The Lagos Journal of Environmental Studies

Published by
Faculty of Environmental Sciences, University of Lagos, Nigeria.

Vol. 6, No 1
2008

About the Journal

The Lagos Journal of Environmental Studies is a bi-annual publication of original research and review alIicles addressing matters of professional and academic interest on the natural and built environment.

The aim is to disseminate results of academic research and encourage debatė between academics and practicing professionals in the field of Architecture, Building, Construction Management, Sustainable Construction, Land Use, Urban and Religion Planning and Management, Real Estate Valuation, Finance and Investment Analysis, Property Assets Management, Quantity Surveying, Land Surveying and Geo-informatics, Environmental Conservation and Conflict Resolution, Environmental Management, Biodiversity, Climatology and related disciplines.

Papers may be theoretical or empirical in nature but must be original and thoroughly researched with policy implications. Analytical reviews of major strands of contemporary thinking-local and international on any of the identified areas are welcome.

Manuscripts are subjected to a double blind review process to preserve academic reliability and integrity.

Instructions to Contributors

Manuscripts should be prepared in Microsoft Word format, using Times New Roman font 12 point size. The manuscript must not be more than 18 pages long and must be typed double-spaced on one side of A4 paper, with 2.5m margin on all the four sides of the page. The title of the article, the name(s), institutional affiliations and contact (including e-mail) addresses of the author(s) must be given on a separate page The main author who should receive the off prints should be identified and his/her full postal address indicated. The author(s) should not be identified anywhere else in the artic le. The first page of the article should bear only the title and the abstract which should not exceed 150 words. Up to six key words may be included which capture the essence of the contents of the article.

The article must be accompanied by a covering letter indicating that it is the original work of the author(s) and has not been submitted for publication elsewhere. Upon acceptance contributors will be required to transfer their copyright to the publishers of the journal.

Tables

Tables should be kept to a minimum. They should be formatted using MS Word Table commands and clearly presented with good pacing between rows and columns. Metric measures should be used. Tables should be given short clear and explanatory titles written at the order in which they are presented in the article.

Tables should conform to the American Psychological Association (APA) style of presentation.

Plates and Figures

Plates and Figures should be used only when they present comparisons or results more clearly and reduce the report. Line graphs used to depict continuous variables must be in black ink and clear The lines or curves on the graph must not be too many and they should be clearly distinguished, It should be noted that in presenting figures, the APA style is preferred.

References

All authors cited in the text should be included in the end list of references with their surname, initials and year of publication. The title of the book should follow in italics. Place at publication and name of publishers must be provided. For journal reference, the title of the article should follow the authors name and year of publication. This should in turn be followed by the journal title in italics, then the volume number and the pages All references must comply with the Harvard Style of referencing. Articles which do not conform, will be rejected.

Submission

The manuscript must be carefully prepared, proofread and submitted electronically via the e-mail address specified below. Hard copies may also be submitted in quadruplicate.

All submissions should be accompanied with a processing fee of N3,000.00 or 25.00 UK Pounds for foreign based contributors.

Record of Paper

A CD Rom copy of the final version of the paper must be submitted when the paper is finally accepted for publication.

Contact Address

The Editor-in Chief
The Lagos Journal of Environmental Studies
C/o Dean's Office
Faculty of Environment Sciences,
University of Lagos
Akoka, Yaba
Lagos, Nigeria.

Tel: 01-5820387, 01-4938637-9
01-4932660 and 01-5454891-5,
Ext. 1100.

e-mail: lagjes@yahoo.co.uk
facjourn@yahoo.co.uk
envis.sci@unilag.edu
ktodusami@yahoo.com

Dr Olawande Oni

The Lagos Journal of Environmental Studies

Table of Contents

EDITORIAL

This issue contains nine papers. The content of each of the papers is summarized below. Udechukwu and Johnson's article is on impact of green building on valuation approaches. In the article, they define green building, provide some background for valuers, and offer suggestions for the valuation process. They also posit that randon, asbestos, and toxic waste may have negative effects on property values.

Aina and Ikpo's article examines the dynamics of rework in Nigeria. The study focused on the causes, extent, and impact of rework on the construction process. It was revealed through the study that frequency of occurrence of rework increased as time span increased. The author concluded that rework phenomenon is root based and is institutional in nature and that it requires government's and the industry's strategic reforms and regulatory regimes.

Oni's paper, 'Graphic-Theoretic analysis of intra-community road network pattern, examines the intra community road network of Covenant University with the aim of determining accessibility and connectivity empirically. It was discovered that there is high negative correlation between the two variables (i.e connectivity and accessibility). The paper recommended the application of the research findings in larger urban property market. This according to the author, will assist in determining the degree of accessibility and connectivity of a particular location. In addition, it will assist valuers in giving proven consideration to the values of comparable properties with due regard to accessibility and connectivity.

Odufuwa worked on Exit, voice and loyalty: The challenges for Nigerian telecommunications providers and users. The paper discusses options often neglected by service providers and government. It explicitly showcases the need to effectively grant "voice" to users via representation in decision-making and operation of telecom services in Nigeria.

Lawanson wrote on effect of locating telecommunication infrastructure in Lagos metropolis. The author observes that there has been a proliferation of the number of telecommunication masts and dishes lining the Lagos cityscape in recent times. The study examines the relevant planning regulations, the level of compliance by telecommunication operators, development control success and environmental health implications of locating masts on the residents of Eti-Osa local government area of Lagos State. It was discovered that environmental health problems in the study area could not be directly linked to the proximity of the masts. However, physical implications including visual obstructions and aesthetic impairment are prevalent. The author recommended that there should be public enlightenment and that Lagos State Infrastructure Maintenance Agency should be empowered to carry out its functions.

Abegunde assesses the role of community based organizations in economic development in Nigeria using Oshogbo as a case study. Findings show that there exists high correlation between capital bases of the community based organizations (CBOs) and the number of members. The study recommends that government at all levels should encourage the proliferation of and economically support the goals of CBOs.

Oduwaye's paper unravels the different dimensions of the changing land use and their implications on land use development of Lagos. Results of the study show that infrastructure and economic factors are the major factors influencing land use in Lagos. The paper suggests that there is urgent need for the preparation of new land use development plan for Lagos with special attention to provision of infrastructure and economic policy. This, according to the author, will improve the quality of life of the people.

Fatoye assesses the performance of physical facilities in students housing at University of Ibadan. The results show that students were more satisfied with criteria under physical elements than those under facilities elements. The study recommended making the provision of hostel infrastructure and the maintenance of higher education residential facilities a priority.

