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Bibliometric Analysis of Effects of Traffic Externalities on the Road Setbacks Squatters Wellbeing in Nigeria

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Abstract

Every country establishes Right of Way (ROW) legislation to protect linear infrastructure like railways, pipelines, and roads, ensuring smooth operation and shielding residents from harmful externalities. Rapid urban encroachment into roads and highways for residential and commercial use is a significant concern in developing nations like Nigeria. Due to linear settlement patterns, residents often overlook traffic-related issues such as emissions, noise, accidents, and congestion, which impact health, safety, and the environment. This study used Scopus-extracted journals for a bibliometric analysis to assess high-impact research on road encroachment, its causes, and implications due to land use patterns. Using VOSviewer and Scopus analytics, it examined keyword co-occurrence, international co-authorship, and publishing trends. Notably, few studies from developing nations addressed land-use-induced road encroachment, whereas developed-country research focused on transportation safety metrics like Post Encroachment Time (PET) in crash analysis. Findings indicate that land use-induced encroachment significantly disrupts traffic flow, safety, and roadside residents' well-being. The study underscores the urgent need for research in developing nations to tackle ROW encroachment and mitigate its adverse effects on health and the environment.

Keywords: Co-Occurrence of Keywords, Hawkers, Health Challenges, Land Use Pattern, Road Setback

Introduction

According Road transportation is the most widely used mode of transport in developing countries like Nigeria, serving as a key driver of economic growth, urbanization, and social integration. The development of road infrastructure enhances connectivity, facilitates trade,

and improves access to essential services such as healthcare, education, and markets (Kuncoro, Wurarah & Erari, 2024). However, the benefits of road transportation come with significant externalities, particularly for communities residing along highways and major roads. These externalities manifest in various forms, including environmental degradation, congestion, traffic hazards, and socio-economic disruptions, which pose severe risks to human health and well-being (Shittu & Bello, 2022). Among the most affected populations are road setback squatters, individuals, and informal traders who encroach upon highway rights-of-way (ROW) for economic survival, exposing themselves to numerous traffic-related hazards (Singh & Punjab, 2018).

Encroachment on road setbacks in Nigeria has grown alongside rapid urbanization, weak regulatory enforcement, and an increasing demand for economic opportunities in high-traffic areas (Okafor, 2020). The illegal occupation of road reserves has led to severe urban challenges, including traffic congestion, waste accumulation, environmental pollution, and compromised road safety (Musa, Philemon, Joseph & Chekwube, 2020). These issues are particularly critical in cities where informal economic activities flourish within ROWs, often leading to conflicts between urban planners, law enforcement agencies, and informal settlers. Despite regulations governing ROW use, enforcement remains inadequate, allowing unregulated settlement and commercial activities to persist along significant transport corridors (Ugochukwu & Habert, 2018).

The health risks associated with such encroachments are profound. Vehicular emissions, including carbon monoxide, nitrogen oxides, and particulate matter, significantly degrade air quality, contributing to respiratory diseases, cardiovascular conditions, and other chronic illnesses among roadside dwellers (Ajayi, Adams, Dumedah, Adebanji, Ababio-Donkor, Ackaah & Kehinde 2023). According to Boogaard, Patton, Atkinson et al. (2022), traffic-related air pollution (TRAP) has become a significant public health concern, particularly in urban areas with high vehicle density. In addition, noise pollution from constant vehicular movement exacerbates stress, sleep disturbances, and cognitive impairments (León, Hernández-Alemán, Fernández-Hernández & Araña 2023). These environmental stressors make life increasingly precarious for those who depend on roadside locations for their livelihoods, creating a paradox where economic survival comes at the expense of health and safety (Ogundahunsi, Adedotun & Adejuwon, 2016).

Furthermore, while road infrastructure development is widely recognized as a catalyst for economic progress (Adesola, Adewuyi & Oyekola, 2019), it also brings unintended consequences that disproportionately affect vulnerable populations. Investments in road networks facilitate mobility, trade, and urban expansion, yet they also contribute to the displacement of communities, environmental degradation, and the marginalization of informal economic actors (El-maissi, Argyroudis & Nazri, 2021). The proliferation of linear transport infrastructure—such as highways, railways, and paved roads—has been linked to both economic prosperity and social displacement, reinforcing the need for sustainable and inclusive urban planning (Wu & Li, 2022). In many Nigerian cities, ROW encroachments are driven by inadequate urban planning policies and a lack of affordable commercial spaces, forcing informal traders and low-income earners to occupy hazardous locations along busy highways (Chauhan, Varshney & Saraswat, 2017).

Despite the growing body of research on transport infrastructure and urbanization, limited studies have systematically analyzed the bibliometric trends of scholarship on traffic externalities and their impacts on road setback squatters. The neglect of this subject in transportation and urban planning literature highlights a critical gap in policy responses to encroachment-related challenges. While previous studies have explored the economic significance of transportation networks (Domagała & Kadłubek, 2023; Agung, Dewi, Taniguchi & Sanjaya, 2020), there is a lack of comprehensive analysis regarding the intersection of transport externalities, environmental risks, and the socio-economic realities of roadside communities.

This study, therefore, employs a bibliometric analysis to examine the extent of scholarly engagement with the effects of traffic externalities on road setback squatters in Nigeria. By mapping research trends, thematic concentrations, and citation networks, the study aims to provide valuable insights into the evolution of knowledge in this domain. The findings will serve as a foundation for evidence-based policymaking, offering urban planners, environmental experts, and transportation authorities a clearer understanding of how roadside encroachments impact public health and safety. Moreover, the study seeks to contribute to the development of more inclusive urban transport policies that balance economic opportunity with sustainable urban development and environmental protection.

