ARTICLE

Assessing the use of spatial information in environmental impact assessment reports: The case of mobile telecommunications projects in Plateau State (Nigeria)

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ABSTRACT

Spatial information presented in environmental impact assessments and their documentation in environmental impact assessment reports is vital for the spatial understanding of proposed infrastructural developments, their environmental impacts, environmental baseline, and the ecological sensitivity of project sites. Such information is crucial for the involvement of different stakeholders in the assessment and mitigation of environmental impacts associated with infrastructure development projects. In this study, the usefulness of spatial information compiled for recent mobile telecommunication projects in Plateau State (Nigeria) is assessed. To achieve this, the environmental impact assessment reports for 70 such projects were examined. The study found that the spatial information provided in the reports was often inadequate or not presented at all. Topographical maps (25%) and architectural illustrations (38%) were used more commonly than photographs (12%) or Google Maps images (12%). There were also weaknesses in the presentation of some of the spatial information including lack of scale, map legend and labels. It is recommended that the availability, types and content of spatial information presented in the environmental impact assessment reports need to increase and be standardised. The spatial representations provided must maximise their visual realism for the end user.

Keywords: Environmental decision-making, Environmental impact assessment, Environmental impact assessment reports, Spatial information, Stakeholders, Visual realism

INTRODUCTION

Globally, the use of spatial information as a means of engaging stakeholders to understand spatial phenomena, and their use in environmental impact assessments (EIAs), is on the increase (Vincent et al., 2019). Spatial information is based on the physical location of objects on the earth's surface and their geographical relationships with one another (ACIL Tasman, 2008). Different types of spatial information are used during EIAs to depict the geographical location of project sites, project orientation, the density of objects within and around them, and the distances between them (Mwenda, 2015). Such information may be in the form of 2D and 3D photo-realistic visualisations, topographical maps, satellite images, orthophotos, terrain models, and street-level photographs, amongst others (Çöltekin et al., 2018). Since the EIA process entails the prediction of anticipated impacts from proposed developments, the utilisation of spatial information is crucial for environmental analysis and decision-making (Vanderhaegen & Muro, 2005). Spatial information is employed during different EIA stages, such as (1) screening and scoping, (2) the generation and presentation of environmental baseline data, (3) impact identification and prediction, (4) public participation, and (5) impact mitigation planning (Atkinson & Canter, 2011; Glasson & Therivel, 2019). Consequently, there is increasing need for accurate spatial information to enhance and support the EIA process (Mwenda, 2015).

Some studies have examined EIA effectiveness from various theoretical perspectives (Veronez & Montaño, 2015). For example, research has identified the procedural, substantive, transactive, and normative dimensions of EIAs (Atkinson & Canter 2011; Byambaa & de Vries, 2020). Procedural effectiveness entails conformity with legal procedures and the adoption of good practices (Veronez & Montaño, 2015). By making use of spatial information during the different stages of an EIA process, procedural effectiveness and compliance can be improved. During an EIA, environmental baseline data on climate, hydrology, topography, natural vegetation and land use are collected and presented using spatial models (Satapathy et al., 2008; Mwenda, 2015). Such knowledge is vital for stakeholders who may be affected by proposed developments and therefore the use of spatial information is important in this process. On the other hand, the substantive dimension examines whether the EIA achieves its intended purpose of supporting decision-making and protecting the environment (Byambaa & de Vries, 2020).

Given the importance of the procedural and substantive dimensions in environmental impact assessment reports (EIARs), spatial information must be presented such that stakeholders can use and understand it effectively. Providing such information may increase environmental awareness while making sure that environmental considerations are taken into account in project planning and assessment. In many developing countries, research on the application of spatial information presented during various stages of the EIA process is limited (Mwenda, 2015; Glasson & Therivel, 2019). There is also a lack of studies in the area of public participation (Mwenda et al., 2013; Mwenda, 2015). Therefore, the main goal of this study was to assess the use of spatial information in EIARs from recent mobile telecommunication projects in Plateau State, Nigeria. This was addressed by (1) analysing the geographical distribution of mobile telecommunications projects across Plateau State; (2) identifying the different types of spatial information used in the project EIARs and considering their accuracy and appropriateness, and (3) discussing their visual realism and usefulness for stakeholders and environmental decision makers.

