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Achieving sustainable cities: analysis of the factors that influence compliance with telecommunication masts siting standards in Ghana

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ABSTRACT

Factors that influence compliance with the standards that regulate the siting of telecommunication masts remain unclear in the conventional literature. Therefore, the purpose of this study is to assess the determinants of compliance with the standards that guide the siting of telecommunication masts in the Ghanaian context. The researchers obtained primary and secondary data from telecommunication operators and regulatory institutions. The results of the study showed that the level of compliance is influenced by the effectiveness of inspection and enforcement, land values and compensations paid for land, and rewards for compliance and penalties for noncompliance with the standards and guidelines. The policy compatibility analysis showed that the guidelines that guide the siting of telecommunication masts in Ghana is compatible with other sectoral policies that promotes environmental sustainability and the safety of human settlement. Through its decentralized agencies, the government should review and enforce the co-location policy to limit the proliferation of telecommunication masts in the cityscape.

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Urban planning; locational standards; compliance; telecommunication mast; Ghana

1. Introduction

The telecommunication industry is rapidly becoming one of the major contributors to improving and developing the Ghanaian economy (Eshun, 2009). The industry contributes up to 10 percent of government income and 2.2 percent of GDP while attracting 7 percent of the country's total investment (National Communication Authority, 2017). Public and private investments in Ghana's telecommunication industry, over the years, has succeeded in exceeding the investment in the main export of natural and agricultural resources such as diamond, gold, and bauxite (Eshun, 2009).

The continuous population growth resulting from rapid urbanization and expansion of cities has resulted in an increased demand for telecommunication and other services in most cities and towns around the globe (Støttrup-Andersen et al., 2017; Winkelmann & Duch, 2019). Masts and towers are installed to ensure effective functioning of mobile

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telecommunication (Bello, 2010; Donkoh et al., 2017). The continuous demand for mobile phones and their related services has consequently resulted in the proliferation of masts and towers across cityscapes over the last few years (Støttrup-Andersen et al., 2017; Winkelmann & Duch, 2019). Telecommunication operators always look for sites that offer height and stability for their cells without meddling with other telephone cells. Service providers sometimes install their antennas on the roof of buildings and other structures to reduce the many environmental risks and health hazards. In other areas, masts are built to hold the antennas (Bond et al., 2003).

Several scholars have provided evidence on the numerous adverse health effects when one lives or works in close proximity to telecommunication masts (Gibson, 2017a; Wolf & Wolf, 2004). For instance, the studies report that prolonged exposure to high-frequency telecommunication fields expose humans to fatigue, headaches, tremors, skin problems, memory disruption, nausea, and irritability as well as leukemia, epilepsy, and a different variety of cancer. It may also affect the wellbeing, reproduction, and behavior of humans and other biological organisms (Abdel-Rassoul et al., 2007; Adeniji et al., 2015; Danladi et al., 2016; Everaert & Bauwens, 2007; Santini et al., 2002) as well as the having huge psychological burden on residents who live closer to it (Odunola et al., 2015). Eneh (2015) also observed how children suffer from dizziness, nose bleeding, and memory loss when their residence or school is less than 10 m away from the telecommunication mast. Adults and staff suffer from muscle pains and aches, fatigue, eye symptoms, stress, digestive disorders, facial pricking, ear/nose/throat symptoms and rashes.

Similarly, in Ghana, there have been several concerns and public outcry about the possible health risks associated with the siting of telecommunication masts, especially in residential areas (National Communication Authority, 2010). In response to the public concerns and outcry, the Government of Ghana has developed standards and regulations to manage the siting of telecommunication. However, studies by Amponsah et al. (2021) and Takyi et al. (2021) revealed an indictment of non-compliance to the standards in siting masts in Ghanaian communities by telecommunication operators.

The available literature on the siting of telecommunication masts (Abdel-Rassoul et al., 2007; Adeniji et al., 2015; Akintonwa & Busari, 2013; Bond et al., 2003; Eneh, 2015; Everaert & Bauwens, 2007; Filippova & Rehm, 2011; Foster, ; Garba et al., 2017; Odunola et al., 2015; Olarewanju, 2016; Santini et al., 2002; Timotijevic & Barnett, 2006; Wolf & Wolf, 2004) report primarily on the possible health risks associated with siting telecommunication masts close to residential areas and the impact of cellular phone station towers on property values. What is unclear in these studies is the inherent weakness in providing the dynamics that could be the driving forces to compliance with the standards that regulate the siting of masts.

The purpose of this study, therefore, is to identify the factors that contribute to compliance with the set locational planning standards that regulate the deployment of telecommunication masts in Ghana. However, for this study, emphasis will be on policy compatibility analysis, enforcement, and inspection, land value and compensations, rewards and penalties for compliance and noncompliance and the subjective determinants of compliance of standards that guide the siting of telecommunication masts. The study will also make proposals and recommendations that can be adopted to address noncompliance and indiscriminate proliferation of masts in Ghana and other sub-Saharan countries.

2. Literature review

2.1 *Best practices in the siting of telecommunication masts-lessons from the global north*

Telecommunication remains important to most economies across the world (Lum, 2011; Cooper, 2019). The siting of masts in countries and cities has been critically scrutinised due to the many health and safety concerns (Aderoju et al., 2014). Some of the countries that have succeeded in facilitating the growth of telecommunication systems while keeping the impact of masts and towers on humans and the environment to the barest minimum are discussed

2.1.1 *Best practices in the siting of telecommunication masts: lessons from the United Kingdom*

The United Kingdom is one of the world's leading mobile telecommunications operators, offering a variety of competitive and innovative services (UK Government, 2008). The telecommunications industry is continuing to develop as new networks are introduced, and established ones upgraded and expanded to meet the increasing demand. The Government telecommunication guideline is the Code of Best Practice on Mobile Network Development. The code was developed by agencies such as the Department for Communities and Local Government, Arqiva, the Department for Culture Media and Sport, the Department for Environment, Historic England, Food and Rural Affairs, the Local Government Association, Mobile UK, National Parks England, Landscapes for Life, and the Planning Officers Society (UK Government, 2016). The code of practice acts as guidelines for telecommunication providers, their agents and contractors and the United Kingdom's local planning authorities. The code is also a useful regulatory tool for other stakeholders, such as infrastructure and amenities organisations, community groups and individuals interested in mobile telecommunication connectivity. The Code's ultimate aim is to achieve policy commitment to the efficient delivery of telecommunication infrastructure that is essential to socio-economic growth and development. The Code also has a vital role in ensuring appropriate involvement and engagement of interested parties and local communities in decisions on telecommunication infrastructure development.

The United Kingdom National Planning Policy Framework (NPPF) recommends that the aim of planning systems is to safeguard sustainable development and proposes to local planning bodies to work proactively with mobile operators to ensure progress which translates into the social, economic and environmental development of their operational areas. The NPPF further recommends the need operators to maintain the number of telecommunications masts and facilities unless the need for additional infrastructures is justified. Encouraging telecommunication operators to share infrastructure to minimize the number of masts remains a long-standing policy goal of the UK Government.

Moreover, the planning authorities request clarification whether the operator wants to upgrade/redevelop existing masts and other facilities or to share them with other operators or to build a new facility. The authority requests documents relating to the compatibility of the proposed development with the plans for local land use. Consultations with the city transport authority on the proximity of masts to the models of traffic light and how masts could be installed without posing challenges to the traffic

lights and the transport network are also carried out. Similar consultations are needed for schools and colleges near the location of the proposed masts. The Civil Aviation Authority must also be consulted for endorsement to ensure the proposed masts are of no threat to the functioning of airlines. Specifically, the standard recommends a minimum of 3 km setback between masts and airfields. Developers are also expected to provide descriptions of their proximity to key areas, services and other features of the city on maps showing the position of the proposed development. The maps are necessary to ensure that the proposed development complies with planning standards (UK Government, 2016).

Additionally, developers are expected to provide information on the: type of structure example masts or tower; overall height of the masts; width; length; material to be used and color of tower/mast; the height of existing buildings; and the reasons for the choice of design. Similarly, a statement in agreement with the International Commission on Non-Ionizing Radiation Safety Guidance on Public Access to Radio Frequency shall be applied to all applicants seeking to erect masts. Compliance of standards is calculated by mathematical calculations based on guidelines from the Council of the European Union (EU).

Furthermore, developers must also provide technical specifications on the coverage plots they want to provide network coverage. Proposals to improve the capacity of a network in an area will not generally need coverage plots (UK Government, 2016). The process of acquiring a permit takes 56 days (8 weeks). The period allows planning authorities to make the necessary consultations and make a decision on the application. The authorities begin reviewing the application, evaluating key content about its position and appearance, informing key stakeholders, including public consultations, and advising the applicant of their decision to accept or offer reasons for refusal. When no notice is issued within 56 days from local authorities, the application shall be deemed approved (UK Government, 2013).