Materials and Methods

Data Sourcing and Processing

The Scopus database was used as the literature search platform to source the high-index published journals and other publications on the subject matter of Road Encroachment. The search was done on 12th February 2023, and as reflected in Table 1 below, the search brought out four hundred and thirty-one (431) retrieved documents that have been published from 1944 to 2023 on road encroachment in the Scopus database. The filtering of the publications was done by removing 2023 publications, non-English language publications, and abstracts were removed leaving three hundred ninety (390) publications, which were saved and subjected to further analysis using the Scopus analytical tool and VOSviewer for the bibliometric analysis. Furthermore, the 390 articles were screened to bring out 17 articles that centred on land use pattern-induced road encroachment.

Table 1
Road Encroachment Scopus Search string and filtering outcomes

S/No	Activities	Search String	Number of Publication
1	**Keywords Search** Road Encroachment	TITLE-ABS-KEY (road AND encroachment)	431
2	**Data filtering** This was done through the exclusion of publication of publications not in the final stage, removal of 2023 publications, removal of document types like abstracts and conference reviews and exclusion of non-English language publications	**TITLE-ABS-KEY** (road AND *encroachment*) AND (EXCLUDE (PUBSTAGE, *"aip"*)) AND (**EXCLUDE** (**DOCTYPE** , *"cr"*) OR EXCLUDE (DOCTYPE, *"ab"*)) AND (**EXCLUDE** (**LANGUAGE** , *"Chinese"*) OR **EXCLUDE** (**LANGUAGE** , *"German"*) OR **EXCLUDE** (**LANGUAGE** , *"French"*) OR **EXCLUDE** (**LANGUAGE** , *"Slovenian"*) OR **EXCLUDE** (**LANGUAGE** , *"Italian"*) OR **EXCLUDE** (**LANGUAGE** , *"Turkish"*) OR **EXCLUDE** (**LANGUAGE** , *"Undefined"*)) AND (EXCLUDE (PUBYEAR , *2023*))	390

Data Analysis

The analysis of the already filtered data was performed using the Scopus analysis tool and VOSviewer for the bibliometric analysis. The Scopus analysis tool was used to analyze the year of publication trend, the countries of publication analysis and types of document analysis of the three hundred and ninety (390) processed publications in which the analysis outcomes are presented in chart formats using bar charts and pie charts. The VOSviewer was used to generate the co-occurrence of keywords and co-authorship by countries visualization in terms of network visualization, overlay visualization and density visualization, as well as the keywords clustered analysis and country clustered analysis in visual map format.

Results and Discussion

In this section, the overall bibliometric analysis outcomes of 390 articles are presented through the Scopus analysis tool and VOSviewer maps and visualization analysis tools. Thus, this section presents the results and discussion of visual maps and charts on the yearly trend of the publications from inception 1964 to 2022, the results of term co-occurrence keywords and co-authorship by country analysis, and the results and discussion of Document Subject areas and Types.

Documents Year of Publications and Sources

This section presents the Scopus analysis results for the documents' year of publication and their sources in terms of publishers.

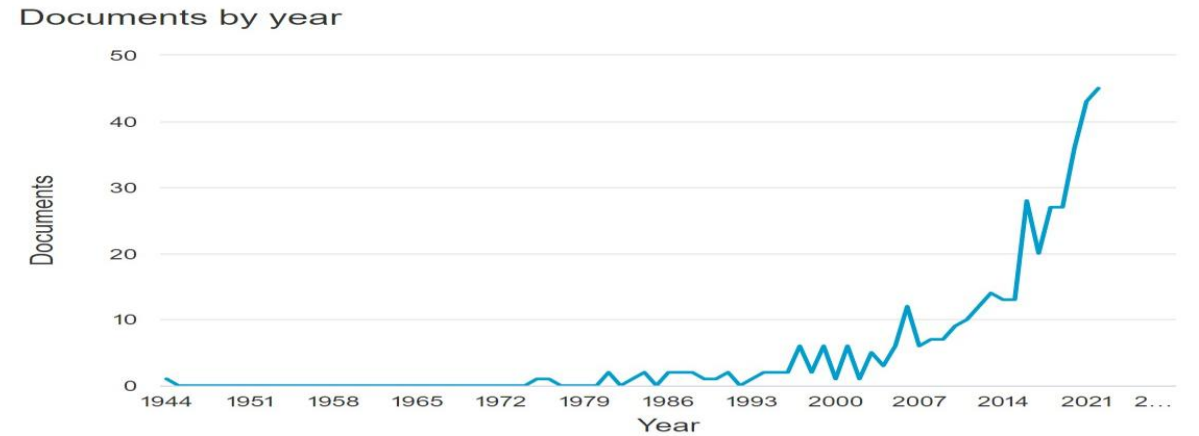

Figure 1. The trend of Publications on Road Encroachment by Years

Figure 1. depicts the trend by year of journal publication and research work on road encroachment using the Scopus database. The findings of the study revealed that publication began in 1944, but a few years later, till around 1974, little or no publications were made. Also, from 1980 to around 2005, there were less than ten (10) publications per year, and it was not until 2014 that the number of publications on the subject began to rise, reaching a peak in 2022. However, from 1944 to 2022, only 390 high-impact publications were made globally using the Scopus database, indicating that much research on road encroachment has not been carried out despite its presence in many urban cities and highways worldwide, particularly in developing countries where it is a significant traffic management issue with adverse effects on traffic, man, and the environment.

