the 11-metre statutory RoW across the 6.4 km surveyed feeder segments. The density of encroachment was notably higher along the central market corridor (Bayan Tasha) compared to the mixed residential-commercial corridor. In the central market area, encroaching structures were observed along almost the entire surveyed route, with buildings and stalls often extending to within 1–2 metres of conductor centre-lines. In the mixed corridor, encroachment was more sporadic, with clusters of structures interspersed with open spaces and undeveloped plots.

Figure 2: Shops directly under 33kV line at Bayan Tasha; **Source:** Field survey, 2026
Figure 3: Encroached structure at central area
Source: Field survey, 2026

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Figure 4: Encroached Structures Within the 5.5 m Buffer Zone of the 33 kV Powerline at Bayan Tasha
Source: Field survey, 2026

Table 1: Distribution of Encroaching Structures by Risk Zone

Risk Zone	Distance Range	Number of Structures	Percentage (%)
High-risk	<3 metres	146	42.1
Medium-risk	3–6 metres	115	33.1
Low-risk	6–11 metres	86	24.8
Total		**347**	**100**

Source: Field survey, 2026

Table 1 shows that 42.1% of the encroached structures lie within less than 3 metres of live 33kV conductors, placing them in the high-risk category. An additional 33.1% fall within the medium-risk zone of 3–6 metres. Cumulatively, 75.2% of encroached structures were within 6 metres of conductors, significantly compromising safety margins and maintenance access (Figure 2). Only a quarter (24.8%) are located in the low-risk zone (6–11 metres), still within the statutory RoW.
The mean distance from conductor centre-line to encroaching structures was 4.2 metres (SD = 3.1 metres), well below the statutory requirement of 11 metres.

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Table 2: Typology of Encroaching Structures

Structure Type	Number	Percentage (%)	Predominant Risk Zone
Commercial (lock-up shops, stalls, awnings)	202	58.2	High-risk (68% of commercial structures)
Residential buildings	85	24.5	Medium-risk (55% of residential structures)
Mixed-use (shop + residence)	35	10.1	Low-risk to Medium-risk
Temporary structures (car washes, generator sheds)	25	7.2	High-risk
Total	**347**	**100**	

Source: Field survey, 2026

The distribution of encroaching structures by type is presented in Table 2. Commercial structures primarily lock-up shops, open stalls, and market awnings constituted the majority of encroached structures (58.2%). Of these, 68% (137 structures) were located within the high-risk zone (<3 metres). Photographic evidence (Figure 1) showed rooftops and awnings passing within 1–2 metres of 33kV conductors in the market area, with some structures incorporating electrical wiring and metallic roofing materials that increase the risk of conduction and arcing. Residential buildings accounted for 24.5% of encroaching structures, with 55% located in the medium-risk zone (3–6 metres). Many residential structures exhibited signs of incremental expansion and modification, suggesting that initial construction may have been at safer distances before progressive encroachment occurred. Mixed-use structures (10.1%) combined commercial activities on the ground floor with residential occupancy above, representing particularly complex encroachment scenarios due to both daytime commercial activity and nighttime residential occupancy. Temporary structures (7.2%), including car wash bays and generator sheds, were predominantly located in high-risk zones, reflecting the informal and transient nature of these activities.

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Figure 4: Encroached Structures; **Source:** Field survey, 2026

The spatial distribution of encroaching structures along the surveyed feeder segments showed distinct patterns. Along the central market corridor, encroachment density averaged 85 structures per kilometre, with almost continuous encroachment along the entire route. The highest concentration was observed near the market entrance and along the main commercial street, where land values and commercial pressure are most intense. Along the mixed residential-commercial corridor, encroachment density averaged 32 structures per kilometre, with clusters concentrated around major intersections, educational institutions, and areas with higher commercial activity. Residential areas generally exhibited lower encroachment densities, though significant encroachment was observed where residential properties had been converted to commercial use or where informal settlements had developed along the corridor.

The study revealed alarmingly low levels of awareness regarding RoW regulations among property occupants residing within the surveyed zones. Table 3 summarises key awareness indicators.

