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Functional Indices of Development of Facility Occurrence and the Distribution of Social Services in Delta State, Nigeria

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Abstract
A fair distribution of accessibility to key activities is a central concern for distributive justice in transport planning. This implies that disparities in accessibility and the negative effects associated with a lack of accessibility should be mitigated. Equitable distribution of public facilities is crucial for social and economic development. It helps reduce disparities between different amenities, promotes well – being, and contributes to a more just and sustainable society. Based on the findings of this study recommendations were proffered such as; community participation involving residents in the planning and decision making process to ensure that their needs are addressed; and accessibility indices using indices that measures the relative accessibility of different areas to public facilities.

Keywords: Equity, Social Services, Accessibility, Functional Indices, Facility, Distribution

Introduction

Walter Christaller proposed his central place theory in (1933). He aimed to rationalize the distribution of cities over geographic space. He was concerned with the way the settlement of different sizes evolve and are spaced out. It is a theoretical account of size and distribution of settlements within an urban system where marketing is predominantly urban function. The work of Christaller (1933) was translated by Baskin (1966) to establish optional spacing of different sizes of cities made the following assumptions:

i. Isotropic plain: This means that the cities are located in an homogenous plain area without topographic undulations;
ii. The population is distributed evenly over this space
iii. All of population demands the same goods e.g, clothing, healthcare etc.
iv. Distance decay; the people tend to fulfil their needs from the nearest city possible. So there is distance decay in context of interaction of people within a certain city
v. Identical income: the income of the consumers is identical i.e. all customers have similar purchasing power.
vi. The cities are arranged in triangular lattice i.e. cities are distributed perfectly, evenly over space.

There have been modifications or refinements of the original single theory (Losch, 1954; Berry and Garnson, 1958; Berry, 1973; Taylor and Hoyler, 2021). The idea of hierarchical ordering of service center has been considered as an important planning tool by regional planners and geographers. Thus, (Hessen 2013; Ng et al, 2014). Considered studies of specific and gateway cities as urban facilities provider of various services locally and even across regions, making a positive contribution to the quality of life of urban residents (Cao et al,

2021; Tahmasbi, 2019; Tanner 2019). However, there remain the serious problem of spatial differentiation in the supply of urban public facilities (Batta et al 2014; Dadashpor et al, 2016, Wolf et al, 2021), Such as the evident urban – rural duality, particularly in developing or middle income countries, thereby resulting in social injustice (Xie & Zhou, 2014). In the past two decades, numerous studies have considerably focused on the spatial distribution, accessibility and equality of urban facilities (Batty, 2008; Chen, 2022, Um et al 2009). Moreover, social equality of education and medical facilities is imminent under the circumstances of the current adjustment of population facility driven by global population aging (Bi et al, 2022; Rees, 2021). previous studies have made important contributions to the equality assessment of specific geographical regions or for some types of public facilities (Seto et al 2017; Chen et al 2016),such as the comprehensive evaluation framework based on accessibility (Taleai et al , 2014; Tahmasbi, et al 2019) .

In Nigeria several studies on accessibility tend to be related to urban centres or urban based activities. Thus Weinnand (1973); Mohammed & Dahuasi (2013); Atubi (2017a) in a study of development in Nigeria observed that spread effects of concentration of development are limited to the vicinity core areas while much of the periphery is virtually immuned to development impulses. This finding is supported by other studies from other developing countries (Robinson and Salih, 1971; Gilbert, 1975; Roger et al, 1999; Bertohini, 2003; Singh, 2022; Taylor and Hoyler, 2020).

However, Onokerhoraye (1976) and Okafor (1982) sought to identify the major factors that influence distribution of post primary schools in Ilorin and Ibadan respectively. They attributed the larger catchments areas to urban schools to travel distance to school and also to population of urban centres.

Method of Classifying and Weighting Central Functions

There are various methods used to classify centres based on central functions. At one extreme are very simple methods such as Christaller's (1933) rank of cities according to the aggregate number of telephone calls, and Grove and Huszar (1964) who suggest differentiating centres on the basis of gross aggregate score of all functions found in a place. Both methods seem unsatisfactory because they do not take into account the variety and magnitude of functions in each centre.

The weighting scale could be arbitrary as in Atubi (1998 and 2007a; Atubi 2011f and 2012d; Atubi, 2019b, 2019c). The need to reflect these dimensions in any ordering of central functions is emphasised by Meulen (1989) and Singh (2002). Apart from merely establishing a hierarchy of central places, ordering of facilities can be used to construct an index of modernisation as in Soja (1968), Gould (1970), Leinbach (1976), and Atubi 2019b, 2019c).

In this study since part of the analysis is to relate the level of network accessibility to the occurrence of public facilities, the author constructed an index of facility occurrence. In this index construction, the hierarchical ordering of functions is taken into account. Groups of functions have been chosen to reflect as wide a variety of services as possible. These include medical facilities, educational facilities, postal services, banking, market and administrative centres.