Finally, **Dada and Ikpe** examine the nature of multi-skilling in the Nigerian construction industry. The results indicate, among others, that multi-skilling reduces workers' idle time and enhances the employability of workers. The study recommended that construction workers should be encouraged to be multi-skilling and that employers of labour should provide training that enables construction workers to be multi-skilled.

The Lagos Journal of Environmental Studies 2008.
Vol 6, No 1, 24-37

GRAPH-THEORETIC ANALYSIS OF INTRA-COMMUNITY ROAD NETWORK PATTERN - CASE STUDY OF COVENANT UNIVERSITY, OTA, NIGERIA.

O. A. Oni
Department of Estate Management, Covenant University, Ota, Nigeria.
Email: wandeoni@yahoo.com

The estate surveyors and valuers strongly believe that accessibility has strong effects on property values. This paper examined the intra-community road network of Covenant University with the aim of determining accessibility and connectivity empirically. The graph of the road network was derived from the master plan of the community and graph theoretic qualitative technique used to determine accessibility and connectivity; while correlation and analysis of variance techniques used showed high negative correlation between the variables. It was discovered that there is high negative correlation between the two variables, r being 0.74 while the coefficient of determination was calculated to be 54.5, thus indicating that only about 55% of the variation in accessibility is explained by the connectivity of the Covenant University intra-community road network. The research finds empirical way of determining accessibility, and recommends the application of the finding to larger urban communities.

Keywords: Road network, graph theoretic analysis, Covenant University, master plan, connectivity, and accessibility.

INTRODUCTION

The configuration of routes network and impedance for traversal along the routes are two influences that affect accessibility, and route network coupled with increased transport investment result in changed levels of accessibility that are reflected in cost benefit analysis, savings in travel time, and other benefits noticeable in increased catchments areas for services and facilities like shops, schools, offices, banks, and leisure activities ; and two influences in particular affect the accessibility and locational value using the network model, these are the configuration of the route network and the impedance for traversal along the routes having implications for transport planning and its consequent effect on property values (Wyatt, 1999); and road network constitutes an important element in urban development with roads providing accessibility to different land uses in the urban areas and proper functioning of human settlement depending on an efficient transportation network, to the extent that human settlements and urban developments generally are incapable of existence except when adequate transport facilities, like roads and road networks, exist (Aderamo, 2003).

The urban road transportation system is one of the important factors responsible for shaping the urban centers (Dickey, 1975), not only that the urban road transportation system acts as a basic component of urban areas' social, economic and physical structure it equally plays essential role in the determination of the scale, nature and form of urban areas (Balchin, et al, 1991). Furthermore, the relationship between accessibility, property values and land use patterns has been the pre-occupation of earliest theorists with indication that travel costs were traded off against rents and population densities from the Central Business District (CBD) to suburbs of a mono-centric city; and accessibility has become more complicated requiring more sophisticated treatment; thus, the importance of studying accessibility in order to understand the locational advantages of individual properties rather than rely on traditional bid-rent theory that places the peak rent contour in the CBD (Henneberry, 1998).

In determining the degree of accessibility, a number of approaches have been adopted, one of which is the

The Lagos Journal of Environmental Studies 2008.
Vol 6, No 1, 24-37

graph theoretic technique. The theory has been used extensively on regional and local levels and can be extended to the analysis of an academic community with implications for estate surveying, physical development and planning in the study of the growth pattern of a community; and by and large, the principle expressed in this study on academic community can be extended to wider and more complex study on the correlation between road network and value of properties.
The graph theoretic approach is applicable to this study as it assists in the analysis of the road network pattern of the study area giving clearer picture of the various inter-nodal points for each of the routes within the study area, which cannot be achieved through a quantitative approach. It also enables a clear comparison to be made between the nodes. The relevance is also confirmed in the ability of the theory to make objective comparison of different networks therefore fitting into scientific research, involving the identification of changes that could have taken place in the spatial pattern of a network.
The choice of Covenant University as case study was borne out of sincere desire to examine the master plan of a private university community that is at infancy stage of development and which has great prospects for further development, thereby aiding future and continuous studies as the community grows in terms of physical developments from year to year. The university is located in Ota, Ogun State in southwestern Nigeria, an industrial town with about 163,000 residents representing about 7% of the total 2,338,570 population estimate for 1991 for Ogun State; it is the fourth largest city in Ogun State. The Covenant University community is located at Kilometre 10 along the Ota/Idiroko Road in the outskirt of the industrial town *en route* to Idiroko a border town with the Republic of Benin.

Over time, the estate surveyor and valuer in his professional practice believe that accessibility has great impact on property values and often conclude that properties located at the point where two or more roads meet would command greater value than those located off the nodal points (Omoogun, 2006). However, this assertion lacks empiricism. This research therefore becomes relevant to show the qualitative technique that is useful in analyzing both inter- and intra- communities road networks. The research will also serve as a means of arousing the interests of professional and academic estate surveyors and valuers in this respect, particularly, with regards to proving the effects of accessibility and transport infrastructures on property values.

This paper examines the intra-community road network pattern of Covenant University, Ota, Nigeria, to determine the most accessible and best connected of the nodal points within the university community and the objectives in relation to this aim are: to examine the intra-community road network pattern of the study area, determine the degree of accessibility and connectivity of the various developments in the community, evaluate the most accessible and best connected points in the university community, and present recommendations that will enhance the issues investigated.

Review of Literature

A lot of earlier works on transportation, road network and accessibility have been carried out on regional level but studies of intra-campus network using the graph-theoretic concept are non-existent. For instance, Garrison and Marble (1960) applied graph-theoretic to measure regional highway network in the United States of America; Nystuen and Dicey (1961) analyzed functional connection between central places in the state of Washington based upon communication flows in a network; Muraco (1972) applied the graph-theoretic technique in his study of intra-urban accessibility of inter-state highways in Indianapolis and Columbus in the United States of America; while Ogunsanya (1986) applied the technique in the estimation of traffic flow in Barnsley, United Kingdom.

In Nigeria, Aderamo (2003) studied the growth of intra-urban network in Ilorin using the graph theoretic analysis and found various indices of network developments for the periods 1963, 1973, 1982 and 1988 thereby making it possible to trace the growth of the intra-urban network of the study area between 1963 and 1988. The study found a relationship between road development, expansion of the city, and significant effect on transportation planning with conclusion that road network is a significant factor in growth and development of a city and community. Also, Oduwaye (2004), in a study of land value determinants in medium density residential neighbourhoods of metropolitan Lagos tested the hypothesis that there is no significant relationship between accessibility and land values using the Spearman's correlation analysis to determine the relationship between the variables with further test using Chi-square to check its validity, with the conclusion that accessibility is a major determinant of residential values in the study area while improvement in transportation facilities, especially roads, brings about improved accessibility.