Table 3: Awareness of RoW Regulations and Risks

Indicator	Number	Percentage (%)
Awareness on the existing regulation	27	22.5
Awareness on the correct setback distance	10	8.3
Information received on RoW from any source	18	15.0
Awareness on the dangers of living near high-tension cables	82	68.3
Risk applies to property under high-tension cables	37	30.8
Experienced electrical incident	20	16.7

Source: Field survey, 2026

The findings reveal that only 22.5% (27 of 120) of respondents were aware that a statutory RoW exists for 33kV distribution lines. Among those aware, only 8.3% (10 respondents) knew the correct setback distance requirement of 11 metres as stipulated by NERC. The majority of respondents (85%) reported having received no information about RoW regulations or electrical safety requirements from any source.

When asked about perceived risks of living or building near high-tension cables, 68% of respondents cited electrocution as their major concern. However, only 30.8% believed that this risk applied to their property, suggesting a significant "optimism bias" in risk perception. Respondents expressed a belief that accidents and incidents "happen to other people" or in other locations, but not to them.

A history of electrical incidents was reported by 17% (20 respondents), including minor electric shocks experienced by household members (12 respondents), sparking or arcing observed on conductors (9 respondents), damage to electrical equipment (5 respondents), and livestock electrocution (2 respondents). No human fatalities were recorded in this sample, though several respondents reported being aware of such incidents in other parts of the city or in neighbouring areas.

Table 4: Primary Drivers of Encroachment

Driver	Number of Respondents	Percentage (%)
Land scarcity / high land prices	58	48.3
Ignorance of regulations	38	31.7
Economic necessity / livelihood needs	18	15.0
Lack of enforcement / no penalties	6	5.0
Total	**120**	**100**

Source: Field survey, 2026

Respondents identified multiple factors driving encroachment on RoW corridors. Table 4 presents the primary drivers cited by property owners and occupants

Land scarcity and high land prices were the most frequently cited drivers, mentioned by 48% of respondents. In Damaturu's expanding urban core, land is increasingly scarce and expensive, particularly in prime commercial locations such as the central market area. Many respondents indicated that they had built on RoW corridors because affordable land elsewhere in the city was not available or was prohibitively expensive.

Ignorance of regulations was cited by 32% of respondents as a driver of encroachment. Many property owners reported being unaware that there were any restrictions on building near power lines or that a statutory RoW existed. This ignorance was particularly pronounced among respondents who had inherited properties, who had purchased second-hand properties without proper title searches, or who had developed properties informally without building permits.

Economic necessity was cited by 15% of respondents, particularly among small-scale traders and entrepreneurs operating in the market area. These individuals indicated that the RoW corridor

provided accessible, affordable (often rent-free or low-rent) space for their businesses, and that relocation would have severe economic consequences for their livelihoods.

Lack of enforcement was cited by only 5% of respondents, reflecting the fact that for most encroachers, enforcement was not a factor they consciously considered when locating or building within the RoW. However, key informants emphasised that this factor was critically important from an institutional perspective, as the absence of effective enforcement has allowed encroachment to continue and expand over many years.

Key Informant Findings

Semi-structured interviews with YEDC officials and Ministry of Lands officials provided additional insight into institutional perspectives on RoW encroachment.

YEDC Maintenance Engineers; The three YEDC engineers interviewed confirmed that RoW violations are documented during routine patrols and maintenance inspections. However, they reported that the company lacks statutory authority to demolish structures or evict occupants, and that enforcement is the responsibility of the State Urban Planning and Development Board. Engineers expressed frustration at the recurring nature of encroachment, with structures often being rebuilt soon after demolition (in the few cases where action was taken). They noted that vegetation encroachment was also a significant problem, compounding the challenges posed by structural encroachment.

Ministry of Lands Officials; Officials from the Yobe State Ministry of Lands and Urban Development acknowledged that RoW enforcement has not been prioritised due to competing demands on limited resources. They cited challenges including inadequate staffing and funding, lack of coordination between state and local government agencies, political pressures from property owners and developers, and the absence of a comprehensive GIS-based inventory of RoW violations. Officials expressed willingness to address the issue but emphasised that institutional strengthening, political support, and public awareness campaigns would be essential preconditions for effective action.

Both sets of key informants highlighted the need for a coordinated approach involving multiple stakeholders, DisCos, state and local governments, regulatory agencies, and community leaders. They noted that isolated actions such as demolitions without compensation or public awareness campaigns without enforcement would be unlikely to achieve lasting results.