Authorities in the United Kingdom use enforcement notice, stop work notice, fines and penalties and judicial hearings to enforce compliance of standards that regulate the siting of telecommunication masts and towers (UK Government, 2008). Appropriate measures are employed depending on the magnitude of contravention. It is against this background that this study will examine the factors that contribute to non-compliance and enforcement of the standards that guide the siting of masts in Ghana.

2.1.2 Best practices in the siting of telecommunication masts: lessons from Canada

Industry Canada is the official authority that regulates the installation of telecommunication mast/tower and related facilities in Canada under [Section 5](#) of the Radio Communication Act (Industry Canada, 2012). Health Canada sets requirements for governing cell phones, Wi-Fi access and telecommunication mast location that mitigate the effects of electromagnetic radiation from base stations (Industry Canada, 2012). The exposure limit from base stations has been set in safety code 6 base on scientific studies (Industry Canada, 201). Industry Canada has the sole responsibility to accept or deny applications from mobile operators on the siting of telecommunication masts and other facilities. Industry Canada partners with local municipalities and telecommunication companies to address challenges with the local mobile industry. The most current Industry Canada Client Procedures Circular CPC-2-0-03, 'Radio communication and

Broadcasting Antenna Systems', states that 'Proponents must follow the land-use process for the siting of antenna systems, established by the land-use authority'. However, Industry Canada can supersede the consultation procedure of the municipal authority where it is deemed unreasonable (Industry Canada, 2012). Even though Health Canada sets the standard found in Safety Code 6 used by Industry Canada, it is not responsible for the licensing and enforcement of telecommunication infrastructure location standards. Health Canada only provides advisory service to industry Canada.

Moreover, land use authorities also known as Town provide guidance on how to make the planned construction or replacement of telecommunication infrastructure compliant with land use plans, zoning plans and other guidelines. The Town also initiates a public consultation process on the proposed development to solicit the views of key stakeholders and interested parties. Such inputs help Industry Canada accept or reject applications in its decisions. The details of the guidelines focus on requirements on preferred location and siting of the base station, general design and visual impact. Specifically, the authority assesses details such as transmission; design; massing; colour; lighting; fencing; tower type; equipment shelters; and signage. Consultations are carried out to solicit concerns and views of stakeholders and interested parties. This policy is reviewed every three years or upon the adoption of new practical requirements by Industry Canada (Industry Canada, 2012).

However, non-compliance of the set standards by mobile operators is usually accidental and is resolved by communicating and working with the violator to find solutions and ensure compliance (Government of Canada, 2015). In other instances, a written notice may be issued advising the violator of the need to ensure compliance to the set standards. An administrative monetary penalty which comes in the form financial penalties is also imposed on companies that violate the standards as a means of discouraging non-compliance. Additionally, the authority carryout compliance promotion programmes, compliance monitoring and enforcement activities to promote and ensure compliance to the standards that govern the siting of telecommunication masts and towers in Canada (Government of Canada, 2015). It is against this background that telecommunication masts in Kumasi will be examined according to the Ghanaian standard and regulations to determine whether the due process was followed before they were sited; the design, and appearance and its compatibility with the surrounding environment; whether the public and key stakeholders were consulted before siting them.

2.2 Best practices in the siting of telecommunication masts-lessons from the global south (the case of South Africa)

The development and location of telecommunication infrastructure have attracted interest from society and governments due to public health and aesthetics. As a result, technology and legislative frameworks have been used by governments and local councils as a new perspective to telecommunication infrastructure development (The City of Polokwane, 2015). The Polokwane City Council in 2004 approved and adopted telecommunication mast policy. The policy was necessary due to the rapid growth of telecommunication infrastructure in the city. Concerns were raised by residents of the city that telecommunication masts affect their visibility, they are ugly, they emit radiation, they are used to spy on them and they do not want them in their backyard. The

policy was in response to the need to update the guidelines and provisions that guide the installation masts. This is due to the potential impacts of telecommunication infrastructure with emphasis on possible health risks associated with exposure to electromagnetic radiation.

Firstly, the policy was formulated to promote public health. It suggests that masts should be located away from residential and other densely populated areas. It further proposes that all telecommunication antennas should be sited more than 50 m away from any habitable building. Masts, antennas on rooftops and base stations should be gated to prevent unauthorized person accessibility within 5 m. The council will also task an independent qualified institution to conduct periodic tests on already installed masts to determine the actual mean radio frequency and other details (The City of Polokwane, 2015).

Furthermore, the policy seeks to address community resistance to the siting of telecommunication masts. It proposes community participation to address the concerns of people who live in close proximity and integrate their needs into the planning and deployment of masts. The policy recommends the need for educational programmes and the formation of project teams to link infrastructure development of communities to their needs and also create public awareness on alternative options available in telecommunication infrastructure development. This should be done through public meetings with community members especially those who will be affected or have an influence on the siting of masts. Public meetings are necessary to capture community participation and address concerns of property owners regarding mast installation. Local authorities are allowed to prevent the installation of masts if public consultations are not done to satisfaction (The City of Polokwane, 2015).

Additionally, the policy seeks to promote public safety. It therefore proposes appropriate location of telecommunication masts outside areas that could be of threat to flight movement. Special precautionary measures have been adopted to ensure that no road, airfield and other public transport structures are threatened due to the installation of masts and other telecommunication infrastructure. Base stations, antenna support structures and other structures per the policy are supposed to be fenced to prevent public access to them. Access to these areas must be restricted through a locked entrance. If the structure is going to be co-used by multiple operators with a lighting system for security reasons, a written agreement with neighboring land users is required. The lighting system must be tested to avoid light pollution (The City of Polokwane, 2015).

Also, to address the aesthetic problems of masts, the policy recommends the use of stealth masts that are camouflaged to belittle their visibility. Applicants must demonstrate that all the necessary measures are put in place to assimilate the intended structure with the environment it has been planned for. Operators are also expected to put in place appropriate periodic maintenance plans to preserve the attractiveness of the structure. This is described as an effective means of camouflaging masts to make them visually attractive. The policy also encourages co-location of antennas of multiple operators. Figure 2 and Figure 3 depicts installed telecommunication masts in Polokwane city, South Africa.

Finally, to address noise pollution associated with telecommunication base stations, the policy proposes the use of wind-powered generators that are locally produced in South Africa by Brolaz Projects. The other alternative contained in the policy is to cover the generator box with fiberglass panels to mute the sound it produces. The measures are

recommended to operators to address the negative challenges of humming sound produced by generators that supply power to telecommunication base stations.

The authority ensures compliance with the set standards as effective monitoring of base stations on a regular and random basis. They also implement all the appropriate sanctions contained in the condition of approval in the events of non-compliance of the standards by operators.

2.3 Overview of regulations that govern the siting of telecommunication masts in Ghana

In response to the health and safety concerns associated with the location or siting of telecommunication masts, the Inter-Ministerial Committee (IMC) was established to champion the design and implementation of a solution framework for siting telecommunication base station. The IMC inaugurated an Industry Technical Committee (ITC) led by the National Communications Authority (NCA) to partner with industry and other stakeholders such as the Environmental Protection Agency (EPA), Ghana Atomic Energy Commission (GAEC), Ghana Civil Aviation Authority (GCAA), and the Metropolitan, Municipal and District Assemblies (MMDAs) to design a set of guidelines for an efficient and effective permitting scheme for siting telecommunication masts in the country (National Communication Authority, 2010).

The regulations guiding the siting of telecommunication masts in Ghana mandate operators to obtain all the necessary approval and permits from the relevant institutions and authorities before the installation of masts (National Communication Authority, 2010). As a result, operators are required to apply to the respective Metropolitan, Municipal and District Assemblies (MMDAs) after obtaining a permit from the Radiation Protection Institute (RPI) and the Ghana Civil Aviation Authority (GCAA) approvals (National Communication Authority, 2010).

2.3.1 Ghana Civil Aviation Authority (GCAA)

The Ghana Civil Aviation is one of the institutions mandated to guide the siting of telecommunication masts in Ghana. Their main goal is to ensure that the siting of mast is of no threat to air navigation. They partner with the National Communication Authority and other institutions to ensure harmonious and safety location of masts and towers in Ghana (National Communication Authority, 2010).

All applications for installation or alteration of masts and other telecommunication structures are forwarded to the GCAA for evaluation and assessment for permits on airspace safety. Additionally, the authority is a member of the Inter-Ministerial Committee, where they collaborate with other institutions to develop and update the standard that governs the siting of masts in Ghana.

