Spatial Distribution of Telecommunications Infrastructure in Residential Neighbourhoods of Lagos Metropolis

Wale Alade, Hakeem Bishi, Oluwafemi Olajide

ABSTRACT
This study examines the spatial distribution of 58 global system of mobile telecommunication (GSM) base stations in nine residential areas which have been stratified into low, medium and high density within Lagos Metropolis. The observed mean distance between base stations in each of the residential areas is approximately 1km but varies between residential densities. The most important factors considered by the operators in location of base stations include population, intensity of commercial activities, customer satisfaction and profit maximization. Besides, most of the base stations within residential areas do not have town planning approval, hence, the study recommends that telecommunication operators should prepare and submit their program on network expansion for integration into the land use plan of the study area and for city in general. The study concludes that location of telecom infrastructure in the study area is random and further should be based on conscious planning decisions.

Key words: Telecommunication, mobile, infrastructure, base station, location, distribution, residential, neighbourhood

1.0 INTRODUCTION

Urbanization is neither a crisis nor a tragedy; it is a challenge for the present and the future. The process of urbanization has created a host of new opportunities enmeshed with new and ill-understood problems. Urbanization is not a new phenomenon on the continent of Africa as shown by cities like Lagos, Ibadan, Addis-Ababa, Cairo, Kano, and Timbuktu. What is noteworthy about contemporary urbanization in Africa is its fast pace (UN, 2004). The dispersion of conurbations, the rate of urbanization and the change in lifestyles cast more or less doubt on the urban model looked on as "the European city". Every society is linked by three different types of infrastructures: transportation, energy, and communications. Contemporary urbanisation is often distinguished by the level of infrastructures present in a place while the

level and availability of telecommunications infrastructures in particular determines the status of cites today. It suffices to say that while cities are the end-result of the urbanization process, infrastructure is definitely the bloodstream of cities. Hence, telecommunication services are backed by certain peculiar infrastructures.

However, Bell (1979) noted that revolution in communications now makes it likely that there will be a major shift in the relative importance of one of the infrastructure hence; communications will be the central infrastructure tying together a society. The new technologies are expected to play certain roles within the scope of a sustainable urban development. The information superhighway is a revolutionary trend occasioned by the widespread effect of globalization the world over. The dawn of globalization effects on information dissemination as well as seamless communication in Nigeria became a reality in 2001 with the introduction of global system of mobile telecommunication (GSM) services by two telecommunication giants namely MTN Communications and Econet Wireless Communications. However, the land tenure system as well as the fragmentation of land in Nigeria has hindered the ease of procuring land for the purpose of installing masts and base stations, especially in built-up areas where the concentration of subscribers is very high. Various methods are adopted for the purpose of having suitable sites and avenue for the erection of the masts and base stations towards serving the conceived purpose.

The choice of the chosen sites for the said purpose depend among others on the elevation of the identified places on the earth surface relative to the surrounding area; direction of expansion of telecommunication service of the proponent; the need to preserve and conserve places and sites

of monumental, architectural and historic importance, among others factor (Omole, 2006). It is against this background that this study seeks to examine the locational pattern of telecommunication base stations in different residential density areas of Lagos Metropolis

2.0 LITERATURE REVIEW

The importance of telecommunication in the socio-economic development of cities is well documented in literature. Moss (1999) noted that communication technologies are transforming the form and function of large metropolitan regions. Similarly, Yen and Mahmassani (1997) observed that the development of telecommunication technologies might affect land use patterns and play a role in the growth of economic activities and the spatial distribution of industry. The authors suggested two specific aspects of office-location decisions by organizations in assessing the impact from the new technology; the need for certain organizations to locate where they can access telecommunication networks; and an increased opportunity for the organizations to locate their offices in the areas where infrastructure costs are generally lower than traditional office locations such as downtown areas are factors that could influence location decision.

On a system-wide level, this trend may result in a decentralizing effect on urban form. George (1999) while explaining the modifications to the Alonso's model of land use pattern in Lagos metropolitan area hinged on the principle of accessibility to alternative locations. Quoting the exact words; "urban location decisions are interdependent". This interdependence very often shows itself in agglomeration of similar establishments. This creates external economies – the ease of face-to-face contacts in the office zone or the fact that locating shops together minimizes commuting costs and attracts customer". In a comparative analysis of this trend in the Chicago

and Seoul regions, it was concluded by some analysts that information technology has a very influential and positive effect on the agglomeration of firms. This tendency also occurs in an interurban context (Jungyul, Tschangho, and Geoffrey, 2003). Audirac and Fitzgerald (2003) reviewed literature on information technology and urban form and concluded that current urban planning discussion regarding the New Economy centers are based on planning, managing, and redesigning form of cities and regions in order to attract and nurture knowledge economies.