LITERATURE REVIEW

Global systems for mobile telecommunication (GSMT) technologies have broadened access to wireless communications to millions of people, thereby overcoming the barriers that were commonly associated with limited landline telecommunications infrastructure (Samkange-Zeeb & Blettner, 2009). In this paper, the focus is on the GSMT infrastructure that is comprised of base transceiver stations (BTSs). These consist of antennas mounted on a tall tower and an array of electronics housed at the base. The antenna components of a typical base station are usually less than 10 cm high but may be clustered into ‘arrays’ with heights of nearly 1 m (Samkange-Zeeb & Blettner, 2009). Such apparatus needs to be lifted up on a tower to prevent obstacles such as trees, hills, or high buildings that stand between the stations and mobile phone users. Mobile phones and BTSs transmit and receive signals using electromagnetic waves (Samkange-Zeeb & Blettner, 2009). The signal reception distance away from the station may be as large as 10 km in a rural area or as little as 0.2–0.5 km in urban areas where the demand is highest.

GSMTs services and technologies are estimated to represent 5% of the Gross Domestic Product (GDP) of the global economy in 2022, contributing to nearly USD $5.2 trillion of economic value (GSMA, 2023). The global number of mobile phone subscribers and users is growing at an accelerated rate, from approximately 3.3 billion people in 2009 (Samkange-Zeeb & Blettner, 2009) to 8.9 billion in 2023 (Statista, 2024). In sub-Saharan Africa, mobile operators and the broader mobile industry created employment for 1.4 million individuals by 2022 (GSMA, 2023) with an additional 2 million jobs in different supporting sectors. USD $170 billion in economic value was attributed to mobile technology and services in sub-Saharan Africa in 2022, amounting to 8.1% of the region’s GDP (GSMA, 2023).

From an environmental perspective, waste that may be generated during the construction phase of BTSs include iron rod cut offs, discarded cement bags, used paint containers, electric wire cuts, and cables. During the operational phase, the waste includes used engine oil and filters, used electrical bulbs and tubes, and spent power backup batteries. Waste from the decommissioning phase may include slabs and concrete, tower and antennae, and other items. Other negative impacts of BTSs and their operations are also noted in Africa. For example, exposure to electromagnetic radiation has raised health concerns related to potential risks of cancer, headaches and noise pollution in Nigeria, South Africa and Ghana (Jayaraju et al., 2023; Odoh & Ezekiel, 2023; Agbosu et al., 2024). There is also concern of declining property values close to BTSs (Cheruiyot et al., 2024). The installation of telecommunications towers and base stations can change the surrounding landscape, leading to visual pollution (Nebedum & Ogbu, 2023), noise pollution (Clark et al., 2020), and oil spillage from generators and fuel tanks (Nebedum & Ogbu, 2023).

THE STUDY AREA

Nigeria with 217.5 million active mobile subscribers by the end of 2023 is by far the largest mobile phone market in Africa (Bell, 2024). With the direct value added from larger ICT businesses and its impact on increasing other sectors' efficiency, the mobile industry's share of GDP in Nigeria in 2023 was 13.5% (GSMA, 2024). Tax revenue from the mobile sector in Nigeria made up 2.4 trillion Naira of the expected 33 trillion Naira of GDP in 2023 (GSMA, 2024).

In Nigeria, most places are located in low or off electricity grid areas (Ikenga & Ogidigben, 2024). Therefore, the majority of BTSs in Nigeria are powered by polluting diesel generators, in particular in Lagos, Oyo, Katsina, and Akwa Ibom (Adeniran et al., 2017). The amount of air pollutants emitted is proportional to the quantity of fuel burnt. Also in Nigeria, there are instances of collapse of cell phone masts leading to injuries and deaths, and the destruction of properties (Amadasun et al., 2021). These dangers highlight the necessity for increased environmental awareness and education, which is essential to balance the advantages from infrastructure development with precautionary measures to reduce environmental risks. This in turn enhances EIA and regulatory compliance.

The study area of the present research is Plateau State in Nigeria (Figure 1). Its total population is approximately 4,075,392 and has an active GSMT capacity of about 3,557,374 subscribers, together with an active internet base connection that caters for 2,431,338 subscribers (National Bureau of Statistics, 2020). The rugged topography of the area presents challenges for siting mobile phone base stations (Quinteros, 2023). Additional infrastructure and specialized planning may be required to optimize signal distribution and overcome the obstacles posed by the terrain (Quinteros, 2023; George, 2024).