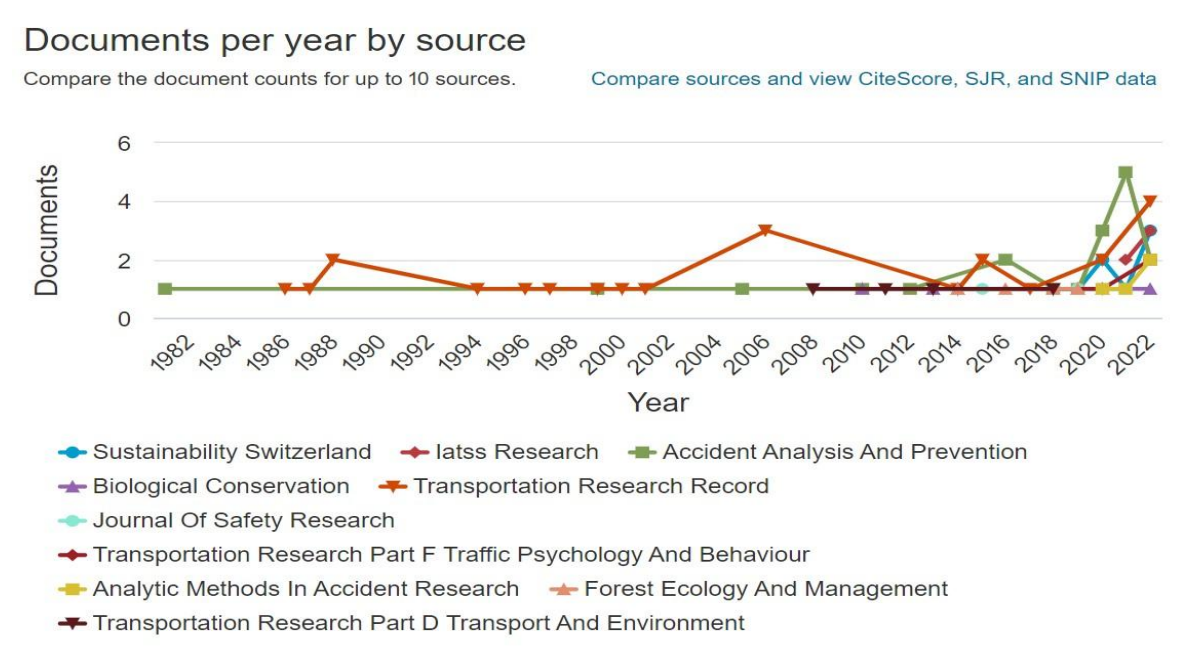

Figure 2. Road Encroachment documents per year and by source from 1944 to 2022 using Scopus Database

Figure 2. depicts the top ten global sources of publications on road encroachment from 1944 to 2022. From 1944 to 1984, the primary source of publication was accident analysis and prevention, though with low levels of publication until around 2019 to 2021. However, Transport Research Record began publishing on road encroachment around 1985 and has had the highest yearly publication since then, though with fluctuations, and has consistently outpaced Accident Analysis and Prevention publications until 2019 to 2021, when Accident Analysis and Prevention had the highest publications. However, it has the highest publications in 2022. Consequently, between 2008 and 2015, Transport Research Part D Transport and Environment joined publications on road encroachment and between 2019 and 2022, Sustainable Switzerland, Biological Conservation, and Transportation Research Part F Traffic Psychology and Behaviour became publishers of publications on road encroachment.

Authors and Co-Authorship Countries

This section contains a discussion of the results of both Scopus and VOSviewer analysis on links and map visualizations of authors and co-authorship countries. However, for the VOSviewer analysis, the default 25 is used as the maximum number per document to have broad-based countries spread, while one is used as the minimum number of documents by countries and zero as the minimum number of citations from a country; a total of 87 countries are reflected. Furthermore, names that are not country names, such as wetlands protection programme and transportation research laboratory, were removed from the verified number of countries. As a result, only 68 of the 80 countries are connected, and the analysis is based on the connection among the 68 countries of co-authorship.