Similarly, Moss (1999) examined the components and implications of the changing urban telecommunications infrastructure and its impact on research and policymaking. The study confirmed that contrary to popular belief, communication technologies have not replaced face-to-face contact. Rather, new communication systems have enhanced those cities that serve as the information centers of the world. Rather than lead to the obsolescence of cities, new communication technologies have contributed to the emergence of a handful of "world cities". Because a new and sophisticated telecommunications infrastructure is being built within large metropolitan regions to accommodate sophisticated data and voice services, those communities that are already equipped to handle such technologies are at an advantage. Moss (1999) suggested that ‘‘we need to improve our knowledge and understanding of the relationship between new telecommunication technologies and the rich web of interpersonal communications that occurs in cities’’. The evidence to date indicates that communication technologies are vital elements in maintaining and stimulating both internal and external patterns of urban communications.

Wakely and Phe (2000) observed that the existing models of residential location are facing difficulties in explaining new trends in urban development such as gentrification and abandonment. Hence, the components of a new theory of residential location were proposed. Frenkel (2001) observed that various studies have provided evidence of the advantages of the ability of metropolitan areas to attract industries, which employ advanced technology and are strongly involved in the process of innovation. The study investigated the effect of different factors on location choice and also identifies the direct contribution factor to the probability of choosing the metropolitan area as a preferred location with implications for industrial policy.

Moriset (2003) focused on the tendency of e-business towards urban concentration in Europe using France as a case study. The study assumed that the complexity of the urban sector results in an increasing variety of business location. The survey of 92 firms in the multimedia sector of Lyon shows that enterprises do not have the same location needs, neither at regional nor Multimedia and software designers are more 'footloose' than Web agencies and Internet service outsourcers, which are linked to their clients and to broad band networks. The former may locate in picturesque renovated areas, or even in rural areas. The latter tend to share high-tech-suited locations with Internet and telecom carriers in state-of-the-art, wired premises. Finally, this study considers the question of the status of a medium city and its different districts in the context of a growing information economy. In the opinion of Rutherford (2005), there appears to be substantial convergence in the type and extent of telecommunications networks being deployed between and in major European cities to serve increasing numbers of corporate clients, thus one of the principal material elements in the development of a world city network.

Through discussion and an empirical exploration of the interurban and intra-urban network development of one major telecommunications providers in Europe, however, it is shown how the planning, construction and expansion of these infrastructures remain crucially shaped by a variety of historical, regulatory, economic, physical and organizational constraints and compulsions which are specific to individuals. The mutually constitutive nature of economic and technological connectivity suggests, therefore, development of a world city network continues to have an important dimension of territorial fixity, reflecting multi-scalar entanglement of territory and globalization that forms the world cities of today. However, Graham (2002) posits that the societal diffusion of information and communications technologies (ICTs) remains starkly uneven at all scales. The contemporary city displays this unevenness most visibly. In cities, clusters and enclaves of 'super-connected' people, firms and institutions often mix with large numbers of people with non-access to communications technologies. In such a context, the study sought to demonstrate that dominant trends in ICT development are currently helping new extremes of social and geographical unevenness within and between human settlements and cities, in both North and the South. It went further to explore the prospect that such stark 'urban digital divides' be ameliorated through progressive and innovative policy initiatives which treat cities and electronic technologies parallel.

Mills and Whitacre (2007) observed that as residential Internet access in the United States shifts toward high-speed connections, a gap has emerged in high-speed access relative to urban high-speed access. Potential causes of this high-speed ``digital divide'' include rural—urban differences in people, place, and infrastructure. Combining current population survey data from 2001, and 2003 with novel infrastructure data, the study determined the relative roles of these

factors in the urban divide. Arguing against the optimistic view of technology, Salomon (1996) mentioned that there have been excessive expectations of the information age, for instance, that telecommunications can eliminate the effects of distance and as a result can have profound effects on the spatial organization of society. Furthermore, there exists a gap between the introduction of new IT and the changes in the spatial pattern of firms (Capello, 1994). This is ascribed to an overestimation of technological potential and to an optimistic and superficial analysis on the relationship between the new technology and spatial restructuring. The study noted that in the long run, those technologies lead to a new production strategy such as the "just-in-time" (JIT) system and it will require a physical proximity (either in an inter-urban or intra-urban context) between firms and eventually a spatial clustering of economic activities are expected.