Discussion

This study provides the first systematic documentation of structural encroachment on 33kV RoW in Damaturu Metropolis, establishing a baseline for future monitoring and intervention. The finding that 42% of encroaching structures lie within less than 3 metres of live 33kV conductors is alarming and represents a significant public safety hazard.

At this distance, the risk of electrical flashover where electricity arcs through the air without physical contact becomes significant, particularly during conditions of high humidity, rainfall, or dust storms common in the Sahel region (Ibrahim & Suleiman, 2020). Flashover distances for 33kV lines can be up to 2–3 metres under adverse conditions, meaning that structures at distances less than 3 metres are at risk of arcing even without physical contact. This finding is consistent with studies from other Nigerian urban centres, where high-risk encroachment rates of 38–52% have been reported (Ogunyemi et al., 2021; Ibrahim & Suleiman, 2020; Adebayo & Ogunjuyigbe, 2021). The mean distance of 4.2 metres from conductor centre-lines is well below the statutory requirement of 11 metres, indicating systemic and widespread non-compliance with regulatory requirements. This pattern reflects broader challenges in urban planning and development control in Nigerian cities, where rapid urbanisation often outpaces regulatory capacity and enforcement (Kasim, 2014; Oyedepo, 2020).

The predominance of commercial encroachment (58.2%) reflects the intense pressure on accessible, high-footfall locations such as the central market. This pattern mirrors findings from Ado-Ekiti, where commercial encroachment was reported at 54% of surveyed sites (Ogunyemi et al., 2021), and Enugu, where 67% of RoW violations were driven by market expansion (Nwosu & Okeke, 2022).

The high concentration of commercial structures in the high-risk zone (<3 metres) is particularly concerning, as these areas experience high levels of daily human activity, increasing the probability of incidents. Market traders, customers, and passers-by are exposed to elevated electrical risks, with potentially severe consequences in the event of flashover, falling conductors, or structural collapse.

The spatial concentration of encroachment along the central market corridor suggests that economic land values and commercial pressures are primary drivers of encroachment patterns. This observation is consistent with economic theories of land use, which posit that higher land values in prime commercial locations lead to more intensive use and greater pressure to utilise any available space, including RoW corridors (Harvey & Jowsey, 2019).

The low level of awareness (22.5% aware of RoW existence, 8.3% aware of setback requirement) is a critical policy failure and represents a significant public education gap. Unlike high-voltage transmission lines (132kV and 330kV), which are visibly marked and widely recognised as dangerous, 33kV distribution lines are often perceived by the public as "ordinary poles and wires" with minimal risk (Ogunleye & Adebayo, 2022).

This perception gap has been noted by NERC (2023), which called for voltage-specific public education campaigns. However, the findings of this study suggest that such campaigns have not been effectively implemented in Damaturu, with 85% of respondents reporting no prior information about RoW regulations or electrical safety requirements.

The discrepancy between general awareness of risks (68% cited electrocution as a concern) and specific awareness that these risks apply to one's own property (only 31% believed the risk applied to their property) indicates a significant psychological distance in risk perception. This "optimism bias" is a well-documented phenomenon in risk communication and has important implications for public education and behaviour change interventions (Weinstein & Klein, 1996). Effective campaigns must not only provide information but also overcome this bias by making risks concrete, personalised, and tangible.

The primary drivers of encroachment identified in this study land scarcity (48%), ignorance of regulations (32%), and economic necessity (15%) are consistent with findings from other Nigerian contexts (Adebayo & Ogunjuyigbe, 2021; Nwosu & Okeke, 2022; Oyedepo, 2020). These drivers operate at multiple levels: macro-level (rapid urbanisation and land market dynamics), meso-level (regulatory awareness and institutional capacity), and micro-level (household and individual economic decisions).

The finding that only 5% of respondents cited lack of enforcement as a driver reflects the fact that enforcement is not typically at the forefront of individuals' decision-making when locating or building within RoW corridors. However, from an institutional perspective, the absence of effective enforcement is a critical enabling factor that allows encroachment to continue unabated.

The widespread, high-risk encroachment documented in this study has significant implications for public safety and service reliability. The concentration of commercial structures in high-risk zones, combined with high levels of human activity in these areas, creates conditions conducive to electrical incidents.

The absence of recorded human fatalities in this sample should not be interpreted as evidence of safety. Rather, it may reflect under-reporting, luck, or the fact that conditions have not yet aligned to produce a catastrophic event. The probability of such an event increases with the duration and intensity of exposure (longer time, more people at risk, adverse weather conditions).