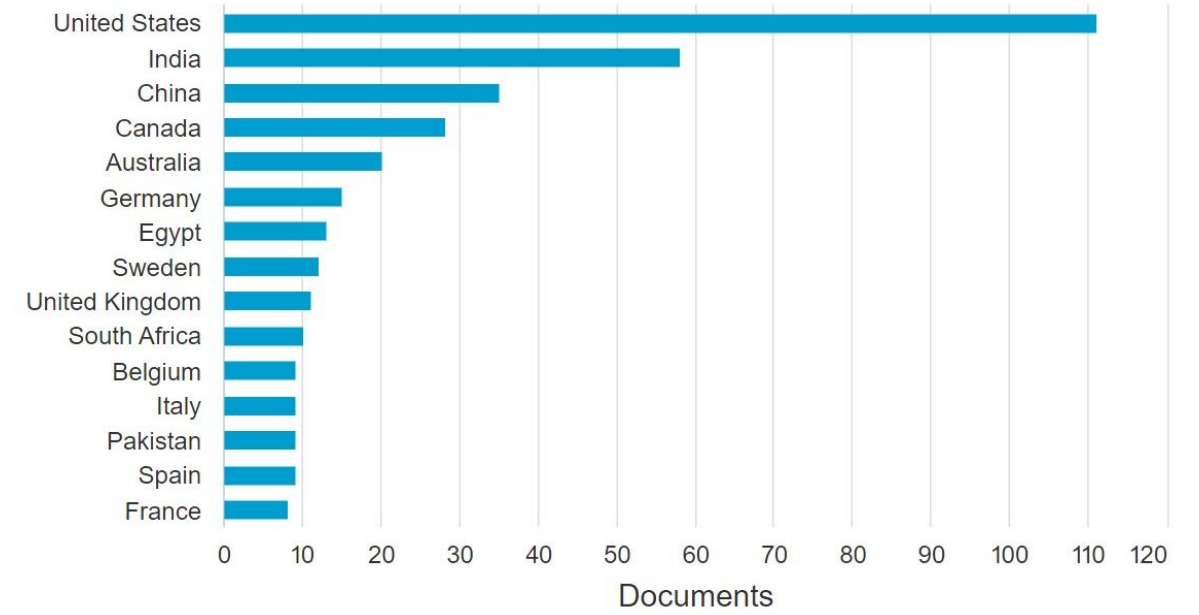

Figure 3. The trend of Publications on Road Encroachment by 15 Countries with the highest publications from 1944 to 2022 using the Scopus Database

According to the Scopus database, Figure 3 depicts the top fifteen (15) countries in road encroachment publications from 1944 to 2022. The United States tops the list with 111 publications, followed by India (58), China (35), Canada (28), and Australia (20) and the ten

remaining countries each have fewer than 16 publications. Furthermore, only four of the top 15 countries are classified as developing, namely India, Egypt, South Africa, and Pakistan, while the other ten fall under the category of developed nations.

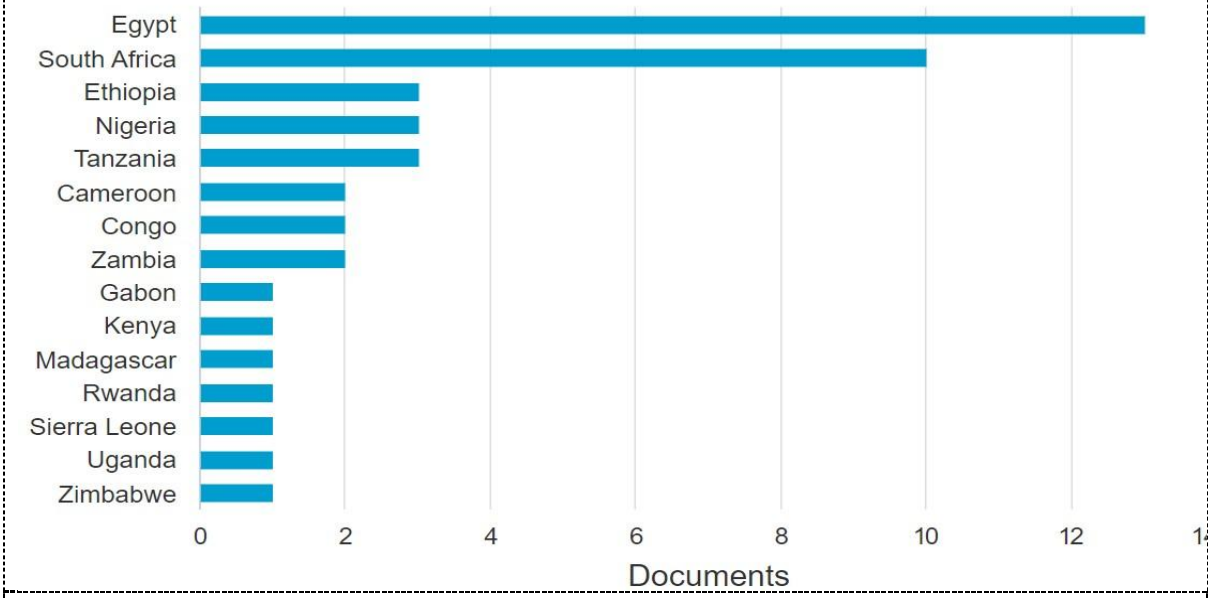

Figure 4. Trend of Publications on Road Encroachment by African Countries from 1944 to 2022 using Scopus Database

Figure 4. Depicts the proportion of African countries represented in the 390 publications on road encroachment extracted from the Scopus database. Egypt leads the way with 13 publications, followed by South Africa with 10. The remaining 13 countries have only one to three publications. This demonstrated that research on road encroachment is very minimal in Africa, which is a developing country, with Nigeria, in particular, having a high rate of road and highway encroachment (Ugochukwu and Habert 2018).