The graph theory is relevant to studies on accessibility and connectivity of two or more locations. In graph theory, line patterns occur which is referred to as network defined as a set of geographical locations interconnected in a system by a number of routes thereby making the use of quantitative approach in giving accurate description in transport and land use planning very difficult, and it is equally difficult to determine accessibility and connectivity of two points to all other points in quantitative terms. Also, the quantitative description is also unsuitable for comparing the characteristics of one network with another, while it is also not useful in the evaluation of the present and future trends of elements in the road networks. Based on these shortcomings, amongst others, the graph qualitative approach emerged as alternative the quantitative approach in capturing adequately all aspects of networks.

The graph theory was first proposed by Garrison and Marble (1960) and further developed by Kausky (1963). It is described as a branch of combinational topology, a powerful and versatile language which allows one to disentangle the basic structure of transportation networks (Lowe and Moryada, 1975); while it is also described as a directed, weighted graph or network in relation to transport typically as networks of roads, streets, pipes, aqueducts, power lines, or any structure that permit either vehicular movement or flow of some commodity (wikipedia online, 2007c).

Transport networks are spatial structures designed to channel flows from the points of demand to points of supply to link the points together in a transportation system, useful for transport network analysis in determining the flow of people, goods, services and vehicles. Similarly, spatial networks are networks of spatial elements derived from maps of open space within the urban context or building, a form of negative image of the standard map, with the open space cut out of the background buildings or walls. The resulting space map is broken into units of road segments, called the nodes of the graph, and linked into a network through their intersections, called the edges of a graph; and by divorcing the function of transport network from their inert spatial form, some useful descriptive indices are derived, while it is possible to evaluate alternative structures by reducing the complex transportation network to its fundamental elements of nodes and links, such evaluation is carried out using elementary mathematics from the graph theory (wikipedia online, 2007a).

Also, transport network can be considered as a topologic graph with three parameters from which quantitative measurements may be computed as a basis for the objective description, comparison and evaluation of networks. The parameters are the number of separate non-connecting sub-graphs in the network represented by G, the number of links (or edges) in the network (E) and the number of nodes (or vertices) in the network (V) (Hodder and Lee, 1982). The description of a network varies between whether the network occurred on a plain, referred to as the planner graph or if non-planner graph. In planner graphs, all the nodes and links occur on a surface whereas in non-planner graph there are infinite numbers of links that are developed; and in graph theory links are referred to as lines, edges or arcs while the points are called nodes, vertices, junctions, intersections, or terminals. The graph theory therefore serves the means by which the theory, nature, form, and characters of the network can be described, analyzed, with temporal changes of the elements observed within a particular geographical space and between one node of the network or another.

The spatial pattern of a network can be carried out in three ways: connectivity index analysis, accessibility index analysis, and measure of compactness. These indices are concerned with network and such analysis can yield valuable measures of the accessibility, connectivity, and compactness of individual nodes. The connectivity of a network refers to the completeness of the lines or links between the nodes or vertices, and can be measured using four indices, namely, beta index (â), chromatic number (CN), alpha index (), and gamma index () (Cole and King, 1968; Hay, 1973; Hodder and Lee, 1982; Rallis, 1988). The Beta Index is a measure of connectivity in terms of the average number of links per node within the network and indicates the relationship between the number of edges (E) and the vertices (V) defined as:

$$\text{Beta Index}\,() = \frac{E}{V}$$

The Gamma Index () measures the ratio of the observed number of links and the maximum number of links in any network, given by the formula:

$$\text{Gamma Index}\,() = \frac{E}{3\,(V\ \ 2G)} \times 100$$

Similarly, The Chromatic Number (CN) indicates the number of circuits within a network. Where there is no complete loop, CN will be equal to zero and where the result is one it indicates one loop, up to any number that thus corresponds to the number of loops using the formula: Chromatic Number (CN) = E V + G; while the alpha index is obtained by dividing the chromatic number with double the number of vertices less five multiples of the sub-graphs.

$$\text{Alpha Index} = \frac{(E\ \ V+G)}{(2V\ \ 5G)} \times 100$$

These indices are concerned with network and such analysis can yield valuable measures of the accessibility of individual nodes, derived from the connectivity matrix, which represents the links between the nodes of a network in a matrix form.

A figure of one in the matrix indicates that there is one inter-nodal link while zero indicates that there is no link. The distance between pairs of nodes is expressed as the number of intervening links along the shortest path that connects them. The total of the figures in the row for each node is a measure of its accessibility in terms of the measure of the total size of the network and total number of links. This measure is known as the dispersion value of the graph, and the average length of path in the network is obtained by dividing the row sum by the total number of positive values in the row (Hay, 1973).

Road networks consist of a large amount of roads which interlink each other. Many patterns exist in road networks these are star-like, grid-like and irregular patterns. Star-like patterns display a radial structure where many roads converge at a point, or a set of dense points. Grid-like patterns consist of two groups of roughly perpendicular roads, corresponding to Manhattan-style street networks. As for irregular patterns, no regular shape and structure can be discerned as the networks consist of a large amount of roads that interwove each other (Zhang, and L.U., 2004). Patterns in this respect are defined as characteristics and properties which are found in repeated and regular manner within one object, or between a number of objects with such repetition in the form of shape, density, distribution, linkages, connection or orientation occurring among the same kind of objects or different kinds of objects (Mackaness and Edwards, 2002).

Road networks consist of large amount of interwoven roads exhibiting many patterns ranging from star-like to grid-like with irregular patterns often become recognized, while modelling such patterns, a parameter-based pattern description appear to be a primitive method as every pattern has a set of properties, which can be described as a set of parameters, including shape, orientation, connectedness, density and distribution and in terms of the parameters, patterns with certain properties are identified, and evaluated in map generalization (Zang, 2004, ors). Other studies namely Mackaness and Beard (1993); Mackaness (1995); Thomson and Richardson (1995); Jiang and Claramunt (2004); and, Jiang and Harrie (2004) used the concepts and parameters of connectivity, shortest path spanning tree, and minimum cost spanning tree, to analyze road network; while Thomson and Richard (1999) used perceptual grouping to analyze road network to group road segments according to continuation principle by ordering and selecting strokes into which the roads are segmented; while yet another approach used was the simulation of the amount of road use and selection of roads that have high level of usage through agent-based simulation consisting of algorithm base for road generalization and creating a version of network of roads that exhibits certain properties of good connectivity, length of the roads, degree of continuation, and degree and frequency of usage. However, as good and exploratory as the agent-based simulation approach is, it does not guarantee that some important properties of road network are not distorted, as some of the approaches ignore the analysis of the road network pattern thereby losing the patterns of the road networks (Morisset and Ruas, 1997).