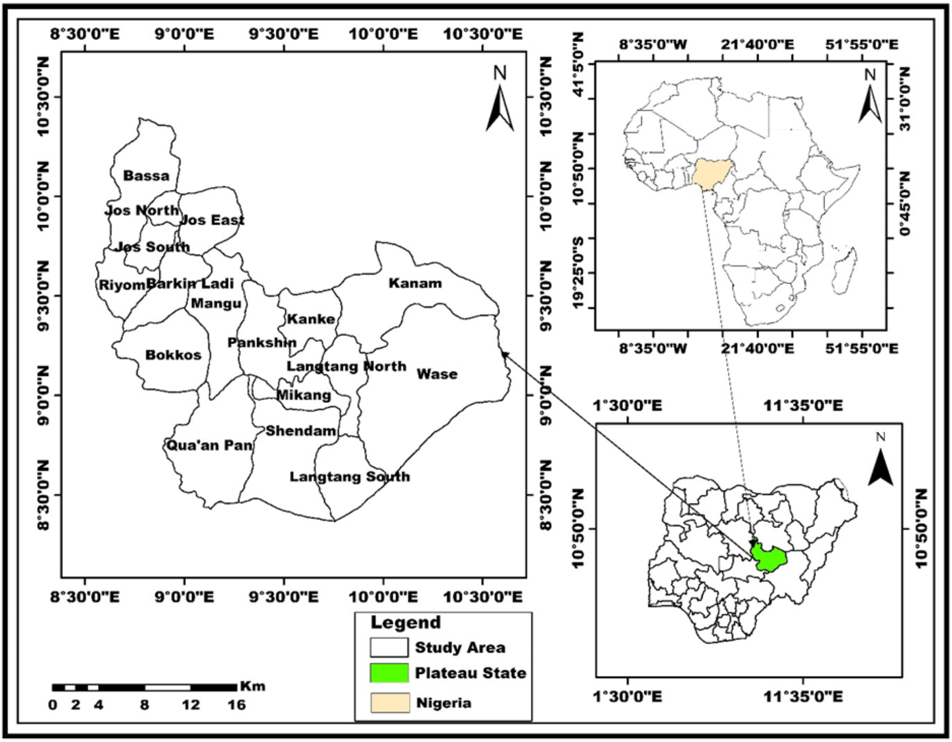

Figure 1: Map showing the geographical location of Plateau State and its 17 Local Government Areas (LGAs)

RESEARCH METHODS

When considering the environmental feasibility of proposed development projects in any locality, the standpoint and opinions of all affected stakeholders are required (Finka et al., 2017). Spatial information can also enhance communication during public participation. The focus of this study is to determine the extent to which spatial information has been utilized for communicating project locations, environmental baselines, landscape sensitivities, and Special Interest Areas of relevance to EIARs. The criteria used in this study for inclusion of different EIARs are described in Tables 1, 2 and 3. Project sites are spatially positioned because they relate to the specific locations of the developments. Mwenda et al. (2013) identified seven criteria that may be employed to characterize the presentation of spatial information in EIARs (Table 1). The term 'availability' in Table 1 refers to the presence or absence of spatial information within the EIARs such as maps, photographs and engineering sketches. 'Content' refers to the actual information used in such illustrations as listed in Table 2. As indicated in the literature, one important factor is the degree of visual realism (Cöltekin et al., 2018) whereby the more realistic the visualisation is, the easier it becomes for viewers to analyse and understand it (Stachoň et al., 2018). Spatial information with high visual realism is more effective and is consequently preferred for environmental assessments (Table 3).

Table 1: Different aspects of spatial information found in EIARs (Mwenda, 2015).

Aspects of spatial information	Indicators
Availability: presentation types	Presence or absence of spatial presentations Types observed based on their visual realism
Content: presentation of the problem	Project locations Project activities or details Special Interest Areas: e.g. hydrology, biodiversity, topography, conservation areas, administrative boundaries

Table 2. The information content groups found in the spatial information analysed in this study (adapted from Mwenda, 2015).

Information content groups	Details
1	Project location
2	Project activities/details
3	Special Interest Areas
4	Project location + Project activities/details
5	Project location + Special Interest Areas
6	Project activities/details + Special Interest Areas
7	Project location + Project activities/details + Special Interest Areas

Table 3. Different levels of visual realism associated with spatial information (adapted from Mwenda, 2015).