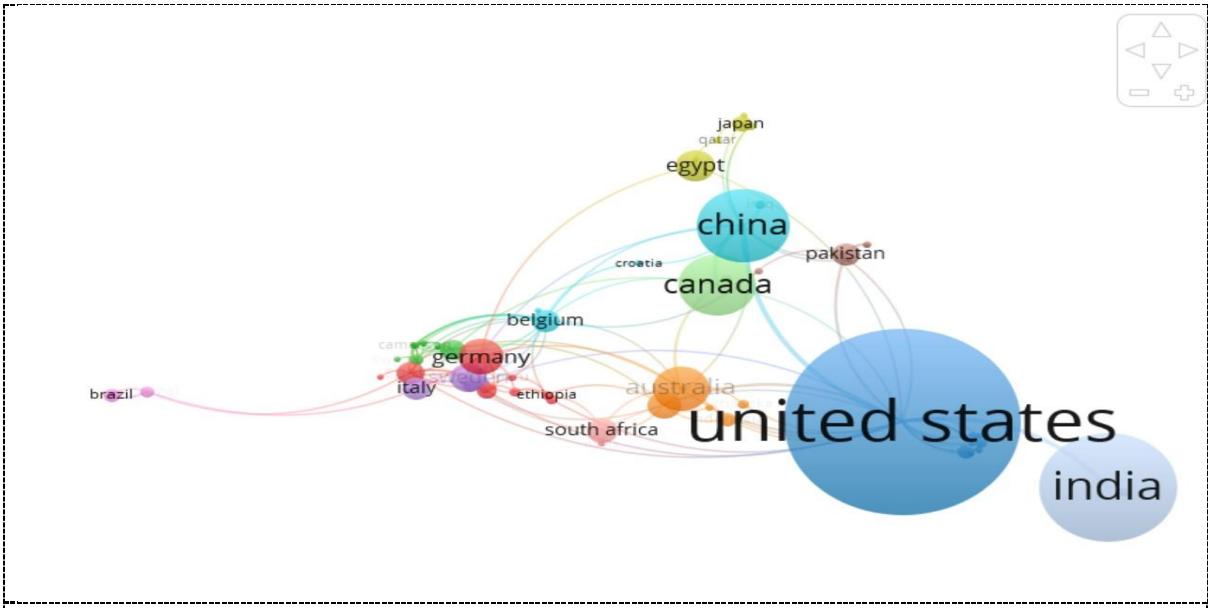

Figure 5. Network visualization by countries' co-authorship

Figure 5 shows a network visualization of co-authorship links among countries that have published on road encroachment using data from the Scopus database. Only 70 of the 87 items in the network are those that are connected in the network visualization. Among the 70 items (Countries), the United States has the highest total link strength of 42, with 111 documents and 2075 citations, followed by China, which has a total link strength of 22, with 36 documents and 471 citations. Consequently, Belgium has a total link strength of 18 with nine documents and 224 citations, Spain has a total link strength of 15, with nine documents and 95 citations, and others have total link strengths of 12 or less.

Co-Occurrence of Keywords

The co-occurrence of all keywords was determined using the VOSviewer analysis tool, and a 10 minimum number of occurrences of keywords were chosen to obtain the top most occurrence keyword, reducing the keywords to 68 from 3795. Furthermore, from the verified keywords box, some of the unrelated seven (7) keywords, such as article, imagery, and country name, among others, were removed, reducing the map visual analysis to the 61 most frequently occurring keywords, revealing the areas in which the research of road encroachment centred on around the world.

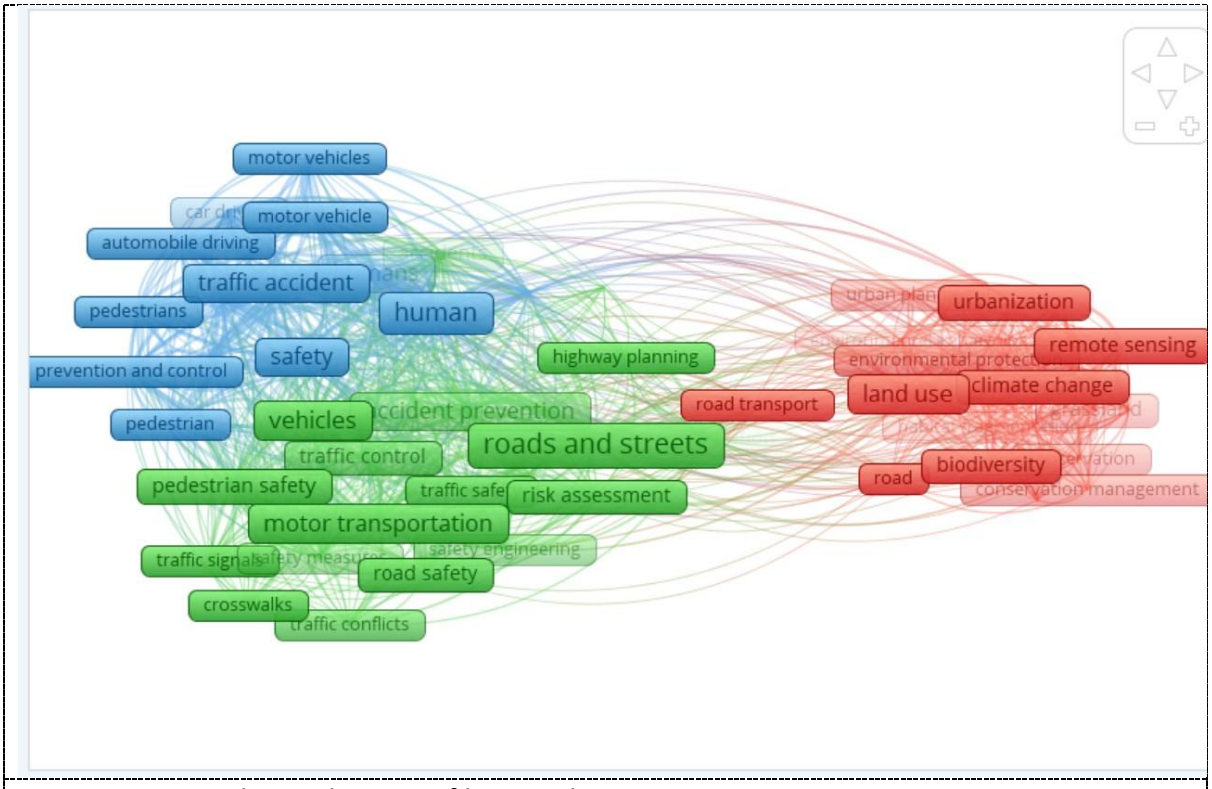

Figure 6. Network visualization of keywords co-occurrence

The occurrence of keywords revealed the direction in which the research in a particular matter was centred, as well as the dominant hot topics happening in the field. Thus, Figure 6 depicts a network visualization map of the co-occurrence of keywords in road encroachment publications extracted from the Scopus database. The dominant keywords found in the network visualization are "human", "Pedestrian(s)", "traffic safety", "Vehicle", "traffic accidents", "Highway Accident", "pedestrian safety", "traffic signal", "land use",

"environmental protection", "Road(s)", "Conservation", "road transportation", "motor traffic". However, keywords with similar meanings were grouped and presented in Table 2.