Following Singh (1979) and Atubi (2019) the author considered both the number of establishments for each type of function to reflect functional distinctiveness. With this procedure, the existence of more than one hospital in a particular centre will reflect a higher order centre than the existence of only one. In addition the facilities will be weighted to reflect the range of services offered at each level of hierarchy. An analysis of correlation coefficient between the various variables was carried out using the Pearson's Product Moment Correlation Coefficient (PPMCC)

Study Area

Delta State is bounded in the north by Edo State, the east by Anambra State, South-East by Bayelsa State, and on the Southern flank by the Bight of Benin which covers about 160 kilometers of the state's coastline (See Figure 1). Delta State is generally low – lying with remarkable hills and covers a landmass of about 18,050km^2 of which more than 60% is land. The state has a wide coastal built inter – laced with rivulets and streams, which form part of the Niger Delta (The Force of Diversity, 2013). Presently, Delta State comprises 25 local government areas, twelve (12) major urban centers with Asaba as the capital city and Warri as her largest commercial city and the most populated in the state.

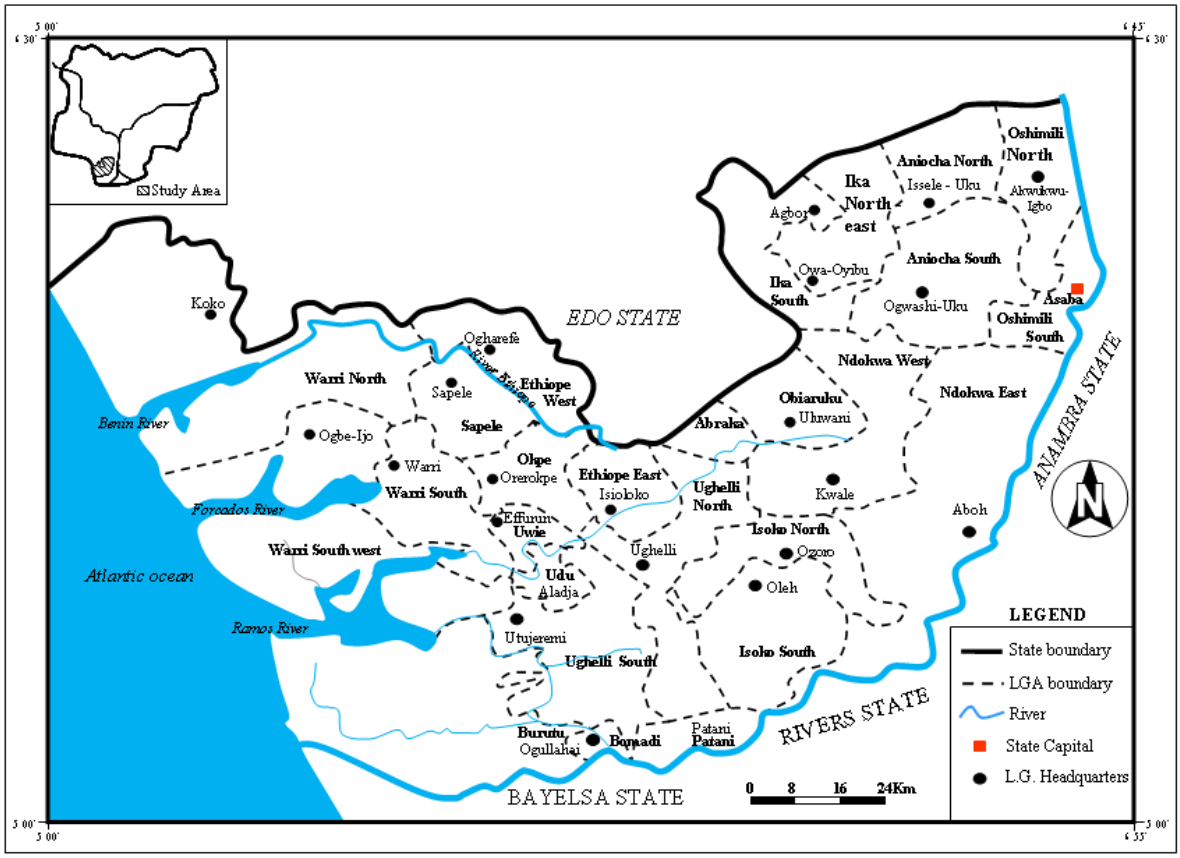


Figure 1. Map of Delta State showing study areas

Research Methods

In this study since part of the analysis is to relate the level of network accessibility to the occurrence of public facilities, an index of facility occurrence was constructed. In this index construction, the hierarchical ordering of functions is taken into account. Not all functions that may be found in a place are considered. The choice of nodes was based on population size. Based on the adopted operational definition of major centres, 51 major centres were identified. The choice of these facilities was based on the fact that they are capable of generating home – to – facility travel, hence such facilities as pipe – borne water, electricity etc. were not included because they lack this quality.

However, having weighted the function, the product of the number of establishments of each function and the weight is summed up for a centre to give functional index of facility occurrence. This index shows the level of concentration of facilities in that centre. Table 1 gives the calculated indices for the 51 centres of the study while figure 2 illustrates the distribution of functional indices.