Category 1 (Low visual realism)	Category 2 (High visual realism)	Category 3 (Mixed visual realism)
Topographical maps Cadastral maps CAD maps Site plans Technical layouts	Photographs Google illustrations 2D/3D visualisations	Both low and high visual realism

Selection of EIARs for this study

Out of 288 available EIARs requested from the Nigerian Ministry of Environment, only 80 were randomly sampled but of these 10 lacked spatial information, resulting in a total sample size of 70 (24% of the total). As shown in Table 4, the number of EIARs approved in each year varies, thus posing a limitation in the selection of reports. It is noted that, before 2006, there was only one EIAR compiled for the construction of mobile telecommunications infrastructure in Plateau State. Table 5 lists those EIARs considered in detail in this study.

Table 4. Numbers of EIARs (out of 70) according to their categories of visual realism.

Year	Number of EIARs (Low visual realism)	Number of EIARs (High visual realism)	Number of EIARs (Combined visual realism)
2006	0	0	0
2012	19	7	13
2014	9	3	6
2015	8	1	4

Table 5. List of EIARs considered in detail in this study.

Environmental Impact Assessment Report (EIAR) No. 26. 2012. Environmental impact assessment for mobile phone base station at Via-Fyang, Zawan, Plateau State (Nigeria). Federal Ministry of Environment, Abuja.
Environmental Impact Assessment Report (EIAR) No. 31. 2012. Environmental impact assessment for mobile phone base station in a Local Government Area (Mangu), Plateau State (Nigeria). Federal Ministry of Environment, Abuja.
Environmental Impact Assessment Report (EIAR) No. 42. 2014. Environmental impact assessment of a cell phone base station at Lo-Hwol Kanang, Plateau State (Nigeria). Federal Ministry of Environment, Abuja.
Environmental Impact Assessment Report (EIAR) No. 48. 2014. Environmental impact assessment for a cellphone mast and associated base transceiver station in Mangu. Federal Ministry of Environment, Abuja.
Environmental Impact Assessment Report (EIAR) No. 62. 2015. Environmental impact assessment for mobile phone base station in Jos, Plateau State (Nigeria). Federal Ministry of Environment, Abuja.
Environmental Impact Assessment Report (EIAR) No. 65. 2015. Environmental impact assessment for mobile phone base station in a Local Government Area (Bomben), Plateau State (Nigeria). Federal Ministry of Environment, Abuja.
Environmental Impact Assessment Report (EIAR) No. 66. 2015. Environmental impact assessment for mobile phone base station in a Local Government Area (Ryom), Plateau State (Nigeria). Federal Ministry of Environment, Abuja.

RESULTS

Distribution of the 70 EIARs used in the study

Based on classifying spatial information in terms of their category of visual realism as shown in Table 3, Table 4 depicts the specific numbers of EIARs according to their degree of visual realism. Those without any relevant illustrations (n=10) were deliberately excluded even if they were part of the random sampling. The chi-square test was applied to test for statistical variations in the utilisation of spatial information amongst EIARs. Based on the EIARs listed in Table 4, 62% of BTS infrastructure was for locations in the city of Jos, the state capital of Plateau State. Other project locations for BTSs were peri-urban areas (21%) and local government areas (17%) found away from the Jos metropolis (Figure 2).

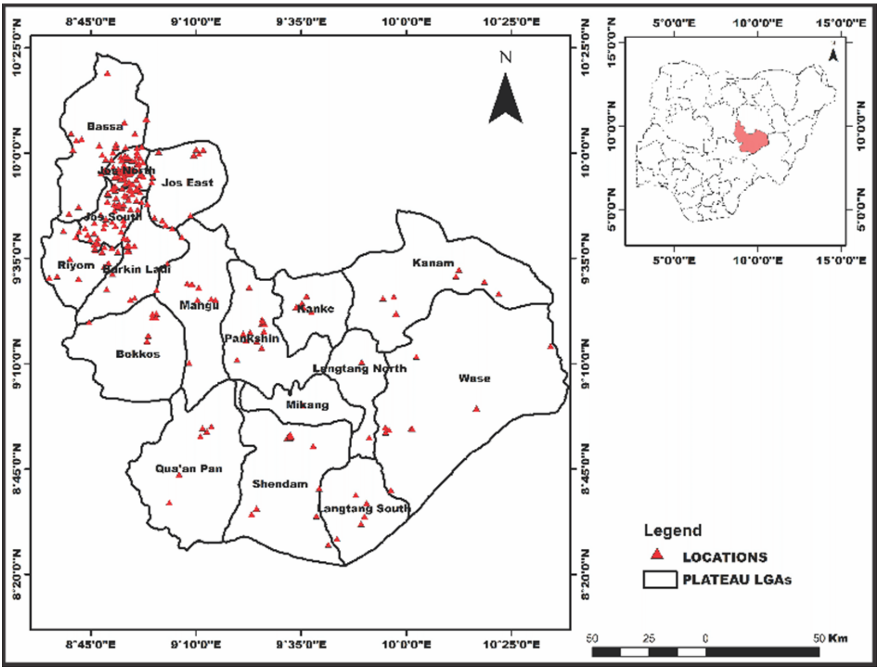

Figure 2. Map showing the location sites for the construction of proposed cell phone base stations in Plateau State, Nigeria, 2006–2015.