Table 2
Ranking of 9 related meaning grouped keywords, occurrences and links' strength

Keywords	Occurrences	Total Links' Strength
Human	114	1135
Vehicular Traffic	131	1011
Environmental Management	199	995
Transport Safety	142	987
Traffic Accident	87	787
Traffic Control	61	350
Road	75	306
Land Use Pattern	81	294
Remote Sensing and GIS	45	156

Source: Compilation through VOSviewer analysis of co-occurrence keywords of publications on road encroachment from 1944 to 2022 using the Scopus Database

Table 2 revealed the categorization of 61 related in-meaning keywords into nine (9) significant keywords, the frequency of occurrences, and the total link strength. Using links to rank keywords, it is revealed that humans are the strongest with 1135 link strength, followed by vehicular traffic with 1011 link strength, environmental management with 995 links strength, and transport safety with 987 links strength. However, in terms of keyword occurrences, environmental management-related keywords have the most occurrences (199), followed by Transport Safety-related keywords (142), vehicular traffic (131), and human-related meaning keywords (114).

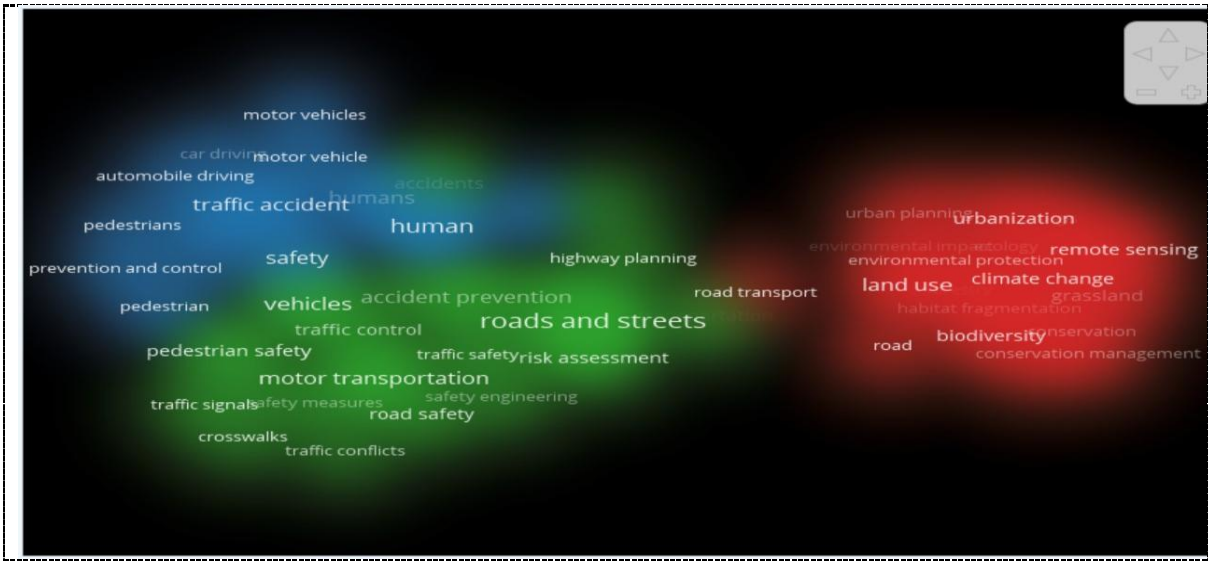

Figure 7. Co-occurrence keywords density visualization by cluster

The VOSviewer analysis of keyword co-occurrence revealed three clusters of overlapping keywords, as shown in Figure 7. Cluster 1 of the VOSviewer analysis has 25 red items (keywords), while Cluster 2 has 22 green items, and Cluster 3 has 14 blue items.

Documents Subjects Areas

This section presents the specialization fields of the authors that contributed to the 390 extracted publications from Scopus for this study.