Table 1. The functional index of facility occurrence in Delta State 2016

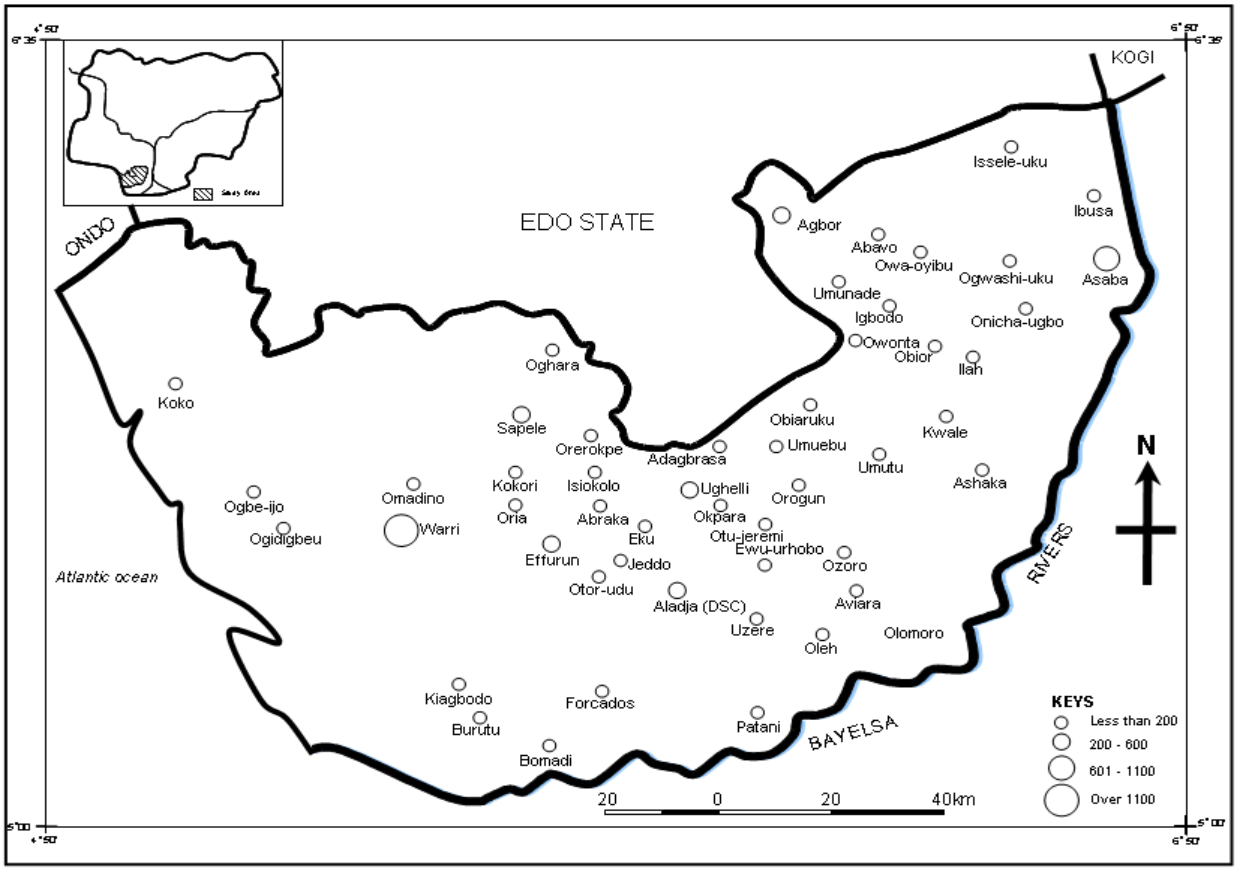
S/N	Mode No.	Population	X1		X2		X3		X4		X5		X6		X7		X8		X9		X10		X11		X12		X13		Total
		2006 Census	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	UNF	WV	Weight
1	Issele-uku	32101	0	0	2	12	1	2	0	0	0	0	5	25	8	8	2	20	2	10	1	5	0	0	1	10	1	10	**110**
2	Ogwashi-Uku	63080	0	0	2	10	2	4	0	0	1	10	6	30	13	13	2	20	2	10	1	5	0	0	3	30	1	10	**142**
3	Owa-oyibu	73000	1	10	1	5	3	6	0	0	0	0	2	10	10	10	2	20	2	10	1	5	0	0	1	10	1	10	**96**
4	Agbor	84020	1	10	10	50	2	2	0	0	2	10	5	25	10	10	9	90	2	10	1	5	1	10	7	70	1	10	**302**
5	Ashaka	41330	0	0	1	5	0	0	0	0	0	0	1	5	8	8	1	10	2	10	1	5	0	0	0	0	1	10	**53**
6	Kwale	54064	0	0	1	5	2	2	0	0	1	10	3	15	8	8	1	10	3	15	0	0	0	0	1	10	1	10	**85**
7	Ibusa	64231	0	0	3	15	0	0	0	0	0	0	5	25	8	8	2	20	3	15	1	5	0	0	1	10	1	10	**108**
8	Asaba	106020	1	10	15	75	0	0	0	0	2	20	10	50	11	11	40	400	1	5	1	5	1	10	26	260	1	10	**856**
9	Obiaruku	46231	0	0	3	15	0	0	0	0	0	0	3	15	4	4	1	10	1	5	1	5	0	0	2	20	1	10	**84**
10	Abavo	23010	0	0	1	5	0	0	0	0	0	0	4	20	8	8	1	10	1	5	1	5	0	0	0	0	0	0	**53**
11	Umuebu	11091	0	0	1	5	0	0	0	0	0	0	2	10	2	2	0	0	1	5	0	0	0	0	0	0	1	10	**22**
12	Bomadi	23072	0	0	3	15	1	2	0	0	0	0	2	10	6	6	1	10	1	5	0	0	0	0	0	0	1	10	**58**
13	Burutu	93224	1	10	4	20	1	2	1	1	1	10	2	10	6	6	1	10	2	10	0	0	0	0	1	10	1	10	**98**
14	Ozoro	74222	1	10	1	5	1	2	0	0	1	10	3	15	8	8	2	20	1	5	1	5	0	0	4	40	1	10	**130**
15	Oleh	102701	1	10	5	25	1	2	0	0	1	10	3	15	8	8	2	20	1	5	1	5	0	0	3	30	1	10	**140**
16	Patani	26021	0	0	1	5	0	0	0	0	0	0	2	10	4	4	1	10	1	5	0	0	0	0	1	10	1	10	**54**
17	Koko	101232	0	0	1	5	4	8	0	0	0	0	2	10	7	7	1	10	1	5	1	5	0	0	1	10	1	10	**70**
18	Warri	201642	1	10	70	300	0	0	0	0	1	10	11	55	30	30	60	600	2	10	1	5	1	10	30	300	1	10	**1390**
19	Ogbe-ijo	88103	0	0	1	5	1	2	0	0	0	0	1	5	3	3	1	10	1	5	0	0	0	0	0	0	1	10	**40**
20	Ogidigbeu	15021	0	0	0	0	1	2	0	0	0	0	1	5	1	1	0	0	1	5	0	0	0	0	0	0	0	0	**13**
21	Omadino	23741	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	5	0	0	0	0	0	0	0	0	**7**
22	Uzere	52061	0	0	1	5	1	2	0	0	0	0	1	5	2	2	0	0	1	5	0	0	0	0	0	0	0	0	**17**
23	Kiagbodo	98201	0	0	1	5	1	2	0	0	1	10	0	0	2	2	0	0	1	5	0	0	0	0	0	0	0	0	**25**
24	Abraka	86224	0	0	10	50	1	2	0	0	1	10	4	20	7	7	1	10	1	5	1	5	0	0	7	70	0	0	**179**