2.3.2 Radiation Protection Institute (RPI)

The Radiation Protection Institute is one of the institutions mandated by the legislation of Ghana to guide the siting of masts in Ghana (National Communication Authority, 2010). The main objective of the Institute is to ensure that the public, workers and the environment are secured from any detrimental effect of radiation from telecommunication base station.

The Institute conduct safety assessment of proposed masts before approval is given for installation. They also conduct periodic measurements of radiation from installed masts to ensure people and the environment are protected from the harmful effects of electromagnetic rays (National Communication Authority, 2010). The Institute furthermore, collaborates with the NCA and other institutions to develop and update the standard that regulate the siting of the masts in Ghana.

2.3.3 Environmental Protection Agency (EPA)

The Environmental Protection Agency is also one of the institutions mandated to guide the siting of telecommunication masts and towers in Ghana (National Communication Authority, 2010). The main goal of the Agency is to ensure that the surrounding environment where people live or work is protected from the damaging effects of telecommunication mast and tower. To achieve the aforementioned goal, the Agency conducts environmental impact assessment before they issue approval for installation of masts and towers. They also carry out periodic assessments of existing masts and towers to ensure they are threat-free to people and the environment (National Communication Authority, 2010).

An operator who plans to construct a telecommunication mast or tower shall obtain EPA permission, who will carry out an environmental impact assessment to protect the environment from the harmful effects of telecommunications mast and tower (National Communication Authority, 2010).

The agency additionally, partner with the NCA to ensure the removal of abandoned masts and others that are sited in contravention to the set standards (National Communication Authority, 2010). The EPA is also a member of the Inter-Ministerial Committee that develops and updates the standards that regulate the siting of telecommunication masts and towers in Ghana.

2.4.4 Metropolitan, Municipal and District Assemblies (MMDAs)

The Metropolitan, Municipal and District Assemblies as local governments are mandated by the legislation of Ghana to ensure the siting of telecommunication masts and towers in the area under their jurisdiction (National Communication Authority, 2010). They ascertain that masts are installed by meeting all the requirements and approval from the agencies and institutions that regulate that siting of masts in Ghana.

Assemblies basically collaborate with institutions to ensure installation and removal masts within their area. Additionally, they ensure that public consultations are carried out in the proposed neighborhood before installation of masts (National Communication Authority, 2010). They are also a member of the inter-Ministerial Committee that develops and updates the standards that regulate the siting of masts and towers in Ghana.

3. Research method

The research adopted a qualitative approach to gather and analyze both primary and secondary data based on the study's objectives. This paper is primarily based on expert interviews and review of literature on planning guidelines that regulate the siting of masts across cityscapes. Primary data were collected through one-on-one structured interview

with one expert each from telecommunication mast companies such as the American Tower Corporation (ATC), Helios Towers, Eaton Towers and Netis Ghana Limited. Questionnaires were also administered to regulatory institutions such as the National Communication Authority, Radiation Protection Institute of the Ghana Atomic Energy Commission, Ghana Civil Aviation Authority, Environmental Protection Agency, and the Kumasi Metropolitan Assembly. The aforementioned institutions were purposively selected based on the important roles they play in regulating the siting of masts within the Ghanaian context as highlighted in the Government of Ghana Guidelines for the Deployment of Communications Towers (National Communication Authority, 2010). A written letter explaining the purpose of the study and the need for data was sent to the heads of the institutions/units. The heads consequently nominated experts who represented the institutions during interviews and response to questionnaires.

The interviews centered on the role of enforcement and inspections, land values and compensations, and rewards and penalties for compliance and noncompliance with standards. The study participants were also allowed to share their subjective determinants of compliance with standards and regulations that govern the siting of masts in Ghana. Notes were taken while interacting with officers of the various institutions and companies. These notes were systematically evaluated to determine the underlying factors that impede mobile operators' compliance with the set locational planning standards. The primary data generated from operators and regulatory institutions were primarily qualitative. The data were, therefore, analysed using content analysis.

Secondary data used for this study were sourced from an extensive literature review within the global and local context. The global review focuses on the nature and characteristics of telecommunication services and their operation from books, peer-reviewed articles, journals, and reports. However, the local review examined reports on telecommunication and other interventions aimed at addressing the indiscriminate deployment of masts. These documents include the Guidelines on Communications Towers (2010) and the Zoning Guidelines and Planning Standards (2011; National Communication Authority, 2010; Town and Country Planning Department, 2011). The compatibility analysis involved a desk review of national policy documents such as the Infrastructural Sharing Policy, Infrastructure Licensing Policy, Zoning Guidelines and Planning Standards, and National Urban Policy. Other policies include the National Health Policy, National Environmental Policy, Land Use and Spatial Planning Standards, Local Government Act, and the National Telecommunication Policy. A three-interval Likert scale was used to determine compatibility between the guidelines that regulate the siting masts and towers in Ghana and other policies (see, Table 1). A record sheet was used to explain identified positive, negative, and neutral relationships (see Table 2). A positive score indicates consistency and supportiveness of policies, while a negative score shows a conflict between the two policies. While a neutral or zero score also shows no direct relationship between the policies.

4. Results of the study

In this section of the chapter, factors that contribute to noncompliance with standards that regulate the siting of masts are assessed. The study also used a compatibility matrix and variables such as enforcement and inspection, land value and compensations, and

Table 1. Literature and their contribution to the study.

Reference	Contribution
National Communication Authority (2010); Town and Country Planning Department (2011)	Provided guidelines that guide the siting of masts in Ghana Provided justification for the selection of stakeholders for interviews
Government of Canada (2015); Industry Canada (2012); UK Government (2008, 2013, 2016); The City of Polokwane (2015). Addy-Nayo (2001); Arthur (2019); Eshun (2009); Osei-Owusu (2015)	Provided the context of how masts are sited in the UK, Canada and South Africa Provided an overview of the telecommunication industry in Ghana
Bello (2010); Bond et al. (2003); Donkoh et al. (2017); Støttrup-Andersen et al. (2017); Winkelmann and Duch (2019)	Highlighted urbanization and the demand for telecommunication services and masts
Abdel-Rassoul et al. (2007); Adeniji et al. (2015); Danladi et al. (2016); Everaert and Bauwens (2007); Santini et al. (2002); Odunola et al. (2015)	Unpack the dangers associated with living in close proximity to telecommunication masts
Amponsah et al. (2021); Takyi et al. (2021)	Provided the level of compliance to the siting of masts in Ghana
Weible and Heikkila (2017)	Provided the context for policy compatibility analysis
Hatsu et al. (2016); Osei-Owusu (2015)	Highlighted the infrastructure sharing policy
Gunningham (2010); Gunningham and Sinclair (2017); O'Callaghan and Vivoda (2017)	Provided the perspective of enforcement and inspection by regulating agencies
Kobayashi and Grasmick (1990)	Highlighted rewards and punishment as a means of ensuring compliance

Source: Author's construct, 2022.

Table 2. Policies' compatibility analysis.

	Sectoral Policies		Other Sectoral Policies						
	ISP	ILP	NUP1	LUSPA	NEP	NHP	NTP	ZGPS	LGA
GCT	1	1	1	1	1	1	1	1	1

Source: Author's construct, 2020.

Key to the acronyms in Table 1

GCT = Guideline on Communication Towers NHP = National Health Policy

ISP = Infrastructure Sharing Policy NTP = National Telecommunication Policy

NUP = National Urban Policy LUSPA = Land Use and Spatial Planning Act

ZGPS = Zoning Guidelines and Planning Standards NEP = National Environmental Policy

LGA = Local Government Act.

rewards and penalties for compliance and noncompliance to measure compliance with the standards that regulate the siting of masts in Ghana.

4.1 Compatibility analysis among the various regulations that guide the siting of masts

Compatibility analysis as a technique was used to assess the comparison of guidelines that regulate the siting of masts with various policies to identify areas of conflict and inconsistencies. It also helped to identify policies that are mutually supporting in achieving the same objectives. Conflicts are potential factors that could account for non-compliance with the guidelines that regulate the siting of masts (Weible & Heikkila, 2017). This study, therefore, used a compatibility matrix to identify conflicts and contradictions between the guidelines that regulate the siting of masts in Ghana and other sectoral policies in Ghana. The analysis also involved a comparison of the Guidelines on Communication Towers (2010) with telecommunication sectoral policies such as

infrastructural sharing policy and infrastructure licensing policy. The national sectoral policies used for this study are: National Urban Policy, Land Use and Spatial Planning Policy, National Environmental Policy, and National Health Policy. The other policies are: National Telecommunication Policy, Zoning Guidelines and Planning Standards, and the Local Government Act. The study, however, used a three-interval Likert scale to determine compatibility between the guidelines that regulate the siting of masts and towers in Ghana and other policies (see, [Table 2](#)). A record sheet was used to explain identified positive, negative, and neutral relationships. A positive score indicates consistency and supportiveness of policies, while a negative score shows a conflict between the two policies. A neutral or zero score also indicates no direct relationship between the policies.