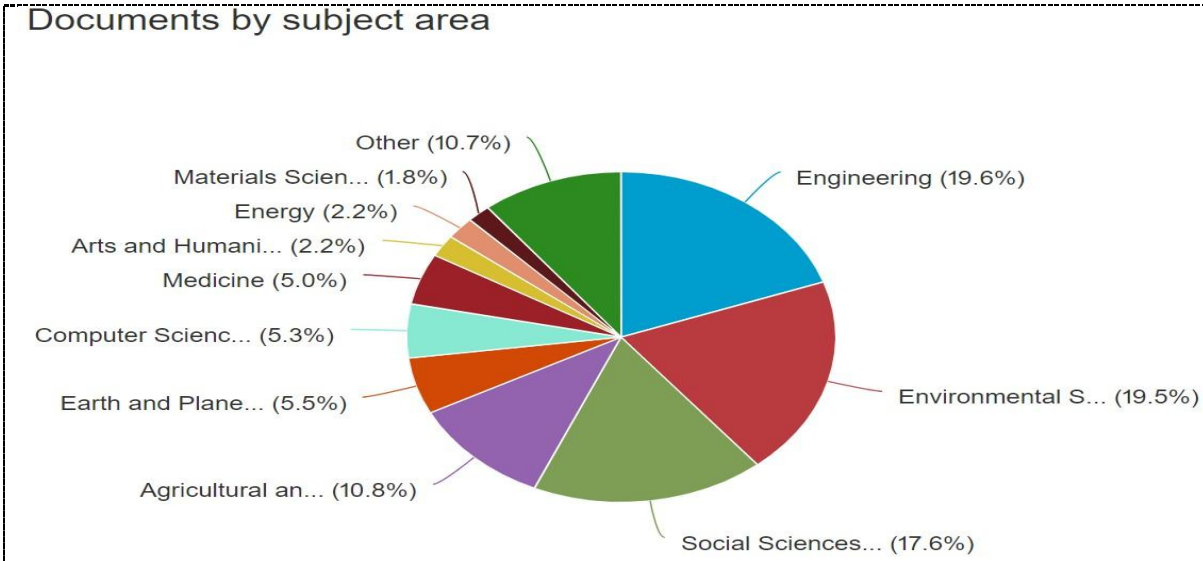

Figure 8. Road Encroachment documents subjects areas from 1944 to 2023 using the Scopus Database

Figure 8 depicts the academic field of specialization from which the publications on road encroachment originated in the Scopus database. The pie chart above revealed four significant fields of specialization with close percentages as follows: engineering (19.6%), environmental science (19.5%), social science (17.6%), and agriculture and biological sciences (17.6%). It demonstrates that transportation operations are multifaceted, as contributions from various fields are required for services to be delivered optimally and efficiently. The other three significant fields by percentage are Earth and Planetary Sciences (5.5%), Computer Science (5.3%), and Medicine (5.0%).

Consequently, the screening shows that the majority of the articles centred their research on a traffic accident and road safety initiative, which has the concept of post-encroachment time (PET) and time-to-collision (TTC) in traffic accident analysis. Furthermore, the other area of road encroachment, as reflected in the articles screened, centred on human activities encroachment into a farm or agricultural lands and ecosystems ecosystems as it affects carnivores and other animals in the ecosystem.

Analysis of Publications on Road Setback Encroachment through Land Use Pattern

The section presents the results of the screening of the 390 Scopus research journals used for the study to find research papers that directly studied the concept of road encroachment as

it related to road setback encroachment and land use patterns challenges with traffic externalizes after-effects on man and the environment. A total of 17 articles out of the 390 articles centred their research on road setback or right-of-way encroachment by man activities, out of which three (3) emanated from Nigeria, as presented in Table 3. In comparison, the summary of the remaining 14 articles is presented in Table 4.

Subsequently, the screening shows that the majority of the articles centred their research on traffic accidents and road safety initiatives, which have the concept of post-encroachment time (PET) and time-to-collision (TTC) in traffic accident analysis. Furthermore, the other area of road encroachment, as reflected in the articles screened, centred on human activities' encroachment into a farm or agricultural lands and ecosystems as it affects carnivores and other animals in the ecosystem.

Discussion of the three Found Publications on Road Setback Encroachment in Nigeria from the Scopus Database

Three (3) authors from Nigeria have published work related to land-use-induced road encroachment, and the submissions of the three (3) authors were summarized as follows:

Victor's (2020) paper, which explored the impacts of road encroachment by herders moving livestock on urban Nigerian highways, comes the closest to the issues posed by land use patterns. Even if their presence is just short, it causes severe disruption to traffic flow, which leads to traffic accidents, and the animals' droppings cause environmental problems (see Figure 9).

While Aguda, Farinde, Adegboyega, and Olawole's (2013) article centred on urban development and slum growth in Nigeria, emphasizing Poor building maintenance and Encroachment onto available spaces (water and open space), which usually resulted in health risks and environmental problems for the populace living within the slum areas, less emphasis was laid on road encroachment.

Badmos, Rienow, Callo-Conda, Greve and Jurgens (2018) examined the spatiotemporal assessment of urban growth of medium-sized and nodal towns for sustainable management using GIS. The study identified Housing problems, inadequate waste disposal systems, Encroachment into agricultural lands, inadequate health facilities, and Poor drainage systems as challenging issues that result in health risks and environmental problems.

Figure 9. Cattle Road encroachment in Nigeria

Discussion of the 14 found publications on Road Setback Encroachment across the globe from the Scopus Database

The 14 papers on road encroachment resulting from land use problems were filtered from the 390 articles on road encroachment from the Scopus database that was used for this study, and these 14 papers were summarized into sub-headings as follows:

i. Traffic Congestion and Mitigation

Ali, Javid, Hussaain, and Rahim (2021) investigated traffic congestion in Lahore, Pakistan, from the standpoint of stakeholders, providing solutions and addressing concerns such as unlawful roadside parking and shopkeeper encroachment. Chauhan et al. (2017) investigated novel approaches to reducing traffic congestion in India by addressing road encroachment, such as hawking and on-street parking.