Similarly, spatial networks are networks of spatial elements, derived from maps of open space within the urban context or building; and space map could be likened to the negative image of the standard map, with the open space cut out of the background buildings or walls with the resulting space map broken into units of road segments, called the nodes of the graph linked together into a network through their intersections called the edges of a graph (wikipedia, 2007c), and in transportation network analysis, a common instance reverses this and treats the road segments as edges and the street intersections as nodes in the graph; and by divorcing the function of transport network from their inert spatial form, it is possible to derive some useful descriptive indices, and by reducing the complex transportation network to its fundamental elements of nodes and links, it is possible to evaluate alternative structures; and such evaluation is carried out using some elementary mathematics from graph theory (Hodder and Lee, 1982).

In modelling network pattern, therefore, a parameter-based descriptive method may be used, with every kind of pattern having a set of properties that can be described as shape, orientation, connectedness, density and distribution in terms of which certain properties are identified, and evaluated in map generalization, with the possibility of using parameters that indicate the main properties of the patterns; while in computing density of the road networks, the networks are partitioned into different parts in order to extract the roads inside each part and calculate the density of each part by density indicator, and number of connections thus recording the number of roads that connect to the road (Zhang and L.U., 2004), while accessibility is a general term used to describe the degree to which a system is usable by as many people as possible and it is the degree of ease with which it is possible to reach a certain location from other locations, and it can also be viewed as the ability to access the functionality, and possible benefit; and in transportation, accessibility refers to the ease of reaching destinations with people in places reaching many other activities or destinations quickly, while people in inaccessible places can reach many fewer places in the same amount of time (wikipedia, 2007b).

Considering property value in relation to transportation and accessibility, the Washington, D.C.'s Metro rail for example encouraged more downtown development than would otherwise have occurred, with Metro rail converging downtown from all directions thus concluding that the market for office and other space within a business center is to build more off-road transit facilities to serve it (Downs, 1992); while contemporary land market theory established that differential firm's access to business activity clusters eliciting significant effects on commercial land market as exemplified in firms valuing main and secondary centers accessibility in the urban areas (Sivitanidou, 1996).

Urban road transportation system is one of the important factors responsible for shaping urban centres, and urban road transportation system does not act as basic component of urban areas' social, economic and physical structure, and plays essential role in the determination of the scale, nature, and form of urban areas (Balchin, et al, 1991); and the relationship between accessibility, property values and land use patterns that was the pre-occupation of the earliest theorists indicated that travel costs were traded off against the rents and population densities from the Central Business District (CBD) to suburbs of a mono-centric city, and accessibility has become a more complicated phenomenon requiring more sophisticated treatment and it is important to study accessibility more rigorously in order to understand the locational advantages of individual properties rather than rely on traditional bid-rent theory that places the peak rent contour in the CBD (Henneberry, 1998).

In explaining the effects of accessibility on property values, modern techniques have been introduced. These techniques range from geographically weighted regression technique, multinomial logit models, to geo-spatial analysis using the Geographical Information Systems (GIS). For instance, Desyllas (1998) used a regression model in a study on office rents in Berlin, Germany between 1991 and 1997, in which he derived a residual figure for the amount of rent not explained by non-locational factors and suggested that in order to find an independent variable it is appropriate to model the street system as a network and calculate accessibility values based on the relationship between individual streets and configuration of the system as a whole.

Data Collection and Methodology

Data required for this study were generated mainly from the secondary source. The master plan of Covenant University (Fig. 1) was used to analyze the network of roads in the community. In this regard, the original master plan was traced out using transparent paper to obtain the graph of the network of roads. The resulting graph was thereafter analyzed to obtain required data for analysis using Graph Theoretic and Pearson's Product Moment Correlation techniques.