3.0 THE CONTEXT OF LAGOS

Lagos, Nigeria's lagoon city and the fastest growing mega city in the world is a product of the country's rapid urbanization. It attained mega city status in 1995 when its population reached the 10 million mark (UN-Habitat). From its global city ranking of 31st in 1985, Lagos population exploded to 13.4 million in Year 2000 to become the world's 6th mega city and Africa's foremost urban centre and hub of national, regional and global socio-economic and political activities. Lagos State population is estimated to be growing at between 6% and 8% annually (LASEED 2004) which is 10 times that of New York and Los Angeles. The population which is estimated at 18 million in 2007 (UN-Habitat 2007) is equal to that of 32 African countries joined together. Indeed the Lekki sub-region in the south-eastern part is growing at about 16.9%

annually as against the National average of 2.9%. On the average, Lagos has a population density of 20,000/sq.km compared to the national average of 1,308 sq. Km.

Lagos plays a dominant role in the country's economy as reflected by the following: Gross National Product (GNP) of Lagos is three times that of any West African Country, (World Bank, 2011). It accounts for over 65% of Nigeria's Gross Domestic Product (GDP); over 70% of National industrial investments and also accounts for over 70% of Nigeria's commercial activities. The city has a large informal sector workforce of 70% and is the hub of aviation activities (82.61% international; 47.30% domestic). Lagos is also the telecommunication and media hub of Nigeria (50% of 20 million PTO/GSM subscribers). There are 29 industrial estates and 4 Central Business Districts in Lagos. The ports in Lagos handle over 70% of total National cargo freight and generate 50% of national port revenue. Lagos utilizes 45% of national electricity supply and consumes 50% of national petroleum products. It is the node of West African gas Pipeline Project and Sub-Saharan Africa's largest ICT market. These facts prompted the NEPAD Cities Forum (2004) to observe that "sustainable development in Africa will be won or lost in Lagos".

4.0 STUDY APPROACH

For the purpose of data collection, three (Lagos Island, Eti-Osa and Ikeja) of the sixteen local government areas within Lagos metropolis were purposively selected because they have high concentration of GSM base stations. Nine (31.0%) of the 29 residential areas in the three local government areas were randomly selected for this study. These include two low, three medium and four high density residential areas. A total of 58 base stations were identified in the nine

residential areas. Two categories of primary data were collected to achieve the goal of the study. The first includes information on location and characteristics of the base stations. A data form was designed to collect information observed by field officers on land use attributes of base stations in the residential areas. Besides, geographical data from all identified base station locations were collected using a GPS instrument. The second category of data was obtained from telecommunication operator with the aid of structured questionnaire. This includes information of factors that influence the location of their base stations in the study area. Both descriptive and inferential statistical techniques were used for data analysis. The main hypothesis in this study is that the spatial pattern of base station locations in residential areas of Lagos is not random. Consequently, the hypothesis was tested with the Nearest Neighbour Analysis tool using the ArcMap 9.2 (extension).

5.0 FINDINGS AND DISCUSSIONS

5.1 Characteristics of Base Station Locations

The distribution of base stations across the three residential density areas reveals that 33.0% of the base stations are located in low density residential areas, 26.0% in medium density residential areas and 41.0% in high density residential areas. The mean number of base stations in each of the residential density areas is 6 in high, 5 in medium and 10 in low density residential areas respectively. The availability of land in low density residential areas rather than population may be responsible for the high concentration of base stations in low density areas. The study further reveals that there are five possible locations for base stations which are further classified as dedicated and non-dedicated. Majority (47.0%) are located on shared or subdivided plots, 10.0% on dedicated plots of land, 31.0% on roof tops, 5.0% on organised open spaces and 7.0% on incidental open spaces. Hence, 90.0% of the base stations are located on non-dedicated locations/plots of land. This suggests lack of conscious planning in the distribution and location of base stations in the study area. Consequently future expansion of base stations in residential areas may continue to invade and succeed the residential uses rather than co-locate with other base stations.