The study identified no conflicts between the guideline that regulate the siting of masts and other sectoral policies in Ghana. The record sheet in Appendix I shows that the siting of masts to promote environmental sanity manifests in all the policies reviewed in this study. The plausible explanation is that the quest to regulate the siting of masts to protect people and the environment from the harmful effect of masts and towers is highly recognized to be vital to the growth and development of Ghana ([Addy-Nayo, 2001](#); [Burby & Dalton, 1994](#); [Eshun, 2009](#); [Lum, 2011](#); [Osei-Owusu, 2015](#); [Ussher, 2015](#)).

The Infrastructure Sharing Policy and Infrastructure Licensing Policy both aim to minimize the proliferation of masts due to the increasing demand for telecommunication services amidst rapid urbanization. The policies encourage the sharing of infrastructure among telecommunication operators to limit the number of masts and their effects on humans and the environment ([Hatsu et al., 2016](#); [Osei-Owusu, 2015](#)). The policies directly resonate with the purpose of the guideline that regulates the siting of masts in Ghana. Moreover, the Zoning Guidelines and Planning Standards also complement the guidelines that regulate the siting of masts by outlining acceptable standards for masts across different land uses.

Furthermore, the National Telecommunication Policy recognizes the need to regulate the telecommunication industry for effective communication ([Addy-Nayo, 2001](#)). As a result, the National Communication Authority is mandated to collaborate with other institutions to regulate the siting of masts in Ghana. Implementing the guidelines that regulate the siting of masts contributes to the achievement of the National Telecommunication Policy objectives. The Guideline on Communication Towers is therefore compatible with the National Telecommunication policy.

In the same vein, the achievement of the goal of Guideline on Telecommunication Towers contributes to the aims of the National Health Policy, National Urban Policy, and Land Use and Spatial Planning Standards. Specifically, the siting of masts according to the guidelines that regulate the siting of masts contributes to the objective of the National Health Policy of creating a healthy environment where people live, school, and work. The guideline that regulate the siting of masts also contributes to the goal of the Ghana National Urban Policy, which seeks to create sustainable, spatially integrated, and orderly development of urban settlements.

The Guideline on Communication Towers is also compatible with the Local Government Act and the National Environmental Policy. The policies are consistent in contributing to a healthy and safe environment through integrated and coordinated environmental management. Additionally, the policies embrace the need for regulations

and control mechanisms to manage the growth of human settlements amid rapid urbanization.

In conclusion, the policy compatibility analysis reveals that the guideline that regulates the siting of telecommunication masts in Ghana is compatible with other policies that promote environmental sanity and the safety of human settlement in the country.

4.2 Determinants of compliance

4.2.1 Enforcement and inspections

Enforcement of standards that guide the siting of masts by regulatory institutions is vital in ensuring compliance by telecommunication operators in deploying their base stations (Gunningham, 2010). Inspection or monitoring of telecommunication base stations and sites by regulatory bodies is also recognized as effective tools to monitor compliance with standards that govern the siting of telecommunication masts (O'Callaghan & Vivoda, 2017).

According to the officials interviewed, enforcement and inspection are key in the siting of telecommunication masts in the country. According to the NCA official,

enforcement and inspection is the process of ensuring compliance to planning standards and regulations through periodic checks and assessment. The process is conducted to prevent the detrimental effects of masts on the environment and people. (A statement by an officer of National Communication Authority, 5 February 2020, Accra)

The checks include environmental impact assessment, structural integrity assessment, and physical measurement of radiation emission. The inspection and assessment of masts in Ghana are carried out by the Environmental Protection Agency, MMDAs, Ghana Civil Aviation Authority, and the Radiation Protection Institute of the Ghana Atomic Energy Commission (GAEC). The NCA official during the study stated that operators whose masts or towers failed to meet the required measurements of the standards are notified and are required to remedy the situation within one (1) month. The failure of the operator to rectify the shortfalls within the stipulated period attracts further sanctions and penalties.

Regulatory institutions during the studies provided evidence to suggest how enforcements and inspection contribute to compliance with standards that regulate mast sitting. They indicated that inspections and enforcement allow them to engage operators and other stakeholders on defects and issues with masts which contribute to compliance with standards. Inspections also inspire operators to site masts according to plans and standards. This is necessary because regulatory bodies will identify deviations from plans and standards during the inspection.

enforcement and inspection by relevant stakeholders ensure that the siting of telecommunication mast complies with the guidelines of the institutions. They also inform stakeholders of concerns (noncompliance) and the measures that will be implemented to address non-compliance. (A statement by an officer of EPA, 16 December 2019, Kumasi)

Therefore, operators will comply with the standards since deviations and noncompliance are exposed to periodic checks and inspections. The need to ensure enforcement of guidelines is supported by Gunningham and Sinclair (2017), who suggested that enforcement is critical to compliance with standards, guidelines, and legislations that are not

enforced hardly achieve its objectives. The need for enforcement and inspections to ensure compliance agrees with O'Callaghan and Vivoda (2017), who pointed out that monitoring and inspections are the only means of determining if operators are adhering to guidelines. Therefore, enforcement and inspections are essential in ensuring that the siting of masts in accordance with the set locational planning standards.

Moreover, telecommunication masts providers also supported the claim that inspections and enforcement contribute to compliance with standards and regulations. They explained that defects and noncompliance are exposed during inspections and periodic assessments. Addressing these defects comes with a huge cost, and the failure to remedy them comes with penalties and sanctions. Operators, therefore, suggested that it is safer to site masts according to standards and regulations to avoid the challenges and sanctions associated with noncompliance that are detected during inspections and assessments.

4.2.2 Land value and compensation

Compensations refer to the amount paid as a lease to land or property owners to allow masts. Interview findings showed that the amount paid depends on the value placed on a particular land/space based on the location and owner's negotiation power. On the influence of land value and the amount paid as compensation for compliance with the standard, the EPA suggested that the inability to meet the demands of land/property owners could mean siting of masts at alternative locations, leading to non-compliance with standards.

Other regulatory institutions such as the NCA, GCAA, RPI, and telecommunication mast companies like ATC and Helios Towers interviewed had a contrary view on the influence of land values and compensations as a determinant of compliance with the standard that regulates the siting of masts. They suggested that there is no relationship between land values and compensation and compliance with standards. They believed that compliance with standards is influenced by other factors aside from land value and the amount paid as a lease for their usage.

The foregoing demonstrates that compensations and land values can affect compliance with standards that regulate the siting of masts in Ghana. Although most institutions aside, the EPA admitted that compensations and land values influence compliance with the set standards and guidelines. As a result, compliance with standards is not influenced by land value or the amount paid as compensation. However, the practice of operators moving to different land/property owners as a result of their inability to settle on compensation and lease agreements with earlier land/property owners opens up the possibility of siting of masts in contravention with the locational planning standards that regulate the location of masts in Ghana. As discussed earlier in this report, operators are limited to a few areas in the already built-up area in the cities for their masts. They also make a rational calculation of expected benefits before they commit to siting of masts. Therefore, moving for alternative land/space amidst stiffer competition for different uses could expose them to siting masts at locations that violate the set standard and regulations.

4.2.3 Rewards and penalties for compliance and noncompliance

Compliance usually comes with a reward as motivation to encourage continuous adherence to the set standards and ethics. On the other hand, punishments and penalties are

applied to serve as deterrence to discourage contravention of ethics and standard (Kobayashi & Grasmick, 1990). The siting of masts comes with rewards and penalties based on how operators apply the standards and guidelines that govern the siting of masts. Compliance with the standards comes with a reward, although it is not common in the Ghanaian context. However, punishments and penalties resulting from noncompliance are stipulated in the standards and guidelines that regulate the siting of masts in Ghana.

Some of the penalties in the Guidelines for the Deployment of Communication Towers (2010) that addresses the growth and environmental sanity are: i) a decommissioned mast/tower which is not removed by the owner within 60 days after discontinuance of use shall attract a fine of GH¢ 10,000 per day and ii) after a notice is served to the owner of mast/tower that is not compliant with the set standards and requirements if it is not removed within 60 days attract a penalty of GH¢ 35,000. These penalties are applied to ensure that operators abide by the conditions contained in the standards that regulate the siting of masts.