Additionally, encroached structures interfere with maintenance activities, making it difficult or dangerous for utility workers to access and service lines (Abubakar, Idoniboyeobu, & Braide, 2020). This interference can lead to delayed response times, extended outages, and compromised maintenance quality, ultimately affecting service reliability for all consumers in the area.

The findings of this study are broadly consistent with previous research on RoW encroachment in Nigerian urban centres, while also revealing some contextual differences.
Ogunyemi *et al*. (2021) reported a commercial encroachment rate of 54% in Ado-Ekiti, slightly lower than the 58% observed in Damaturu. High-risk encroachment rates in Ado-Ekiti were similar (38% at <5 metres compared to 42% at <3 metres in Damaturu). Awareness levels in both contexts were notably low (<25%), suggesting a pervasive public education gap across Nigerian urban centres.
Nwosu and Okeke (2022) found 67% of RoW violations in Enugu were driven by market expansion, a figure consistent with the 58% commercial encroachment observed in Damaturu. However, the high-risk encroachment rate in Enugu (47% at <5 metres) was similar to Damaturu's high-risk rate, suggesting comparable exposure levels.
Similarly, Ibrahim and Suleiman (2020) reported high-risk encroachment rates of 52% (<3 metres) in Kano, higher than the 42% observed in Damaturu. This difference may reflect Kano's larger population and more intense commercial pressure, as well as differences in the urban environment and regulatory context.

Limitations of the Study
Distances were measured horizontally from conductor centre-lines. Vertical clearance (conductor sag) was not measured and may further reduce safety margins, especially during periods when conductors heat and sag due to increased load or high ambient temperatures. Under such conditions, the effective clearance between conductors and structures may be substantially less than horizontal distance would suggest.

Conclusion and Recommendations

Conclusion

This study provides empirical evidence of extensive, high-risk structural encroachment on the 33kV distribution right-of-way in Damaturu Metropolis, Yobe State. Over 40% of encroaching structures are located in the high-risk zone (<3 metres from conductors), with commercial structures constituting the majority of encroachments. Awareness of RoW regulations among affected residents is dangerously low, and enforcement mechanisms remain absent or ineffective. Without urgent intervention, the probability of a major electrocution or fire event is significant and increasing.
The findings underscore the need for a comprehensive, multi-stakeholder approach that addresses both the immediate safety risks posed by existing encroachment and the underlying drivers that perpetuate encroachment including land scarcity, regulatory ignorance, economic pressure, and institutional weakness. Such an approach must involve utility companies, state and local governments, regulatory agencies, community leaders, and property owners working in concert to achieve lasting change.

Recommendations

Based on the findings of this study, the following recommendations are proposed:
YEDC, in collaboration with local authorities, should install prominently displayed warning signs along 33kV RoW corridors at intervals of no more than 100 metres. Signs should include pictorial warnings and textual information in English and Hausa, the primary languages spoken in the area.

The Yobe State Ministry of Lands and Urban Development, in collaboration with YEDC, should conduct a comprehensive GIS-based inventory of all structures within RoWs. This inventory should prioritise high-risk structures (<3 metres) for immediate attention and phased relocation. YEDC, in collaboration with the State Government and NERC, should launch a comprehensive public awareness campaign explaining 33kV hazards and the 11-metre safe clearance requirement. Campaign media should include: radio broadcasts (particularly in Hausa), market meetings and community gatherings, distribution of printed materials (posters, leaflets), engagement with religious and community leaders, and integration of safety messaging into school curricula. NERC should amend regulations to require distribution companies to report RoW encroachment metrics quarterly, including: number and location of encroaching structures, risk zone classification, actions taken, and progress toward compliance. This reporting requirement would create accountability and enable monitoring of trends over time. The baseline established in this study should be maintained and updated through regular monitoring surveys. Indicators to track should include; Number and location of encroaching structures, proportion of structures in each risk zone, awareness levels among property occupants, number and nature of electrical incidents and Progress on relocation and enforcement actions.

Future research should address the following gaps;
Assessment of vegetation encroachment on 33kV and 11kV lines in the study area
Economic valuation of costs associated with RoW encroachment (outages, repairs, incidents)
Evaluation of the effectiveness of public awareness campaigns
Comparative study of RoW encroachment across different Nigerian states

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