Availability and types of spatial representations

In total, 689 individual spatial representations were identified in the different EIARs. This means that on average each of the 70 different EIARs had about nine spatial illustrations. Technical layouts and engineering design sketches were the most common (38% of the total), occurring in 58 EIARs (Figure 3). Such illustrations are classified under Category 1 (Table 3) given their low degree of visual realism. Google Maps images represent 9% of the spatial representations, occurring in 29 EIARs. These fall under Category 2, along with photographs (15%).

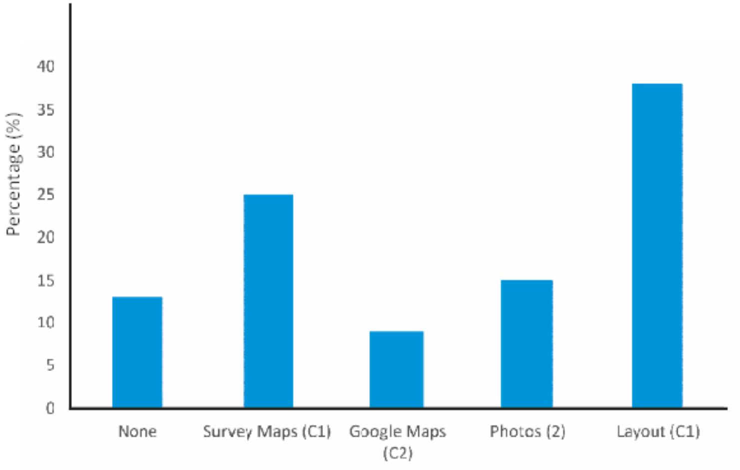

Figure 3. The proportions of different spatial representations provided in the EIARs.

Table 6 indicates the degree of accuracy or inaccuracies in the presentation of the spatial information found in the EIARs. While the majority of spatial illustrations had proper scales and related cartographical detail, others had inaccurate scales and sometimes the scale was not indicated at all (Table 6). The lack of scale was highest amongst site layouts (n=166) and other engineering sketches, whereas fewer Google Maps (n=13) and survey maps (n=26) were affected by this problem.

Table 6. The extent of accuracies and inaccuracies in the presentation of spatial illustrations.

Spatial information	Spatial illustrations with clearly readable scales	Illustrations with inaccurate or incomplete scales	Illustrations without scales
Google Maps images	34	15	13
Survey maps	133	13	26
Site layouts	73	23	166
Photographs	0	0	0

It is also possible to identify the biophysical and socio-economic features associated with the project locations and the engineering designs. The spatial illustrations indicate the locations of rivers, natural vegetation zone, and landforms, as well as different land uses and built-up areas. Thus, the stakeholders involved in the public participation stage of environmental assessment were able to visualise the project sites and the buffer areas necessary to prevent environmental damage.

Spatial illustrations and their uses

In the analysed EIARs, colour photographs were often used to show the locations of project sites and their proximity to certain land uses (Figure 4). This gives higher visual realism than topographical maps and engineering sketches. Additionally, some of the photographs can indicate the technical configurations of the proposed BTS infrastructure (Figure 5).

Figure 4. The site of a cell phone base station near a mining water pond at Lo-Hwol Kanang, Plateau State (Source: EIAR No. 42, 2014, Table 5).

Figure 5. A cell phone base station and some of its components in Via-Fyang, Zawan, Plateau State (Source: EIAR No. 26, 2012, Table 5).

However, despite their higher degree of visual realism and the different features shown on them, some photographs had shortcomings, thus minimising their visual quality. For instance, some failed to show important features such as roads, rivers, natural vegetation and mining ponds that were close to the sites. This means that their framing was inappropriate and important biophysical and socio-economic features were not shown. An example is shown in Figure 6, where the focus is on the security iron bars hiding the supporting BTS components such as fuel tanks, electrical cables and generators.