The study revealed that rewards and penalties for compliance and noncompliance influence how telecommunication masts are sited based on the standards. The study participants from the regulatory institutions and mobile operators overwhelmingly agree that applying sanctions and penalties enforces compliance with standards in the siting of masts. Operators cited that the purpose of their operation is for-profit, and the avoidance of such damages that are charged for noncompliance is a good fortune for their business. They also acknowledged that, although there is no clear reward for compliance, adherence to the set standards ensures continuity of operation and the safety of their investment.

penalties and decommissioning of masts serve as a deterrent for noncompliance. The assurance of knowing that you will not be fined or your site will not be decommissioned ensures that your investment is safe. (A statement by an agent of telecommunication operating company, 14 January 2020, Accra)

During the study, representatives of regulatory institutions such as the EPA, GCAA, NCA and the KMA also suggested that compliance with set standards and guidelines is rewarding to telecommunication companies in the form of safer operations devoid of high remediation and damage cost to the mobile industry. They indicated that demolishing unauthorized masts at the cost of operators should be enough deterrent to enforce the siting of masts according to the set standard.

According to the NCA official

penalties cited in the guidelines for the deployment of Communication Towers (2010 Guidelines) and regulations from permitting agencies is enough to encourage companies to abide by the conditions (standard and regulations).

They, however, suggested that cases of noncompliance could give rise to the formulation of harsh policies, regulations, and strategies, which may create an unfavorable economic and regulatory environment for the telecommunication industry. Therefore, it is essential for operators to site masts in compliance with the guidelines that regulate the deployment of masts to maintain a healthy business environment.

The foregoing findings revealed that penalties and rewards influence the siting of masts and towers according to standards and guidelines. Key stakeholders in the mobile telecommunication industry in Ghana (regulatory bodies and operators) admitted that penalties are pragmatic measures to curb noncompliance with standards in the siting of masts. The standard that regulates the siting of masts in Ghana, as discussed earlier, has clearly outlined penalties and sanctions to guide the growth and environmental sanity amidst rapid urbanization in Ghanaian cities

4.2.3 Subjective determinants of compliance with standards that guide the siting of masts

The study participants also shared their opinions on other factors that determine compliance with the standard regulating the siting of masts in Ghana. Opinions from representatives of regulatory institutions and telecommunication mast firms are summarized in [Figure 1](#).

As illustrated in [Figure 1](#), compliance with standards and guidelines that regulate the siting of masts and towers are influenced by factors such as population density, availability of suitable land and space within the already-built neighborhood, and the effectiveness of zoning in the city.

Furthermore, the attitude of residents and property owners towards telecommunication masts was also mentioned to be one of the factors that influence compliance with standards that regulate the siting of masts. Telecommunication mast providers during the study revealed that the acceptance of masts by property owners and residents at an appropriate site promotes compliance with standards. However, rejection of masts at the appropriate site means operators will have to seek an alternative location, which could lead to noncompliance with the standards.

Additionally, land tenure and ownership and its associated conflicts and litigations also influence the siting of masts in compliance with the set planning standards. The inability to reach agreement with land/property owners at appropriate locations due to multiple ownership as a result of conflicts and litigations leaves operators with the option of seeking another site within neighborhood to satisfy its customers. The practice according to experts from telecommunication firms during the interviews influences compliance with standards.

Moreover, the motivation to meet standards was also identified as a factor that influences compliance with standards that govern the siting of masts. Telecommunication operators during the study suggested that compliance with standards ensures continuous operation and security of investment. It, therefore, motivates them to comply with the standard in order to sustain their business and revenue.

Lastly, the effectiveness and appropriateness of the standard that regulates the siting of masts were also mentioned as factors that largely influence the siting of masts according to standards. Representatives of mast firms suggested the friendliness of the standards and permit scheme to operators promote compliance. It can, therefore, be deduced that the adequacy of the regulatory framework is crucial in ensuring compliance with standards.

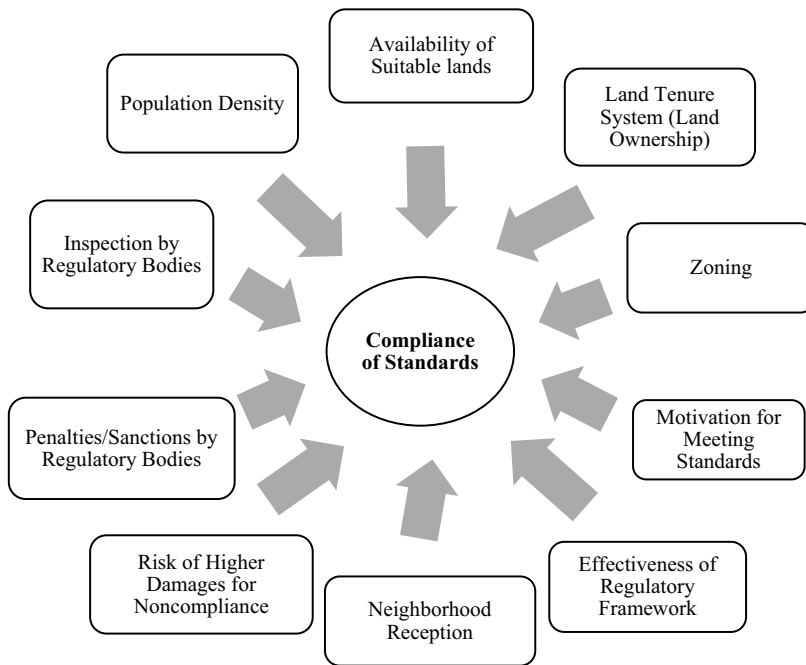


Figure 1. Factors influencing compliance of standard in siting telecommunication masts. Source: Author's Construct, 2021.



Figure 2. Installed Camouflaged Telecommunication Mast, South Africa. Source: The City of Polokwane, 2015.

5. Discussion of the study results

The findings revealed that the guidelines that regulate the siting of masts in Ghana are compatible with telecommunication sectoral policies and other sectoral policies. The compatibility analysis reveals that the siting of masts to promote environmental sanity



Figure 3. Installed Telecommunication Tower in Polokwane, South Africa. Source: The City of Polokwane, 2015.

features in all the policies reviewed in this study. The study identified no conflict between the Guidelines on Communication Towers and Infrastructural Sharing Policy, Infrastructure Licensing Policy, Zoning Guidelines, and Planning Standards and National Urban Policy. The guidelines that regulate the siting of masts are also consistent with the National Health Policy, National Environmental Policy, Land Use and Spatial Planning Standards, Local Government Act, and the National Telecommunication Policy.

Ghana, like other countries, adopted locational planning standards to guide the siting of telecommunication masts and towers due to the health and safety concerns associated with the infrastructure. The current guidelines (i.e. Guidelines on Communication Towers) that guide the siting of masts are not only compatible with other policies but also complement most of the interventions, plans, policies and other legislations that seek to promote environmental sanity. It can be concluded that planning response to the siting of masts in Ghana is compatible and appropriate, but the challenge has been the implementation of the various responses. The findings lend credence to scholarly works (Amponsah et al., 2021; Olaide, 2013; Takyi et al., 2021) that identified poor implementation and noncompliance with the standards that regulate the siting of masts in Ghanaian and other cities.

The study revealed that enforcement and inspection are key determinants of compliance with standards that govern the siting of masts. The study respondent provided evidence to suggest how enforcement and inspection impact how masts are installed

based on how they respond to the incidence of noncompliance. The findings show how effective inspection and enforcement influence compliance with standards that regulate the siting of masts. Effective inspections and enforcement could be a powerful tool to prevent the indiscriminate proliferation of masts across cityscapes. The finding is in tandem with studies (Gunningham, 2010; Kobayashi & Kerbo, 2009; O'Callaghan & Vivoda, 2017) that highlighted the importance of enforcement and inspection to compliance with standards and regulations. Therefore, it is important for the government and other stakeholders to reinvest attention and resources in inspections and enforcement to ensure the siting of masts and towers according to the locational planning standards. As earlier discussed, the siting of masts in close proximity to residential and commercial areas is associated with health and safety concerns (Abdel-Rassoul et al., 2007; Adeniji et al., 2015; Eneh, 2015; Everaert & Bauwens, 2007; Gibson, 2017b; Odunola et al., 2015). The foregoing highlights the need to reinforce the infrastructure sharing policy to reduce the number of masts across cityscapes (Amadasun, 2020; Arthur, 2019; Hatsu et al., 2016).