Analysis of the nature of adjacent land uses shows that 28.0% of the base stations have residential uses as the dominant adjacent land use, 40.0% have commercial and 33.0% have other types of land uses (public, recreation and industrial) as their adjacent land uses. This again reveals that location of base stations in the study area lacks coordination in term of land uses planning. The study reveals that 41.0% of the base stations are located adjacent to access roads, 22.0% are located adjacent to arterial or expressways, 16.0% along distributor roads and 21.0%

along collector roads. This suggests that telecom operators prefer to locate most of their base stations adjacent to higher hierarchy of roads in and around residential areas. Accessibility is considered as the major factor for this pattern since the base stations need to be serviced on regular basis especially for the supply of fuel for the electricity generating sets that power the base stations.

5.2 Spatial Pattern of Base Station Locations

The main hypothesis in this study is that location of base stations in Lagos is not random. This suggests that location of base stations in Lagos follows conscious planning efforts. However, descriptive analysis so far suggests that there were no conscious planning in the location of base stations by telecom operators. The results of the nearest neighbour analysis using ArcMap 9.2 (extension) tool shows that for five contiguous residential areas in Eti-Osa and Lagos Island local governments, the observed mean distance of all the 27 base stations is 0.98km and the recorded standard deviation (Z-score) is 0.16. Thus the spatial pattern observed is neither clustered nor dispersed but random in nature. A higher mean distance of 1.4km with a Z-score of 2.15 was observed in medium density residential areas of Ikeja. This also confirms random pattern of base station locations. It is obvious from this study that the mean distance of base stations in high density residential areas of Lagos is less than 1Km while they are higher than 1Km in both medium and low density residential areas. These results further confirm the earlier low ranking of proximity of base station as a factor of location of base stations by operators. The random pattern observed further confirms the absence of a definite spatial planning and technical threshold standard to guide base station locations.

5.3 Factors Influencing Location of Base Stations

Ten (10) key factors influenced location of base stations in the study area. These include accessibility, land value, size of land area, population, availability of power/electricity, security and proximity to other base stations, topography, regulatory standards and technical specifications. These factors were ranked based on their importance. Population was ranked first, followed by topography, technical specifications, land value, security level of the location, accessibility to the location, availability of power, size of the land, regulatory standard (Planning/NCC) and lastly proximity to other base stations. While there is an agreement among telecom operators about the most important factor being population of the community, there is no common template used as guide in the choice of location. Hence availability of land becomes a dominant factor of location and the implication of this is that most of the locations are unplanned and thus the spatial distribution is likely to be haphazard. A major challenge faced by telecom operators in locating their base stations is in securing town planning approvals/ permit. The absence of a city-wide plan for the provision and location of telecommunication infrastructure makes it difficult to get secure adequate locations. Further, scarcity of land in a highly populated city like Lagos is a big challenge for infrastructure development.

Consequently, locations that could be adapted for base stations such as roof tops, incidental open spaces and shared plots of land in residential areas as previously observed become the alternative sites. However, due to the pressure on infrastructure, the telecom operators need to expand their network to meet up with service demand. Thus, most of the operators prefer to approach land owners to lease part of their properties for the purpose of locating their base stations. This explains why majority of base stations are on shared plots of land. However, these shared

properties hardly conform to the town planning and NCC regulations. This leads to non approval of many locations of base stations by the regulatory agencies and thus limits infrastructure expansion which ultimately affects capacity of operator for service delivery.

6.0 CONCLUSION

The significance of telecommunication in the socio-economic development of cities in both developed and developing nations have been recognized by scholars, hence this study has investigated the spatial distribution and location characteristics of telecommunication base stations in Lagos. The study concludes that the spatial distribution of base station locations is random due to the absence of conscious spatial planning efforts to guide the telecom operators in the location of their infrastructure. This situation will surely have environmental, safety, and health implications which are not yet determined. It concludes further that future expansion will be difficult due to scarcity of appropriate property and stringent physical planning regulations. In the future, more residential uses will have to give way to base stations especially in high density residential areas either through lease or outright purchase of such properties by telecom operators. The study also concludes that economic factors rather than standards and government regulations influence location of base stations in Lagos. The study recommends that the government agency (LASMIRA) in charge of safety, environmental and health concerns of telecom infrastructure should be alive to its responsibilities given the unplanned nature of base station locations. It recommends further that the telecom operators should put in place their infrastructural expansion plan which should be integrated with the existing land use plan of the residential areas.