Figure 6. A photo which failed to show the technical layout of the supporting infrastructure at the selected site (Source: EIAR No. 65, 2015, Table 5).

Google Maps

In the EIARs examined, Google Maps images were used to show major roads, footpaths, human settlements, locations of the proposed infrastructure, and farmland (Figure 7). Despite the viewpoint that Google Maps images have high visual realism (Kozakiewicz, 2015), some of those presented in the EIARs were of poor quality. This was mainly associated with inappropriate map legends and poor spatial resolution, thereby limiting their usefulness.

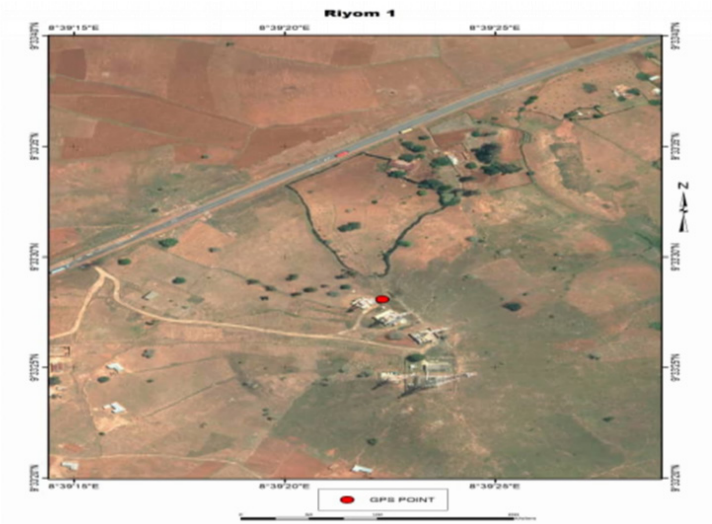

Figure 7. Google Maps image showing the project location (red circle) and other landscape features (Source: EIAR No. 66, 2015, Table 5).

Site layouts

In any construction work, site planning is crucial in determining the location of proposed facilities (Umar et al., 2017). In the case of mobile telecommunications infrastructure, a site layout plan should indicate where fuel tanks, generators, electric transformers, cell phone masts, air conditioners and other components are located (Figure 8). With proper planning, the location of site facilities can be optimized in line with engineering considerations (Umar et al., 2017). In the present study, there were more technical representations in the form of site layouts and engineering designs (38%) relative to other spatial illustrations (Table 6). This may reflect the technical and engineering configuration of the infrastructure. However, some of the illustrations had inaccurate or missing scales. While 22% of the layouts were designed in different colours, the majority were presented in black and white (Figure 8) which may mean some features being shown are not easily discernible.

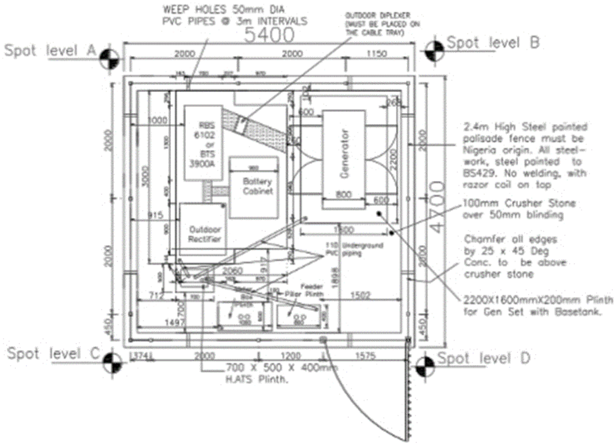

Figure 8. Example of a technical layout showing a typical cell phone base station and related project components (Source: EIAR No. 62, 2015, Table 5).

Topographical maps

Topographical maps in the selected EIARs were used to show the locations of mining ponds, plains, valleys, spurs, hills and vegetation cover. Human-made features such as roads, build-up areas, local government boundaries and project site locations were also depicted (Figure 9). Certain features were identified in specific colours such as rivers, and mining ponds (blue); built-up areas (brown) and vegetation cover (green). Map legends and contour lines are also shown.