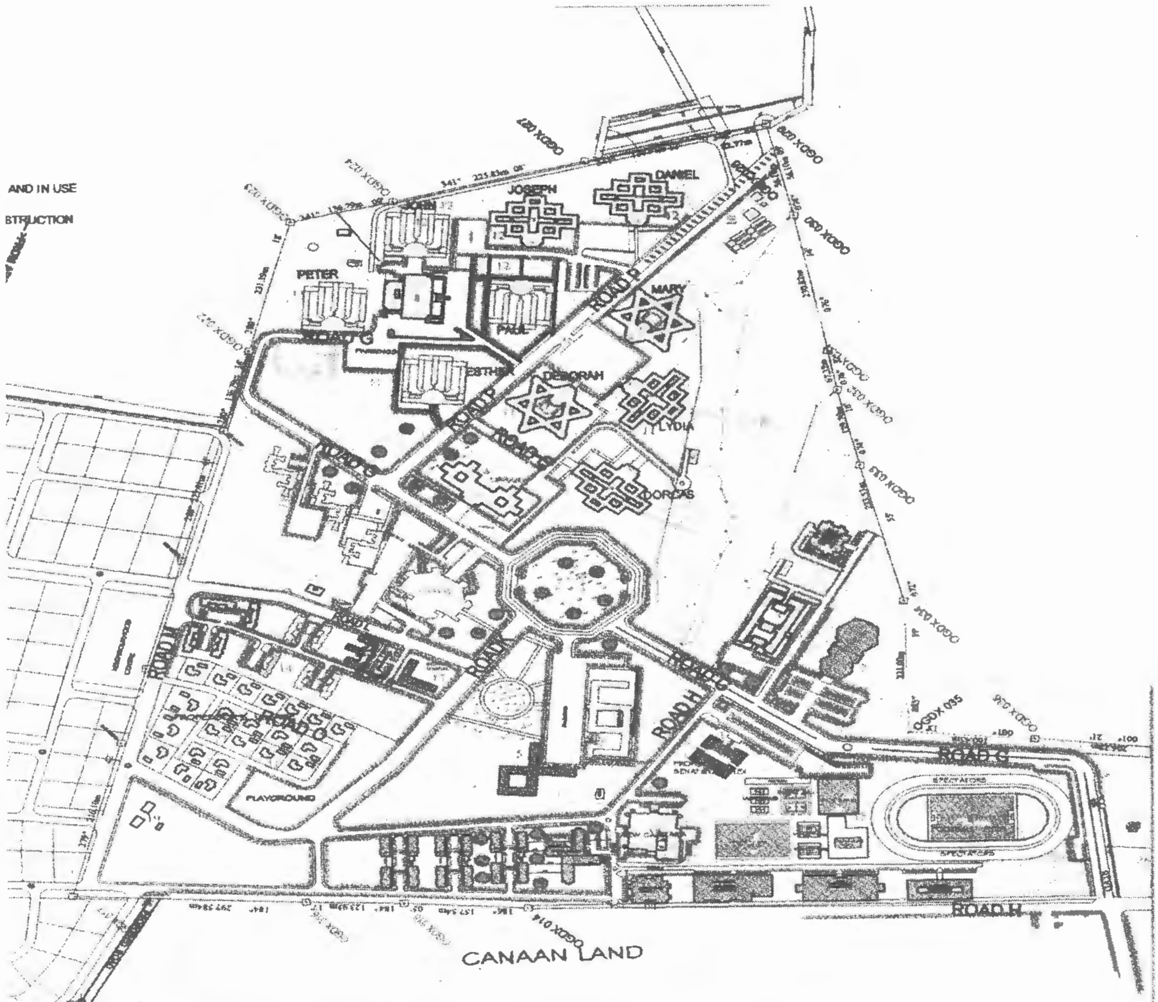
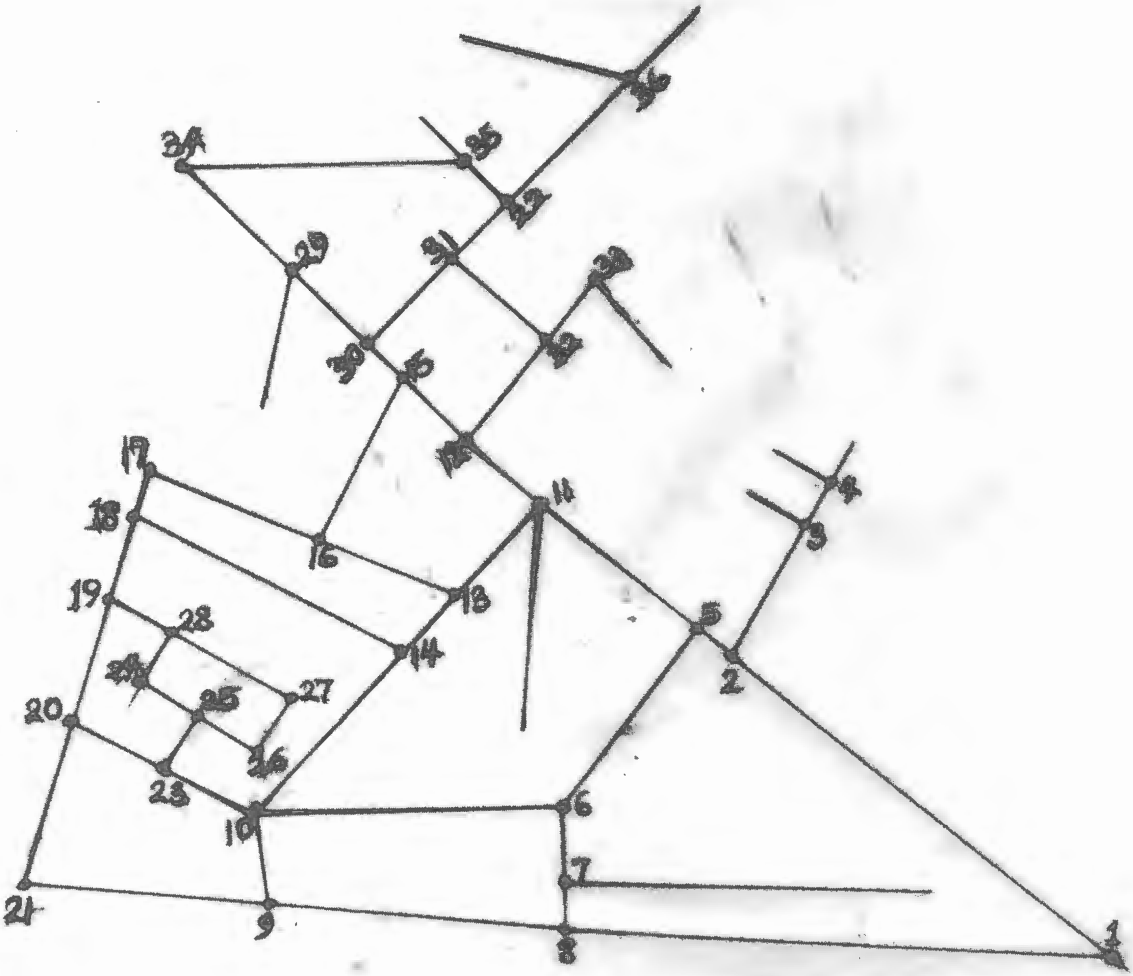


Fig. 1: Master Plan of Covenant University
Source: Physical Planning & Development Unit, Covenant University

In this regard, the original master plan (Fig. 1) was traced out using transparent paper to obtain the graph of the network of roads. The resulting graph was thereafter analyzed to obtain required data for the research work, and The Graph Theoretic Analytical technique adopted to determine the connectivity and accessibility indices of each node within the network in Covenant University community. In using the graph theoretic qualitative technique, the road network map as indicated in the master plan was converted into linear graph, with each route represented by single line regardless of the width, quality, and standard of the roads but taking the shortest route possible, the connectivity and accessibility matrices were consequently prepared, and the nodes within the graph numbered serially as shown in Fig. 2.



From Fig. 2, the levels of accessibility and connectivity using the Shimbel Index and Connectivity Matrix (Tables 1 and 2) were determined. In this regard, the Shimbel Index indicating the accessibility indices summarizes the number of edges required to connect each node or vertex with other nodes in the network through the shortest path as shown in Table 1, while the Connectivity Index indicates the node with the highest total number of connections or linkage with the other nodes. In the Connectivity Matrix, a score of 0 or 1 was given to each node, that is where two nodes are directly linked, a value of 1 point was given and where they are not directly linked, a score of 0 point was given. The Connectivity Matrix therefore indicates the number of other nodes that a particular node is directly linked with and the node with the highest number of points is therefore considered as the most connected while the node or vertex with the least Shimbel Index is regarded as the most accessible as detailed in Tables 1 and 2.