25	Oghara	103060	2	20	4	20	0	0	0	0	2	20	6	30	10	10	1	10	1	5	1	5	0	0	3	30	1	10	**170**
26	Orerokpe	68021	0	0	6	30	0	0	0	0	0	0	10	50	10	10	0	0	1	5	0	0	0	0	2	20	1	10	**125**
27	Sapele	92101	0	0	10	50	0	0	0	0	0	0	10	50	13	13	8	80	1	5	1	5	1	10	6	60	1	10	**283**
28	Otor-utu	101221	0	0	3	15	0	0	0	0	0	0	6	30	10	10	1	10	1	5	0	0	0	0	1	10	1	10	**90**
29	Ughelli	183201	0	0	8	40	0	0	0	0	1	10	10	50	11	11	7	70	1	5	1	5	1	10	5	50	1	10	**301**
30	Otu-jeremi	104231	0	0	5	25	0	0	0	0	0	0	10	50	10	10	3	30	2	10	0	0	0	0	2	20	1	10	**145**
31	Effurun	101021	0	0	40	200	0	0	0	0	2	20	12	60	10	10	14	140	1	5	1	5	1	10	15	150	0	0	**310**
32	Isiokolo	34010	0	0	3	15	1	2	0	0	0	0	2	10	4	4	1	10	1	5	1	5	0	0	0	0	1	10	**61**
33	Jeddo	16201	0	0	1	5	0	0	0	0	0	0	3	15	2	2	1	10	1	5	0	0	0	0	2	20	0	0	**57**
34	Oria	18220	0	0	0	0	0	0	0	0	0	0	2	10	2	2	0	0	1	5	0	0	0	0	0	0	0	0	**17**
35	Eku	241221	0	0	1	5	0	0	0	0	0	0	2	10	2	2	0	0	1	5	1	5	0	0	1	10	0	0	**37**
36	Aviara	29010	0	0	1	5	0	0	0	0	0	0	2	10	2	2	1	10	1	5	1	5	0	0	0	0	0	0	**37**
37	Kokori	30071	0	0	2	10	0	0	0	0	0	0	2	10	2	2	0	0	1	5	1	5	0	0	0	0	0	0	**30**
38	Adagbrasa	19772	0	0	1	5	0	0	0	0	0	0	2	10	2	2	0	0	1	5	5	0	0	0	0	0	0	0	**26**
39	Aladja (DSC)	31010	0	0	10	50	1	2	0	0	0	0	5	25	4	4	5	5	1	5	1	5	0	0	6	60	0	0	**201**
40	Ewu/Urhobo	161222	0	0	1	5	1	2	0	0	0	0	2	10	3	3	0	0	1	5	1	5	0	0	0	0	0	0	**30**
41	Forcados	12990	0	0	1	5	1	2	1	1	0	0	1	5	1	1	1	10	1	5	1	5	0	0	0	0	0	0	**34**
42	Igbodo	13030	0	0	1	5	0	0	0	0	0	0	1	5	1	1	0	0	1	5	1	5	0	0	0	0	0	0	**21**
43	Illah	18241	0	0	1	5	1	2	0	0	0	0	2	10	2	2	0	0	1	5	1	5	0	0	1	10	0	0	**39**
44	Obior	12080	0	0	1	5	1	2	0	0	0	0	3	30	4	4	1	10	1	5	1	5	0	0	0	0	0	0	**61**
45	Orogun	16209	1	10	1	5	0	0	0	0	0	0	3	30	3	3	0	0	1	5	1	5	0	0	0	0	0	0	**58**
46	Okpara	41090	0	0	2	10	0	0	0	0	0	0	8	40	10	10	1	10	2	10	1	5	0	0	2	20	0	0	**105**
47	Olomoro	29330	0	0	1	5	1	2	0	0	0	0	2	10	3	3	1	10	1	5	1	5	0	0	0	0	0	0	**40**
48	Onicha-ugbo	22410	0	0	1	5	0	0	0	0	0	0	2	10	3	3	1	10	1	5	1	5	0	0	0	0	0	0	**38**
49	Ononta	16020	0	0	1	5	0	0	0	0	0	0	2	10	3	3	0	0	1	5	1	5	0	0	0	0	0	0	**28**
50	Umunede	28090	0	0	1	5	1	2	0	0	0	0	4	20	6	6	1	10	1	5	1	5	0	0	2	20	0	0	**73**
51	Umutu	26220	0	0	1	5	0	0	0	0	0	0	2	10	3	3	0	0	1	5	1	5	0	0	0	0	0	0	**28**