REFERENCES

Audirac, & Fitzgerald (2003). Information technology (IT) and urban form: an annotated bibliography of the urban deconcentration and economic restructuring literatures. Journal of Planning Literature, 17 (4), 480-511 [Online] Available: http://www.usj.sagepub.com

Capello, R., (1994). Towards new industrial and spatial systems: the role of new technologies, The Journal of the Regional Science Association International, 73, 189-208

Drucker, P.F., (1989). Information and the future of the city, Urban Land Journal, 48, 38- 39

Echeverri-Carroll, E.L., (1996). Flexible production, electronic linkages, and large firms: Evidence from the automobile industry, The Annals of Regional Science, Springer publishers, Verlag Heidelberg, 30(1), 135-152

Fujita, M. and N. Hamaguchi, (2001). Intermediate goods and the spatial structure of an economy, Journal of Regional Science and Urban Economics, 31, 79-109

Frenkel, A., (2001). Why high-technology firms choose to locate in or near metropolitan areas, Journal of Urban Studies, 38(7), 1083-1101. [Online] Available: www.usj.sagepub.com (May 1, 2009)

Gasper, J. and E.L. Glaeser, (1998). Information technology and the future of cities, Journal of Urban Economics, Academic press, Washington DC, 43(1), 136-156

George, C. K. (1999). Principles and methodology in urban and regional planning, Lagos: Librogem Books.

Gordon, P. and H.W. Richardson, (1996). Beyond polycentricity: the dispersed metropolis, Los Angeles, 1970-1990, Journal of the American Planning Association, 62(3), 289- 295

Graham, S. (2002). Bridging urban digital divides: Urban polarisation and information and communications technologies (ICTs), Journal of Urban Studies 39(1), 3-24

Jerome (2008). Private sector participation in infrastructure in Africa, African Peer Review Mechanism, South Africa, JEL Classifications: F3, L3, L9, N17, 055[Online] Available: http://www.afdb.org (January 11, 2011)

Jungyul, S, Tschangho, J. K. & Geoffrey, J.D. Hewings (2003). Information technology and urban spatial structure: a comparative analysis of the Chicago and Seoul regions, Epil Discussion Paper Series 03-0405.

Mokhtarian, P.L., (1998). A synthetic approach to estimating the impact of telecommuting on travel, Journal of Urban Studies, 35(2), 215-241

Moriset, B. (2003). The new economy in the city: emergence and location factors of internet-based companies in the metropolitan area of Lyon, France, Journal of Urban Studies, 40(11), [Online] Available: http://www.usj.sagepub.com 2165-2186 (May 1, 2009)

Moss, Mitchell (1999). The new urban telecommunications infrastructure, originally published in the Computer/Law Journal, 6(2), [Online] Available: http://www.mitchellmoss.com (April 27, 2010)

Muth, Richard (1968). Urban residential land and housing markets. In Harvey S. Perloff & Lowden Wingo, Jr., (Eds.), Issues in urban economics (pp. 285-333). Baltimore, Maryland: The John Hopkins Press for Resources for the Future, Inc.

Omole, K. (2006). Assessment of telecommunication base stations in Eti-Osa, B.Sc dissertation submitted to the department of Urban and Regional Planning, University of Lagos.

Rutherford, J. (2005). Networks in cities, cities in networks: Territory and globalisation intertwined in telecommunications infrastructure development in Europe, Journal of Urban Studies, 42(13), 2389-2406, [Online] Available: http:// www.usj.sagepub.com (November 1, 2010)

Salomon, I., (1996). Telecommunications, cities and technological opportunism, The Annals of Regional Science, Springer publishers, Verlag Heidelberg, 30(1), 75-90

Schuler, R. E., (1992). Transportation and telecommunications networks: Planning urban infrastructure for the 21st Century, Journal of Urban Studies, 29(2), 297-310. [Online] Available: http:// www.usj.sagepub.com (November 1, 2010)

Skuse, A. & T. Cousins (2008). Getting Connected: The social dynamics of urban telecommunications access and use in Khayelitsha, Cape Town, New Media Society, 10 (9), 1-26. [Online] Available: http:// www.usj.sagepub.com (October 5, 2010)

United Nation (2004). World urbanisation prospects 1991, United Nations, New York

Wakely, P. and Phe, H., (2000). Status, quality and the other trade-off: towards a new theory of urban residential location, Journal of Urban Studies, 37(1), 7-35. Available: http:// www.usj.sagepub.com (November 1, 2010)

Yen, J. and H.S. Mahmassani (1997). Telecommuting adoption: conceptual framework and model estimation, Transportation Research Record No.1606, Washington DC, pp.95-102