The Lagos Journal of Environmental Studies 2008.
Vol 6, No 1, 24-37

Table 1: Shimbel Matrix Indicating the Analysis of Accessibility within the Covenant University Community

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	INDEX
1	0	1	2	3	2	3	2	1	2	3	3	4	4	4	5	5	7	6	5	4	3	7	4	6	5	6	7	6	7	6	7	5	6	8	8	8	**165**
2	1	0	1	2	1	2	3	2	3	3	2	3	3	4	4	5	5	6	6	5	5	7	4	6	5	6	7	7	6	5	5	4	5	7	7	7	**154**
3	2	1	0	1	2	3	4	3	4	4	3	4	4	5	5	5	6	6	7	6	5	7	5	7	6	7	8	8	6	5	6	5	6	8	8	8	**180**
4	3	2	1	0	3	4	5	4	5	5	4	5	5	6	6	6	7	7	8	7	6	8	6	8	7	8	9	9	8	7	7	6	7	9	9	9	**216**
5	2	1	2	3	0	1	2	3	4	2	1	2	2	3	3	3	4	4	5	4	4	5	3	5	4	5	6	6	5	4	4	3	4	6	6	6	**127**
6	3	2	3	4	1	0	1	2	3	1	2	3	3	2	4	4	4	3	4	3	3	6	2	4	3	4	5	5	6	5	5	4	5	7	7	7	**130**
7	2	3	4	5	2	1	0	1	2	2	3	4	4	4	5	5	6	4	5	4	3	7	3	5	4	5	6	6	7	6	7	5	6	8	8	8	**160**
8	1	2	3	4	3	2	1	0	1	2	4	5	5	6	6	6	6	4	4	3	2	8	3	5	4	5	6	5	8	7	7	6	7	9	9	9	**168**
9	2	3	4	5	3	2	2	1	0	1	4	5	3	2	6	4	4	3	3	2	1	8	2	4	3	4	5	4	7	6	7	6	7	9	9	9	**150**
10	3	3	4	5	2	1	2	2	1	0	3	4	2	1	4	3	4	2	3	2	2	7	1	3	2	3	4	4	6	5	6	5	6	8	8	8	**129**
11	3	2	3	4	1	2	3	4	4	3	0	1	1	2	2	2	3	3	4	5	5	4	4	6	5	6	6	5	4	3	3	2	3	5	5	5	**123**
12	4	3	4	5	2	3	4	5	4	4	1	0	2	3	1	1	3	4	5	6	6	3	5	7	6	7	8	6	3	2	2	1	2	4	4	4	**134**
13	4	3	4	5	2	3	4	4	3	2	1	2	0	1	2	1	2	2	3	4	4	5	3	5	4	5	5	4	4	3	4	3	4	5	6	6	**122**
14	4	4	5	6	3	2	3	3	2	1	2	3	1	0	3	2	2	1	2	3	3	6	2	4	3	4	4	3	5	5	5	4	5	6	7	7	**125**
15	5	4	5	6	3	4	5	6	6	5	2	1	2	3	0	1	2	3	4	5	6	3	6	6	6	7	6	5	2	1	2	2	3	3	4	4	**138**
16	5	4	5	6	3	4	5	5	4	3	2	2	1	2	1	0	1	2	3	4	5	4	5	5	5	6	5	4	3	2	3	3	4	4	5	5	**130**
17	6	5	6	7	4	5	6	6	5	4	3	3	2	2	2	1	0	1	2	3	3	5	4	4	5	5	4	3	4	3	4	4	5	5	6	6	**143**
18	5	5	6	7	4	3	4	4	3	2	3	4	2	1	3	2	1	0	1	2	3	6	3	3	4	4	3	2	5	4	5	5	6	6	7	7	**135**
19	5	6	7	8	5	6	5	4	3	3	4	5	3	2	4	3	2	1	0	1	2	2	2	3	3	2	2	1	6	5	6	6	7	7	8	8	**147**
20	4	5	6	7	4	3	4	3	2	2	5	6	4	3	5	4	3	2	1	0	1	8	1	3	2	3	4	2	7	6	6	7	8	8	9	9	**157**
21	3	4	5	6	5	4	3	2	1	2	5	6	4	3	6	5	4	3	2	1	0	9	2	4	3	4	4	3	8	7	8	7	8	9	10	10	**170**
22	7	6	7	8	5	6	7	8	8	7	4	3	5	6	3	4	5	6	7	8	9	0	8	9	9	10	10	8	3	2	1	2	2	2	1	1	**197**
23	4	4	5	6	3	2	3	3	2	1	4	5	3	2	5	4	4	3	2	1	2	8	0	2	1	2	3	2	7	6	7	6	7	7	9	9	**144**
24	6	6	7	8	5	4	5	5	4	3	6	7	5	4	6	7	4	3	2	3	4	9	2	0	1	2	2	1	8	7	8	8	9	8	10	10	**189**
25	5	5	6	7	4	3	4	4	3	2	5	6	4	3	6	5	5	4	3	2	3	9	1	1	0	1	2	2	8	7	8	7	8	9	10	10	**172**
26	6	6	7	8	5	4	5	5	4	3	6	7	5	4	7	6	5	4	3	4	5	10	2	2	1	0	1	2	9	8	9	8	9	10	11	11	**202**
27	7	7	8	9	6	5	6	6	5	4	7	7	5	4	6	5	4	3	2	3	4	9	3	2	2	1	0	1	8	7	8	8	9	9	10	10	**200**
28	7	7	8	9	6	5	7	6	5	4	6	6	4	3	5	4	3	2	1	2	3	8	3	1	2	2	1	0	7	6	7	8	8	8	9	9	**182**
29	7	6	7	8	5	6	7	8	7	6	4	3	4	5	2	3	4	5	6	7	8	3	7	9	8	9	8	7	0	1	2	3	4	1	2	4	**186**
30	6	5	6	7	4	5	6	7	8	5	3	2	3	4	1	2	3	4	5	6	7	2	6	7	7	8	7	6	1	0	1	2	3	2	3	3	**157**
31	6	5	6	7	4	5	6	7	7	6	3	2	4	5	2	3	4	5	6	7	8	1	7	8	8	9	8	7	2	1	0	1	2	3	2	2	**169**
32	5	4	5	6	3	4	5	6	6	5	2	1	3	4	2	3	4	5	6	7	8	2	6	8	7	8	8	7	3	2	1	0	1	4	3	3	**157**
33	6	5	6	7	4	5	6	7	7	6	3	2	4	5	3	4	5	6	7	8	8	3	7	9	8	9	9	8	4	3	2	1	0	5	4	4	**190**
34	8	7	8	9	6	7	8	8	8	7	5	4	5	6	3	4	5	6	7	8	9	2	8	9	9	10	9	8	1	2	3	4	5	0	1	3	**212**
35	8	7	8	9	6	7	8	9	9	8	5	4	6	7	4	5	6	7	8	9	10	1	9	10	10	11	10	9	2	3	2	3	4	1	0	2	**227**
36	8	7	8	9	6	7	8	9	9	8	5	4	6	7	4	5	6	7	8	9	10	1	9	10	10	11	10	9	4	3	2	3	4	3	2	0	**231**