NNF = Un-weighted number of facilities, WV = Weighted value

Source: National Population Commission and Fieldwork, (2016)

X_1 = Specialist hospital
X_2 = General + private hospitals
X_3 = Health centre + Maternity homes
X_4 = Dispensary
X_5 = Post-secondary institutions (Universities, polytechnics, colleges of education, etc)
X_6 = Secondary school + vocational schools
X_7 = Primary schools
X_8 = Daily market with lockup stores
X_9 = Weekly market
X_{10} = General post office agency
X_{11} = General post office headquarter
X_{12} = Commercial banks
X_{13} = Local government administrative headquarters

Figure 2. Map of Delta State Functional Indices of Centres
Source: Fieldwork, (2016)



Discussion of Results/Findings

The illustrations of the number of facilities or functions considered along with the weighting score is shown in Appendix A. The weighting system follows closely that of Atubi (2019) by attaching 10 to first order functions, 5 to second order, and 1 to-third order functions. The correlation coefficient tells us the direction of the relationship. Appendix B gives a pair wise correlation matrix of the 13 variables employed in the index construction. The analysis reveals a certain pattern of association. For example it is seen that the occurrence of specialist hospital (X_1) is highly associated with occurrence of post-secondary institution (X_5) and has little association with such variables as secondary schools (X_6), daily markets (X_8), general post office (X_{11}) and non-accounting postal agency (X_{10}). At the other extreme, is the occurrence of dispensaries (X_4) which has negative association with most of the variables? This implies that whereas specialist hospitals, health centres/maternity homes and general hospitals are found in higher order centres, dispensaries are found in lower order centres. However, care should be taken in interpreting the correlation matrix as high correlation coefficient between two variables does not necessarily mean that the occurrence of one will lead to the occurrence of the other. For example, that the high correlation coefficient between specialist hospitals (X_1) and post-secondary institutions (X_5) ($r = 0.60$) does not mean that occurrence of a hospital, necessarily lead to the occurrence of post-secondary institutions, but it does imply that both tend to be located in the same place within the study area. From figure 2 and Table 1 we observe that Warri has the greatest value (1390) followed by Asaba (856). These incidentally are centres with very high accessibility. At the extreme, centres with the least indices include Omadino (7) and Ogidigbeu (13). These are centres with low accessibility and low order centres.

Policy Implications/Recommendations

In a pilot survey it was found out in Eku, Ewu-Urhobo, Igbodo, Bomadi and Kiagbodo the major facility the centres desired was a commercial bank while at Ughelli and Umutu it was a specialist hospital. In these centres the nearest commercial bank for Eku is located at Abraka, and for Ughelli the nearest specialist hospital is located at Warri providing those with the facilities would reduce the distance travelled to obtain these services. This is because the optimal location of public facilities aims to maximize accessibility, efficiency and equality for all citizens. This involves strategically placing facilities to minimize travel time, distance and cost for users,

while also ensuring that everyone has access to necessary services. However, location decisions are influenced by various factors, including community needs, existing infrastructure and environmental considerations.

Conclusion

Spatial accessibility, the case of reaching destinations, is a fundamental concept and performance measure in transportation geography, planning and policy. Accessibility in urban and rural areas allows individuals to participate in essential (e.g. job, healthcare, education, markets etc) and leisure activities, obtain basic necessities and interact with other people more easily. To improve accessibility municipalities around the world have implemented a major transit interventions. These include redesigning network, experimenting with micro transit, and constructing new public transportation services (e.g. bus rapid transit or BRT)

Public facilities, such as schools, libraries, parks, health centres and markets are essential for providing access to basic services and enhancing the quality of life of urban residents. However, locating these facilities in optimal cities is not an easy task, as it involves balancing multiple factors, such as demand, supply, costs, benefits and equity.