It was also revealed that land value and the amount paid as lease or compensation for land/space could influence how masts are sited according to standards and guidelines. Although most institutions during the study discredit it as determinant of compliance, the practice of negotiating with land/property owners on the amount paid as lease and the cases of moving for alternatives due to the inability to meet the owners' demands could open up for noncompliance of standards. The Environmental Protection Agency strongly agrees that compensations and land values influence compliance with planning standards of siting telecommunication masts. As discussed earlier, masts are usually sited in already built-up areas with limited spaces. The demand from property owners could be a contributive factor to noncompliance with the locational planning standards. The finding support studies (Cobbinah & Darkwah, 2016; Gyau et al., 2014; Karvonen et al., 2020; Lei et al., 2021; Poku-boansi, 2021; Siiba et al., 2018; Xue, 2022) that emphasized the challenges of land use and urbanization to urban planning in developing countries.

The findings from stakeholders further showed that rewards and penalties for compliance and noncompliance influence how telecommunication masts are sited according to standards. Experts during the interview argued that rewarding operators for complying with the planning standards while punishing violators of the regulations are key in ensuring compliance with planning standards and guidelines. Moreover, successful countries like the UK, Canada and South Africa as discussed in this study do not rely on penalties and rewards to ensure compliance. They have developed pragmatic and efficient regulatory bodies that ensure that standards are met before the installation of masts. It is, however, unclear whether these penalties and sanctions in the Ghanaian standards are applied appropriately and promptly. The foregoing highlights the reactive nature of urban planning in Ghana in terms of managing unapproved developments. A renewed effort by the government and other stakeholders through the National Communication Authority to reinforce the application of sanctions and penalties is highly recommended.

In terms of subjective determinants of compliance, the study found limited availability of suitable land and space; land tenure and ownership and its associated conflicts and litigations; population density; zoning; effectiveness of regulatory framework; and

neighborhood reception to influence compliance with standards. These are similar to the variables used in measuring compliance (discussed in 4.4). Therefore, policymakers, regulatory institutions, and other stakeholders are advised to reconsider and manage the aforementioned factor to ensure they don't negatively affect the siting of masts and towers across cityscapes.

6. Conclusion

Urbanization and increasing demand for telecommunication services have resulted in the proliferation of masts across cityscapes. The health and safety concerns associated with telecommunication masts resonated calls to adopt planning responses in locational standards, policies, and guidelines to manage their siting. The study sought to identify the factors that contribute to compliance with the set locational planning standards that regulate the deployment of telecommunication masts in Ghana. The results showed that compliance is influenced by inspection and enforcement, land values and compensations paid for land and space and rewards and penalties for compliance and noncompliance with set standards and guidelines. The dominant factors underlying subjective determinants of compliance with standards and regulations that guide masts' siting by mobile operators are the availability of suitable lands, population density, inspections by regulatory bodies, and neighborhood reception. Other factors include zoning, motivations for meeting standards, and penalties/sanctions by regulatory bodies.

The study suggests that the incidence of siting masts in contravention of standards can be addressed by enforcing the standards and guidelines that govern the siting of masts. The government, through its relevant agencies, should roll out measures to strengthen the monitoring and site inspection of mobile base stations by authorities. The authorities should be equipped with all the necessary logistics to monitor compliance with standards. There should also be mechanisms to assess institutions, their activities, and agents responsible for monitoring compliance with standards. Authorities mandated to regulate the siting of masts should adequately enforce all the sanctions and penalties to operators who site masts in contravention with the standards. They should also review the sanction and penalties to make them stiffer to ensure strict compliance with standards.

Since the harmonious location of masts cannot be achieved by government and regulatory institutions alone, efforts should be made to involve all stakeholders to review the guidelines and standards to meet the current rate of urbanization and telecommunication growth. Furthermore, there is a need to educate the public about telecommunication masts to clear the fears, myths, and diverging views that go a long way to influence how they are sited. Through its decentralized institutions and authorities, the government should review and enforce the co-location policy to ensure infrastructure sharing among telecommunication operators, limiting the proliferation of masts across cityscapes. This will facilitate the safety and harmonious locations of masts and other facilities that promote sustainable cities

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References

- Abdel-Rassoul, G., El-Fateh, O. A., Salem, M. A., Michael, A., Farahat, F., El-Batanouny, M., & Salem, E. (2007). Neurobehavioral effects among inhabitants around mobile phone base stations. *NeuroToxicology*, 28(2), 434–440. <https://doi.org/10.1016/j.neuro.2006.07.012>
- Addy-Nayo, C. (2001). *3G mobile policy: The case of Ghana*. International Telecommunication Union (ITU).
- Adeniji, A. M., Oyeleye, O. I., Raheem, W., & Aladekoyi, O. (2015). Effects of telecommunication masts' locations on health and urban livability in Osogbo, Nigeria. *International Journal of Advanced Scientific and Technical Research*, 7(5), 476–492. <https://docplayer.net/52748351-Effects-of-telecommunication-masts-locations-on-health-and-urban-livability-in-osogbo-nigeria.html>
- Aderoju, O. M., James, G., Olabamiji, O., Ademuyiwa, O., Joseph, E., Onuoha Hilda, U., & Khalid, S. (2014). Space-Based Assessment of the Compliance of Gsm Operators in Establishing Base Transceiver Station (Bts) in Nigeria Using Abuja Municipal Area Council as Case Study. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 8, 46–57. <https://doi.org/10.9790/2402-081014657>
- Akintonwa, A., & Busari, A. (2013). The Hazards of non-ionizing radiation of telecommunication mast in an Urban Area of Lagos, Nigeria. *African Journal*. <http://www.ajol.info/index.php/ajbr/article/view/95129>
- Amadasun, K. (2020). Telecommunication infrastructure sharing a remedy for the reduction of network operator cost and environmental pollution. <https://doi.org/10.1109/EEEIC/ICPSEurope49358.2020.9160661>
- Amponsah, E., Takyi, S. A., Asibey, M. O., & Amponsah, O. (2021). *Assessing the level of compliance of telecommunication masts to locational planning standards towards harmonious and orderly city growth*. *Cities & Health* (Vol. 1–14). Taylor and Francis. <https://doi.org/10.1080/23748834.2021.1956837>
- Arthur, J. K. (2019). ANALYSIS OF CO-LOCATION OF TELECOMMUNICATION INFRASTRUCTURE IN GHANA. <https://doi.org/10.1109/ICCMA.2019.00019>
- Bello, M. O. (2010). Effects of the Location of GSM base stations on satisfaction of occupiers and rental value of proximate residential property. *Computer and Information Science*, 3(4), 159–170. <https://doi.org/10.5539/cis.v3n4p159>
- Bond, S., Mun, S. Y., Sakornvanasak, P., & McMahon, N. (2003). The impact of cellular phone base station towers on property values. *Unpublished Conference Paper Presented at the Ninth Pacific-Rim Real Estate Society Conference, Brisbane, Australia*. 19, 22.
- Burby, R. J., & Dalton, L. C. (1994). Plans can matter! the role of land use plans and state planning mandates in limiting the development of Hazardous areas. *Public Administration Review*, 54(3), 229. <https://doi.org/10.2307/976725>
- Cobbinah, B. P., & Darkwah, R. M. (2016) Urban planning and politics in Ghana. *GeoJournal*. <https://doi.org/10.1007/s10708-016-9750-y>
- Danladi, A., Gaya, G., Aliyu, B., Stephen, M., Michael, Y., & Na'imu, A. (2016). Determination of safety distance for installing GSM mast in residential areas in Nigeria. *Journal of Applied Sciences and Environmental Management*, 20(4), 997. <https://doi.org/10.4314/jasem.v20i4.12>
- Donkoh, E. K., Amponsah, S. K., Opoku, A. A., & Buabeng, I. (2017). Hexagonal tessellation model for Masting GSM Antenna: Case Study of MTN Kumasi. *International Journal of Applied Mathematics*, October. https://www.researchgate.net/profile/Elvis-Donkoh/publication/320475104_Hexagonal_Tessellation_Model_for_Masting_GSM_Antenna_A_Case_Study_of_MTN_Kumasi-East_Ghana/links/59e7bcc7458515c3630fab12/Hexagonal-Tessellation-Model-for-Masting-GSM-Antenna-A-Case-Study-of-MTN-Kumasi-East-Ghana.pdf

