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Public water infrastructure in property prices: an environmental valuation approach

Funlola Famuyiwa* and Austin C. Otegbulu

Department of Estate-Management, Faculty of Environmental Sciences, University of Lagos, Lagos, Nigeria.

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ABSTRACT

Public infrastructure is very vital for the functioning of an urban area. Potable water specifically remains a major United Nations target conveyed through the Millennium development goals. It is crucial for health, safety, environmental sustainability as well as for economic growth and development. Evidence from literature suggests that infrastructure services generally have positive effects on housing values, as they constitute positive externalities to surrounding properties. To this end, an investigation was made on the relative contribution of public water infrastructure on housing rental values in a residential neighborhood in Lagos, Nigeria using a hedonic regression model. Findings from the study revealed the relative impact of public water supply on property rental values. The application of the findings of this study will help direct policy formulation in the areas of urban infrastructure planning and development for investment returns and cost recovery. This is particularly necessary in a region characterized by incoherent institutional arrangements and poor financing strategies for urban infrastructure delivery and maintenance.

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Introduction

1.0 Background

Public infrastructure when adequately provided offers multi-dimensional benefits within its operative network. In this regard, it is considered a positive externality as well as an environmental good. In modern society, these public services have simply become lubricants in the wheels of national development and are extremely essential for public welfare and fiscal growth. Economies require the development of infrastructure, such as water, energy, roads development, transport networks, information, and communication technology for sustainability and these urban services also positively influence the value of real estate as they improve housing conditions and quality. Odudu (2003) observed that housing values tended to peak in those locations that enjoyed one form of infrastructure or the other. Similarly in Lagos, Nigeria, recent road redevelopment projects have significantly increased the value of property in certain locations. This can be traced to the fact that housing embraces the totality of the environment and the quality of a neighborhood largely influences housing conditions and preferences. Otegbulu and Adewunmi (2009) explain that in civilized societies, housing represents more than mere shelter but includes both internal and external services.

The valuation of environmental goods on property prices is a subject which has continued to gain recognition. Des Rosiers, Bolduc and Theriault (1999) state that environmental issues have attracted attention in economic and real estate literature, particularly with respect to their impact on property prices and that analytical approaches are also currently being used to measure urban externalities and the extent to which they are internalized into real estate values. Because of its immobility, real estate tends to be affected by externalities more strongly than most other economic goods, services and commodities

(Babawale and Adewunmi, 2011). Determining the effects of externalities on property value provides a basis by which each attribute is inherently priced in the aggregated value of the building as they usually constitute part of the housing bundle, and represent significant aspects in fiscal and economic terms.

There are various means by which the measurements of the value of housing attributes can be made. However; the *hedonic approach* remains the most reliable tool for such purposes as it reveals buyers' perception through their actual pricing behaviour. It aims to explain property values on the basis of house characteristics, physical and neighbourhood-related. This tool was birthed by Rosen (1974) and has remained extensively used in empirically evaluating housing characteristics.

In this study, an investigation is made into the influence of municipal public supplied water on the rents of residential properties. The objectives that will help achieve this are as follows:

- To highlight the importance of public water infrastructure, as well its current status in the study area.
- To weigh the comparative value influence of various other infrastructure on property prices in the study area.
- To determine the influence of urban water supply on rental values within the study area.

The research will help with a view to policy formulation and administration, within the context of property based taxes. The term 'public infrastructure' in this paper will be used interchangeably with 'infrastructural facilities', 'physical infrastructure', 'urban services', 'urban infrastructure', 'public facilities' and 'infrastructure', as the distinctions between them are little and not necessarily of much consequence within the context of this study.

This section introduces the essence of the study, and subsequent sections of the paper treat related literature, methods

Tele:

E-mail addresses: ffamuyiwa@unilag.edu.ng

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employed, results and findings of the research. Conclusions are then presented in the last section.

2. Literature

2.1 Public Infrastructure and Property Values Review

Adebayo (2006) asserts that one of the determinants of property values is infrastructural facilities, the presence of which leads to appreciation in property values. Its absence affects neighbourhood properties adversely (Briton et al, 1989; Adebayo, 2006). Odudu (2003) compared different neighbourhoods in Lagos and noticed that housing values tended to peak in those areas that enjoyed one form of infrastructure or the other. Land uses out-compete less productive uses through better rent offers. Competition for locations with good urban infrastructure usually results in an increase in land and housing values, either sales or rentals (Harvey, 1994; Adebayo, 2006).