References

Atubi, A.O. (1998). "*The accessibility of centres to the road network in Lagos Island Local Government Area, Lagos State*. Unpublished M.Sc. Thesis, University of Nigeria Nsukka. [Publisher]

Atubi, A.O. (2007a). Network accessibility and occurrence of public facilities in Lagos Island, Nigeria. *Journal of Geography and Planning sciences, vol. 1*(1), pp. 1-17. [Google Scholar] [Publisher]

Atubi, A.O. (2012d) Effective Traffic Control in Warri Metropolis using Geographic Information System (GIS). *Journal of Environmental Sciences and Policy Evaluation*, Vol. 2, No. 1, Pp. 1-11. [Publisher]

Atubi, A.O. (2019a) Patterns of nodal accessibility on influence of cost and time in Delta State, Nigeria (1976-2016). *Abraka Humanities Review, Vol. 9*, No. 1, Pp. 292-331. [Google Scholar] [Publisher]

Atubi, A.O. (2019b) Accessibility and the provision of public facilities in Delta State, Nigeria (1976-2016): A nexus. *International Journal of Scientific Research. Vol. 8*, No. 4, Pp. 1-7. [Google Scholar] [Publisher]

Atubi, A.O. (2019c) Relationship between distance accessibility and functional index of facility occurrence in Delta state. *Nigeria. Journal of Social and Management Sciences, Vol. 14*(1), pp. 35-48. [Google Scholar] [Publisher]

Batta, R., Lejeune, M. & Prasad, S. (2014) Public facility location using dispersion, population and equity criteria. *Eur. J. Oper. Res. 234*, 819-829. [Google Scholar] [Publisher] https://doi.org/10.1016/j.ejor.2013.10.032

Batty, M. (2008). The size, scale, and shape of cities. *Science 319*, 769-771. [Google Scholar] [Publisher] https://doi.org/10.1126/science.1151419

Berry B.J.L. and Garrison, W.L. (1958), "The functional bases of the central place hierarchy." *Economic Geography*, Vol. 34, Pp. 145-154. [Google Scholar] [Publisher] https://doi.org/10.2307/142299

Berry, B.J.L. (1973). *The Human Consequences of Urbanisation*. Hutchinson Educational Publishers, London. [Publisher]

Bertolini, L. (2003), "Mobility environment and network cities "*Journal of Urban Design, Vol. 8*, No. 1, Pp. 27-43. [Google Scholar] [Publisher] https://doi.org/10.1080/1357480032000064755

Bi, S.; Bie, S.; Hu, X. & Zhang (2022) Analysis on the characteristics of spatio-temporal evolution and aggregation trend of early Covid-19 in mainland china. *Sci, Rep.* UK 12, 1-7. [Google Scholar] [Publisher] https://doi.org/10.1038/s41598-022-08403-w

Cao, W.; Shakya, P. & Karmacharya, B. (2021) Equity of geographical access to public health facilities in Nepal. *BMJ Glob. Health, 6*, e6786. [Google Scholar] [Publisher] https://doi.org/10.1136/bmjgh-2021-006786

Chen, M.; Palmer, A.J. & Si, L. (2016) Assessing equity in benefit distribution of government health subsidy in 2012 across east China: Benefit incidence analysis. *Int. j. Equity Health, 15*, 1-10. [Google Scholar] [Publisher] https://doi.org/10.1186/s12939-016-0306-z

Chen, Y. (2022) inequalities of urban green space areas and ecosystem services along urban centre edge gradients: Landsc; urban plan. 217, 104266. [Google Scholar] [Publisher] https://doi.org/10.1016/j.landurbplan.2021.104266

Christaller, W. (1933). *Central places in Southern Germany*. Translated (1966) by C.W. Baskin, Prentice-Hall, Englewood-Cliffs N.J. [Google Scholar] [Publisher]

Dadashpoor, H., Rostami, F. & Alizadeh, B. (2016). 15 inequality in the distribution of urban facilities inequitable? Exploring a method for identifying spatial inequality in an Iranian city. *Cities 52*, 159-172. [Google Scholar] [Publisher] https://doi.org/10.1016/j.cities.2015.12.007

Gilbert, A. (1975). "A note on the incidence of development in the vicinity of a growth centre". *Regional Studies, Vol. 9*, pp. 325-333. [Google Scholar] [Publisher] https://doi.org/10.1080/09595237500185371

Gould, P.R. (1970). "Tanzania, 1920 - 1963: The Spatial impress of the modernisation process". *World Politics, Vol. 22*, pp.149-170. [Google Scholar] [Publisher] https://doi.org/10.2307/2009860

Grove, P. & Huszar, L. (1964). *The towns of Ghana: the role of service centres in regional planning*, Ghana University Press, Accra. [Google Scholar] [Publisher]

Hessen, W.G. (2012). How accessibility shapes land use". *Journal of the American Institute of Planners, Vol. 25*, No. 2, pp. 73-78. [Google Scholar] [Publisher] https://doi.org/10.1080/01944365908978307