- Eneh, O. C. (2015). Environmental pollution health effects of electromagnetic radiations from Antennae of telecommunication masts Erected Near residential and educational facilities in Enugu. *Nigeria Environmental Pollution Health Effects of Electromagnetic Radiations From. Ciência E Técnica Vitivinícola Journal*, 30(9), 146–154. [https://www.researchgate.net/publication/282908936_ENVIRONMENTAL_POLLUTION_HEALTH_EFFECTS_OF_ELECTROMAGNETIC_RADIATIONS_FROM_ANTENNAE_OF_TELECOMMUNICATION_MASTS_ERECTED_NEAR_RESIDENTIAL_AND_EDUCATIONAL_FACILITIES_IN_ENUGU_NIGERIA#:~:text=Results%20showed%20that%20children%20exposed,and%20aches%2C%20eye%20symptoms%20\(such](https://www.researchgate.net/publication/282908936_ENVIRONMENTAL_POLLUTION_HEALTH_EFFECTS_OF_ELECTROMAGNETIC_RADIATIONS_FROM_ANTENNAE_OF_TELECOMMUNICATION_MASTS_ERECTED_NEAR_RESIDENTIAL_AND_EDUCATIONAL_FACILITIES_IN_ENUGU_NIGERIA#:~:text=Results%20showed%20that%20children%20exposed,and%20aches%2C%20eye%20symptoms%20(such)
- Eshun, F. (2009). The role of telecommunication on banking services in Ghana. <https://urn.fi/URN:NBN:fi:amk-200910225077>
- Everaert, J., & Bauwens, D. (2007). A possible effect of electromagnetic radiation from mobile phone base stations on the number of breeding house sparrows (*Passer domesticus*). *Electromagnetic Biology and Medicine*, 26(1), 63–72. <https://doi.org/10.1080/15368370701205693>
- Filippova, O., & Rehm, M. (2011). The impact of proximity to cell phone towers on residential property values. *International Journal of Housing Markets and Analysis*, 4(3), 244–267. <https://doi.org/10.1108/17538271111153022>
- Garba, N., Umar, S., & Zakari, Y. I. (2017). Assessment of radio-frequency radiation exposure from selected mobile base stations in Kaduna state, Nigeria. *Nigerian Journal of Scientific Research*, 16(2), 184–186. https://www.researchgate.net/profile/N-Garba/publication/325060603_ASSESSMENT_OF_RADIO-FREQUENCY_RADIATION_EXPOSURE_FROM_SELECTED_MOBILE_BASE_STATIONS_IN_KADUNA_STATE_NIGERIA/links/5af429210f7e9b026bcd088d/ASSESSMENT-OF-RADIO-FREQUENCY-RADIATION-EXPOSURE-FROM-SELECTED-MOBILE-BASE-STATIONS-IN-KADUNA-STATE-NIGERIA.pdf
- Gibson, P. R. (2017a). *Introduction to the special issue on environmental sensitivities : with access denied*. 9(2), 53–59. <https://doi.org/10.1089/eco.2017.0017>
- Gibson, P. R. (2017b). *Introduction to the special issue on environmental sensitivities: Living on the margins with access denied*. *Ecopsychology*, 9(2), 53–59. <https://doi.org/10.1089/eco.2017.0017>
- Government of Canada. (2015). *Compliance and Enforcement and Telecom Information Bulletin CRTC 2015-111 Guidelines regarding the general administrative monetary penalties regime under the Telecommunications Act*. Canadian Radio-television and Telecommunication Commission. <https://crtc.gc.ca/eng/archive/2015/2015-111.htm> Accessed (07/September/2022)
- Gunningham, N. (2010). Enforcement and Compliance Strategies. In R. Baldwin, M. Cave, & M. Lodge (Eds.), *The Oxford Handbook of Regulation* (pp. 119–145). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199560219.003.0007>
- Gunningham, N., & Sinclair, D. (2017). Smart regulation. Regulatory theory: Foundations and applications. 133–148. <https://library.oapen.org/bitstream/handle/20.500.12657/31596/626829.pdf?sequen#page=169>
- Gyau, K., Awuah, B., Nikoi, F., Elizabeth, J., & Booth, C. (2014). Geoforum Benefits of urban land use planning in Ghana. *Geoforum*, 51, 37–46. <https://doi.org/10.1016/j.geoforum.2013.09.019>
- Harris, A., & Cooper, M. (2019). Mobile phones: Impacts, challenges, and predictions. *Human Behavior and Emerging Technologies*, 1(1), 15–17.
- Hatsu, S., Mabeifam, U. M., & Paitoo, P. C. (2016). Infrastructure Sharing Among Ghana's Mobile Telecommunication Networks: Benefits and Challenges. *American Journal of Networks and Communications*, 5(2), 35. <https://doi.org/10.11648/j.ajnc.20160502.14>
- Industry Canada. (2012). *Telecommunications Facility Policy (Protocol)*. [https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/CSTAC-security-best.practices2013.pdf/\\$file/CSTAC-security-best-practices2013.pdf](https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/CSTAC-security-best.practices2013.pdf/$file/CSTAC-security-best-practices2013.pdf) Accessed (12-November-2020)

- Karvonen, A., Cook, M., & Haarstad, H. (2020). *Urban Planning and the Smart City: Projects, Practices and Politics*. 5(1), 65–68. <https://doi.org/10.17645/up.v5i1.2936>
- Kobayashi, E., & Grasmick, H. G. (1990). *Punishment for Noncompliance and Reward for Compliance: A Comparison of Japanese and American Workers*. https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1065&context=ssci_fac
- Kobayashi, E., & Kerbo, H. R. (2009). Punishment for Noncompliance and Reward for Compliance: A Comparison of Japanese and American Workers. *NUCB Journal of Economics and Information Science*, 47(2), 125–136. https://digitalcommons.calpoly.edu/ssci_fac/65
- Lei, Y., Flacke, J., & Schwarz, N. (2021). Land Use Policy Does Urban planning affect urban growth pattern? A case study of. *Land Use Policy*, 101(September 2020), 105100. <https://doi.org/10.1016/j.landusepol.2020.105100>
- Lum, T. A. (2011). *Mobile goes global: The effect of cell phones on economic growth and development*. 62. https://digitalcommons.bucknell.edu/honors_theses/4
- National Communication Authority. (2010). *Government of Ghana Guidelines for the Deployment of Communications Towers*. <https://www.nca.org.gh/assets/Uploads/Communications-Towers-Guidelines3.pdf>
- National Communication Authority. (2017). *Determining the Contribution of the ICT/ Telecommunication Sector to GDP in Ghana*. Government of Ghana, Accra.
- O’Callaghan, T., & Vivoda, V. (2017). Regulatory Regimes, Foreign Mining Investment. and Risk in the Asia-Pacific Region: *Comparative Evaluation and Policy Implications*, 35–48. https://doi.org/10.1007/978-3-319-61395-6_3
- Odunola, O. O., Omoakin, J. M., & Afolabi, A. M. (2015). Telecommunication mast location and it’s health implication for residents in Ogbomosho, Nigeria. *Civil and Environmental Research*, 7 (9). <https://www.iiste.org/Journals/index.php/CER/article/view/25438>
- Olaide, A. (2013). Assessment of the level of noise from base transceivers’ station using geospatial techniques: In Abuja municipal area council. *IOSR Journal Of Environmental Science, Toxicology And Food Technology*, 7(4), 30–39. <https://doi.org/10.9790/2402-0743039>
- Olarewanju, I. Z. (2016). Environmental impact of telecom installations: A call for an aggressive legal solution. *International Journal of Innovative Legal & Political Studies*, 4(3), 44–52. <https://seahipaj.org/journals-ci/sept-2016/IJILPS/full/IJILPS-S-5-2016.pdf>
- Osei-Owusu, A. (2015). The analysis of the Ghana telecom industry. *26th European Regional Conference of the International Communications Society (ITS): “What Next for European Telecommunications?”*, Madrid, Spain, 24th-27th June, 2015, 24–27. EconStor.eu. <http://hdl.handle.net/10419/127172www.econstor.eu>
- Poku-boansi, M. (2021). Land Use Policy Multi-stakeholder involvement in urban land use planning in the Ejisu Municipality, Ghana: An application of the social complexities’ theory. *Land Use Policy*, 103(April 2020), 105315. <https://doi.org/10.1016/j.landusepol.2021.105315>
- Polokwane telecommunication mast policy 2015 (2015). Available from: <https://www.polokwane.gov.za/CityDocuments/Shared%20Documents/Policies/Telecom%20Masts%20Policy%20version%202.pdf>
- Santini, R., Santini, P., Danze, J. M., Le Ruz, P., & Seigne, M. (2002). Study of the health of people living in the vicinity of mobile phone base stations: I. Influences of distance and sex. *Pathologie et biologie*, 50(2), 369–373. [https://doi.org/10.1016/S0369-8114\(02\)00311-5](https://doi.org/10.1016/S0369-8114(02)00311-5)
- Siiba, A., Adjei, E., & Brandful, P. (2018). Chieftaincy and sustainable urban land use planning in Yendi, Ghana: Towards congruence. *Cities*, 73(October 2017), 96–105. <https://doi.org/10.1016/j.cities.2017.10.015>
- Støttrup-Andersen, U., Nielsen, M. G., & Laursen, T. B. (2017). Optimisation of masts and towers. *Ce/Papers*, 1(2–3), 4361–4370. <https://doi.org/10.1002/cepa.495>
- Takyi, S. A., Amponsah, O., Duamor, S. N., Azunre, G. A., & Ahadzie, D. K. (2021). An assessment of regulatory compliance and residents’ perceptions of the siting of telecommunication masts: Insights from a rapidly urbanising Ghanaian city. *African Geographical Review*, 1–22. <https://doi.org/10.1080/19376812.2021.1923538>