There is no standard definition of infrastructure across economic studies and many studies utilize the term 'infrastructure' with particular respect to its economic impact. (Torrissi, undated). Specifically, physical infrastructure can be regarded as man-made municipal services, structures, or facilities that are designed to aid and ease the functioning of economic, domestic and social activities in a region. These services can be provided through private or public means. More recently, the term has gone to include information technology systems such as internet services, telephone networks, etc. Public infrastructure covers a wide range of services and facilities, namely electricity, passenger and cargo transportation services, water supply systems, roads, waste disposal, drainage, communication, primary health services, schools and housing as the key ones. They are *more often* provided by government. This definition hinges on a very key term - productivity.

Hammer et al (2000) as cited in Adebayo (2006) suggests that a residential user may be prepared to pay a high value for a property depending on his consideration for basic facilities such as accessibility, water and electricity. A few other empirical studies also reveal this correlation.

Ki and Jayantha (2010) empirically investigated how redevelopment affected housing values in a specific location. The results exhibited significant rises in property values from implementation to after completion of the redevelopment project. Property value enhancements well ahead of the actual project completion are also observed. Properties with the closest proximity to the redevelopment experienced greater increase in their prices after redevelopment. The study broadly assessed infrastructure, and not necessarily their interaction or how one affects the other (which is validated later in this paper in the last paragraph of section 2.3).

Mallios, Papageorgiou, Latinopoulous and Latinopoulous (2009) applied the hedonic pricing model using the spatial econometrics in order to assess the economic value of irrigation water as one of the individual attributes of agricultural parcel lands. Results from the application revealed that spatial methods increase efficiency and consistency, and reduce the bias of parameter estimates. This study was however more concerned with proving that the spatial error model provides and therefore better in estimating the value of irrigation water. Thus there was a heavy concentration on the methods employed in the research process as opposed to the variables (infrastructure) used for the study. Regarding the value of irrigation water, the importance of its availability in the configuration of the land parcels value was found apparent.

Similarly, Des Rosiers, Bolduc and Theriault (1999) in their study discovered that negative externalities linked to water supply/quality problems in a given neighbourhood adversely affected property values within the study location. Des Rosiers et al adopted the hedonic pricing model in quantifying the economic influence of this externality in property values within their study area. Findings indicated that water-related health hazards exert a detrimental and measurable impact on higher property values. It was observed that the higher the price of the property, the sharper the decline in market value. This is the closest to this study, but actually delved into investigating negative impact of water quality. Within a more contextualized approach, this present study helps to close the gap of investigating the extent to which public water infrastructure and property prices express a positive correlation.

2.2 Public Water Infrastructure

Water is invaluable to most if not all living creatures. As a commodity, it is different to other commodities and consumers have no alternative as regards water while shopping for other municipal products. The development and maintenance of a regular potable water supply is needed to facilitate healthy living and national development. The uniqueness of water in this regard has made it imperative in this study to treat this variable in isolation from other neighbourhood infrastructure and subject it to empirical investigation.

Public water infrastructure in this study refers to the controllable pipe-borne flow of potable water in individual dwelling premises from public mains that is provided by municipal, state or federal governments. Usually the quality and 'potability' of such water is not doubtful. In Daniels and Daniels (2003), water supply planning is essentially important in places experiencing rapid population growth and development and the lack of a reliable water supply can be a serious limit to growth and can hasten a community's decline. For sustainable water supply planning, it is necessary to broadly study water demand as well as its inherent value in property prices as expressed in its existence or otherwise in residential dwellings. In Sowdagur (2006) according to the UNDP, some 1.2 billion people still lack access to safe and adequate supply of drinking water and Close to 3 billion people lack sanitation facilities. A large percentage of these figures are represented in developing countries. Ogunleye (2003) reports that as at 1999, an average of 52% of the Nigerian population was said to have access to potable water. The figure for some regions in the country is said to be less than the annual average. The ideal standards for water transportation and supply have not been met as many households remain in dire need of or privately provide their own water – usually at exorbitant costs. (Otegbulu and Adewunmi, 2009). According to Lagos State Government Ministry of Finance (2008), the status of Lagos State as a Mega City has created an urbanization challenge of providing new infrastructure and maintenance of the existing ones for a sustainable value for its citizens till the next quarter of the century. The challenge provides opportunities to explore creative and innovative ways of addressing the urban infrastructure deficit. Investment opportunities abound in the public water supply sector of Lagos State economy, for the private sector within the next two decades. On a global scale, the world is on track to meet the drinking water target, though much remains to be done in some regions (United Nations, 2012). The United Nations further includes the following under key areas of focus

- Accelerated and targeted efforts are needed to bring drinking water to all rural households. (And urban areas is many third world nations)
- Safe water supply remains a challenge in many parts of the world
- With half the population of developing regions without sanitation, the 2015 target appears to be out of reach
- Disparities in urban and rural sanitation coverage remain daunting

This research on water infrastructure and related issues is therefore essential in a developing country where inadequate government (public) water supply is an identifiable feature. For financing mechanisms to be apt there has to be a thorough understanding of the operations and dynamics of the system. This is necessary particularly in terms of understanding specific pricing behaviour of value inducing variables.