Leblanc, L.J. (1975), Algorithm for the disease network design problem. *Transportation science*, 39(1), 63-79. [Publisher] http://dx.doi.org/10.1287/trsc.9.3.183

Losch, A. (1954). *The economics of location.* (Translated by William, H.W.) New Haven: Yale university press, Pp. xxviii. 520. [Google Scholar] [Publisher]

Meulen, T.V.D. (1989):" Hierarchy of Centre: Some notes on a concept" *Tijdschrift Voor economiehe en sociale geografie*, Vol. 70 (6), pp. 361-365. [Google Scholar] [Publisher] https://doi.org/10.1111/j.1467-9663.1979.tb01899.x

Mohammed, H. & Dahunsi, B.I.O. (2013), "Evaluation of Road transport accessibility to Local Government Headquarters in Edo state, Nigeria, using GIS", *Trans-national Journal of Science and Technology,* Vol. 3, No. 7, Pp. 35-47. [Google Scholar] [Publisher]

Ng, M; Efeming, T; Robinson, M. (2014) Global, regional, and national prevalence of overweight and obesity. A children and adults during 1980-2013. *The lancet 384*, 766-781. [Google Scholar] [Publisher] https://doi.org/10.1136/bmj-2021-068208

Onokerhoraye, A.G. (1986) A conceptual framework for the location of public facilities in the urban areas of developing countries: The Nigerian case". *Socio-economic planning sciences, Vol. 10*, Pp. 237-276. [Google Scholar] [Publisher] https://doi.org/10.1016/0038-0121(76)90010-0

Rees, P.H. (2021) Education's rule in China's demographic future. Proc. *Natl. Acad. Sci 118*, e211568118. [Google Scholar] [Publisher] https://doi.org/10.1073/pnas.2115618118

Robinson, G. & Salih, K.B. (1971). "The spread of Development around Kuala Lumpur: a methodology for an exploratory test of some assumptions of a growth-Pole model". *Regional Studies*, Vol. 5, pp. 303-314. [Google Scholar] [Publisher] https://doi.org/10.1080/09595237100185351

Roger, V. & Spiekermann, K. (1999), "Accessibility and economic development in Europe" *Regional studies*, Vol. 33, No. 1, Pp. 1-15. [Google Scholar] [Publisher] https://doi.org/10.1080/00343409950118878

Seto, K.C., golden, J.S.; Alberti, M. & Turner, B.L. (2017). Sustainability in an urbanizing planet. Proc. *Natl. Acad. Sci 114*, 8935-8938. [Google Scholar] [Publisher] https://doi.org/10.1073/pnas.1606037114

Singh, J. (1979). "Central Place hierarchy in a backward economy: Gorakhour region (India)". *Tijdschrift Voor Economicsche en Sociale geografie*. Vol. 70, pp. 300-306. [Google Scholar] [Publisher] https://doi.org/10.1111/j.1467-9663.1979.tb01888.x

Singh, K. (2022). *Reverence and criticism of central place theory*: Jawaharial Nehru University, New Delhi. [Publisher]

Soja, E.W. (1968). *The Geography of Modernisation in Kenya: A Spatial Analysis of Social, economic and Political change.* Syracuse Geographical Series. No.2, Syracuse New York. [Google Scholar] [Publisher]

Tahmasbi, B.; Mansourianfar, M.H., haghshenas, H. & Kim, I. (2019). Mulhmodal accessibility-based equity assessment of urban public facilities distribution. *Sustain. Cities Soc. 49*, 101633. [Google Scholar] [Publisher] https://doi.org/10.1016/j.scs.2019.101633

Taleai, M.; Siliuzas, R. & Flacke, J. (2014). An integrated framework to evaluate the equity of urban public facilities using spatial multi criteria analysis. *Cities. 40*, 56-69. [Google Scholar] [Publisher] https://doi.org/10.1016/j.cities.2014.04.006

Tanner, C.J. (2014). Urban ecology: advancing science and society, Front. Ecol. *Environ. 12*, 574-581. [Google Scholar] [Publisher] https://doi.org/10.1890/140019

Taylor, P.J. & Hoyler, M. (2020). Lost in plain sight: revealing central flow process in Christaller's original central place systems. *Regional Studies Vol. 55*(2) Pp. 345-353. [Google Scholar] [Publisher] https://doi.org/10.1080/00343404.2020.1772965

Um, J., Son, S.W., Lee, S.I, Jeong, H. & Kim, B. J. *Scaling Laws between Population and facility densities*. Proc, Natl. Acad. Sci. PNAS, 106, 14236-14240. [Google Scholar] [Publisher] https://doi.org/10.1073/pnas.0901898106

Weinand, H.C. (1973). "Some Spatial Aspects of economic development in Nigeria". *Journal of Developing Areas*, Vol. 7, pp. 247-263. [Google Scholar] [Publisher]

Wolf, J., Feitosa, F. & Margues, J.L. (2021). Efficiency and equity in the spatial planning of primary schools. *Int. J.E. Plan. Res, 10*, 21-38. [Google Scholar] [Publisher] https://doi.org/10.4018/ijepr.2021010102