ii. Pedestrian and Sidewalk Issues

Caputcu, Sengoz, Tanyel, Kaplan and Karabayir (2016), Khan, Jawaaid, Chotani and Luby (1999) and Mukherjee and Mitra (2020) researched pedestrian sidewalk problems. Caputcu et al. presented various methodologies for researching pedestrian movements along Turkish sidewalks, highlighting sidewalk difficulties and conflicts caused by obstructions and encroachments. In Karachi, Pakistan, Khan et al. investigated pedestrian behaviour and sidewalk encroachments. In contrast, Mukherjee and Mitra (2020) focused on pedestrian safety in India, stressing risk variables such as pedestrian-vehicle interactions, land use, and footpath encroachments.

iii. Urban Development and Environmental Impact

According to the findings of Mahmudul, Nawshad and Ahmad (2017), Schulten and Parnell (2015) and Sheuya (2009) investigated the impact of ribbon development along arterial motorways in Bangladesh, focusing on topics such as water body encroachment, rising land costs, and urban service growth. Whereas Schulten and Parnell (2015) examined rail line

noise pollution and its consequences on residential projects in Australia, focusing on planning regulations and mitigation strategies. Sheuya (2009) investigated urban poverty and housing alterations in Tanzanian informal settlements, highlighting issues such as in-house congestion, occupational health concerns, and encroachment into highways.

iv. Transport Infrastructure and Road Safety

Examining the studieS by Chandra (2003), Rao, Velmurugan and Lakshmi (2017), Tran, Subhani and Ushakov (2020), and Umair, Rana and Lodhi (2022) accordingly. Firstly, Chandra (2003) in India studied the impact of roadside impediments on traffic speed and safety, with an emphasis on road encroachments induced by car parking on pavements. While Rao et al. (2017) investigated the impact of roadside frictions on road capacity in Delhi, India, such as kerbside bus stops and on-street parking. Hence, Tran et al. (2020) investigated Pakistan's urban transportation infrastructure and commuting issues, focusing on road encroachment in key cities and its influence on congestion. Consequently, Umair et al. (2022) evaluated the influence of urban design components on road traffic accidents in Rawalpindi, Pakistan, taking into account factors such as land use and road encroachment.

However, as shown in Figure 3, the five leading nations in road encroachment articles are the United States, India, China, Canada, and Australia. Only India and Australia are among the five leading countries in publications based on road encroachment driven by land use concerns. However, just five (5) of India's 58 papers dealt with road encroachment and land use issues, whereas Australia had one of the 20 publications.

Consequently, Pakistan has four of the nine publications on road encroachment with land use pattern as a causative factor, whereas Bangladesh, Kenya, Tanzania, and Turkey each have one article on road encroachment influenced by land use pattern. Even though little study has been conducted in this area, the screened publications demonstrated that it is a problem in developing nations, including Nigeria.

On the causes of road encroachment in the 14 screened publications from Scopus used for this study, activities such as street hawking, illegal and wrong on-street parking by vehicles, illegal mounting of temporary or permanent structures to display items for sale by roadsides, having residential buildings close to linear infrastructure lines such as rail lines, having items displayed for sale on pedestrian walkways and sidewalks, among others, are the land use patterns that cause road encroachment on urban roads and highways.

Whereas on the effects of the land used encroachment according to the 14 screened publications from Scopus used for this study, the road setbacks or right of way encroachment by dwellers has a double impact on vehicular movement and the dwellers residing and engaging in activities along the roadside in the following ways: creating traffic congestion, causing vehicular traffic accidents, particularly pedestrian accidents, exposing the dwellers to traffic noise pollution and other health challenges, hindering pedestrian free mobility, causing damage to the scenic view of the environment and lead to vegetation and agricultural land damage.

Conclusions

This paper provided an overview of land use pattern-induced road encroachment and employed a bibliometric method to analyze Scopus general publication on road encroachment, dominant hot topics in the form of keyword co-occurrences in the subject matter, the leading co-authorship countries in road encroachment research, and an analysis of significant fields of specialization in road encroachment research. Consequently, the analysis excluded particular articles on road encroachment caused by land use pattern challenges and fished out the reasons for the encroachment by dwellers, the impact of the encroachment on vehicular traffic, residents, and the environment in general. Thus, the study advances the following key findings:

Firstly, the study discovered that high-impact publications are extremely rare in road encroachment, with only 390 publications published in the English language and 431 in all languages worldwide from 1944 to 2022, according to the Scopus database.

Secondly, the United States contributed the most articles, followed by India, China, Canada, and Australia. In contrast, developing countries, particularly Africa, have a prevalent road encroachment issue and antecedent health and safety implications, which contributed little to high-impact road encroachment publications.

Thirdly, the main hotspot keyword topics included environmental management, traffic accidents, traffic safety, and traffic control; however, some other hotspot topics, such as traffic externalities such as traffic congestion, vehicular pollution, road dust, noise, health challenges, and causes of road encroachment such as street trading, roadside markets, and squatting settlements, are also of great concern.

Fourthly, very few publications (17 articles) on land use-induced road encroachment are from developing countries. In contrast, the majority of other publications from the developed world on road encroachment centred on transport safety and traffic crash analysis concept of Post Encroachment Time (PET) on road traffic crash analysis.

Fifthly, the study discovered that the land use pattern-induced road encroachment impacts are very detrimental to vehicular traffic flow and safety, pedestrian mobility and safety, the health and well-being of those who live and engage in activities near the roadside, the scenic environment, and the ecosystem within the environment.

Finally, road encroachment is a multifaceted issue that cuts across engineering, environmental sciences, medical, agricultural, and biological sciences, and even computer science. Even though it cuts across many fields of specialization, publications in the area are still minimal globally, most especially in the area of land use pattern-induced road encroachment, which is highly pronounced in developing countries, especially Nigeria.

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