Table 2: Analysis of the Connectivity Index of Covenant University Intra-Community Road Network

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Index
1	_	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2	1	_	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
3	0	1	_	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4	0	0	1	_	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5	0	1	0	0	_	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
6	0	0	0	0	1	_	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
7	0	0	0	0	0	0	_	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
8	1	0	0	0	0	0	1	_	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
9	0	0	0	0	0	0	0	1	_	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
10	0	0	0	0	0	1	0	0	1	_	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
11	0	0	0	0	1	0	0	0	0	0	_	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
12	0	0	0	0	0	0	0	0	0	0	1	_	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
13	0	0	0	0	0	0	0	0	0	0	1	0	_	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
14	0	0	0	0	0	0	0	0	0	1	0	0	1	_	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
15	0	0	0	0	0	0	0	0	0	0	0	1	0	0	_	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
16	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	_	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	_	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
21	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	_	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	_	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
23	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	_	0	1	0	0	0	0	0	0	0	0	0	0	0	3
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	_	1	0	0	1	0	0	0	0	0	0	0	0	2
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	_	1	0	0	0	0	0	0	0	0	0	0	3
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	1	0	0	0	0	0	0	0	0	0	2
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	1	0	0	0	0	0	0	0	0	2
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	_	0	0	0	0	0	0	0	0	2
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	_	1	0	0	0	1	0	0	2
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	1	0	0	0	0	0	3
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	_	1	0	0	0	0	3
32	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	1	0	0	0	3
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	_	0	0	0	1
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	_	1	0	2
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	_	0	2
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	1

Test of the Hypothesis

The hypothesis tested is: there is no correlation between accessibility and connectivity of the various nodes within the intra-campus road network pattern. In doing so, the Pearson's Product Moment Correlation Coefficient Technique was adopted using the formula:

$$r = \frac{n\sum XY - (\sum X)(\sum Y)}{\sqrt{\left[n(\sum X^2) - (\sum X)^2\right]\left[n\sum Y^2 - (\sum Y)^2\right]}}$$

where, r : co-efficient of correlation;
Y: accessibility index for each node;
X: connectivity index for each node;
n : number of nodal points

In using the technique to determine the relationship between dependent variable (accessibility) and independent variable (connectivity), details of accessibility index and connectivity index extracted from Tables 1 and 2 are used for the analysis. The extract is shown in Table 3.

Table 3: Indices for Accessibility and Connectivity in the Study Area

Nodal Point	Accessibility Index (Y)	Connectivity Index (X)
1	165	2
2	154	3
3	180	2
4	216	1
5	127	3
6	130	3
7	160	1
8	168	3
9	150	3
10	129	4
11	123	3
12	134	3
13	122	3
14	125	3
15	138	3
16	130	3
17	143	2
18	135	3
19	147	3
20	157	3
21	170	2
22	197	2
23	144	3
24	189	2
25	172	3
26	202	2
27	200	2
28	182	2
29	186	2
30	157	3
31	169	3
32	157	3
33	190	1
34	212	2
35	227	2
36	231	1

Source: Extract for Tables 1 and 2

Analysis and Discussion

As revealed in Fig. 2, the Covenant University's road network, as at August 2007, has 36 vertices and 60 edges, with connectivity indices ranging from 1 to 4, while accessibility indices range from between 122 and 231 (Table 2). Also, the nodal point 13 indicates the least index of 122 followed by node 11 (123). This indicates that sector of the community around the PG School and University Chapel is the most accessible. On the other hand, nodal points 4 with index of 216; 26 (202 index); 27 (200); 34 (212); 35 (227); and 36 (231) all having accessibility indices above 200 situate at remote locations with no link to other locations indicating that they are the least accessible. The locations include New Engineering Building at the back of College of Science and Technology, Peter, John, Dorcas, and Daniel halls of residence. The connectivity analysis shows that the indices are between and inclusive of 1 and 4, with nodal point 10 having the highest index of 4, thus indicating that the node is the most connected as it affords the highest number of linkages aiding easy movements. The location with the highest level of connectivity is around the Professors' Quarters and the University Guest House, this might have arisen out of deliberate action to make it so, as a well-planned neighbourhood obviously would make locations where residents would have easy access to land use that meet their daily needs and aspirations. Plan might have been deliberately made to given the highest level of accessibility to the Chapel complex housing a shopping mall and place of worship.

The percentages of connectivity of locations with regard to their number of links with others within the community are detailed in Table 4.

Table 4: Percentages of Connectivity of Locations Within the Covenant University Community

S/No	Locations/Neighborhoods	Nodal Points	No. of links	Percentage of total No. of nodes
1.	New Engineering Complex behind CST, Behind the new Cafeteria, Lydia Hall, Daniel Hall	4, 7, 33, and 36 **(4 nodal points)**	1	11.11
2.	CU Gate, Dorcas, Southern End of Senior Staff Quarters, Southeastern End to Senior Staff Quarters, Generator House behind CST, Lydia Hall, Deborah, Some Roads within Professors' Quarters except the entrance road, Paul and Esther Halls.	1, 3, 17, 21, 22, 24, 26, 27, 28, 29, 34, and 35 **(12 nodal Points)**	2	33.33
3.	Junction near Professors Quarters, CST, New Cafeteria, PG School, Central Rotary Junction, Library, Entrance road into Professors' Quarters,	2, 5, 6, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 23, 25, 30, 31, and 32 **(19 nodal points)**	3	52.78
4.	Junctions connecting Professors' Quarters with New Cafeteria via University Guest House, with Road from the Central Rotary Junction	10 **(1 nodal point)**	4	2.78
TOTAL		**36**		**100.00**

Further from Table 4, out of 36 nodal points in the community only one nodal point (representing about 3%) has direct links with four other nodes; four nodes out of thirty-six nodal points (about 11%) have links with one other point; twelve nodal points (about 33%) have direct links with two other points; while nineteen nodal points (about 53%) have direct links with three other points. It can therefore be deduced that about ninety percent of the roads in the Covenant University community are well connected, with links to at least two nodal points while about ten percent of the roads have at least one link to another point. This implies that the degree of connectivity of the road network in the university community is high, aiding free movements of residents without traffic "hold-ups"

The results of the application of the Pearson's Product Moment Correlation Coefficient Technique in the analysis of the data in Table 3 gave r to be - 0.7439 with a measure of statistical significance at 95% confidence level. Further analysis of these data using multiple regression technique gave R-squared value as:. This indicates that a linear relationship between connectivity and accessibility is capable of explaining up to 55.34% variability in the parameters at 95% confidence level, and also means that about 44.66% variability in accessibility is explained by other parameters not considered in this work.