2.3 Hedonic Pricing Model for Water Infrastructure

The multifaceted nature of infrastructure sustainability objectives requires decision makers to adopt a holistic and broad approach in infrastructure planning. For example, demand as indicated in stakeholder preferences should be critically analyzed for effective and sustainable provision. One of the ways by which the implicit prices of infrastructure in property values can be determined is through environmental valuation methods, one of which is the hedonic pricing model which is based on the premise that a house represents a bundle of varying attributes with each attribute constituting a part of the price at which the property would most likely change hands in a fair and competitive market (Open market value). Many researchers have adopted this model in empirical based studies in determining the value of variables inducing real estate pricing.

Rosen (1974) helpfully birthed the hedonic approach in environmental studies. The models are advanced forms of ex-post (transaction-based) models that estimate the marginal contributions or implicit prices of property characteristics to their total value by comparative analysis using past sale transactions. (Roubi and Littelljohn, 2004). Hedonic models introduce a broad spectrum of physical and other asset characteristics and bring objectivity to transaction-based valuation methods. Otegbulu and Adewunmi (2009) suggest that infrastructure systems are not treated as combined facilities but rather are designed independently by specialists in individual areas of specialties (e.g. road and drainage, water distribution, transportation, etc). Such specialists may lack an understanding of how all the infrastructure system interact as a whole. Therefore to achieve sustainable neighbourhood design, those involved in the neighbourhood design process must consider the interaction among local infrastructure and systems and between the neighbourhood and the greater urban region (Engel-Yan et al., 2005, Adewunmi and Otegbulu 2009).

According to Watkins (1999), by regressing the physical and locational characteristics of properties on the selling price, the technique allows buyers to estimate the value of individual property attributes, and from these to construct estimates of the value of properties whose characteristics are known. Further, this approach is analogous to the comparable method of valuation and has been shown to be cost effective in valuing large number of properties and accurate. (Dodgson and Topham, 1990). However, characteristics of a particular housing unit alone cannot determine its price because the number and the nature of attributes influencing housing prices are enormous and heterogeneous (Ki and Jayantha, 2010). The house prices in this

study are assumed to be affected by neighborhood, structural and locational attributes of dwellings. Neighbourhood infrastructure is focused on however.

3. Study Area and Methods

The area under study for this research was Bourdillon Road and its environs in Ikoyi, a prime settlement in Lagos state which spans a total land area of 815.73 hectares. This scheme, a former British colonial settlement was prepared by the British colonial Government and has been in use for over 70 years (Lagos State Ministry of Physical Planning and Urban Development, 2006). Ikoyi is located at the beginning of the South-eastern corridor of Lagos state within latitudes 4° and 5° north. It is also bounded to the north and East by the Lagos Lagoon. Bourdillon road is a dual carriage way and the second longest road within Ikoyi with a length of 24 kilometers.

The increase in population has been attributed partly to the *emergence* of an increasing number of upwardly mobile, high income class people requiring accommodation in the highbrow area. Ikoyi neighbourhood was planned as residential serviced by the usual complimentary uses. Land in this area at inception was planned to provide residential accommodation for senior government officials. The current initiatives and pro-active policies of the current Lagos state Government since it assumed authority in May 2007 have been geared towards infrastructure development which has been very visible in the study area.

Data of open market rental values were obtained from selected Estate-Surveying and Valuation firms operating within the jurisdiction. A questionnaire survey was carried out on residents in the study area order to elicit information on housing attributes and demand preferences. A total of 118 questionnaires were found useable for the study. Given the difficulty and tough circumstances surrounding the eliciting of primary data of this nature, as well as the relative homogeneity of properties in the study area in this regard, this sample size is considered reasonably adequate.

Tse and Love (2000) report that house prices for dwelling units are determined by the consumer's evaluation of a bundle of attributes. Specifically, a hedonic equation helps to explain house prices in terms of their own characteristics: each of these attributes is assumed to be implicitly priced. Further, a feasible approach in using the hedonic regression is to choose a sample with similar locational characteristics and income groups that are supposed to have homogenous tastes so that the net effects of various attributes and location specific factors of the neighbourhood are similar. Babawale and Adewunmi (2011) suggest that at its simplest, a hedonic equation is a regression of expenditure (rental or capital values) on characteristics that determine house rent or capital value.