Xie, Y. & Zhou, X. (2014). *Income inequality in today's china.* Proc. Natl. Acad. Sci. 111, 6928-6933. [Google Scholar] [Publisher] https://doi.org/10.1073/pnas.1403158111

APPENDIX A
DEVELOPMENT OF HIERARCHY OF CENTRAL FACILITIES

I. **Medical Facilities**

X_1 = Specialist hospital — Weighting Score = 10

Attribute

– Facilities for specialised treatment of diseases such as psychiatry, eye, dental care etc. diseases

X_2 = General + private hospitals — Weighting Score = 5

Attributes

– Refer cases to specialised/teaching hospitals
– Absence of specialist in any particular disease

X_3 = Health clinics/health centres +/Maternity homes

Weighting Score = 2

Attribute

- Registered nurse/midwife in-charge

X_4 = Dispensary — Weighting Score = 1

Attributes

- Local health assistant in-charge
- Dispenses drugs
- Refers cases to health centre or general hospitals

II **Educational Facilities**

X_5 = Post-secondary institutions (Universities, polytechnics, colleges of education, technology, Research institutions)

Weighting Score = 10

Attributes

- Training in specialised disciplines or profession
- Institution headed by Vice-Chancellor, Rector or Provost
- Staff oriented towards research writing or creation of new ideas
- Age limit for admission is 16 years hence students are considered as adults

X_6 = Secondary (post primary institution)
(Secondary grammar, vocational/domestic science schools)

Weighting Score = 5

Attributes

- Courses are geared towards entry into the tertiary institution or use towards lower level manpower
- The staff are oriented towards effective teaching;
- Students are mostly adolescents (11-16 years)
- Institution is headed by a principal

X_7 = Primary institution

Weighting Score = 1

Attributes

- Pupils trained to acquire the 3RS – reading, writing and arithmetic
- Staff oriented towards general education
- Age limit for admission is 6 years (that is pupils are generally children)
- Pupils are still in the custody of their parents

III **Daily Markets**

X_8 = Daily markets

Weighting Score = 10

Attributes

- Daily openings
- Lock-up store and upon shades;
- Supervised by a market master

- Retail trading especially food items
- Wholesale trading

X_9 = Weekly market

Weighting Score = 5

Attributes
- Weekly opening
- Lock-up stores and open space sheds
- Supervised by local government council
- Retail trading

IV. **Postal Facilities**

X_{10} = General post office (Head office)

Weighting Score = 10

Attributes
- Automatic telephone exchange
- Telegraph services
- Public holiday and weekend openings

X_{11} = Departmental/Sub-post office

Weighting Score = 5

Attributes
- Letters and parcel acceptance
- Telegraph acceptance
- Collect mails from the postal agencies

X_{12} = Banking facilities

Weighting Score = 10

No distinction is made between bank branches located at various places. Rather the location of a single banking institution in a particular place is regarded as a high order service

X_{13} = Administrative Facilities

Weighting Score = 10

Local government headquarters. Any local government headquarters located in an urban centre

APPENDIX B
PAIRWISE CORRELATION MATRIX BETWEEN THE VARIOUS FUNCTIONS

	X1	X2	x3	x4	x5	X6	X7	x8	x9	x10	x11	x12	x13
x1	1.00	0.15	0.07	0.08	*0.60	0.21	0.42	0.37	0.23	0.20	-0.11	0.25	0.40
x2	0.15	1.00	*-0.53	-0.21	0.42	0.24	-0.02	*0.96	-0.16	*-0.64	-0.34	-0.27	0.00
x3	0.07	*-0.53	1.00	0.03	0.00	-0.27	0.02	-0.15	0.30	0.14	0.25	-0.18	0.14
x4	0.08	-0.21	0.03	1.00	*0.59	-0.25	-0.15	-0.07	0.11	-0.19	-0.02	-0.09	-0.01
x5	0.60*	0.42	0.00	*0.59	1.00	0.05	0.48	0.46	0.18	0.15	-0.04	*0.54	0.42
x6	0.21	0.24	-0.27	-0.25	0.05	1.00	*0.66	*0.57	*0.86	0.21	-0.01	0.38	0.47
x7	0.42	-0.02	0.02	-0.15	0.48	*0.66	1.00	*0.76	*0.82	-0.27	-0.12	*0.62	*0.69
x8	0.37	0.96*	-0.15	-0.07	0.46	*0.57	*0.76	1.00	0.03	0.00	-0.07	*0.73	0.33
x9	0.23	-0.16	0.30	0.11	0.18	*0.86	*0.82	0.03	1.00	*0.66	0.36	0.13	*0.73
x10	0.20	-0.64*	0.14	-0.19	0.15	0.21	-0.27	0.00	*0.66	1.00	-0.07	0.25	-0.01
x11	-0.11	-0.34	0.25	-0.02	-0.04	-0.01	-0.12	-0.07	0.36	-0.07	1.00	-0.02	*0.51
x12	0.25	-0.27	-0.48	-0.09	0.54	*0.38	*0.62	*0.73	0.13	0.25	-0.20	1.00	0.37
x13	0.40	0.00	0.44	-0.01	0.42	0.47	*0.67	0.33	*0.73	-0.01	*0.51	0.37	1.00

Note: Figures in asterisks (*) indicate highly significant coefficients.