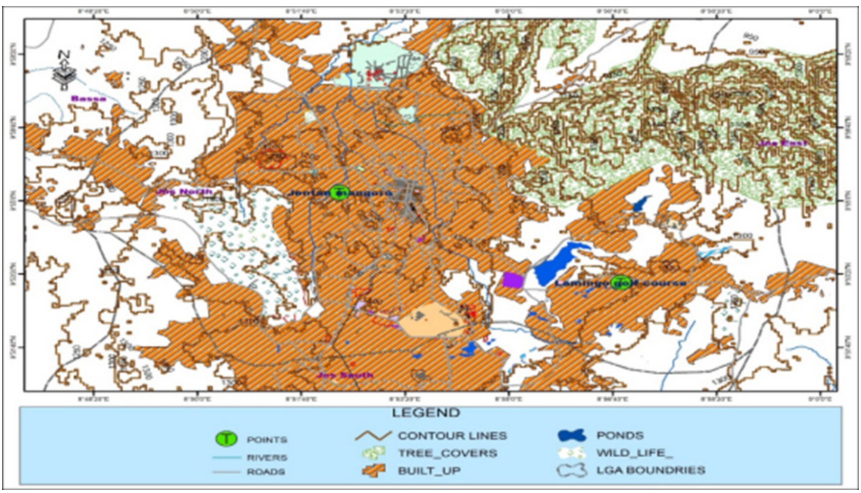

Figure 9. Example of a topographical map showing the proposed location of mobile telecommunications infrastructure (Source: EIAR No. 31, 2012, Table 5).

Characterising degrees of visual realism

The information provided by the spatial representations in the EIARs were classified into 7 different groups (as indicated in Table 2), thus in line with the approach developed by Mncwabe (2021) (Table 7).

Table 7. The number of EIARs (n=70) according to their visual realism.

	Category 1: Low visual realism	**Category 2: High visual realism**	**Category 3: Combined visual realism**
Project location	0	11	23
Project activities/details	30	0	0
Special Interest Areas	6	0	0
Project location + project activities/details	0	0	0
Project location + Special Interest Areas	0	0	0
Project activities/details + Special Interest Areas	0	0	0
Project location + project activities/details + Special Interest Areas	0	0	0

Project locations were the most common spatial information presented in 34 EIARs (Table 7) and included a mix of visual realism comprised of topographical maps, Google Maps images, and site layouts. However, some of the project locations exhibited relatively high visual realism in the form of photos (in 11 EIARs).

In 30 EIARs, project activities were shown by spatial illustrations with low visual realism and geo-visualisation potential. These illustrations were in the form of engineering sketches and site layouts that include details on electrical power sources, transformers, electric generators, fuel reservoirs, air conditioning systems and cell phone masts. A low level of realism was also found in the display of Special Interest Areas. These areas were depicted mainly by site plans and engineering layouts in six EIARs. Figure 10 shows that while there is a decreasing trend for all types of visual realism in the years under consideration, no statistically significant variations were identified (chi-squared value 6.592, df=4, $p>0.159$).

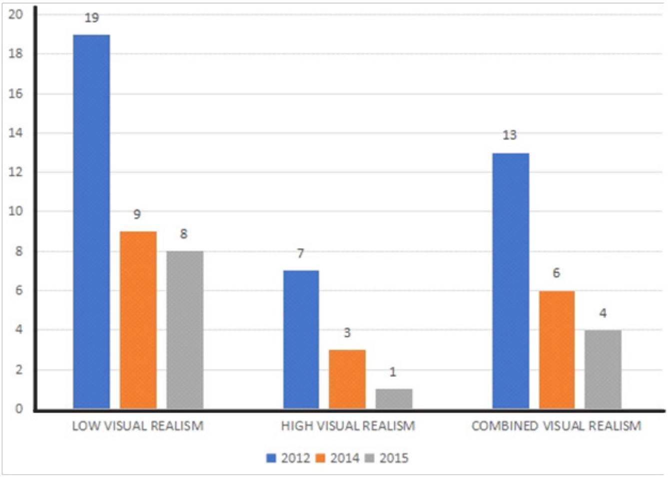

Figure 10. Differences in the degree of visual realism amongst EIARs in different years.

DISCUSSION

In many countries, instruments such as EIAs are used to consider sustainability in the planning and construction of new infrastructure, especially those that can result in harmful impacts on environmental quality and human health (Joseph et al., 2019; Glasson & Therivel, 2019). In Plateau State, more than 60% of the BTS projects examined in this study are located in the Jos metropolis, which may reflect the greater magnitude of economic and commercial activities taking place relative to peri-urban areas. While telecommunication facilities are needed everywhere, developing countries have particular development challenges such as low-income households, underutilized land, limited variety of services and the high cost of providing them, infrastructure backlogs, scarce job opportunities, and uncoordinated spatial planning (Azi et al., 2021).