Recommendations and Conclusion

This work has demonstrated that graph theoretic technique, though used in analyzing urban and regional transportation and property values, is equally applicable in the analysis of a developing community like Covenant University. From mere visual observation, one would think that particular land use within the community, such as the library, cafeteria, or rotary junction, would be the most centrally located or most accessible to students, lecturers, residents and non-resident staff but the study shows that the chapel housing the shopping mall is the most accessible, and curiously, the nodal point close to the Professor Quarters and the new Guest House is the most connected in the network. The study has also revealed that there is high negative correlation between connectivity and accessibility of the various nodal points on the campus network, and that apart from connectivity other factors could be used to explain changes in accessibility of a point within a community. The estate surveyors and valuers hitherto strongly believe that accessibility has great effects on property values but without empirical means to prove it; the paper has therefore shown that accessibility and connectivity of a location can be proved empirically.

It is recommended that the application of this research in larger urban property market will assist in determining the degree of accessibility and connectivity of a particular location, and assist valuers in given proven consideration to the values of comparable properties with due regards to accessibility and connectivity.

REFERENCES

Aderamo, A. J. (2003): A Graph Theoretic Analysis of Intra-Urban Road Network in Ilorin, Nigeria. *Research for Development The Journal of the Nigerian Institute of Social and Economic Research.* 17 (1 & 2,) 221 - 240

Balchin and P.N., Kieve, J.L., and Bull, G.H. (1991):. *Urban Land Economics and Public Policy (Fourth Ed.)* Hampshire: Macmillan Educational Limited

Cole, J.P. and King, C.A.M. (1968): *Quantitative Geography Techniques and Theories in Geography.* London: John Wiley & Sons .

Desyllas, J. (1998): *When Downtown Moves: Isolating, Representing and Modelling The Location Variable in Office Rents.* Cutting Edge, RICS, Leicester

Dickey, J. W. (1975): *Metropolitan Transportation Planning.* Washington, D.C: Scripta Books.

Downs, A. (1992): *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion.* Brookings Institution/Lincoln Institute of Land Policy

Garrison, W.L. and Marble, D.F. (1960): Connectivity of the Inter-State Highway System. *Papers of the Regional Science Association*, 6:121-137

Hay, A. (1973): *Transport for the Space Economy. A Geographical Study.* London: The Macmillan Press Limited

Henneberry, J. (1998): Transport Investment and House Prices. *Journal of Property Valuation and Investment.* 16 (2) 144 -158

Hodder B. W. and Lee, R. (1982): *Economic Geography.* London: Methuen & Co. Limited

Jiang, B. and Claramunt C. (2004): A Structural Approach to the Model Generalisation of an Urban Street Network. *GeoInformatic* 8(2): 157-171

Jiang, B. and Harrie L. 2004: Selection of Streets from a Network Using Self-Organizing Maps. *Transactions in GIS* 8(3): 335-350

Kausky, K.J. (1963): The Structure of Transportation Networks. *Chicago Department of Geography*

Research Paper No 84

Lowe, J.C and Moryada, S. (1975): *The Geography of Movement*. Buston: Houghton Mifflin Co.

Mackaness W. A. and Beard M. K., (1993). Use of Graph Theory to Support Map Generalisation. *Cartography and Geographic Information Systems*, 20, 210 221.

Mackaness W. A., (1995): Analysis of Urban Road Networks to Support Cartographic Generalization. *Cartography and Geographic Information Systems*, 22, 306 316.

Mackaness, W. and Edwards, E., (2002): The Importance of Modelling Pattern and Structure in Automated Map Generalisation, Joint ISPRS/ICA workshop "Multi-Scale Representations of Spatial Data", Ottawa, Canada, 7-8 July 2002

Morisset, B. and Ruas, A. (1997): Simulation and Agent Modelling for Road Selection in Generalisation. In *Proceedings of the ICA 18th International Cartographic Conference* (Stockholm, 23-27 June 1997), 1376-1380

Muraco, W.A. (1972): Intra-Urban Accessibility: A Quantitative Analysis Use of Graph Theoretic Method. *Economic Geography* 48:388-405

Nystuen, J. D. and Dicey, M.F. (1961): A Graph Theory Interpretation of Modal Regions. Papers and Proceedings Regional Science 7: 29-42

Oduwaye, L. (2004): Land Value Determinants in Medium Density Residential Neighbourhoods of Metropolitan Lagos. Journal of the NITP, XVII, 97 111

Ogunsanya, A. A. (1986). Graph Theory in Intra-urban Traffic Flow Estimation. *Geo-Journal*, 12 334-336

Omoogun, C. B. (2006): The Centripetal Effects of Location on Rental Values of Residential Property in Metropolitan Lagos. Conference Proceedings on the Built Environment: Innovation Policy and Sustainable Development. Department of Architecture, Covenant University, Ota, Nigeria. 328 - 334

Rallis, T. (1988): *City Transport in Developed and Developing Countries*. London: The Macmillan Press Limited.

Salau, T. I. (1997): *An Analysis of Road Transport Infrastructural Facilities in Abeokuta*. Unpublished M.Sc. project dissertation submitted to Department of Geography and Regional Planning, Faculty of Social and Management Sciences, Ogun State University, Ago-Iwoye, Nigeria.

Sivitanidou, R. (1996): Do Office-Commercial Firms Value Acess to Service Employment Centres? A Hedonic Value Analysis within Polycentric Los Angeles. *Journal of Urban Economics 40(2) 125 149*

Thomson R. C. and Richardson D. E. (1995): A Graph Theory Approach to Road Network Generalisation. In *Proceeding of the 17th International Cartographic Conference*, 18711880.

Thomson, R. C., and Richardson, D. E., (1999): The 'Good Continuation' Principle of Perceptual

Organization Applied to the Generalization of Road Networks. *Proceedings of the ICA 19th International Cartographic Conference* (Ottawa, 14-21 August 1999), 12151223.

Wyatt, P. (1999): Geographical Analysis in Property Valuation. *Research Report, Royal Institution of Chartered Surveyors*, London.

Zhang, Q. and Lund University GIS Centre 2004: *Modelling Structre and Patterns in Road Network Generalization*. ICA Workshop on Generalisation and Multiple Representation, 20-21 August 2004 - Leicester in http://ica.ign.fr/Leicester/paper/
Zhang-v2-ICA Workshop.pdf

wikipedia, online, (2007a): http:/ /en.wikipedia.org /wiki/Graph_theory; June 10, 2007

wikipedia, online, (2007b): http:// en.wikipedia. org/wiki/Road_ network; June 10, 2007

wikipedia, online, 2007c: http://en.wikipedia.org/wiki/Transport_network; June 10, 2007