- Timotijevic, L., & Barnett, J. (2006). Managing the possible health risks of mobile telecommunications: Public understandings of precautionary action and advice. *Health, Risk & Society*, 8(2), 143–164. <https://doi.org/10.1080/13698570600677324>
- Town and Country Planning Department. (2011). Zoning Guidelines and Planning. *Zoning Guidelines and Planning Standards*, 87. https://www.luspa.gov.gh/media/document/ZONING_GUIDELINES_final_DESIGN.pdf
- UK Government. (2008). *Enforcement and post-permission matters - GOV*. <https://www.gov.uk/guidance/ensuring-effective-enforcement> Accessed 27/August/2022)
- UK Government. (2013). *Mobile connectivity in England*. <https://planningjungle.com/wp-content/uploads/Mobile-connectivity-in-England-Technical-consultation-May-2013.pdf> Accessed (07/September/2022)
- UK Government. (2016). *Code of best practice on mobile network development in England this document has been developed and is*. https://uploads-ssl.webflow.com/5b7ab54b285dec5c113ee24d/5d5d4cd69a3f3827f30d06e9_Codes.of.Practice.pdf Accessed (07/September/2022)
- Ussher, Y. A. A. (2015). The economic and social effects of mobile phone usage: The case of women traders in Accra. *October*, 1–282. https://scholar.sun.ac.za/bitstream/handle/10019.1/97706/ussher_economic_2015.pdf?sequence=2&isAllowed=y
- Weible, C. M., & Heikkila, T. (2017). Policy Conflict Framework. *Policy Sciences*, 50(1), 23–40. <https://doi.org/10.1007/s11077-017-9280-6>
- Winkelmann, K., & Duch, S. (2019). *Basic sensitivity analysis of a telecommunication tower complementing standard reinforcement design process basic sensitivity analysis of a telecommunication tower complementing standard reinforcement design process*. 020061 (February). AIP Publishing LLC. <https://doi.org/10.1063/1.5091922>
- Wolf, R., & Wolf, D. (2004). Increased incidence of cancer near a cell- phone transmitter station. 1 (2), 1–19. <https://www.semanticscholar.org/paper/INCREASED-INCIDENCE-OF-CANCER-NEAR-A-CELL-PHONE-Wolf-Wolf/ce35fbdfa7b67b0dafd574a1e04fe3cc1f2ec7de>
- Xue, J. (2022). *Urban planning and degrowth : A missing dialogue*. *Local Environment*, 27(4), 404–422. <https://doi.org/10.1080/13549839.2020.1867840>

Appendix 1

Policies' Compatibility Matrix

Policies	Score	Explanation for the Score
Guideline on Communication Towers (GCT) and Infrastructure Sharing Policy (ISP)	1	ISP recognises the importance of reducing the growing number of telecommunication masts and towers in the cities. In this vein, ISP acknowledges the need for fair competition, minimize public inconvenience and cost of each operator using a separate infrastructure in an area. Again, ISP intends to protect people and the environment from the harmful effects of telecommunication infrastructure by reducing the number of masts and towers across the cityscape. These provisions complement the GCT intent of addressing the growth and environmental sanity in the siting of telecommunication masts and towers. The study sees the guideline and the policy document as compatible.
Guideline on Communication Towers (GCT) and Infrastructure Licensing Policy(ILP)	1	The policy made way for tower business in Ghana. ILP allowed independent companies to build and own telecommunication infrastructure in the country. ILP recognize the need to reduce the number and cost of telecommunication infrastructures, leveraging competition among mobile operators while improving network in remote areas that would have been difficult financially for a single operator. It has a focus to minimise the number of masts across the cityscape by ensuring that different operators share infrastructure owned by tower companies. The ILP also seeks to minimize the negative impacts of masts people and the environment. The study sees the guideline and policy as compatible because both intend to reduce the impact telecommunication masts on humans and the environment. This practice(ILP) is expected to promote compliance by ensuring there is competition in the provision of masts and towers.
Guideline on Communication Towers (GCT) and National Urban Policy (NUP)	1	The goal of the NUP is to promote a sustainable, spatially integrated and orderly development of urban settlements with adequate housing, infrastructure and services, efficient institutions, and a sound living and working environment for all people to support the rapid socio-economic development of Ghana. The NUP aims to address some of the fundamental issues associated with urban development and management in Ghana. The issues include urban land use disorder, uncontrolled urban sprawl, inadequate urban services and increasing environmental deterioration. NUP also seeks to ensure efficient urban infrastructure and service delivery while promoting spatially integrated order of urban centres on a sustainable basis. The study sees the guideline and policy document as compatible.

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Policies	Score	Explanation for the Score
Guideline on Communication Towers (GCT) and the Land Use and Spatial Planning Act (LUSPA)	1	The purpose of the LUSPA is to provide for sustainable development of land and human settlements through a decentralised planning system, ensure judicious use of land in order to improve quality of life, promote health and safety in respect of human settlements and to regulate national, regional, district and local spatial planning. The Act stresses the need to develop District Assemblies and other institutions for the effective performance of their spatial planning and human settlement management functions. The need to strengthen MMDA's and other institutions for sustainable implementation of the LUSPA and the effective collaboration of agencies responsible for monitoring and inspection of spatial activities which include telecommunication base stations is in tandem with the goal of GCT of ensuring the growth and environmental sanity in the siting of masts. The study sees the two policy documents as compatible.
Guideline on Communication Towers (GCT) and National Environmental Policy (NEP)	1	The NEP sees the need for an environment that is not harmful to the health and wellbeing of people and is enjoined to have the environment protected for the benefit of present and future generations through reasonable legislative and administrative measures. The policy intends to manage the environment to sustain society at large. The NEP under the aegis of EPA is to ensure integrated and coordinated implementation of environmental management to promote citizens' quality of life and their living and working environments. NEP supports interventions and the need to institute regulatory mechanisms aimed at monitoring and regulating actions that have an impact on the environment. The study sees the two policy documents as compatible.
Guideline on Communication Towers (GCT) and National Health Policy (NHP)	1	The NHP recognises the important role of healthy environments where people live, go to school, and work to national development. In this vein, the NHP recognizes the need to engage stakeholders to enact and enforce legislation to reinforce health promotion attitudes and protect the environment. The study sees the two policy documents as compatible.
Guideline on Communication Towers (GCT) and National Telecommunication policy (NTP)	1	The NTC recognises the need to regulate the telecommunication sector. The NCA is mandated to have the authority to monitor and enforce compliance with standards, and issue penalties that appropriate for non-compliance. The NTC strongly recommend facility sharing among telecommunication operators. Facility sharing is however, the first option for operators to expand coverage in the GCT. The NTP largely provides a general context for which the telecommunication industry in Ghana can realize its full potentials and goals. The NTP objective is supported by the GCT. The study sees the two policy documents as compatible.

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Policies	Score	Explanation for the Score
Guideline on Communication Towers (GCT) and Zoning Guidelines and Planning Standard (ZGPS)	1	The ZGPS provides clarification on the permissible uses of land and the space requirements for spatial developers. The guideline specifically, provides clear definitions for land use activities within each land use zone; the uses that are permitted and prohibited in these zones. ZGPS aims to supports planning authorities in their efforts to promote harmonious human settlement planning and management. ZGPS provides location criteria and safety standards for the siting of telecommunication masts support the GCT. The study sees the two policy documents as compatible.
Guideline on Communication Towers (GCT) and Local Government Act (LGA)	1	The LGA recognize the need for MMDAs' to be responsible for the development, improvement and management of human settlements and the environment within the catchment area of the Assembly. The LGA also posits that all spatial development must conform to planning standards and approvals which is in tandem with the GCT's strategy of regulating the deployment of masts according to standards. Thus, LGA and GCT are mutually reinforcing to prevent as much as possible the destruction of the environment. The study sees the two policy documents as compatible.

Source: Author's construct, 2020.