In the present study, nearly 690 spatial representations were found in the different EIARs. This confirms the frequent use of spatial information in EIA processes, thus similar to results of previous studies (Warner & Diab, 2002). Although studies in Nigeria have examined spatial information to address natural resource management challenges (Nkwunonwo, 2020; Lasisi, 2023; Enoguanbhor et al., 2024), no similar studies have specifically examined the role of spatial information in Nigerian EIARs. Therefore, the results of the present research highlight the significant role that spatial information plays in environmental assessment.

The proportion of technical layouts and engineering design sketches was highest at 38% (i.e. 261 sketches in 58 EIARs) while Google Maps (9%, 62 maps) featured in only 29 EIARs. These types of spatial information fall under Category 1 and Category 2 in terms of their degree of visual realism, respectively. The Google Maps images were more commonly used than topographic maps, and they exhibit a higher level of visual realism which is an advantage that enhances their interpretation for users. By contrast, some EIARs (13%, n=10) lacked any kind of spatial information, thereby limiting an understanding of their spatial dimensions. While technical layouts conveyed key information about the engineering configurations of the proposed infrastructure, their spatial usefulness is generally limited compared to other representations. The Google Maps presented indicate the locations of key features (roads, footpaths, settlements and land uses). Similarly, photographs (Category 2 spatial information) depicted the same project sites but with more spatial detail.

In addition, some of the spatial illustrations used were inappropriately presented and designed. For instance, in 13 Google Maps images there was no detail on scale while 15 illustrations exhibited either wrong or incomplete scales. The extent of this problem was higher in the presentation of layouts as 166 of them were without scale, while 23 had defective scales. This weakness may mean that stakeholders reading such spatial information may arrive at wrong judgements. Furthermore, some of the photographs were too dim to show the aspects that were supposed to be indicated, and some Google Maps images were not readable because their spatial resolution was too coarse. Presenting spatial information with poor quality has negative repercussions for the EIA process as different stakeholders may be unable to understand what the representations mean (Samitsch, 2014; Stein et al., 2016).

Overall, following the methods applied by Mwenda (2015) in Kenya and Mncwabe (2021) in South Africa, the spatial information was grouped into seven categories (Table 2) in addition to the three categories of visual realism (Table 3). In total, 36 EIARs used spatial information with low realism and 23 EIARs displayed combined levels of visual realism. However, those with high visual realism were relatively few, featuring in only 11 EIARs.

These results reveal the extent to which the spatial information was either present or lacking in depicting the proposed projects and their environmental aspects. The results also go against broader trends in the literature where there is a growing popularity for spatial information with higher levels of visual realism (Fan et al., 2017). The low quality of the spatial information presented in the EIARs may be attributed to the generally low professional standards in Nigerian EIA practice, historical difficulties in accessing appropriate spatial information, and the lack of technical skills to use spatial data architecture effectively (Dekolo & Oduwaye, 2016). These weaknesses differ from EIA practice in countries such as South Africa where the quality of EIARs is comparatively higher (Sandham et al., 2008, 2010).

CONCLUSIONS AND RECOMMENDATIONS

This study has examined the usefulness of spatial information presented in EIARs compiled for environmental impact assessments and the legal authorization of various mobile telecommunication projects (BTSs) in Plateau State, Nigeria. The precision and clarity of spatial information presented in such reports has the potential to communicate relevant knowledge and enhance dialogue amongst EIA specialists and the public, thus aiding environmental decision-making. The results show that most project locations in Plateau State were for the city of Jos, owing to its larger population size and its commercial functions. Peri-urban areas are less preferred for the siting of BTSs. Nonetheless, the environmental assessment of such infrastructure must be performed effectively so that environmental sustainability can be enhanced.

Most spatial representations were in the form of site and engineering layouts (262 sketches) and topographical maps (172 illustrations). On the other hand, Google Maps images (62 illustrations) and photographs (103 illustrations) that have higher visual realism were used to a lesser extent. Some spatial representations had distortions or were wrongly designed, thus weakening their usefulness. Most EIARs in the present study used information that revealed project location, project activities/details, and Special Interest Areas in isolation rather than in amalgamated forms, contrary to trends shown in previous studies. A declining trend over time in the degree of visual realism in the EIARs was also identified. Given these shortcomings, the extent to which stakeholders are able to visualise spatial relationships in the proposed projects may be limited. There is therefore need for further research to understand the influence of these constraints on spatial understanding, especially given the expertise of some stakeholders, their cultures, gender, and their ability to interpret spatial presentations with different levels of visual realism.

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