4. Analysis and Results

This study adopted the hedonic pricing Model in determining the effects of public water infrastructure on house prices on Bourdillon road and its environs in Ikoyi.

The estimated equation in may be expressed as follows:

$$\text{Rental Value} = \beta_0 + \beta_s S_{ij} + \beta_l L_{ij} + \beta_n N_{ij} + u_{ij}$$

Where β_0 is the constant, and

- β_s – the coefficient vector for the structural attributes (S) which measures *structural* effect on housing price.
- β_l is a regression coefficient representing *location* effects on house price and
- β_n – is a regression coefficient representing *neighbourhood* effects on house price and

• u = the random element that reflects the unobserved variations in the house.

Since the effect of water infrastructure is our focus in this study the following model aptly suited to extract results is below with a total of 15 independent variables. 'Rent per annum' the constant.

Where:

Y =	Rent Per Annum
X ₁ =	Accessibility
X ₂ =	Road Conditions
X ₃ =	Electricity
X ₄ =	Drainage
X ₅ =	Street Light
X ₆ =	Public Water Supply
X ₇ =	Security
X ₈ =	Public Transport (proximity)
X ₉ =	Serenity of Environment
X ₁₀ =	Aesthetics
X ₁₁ =	Waste Disposal Services
X ₁₂ =	Proximity to Central Business District
X ₁₃ =	Prestige
X ₁₄ =	Commercial environment
X ₁₅ =	Physical Structure
e =	Error Term

According to Kyrvobokov, (2007) the comparative influence of the attributes is important for our task: not how one or another attribute influences the value directly, but rather the differences in influence between various attributes. The comparative weight of an attribute can be calculated as a ratio, where the numerator is the absolute value of the corresponding regression coefficient, and the denominator is the sum of the absolute values of coefficients for all location attributes. Hedonic prices are, in fact, the implicit valuations of the characteristics of the housing unit, and these can be determined from a regression equation. Specifically, a hedonic equation helps to explain house price in terms of its own characteristics such as size of the flat, age, floor, neighbourhood characteristics, job accessibility, etc.; each of these attributes is assumed to be implicitly priced (So, Tse and Ganesan, 1997). Further, hedonic prices are, in fact, the implicit valuations of the characteristics of the housing unit, and these can be determined from a regression equation.

The empirical results of the survey are presented below.

Table 1. Regression Results for Public infrastructure on Bourdillon Road, Ikoyi, Lagos

Model	Estimates	Std. Error	t value	Sig
(Coast)	3.124	1.572	2.102	0.038
Accessibility	0.410	0.126	3.247	0.002
Road conditions	0.467	0.155	3.024	0.003
Electricity	0.075	0.106	0.712	0.478
Drainage	0.061	0.119	0.517	0.606
Street Light	0.014	0.035	0.410	0.683
Public Water Supply	0.020	0.160	0.123	0.903
Security	0.378	0.156	2.424	0.017
Public transport (proximity)	0.075	0.106	0.712	0.478
Serenity of environment	0.240	0.120	1.984	0.050
Aesthetics	0.144	0.120	1.206	0.230
Waste disposal services	0.061	0.119	0.517	0.606
Proximity to CBD	0.168	0.105	1.600	0.112
Prestige	0.230	0.120	1.912	0.058
Commercial environment	0.452	0.144	3.167	0.002
Physical structure	0.236	0.137	2.104	0.037
R ²	0.657			
Adjusted R ²	0.621			
Std. Error	1.056			
DW	0.896			
F	19.361			

Source: Field Survey, 2011

**Significant at 1% level,*Significant at 5% level;

The linear specification thus is as follows;

$$Y = b_0(3.124) + b_{x1}(0.410) + b_{x2}(0.467) + b_{x3}(0.075) + b_{x4}(0.061) + b_{x5}(0.014) + b_{x6}(0.020) + b_{x7}(0.378) + b_{x8}(0.075) + b_{x9}(0.240) + b_{x10}(0.144) + b_{x11}(0.061) + b_{x12}(0.168) + b_{x13}(0.230) + b_{x14}(0.452) + b_{x15}(0.236) + e(1.056)$$

The above table shows the result of the regression analysis. Regression log result was chosen based on the number of dependent variables that are significant (the value of the coefficient of multiple determinations (R^2), the F-value as well as the value of the standard error). From the table above, an R^2 of 0.657 was achieved which implies a good explanatory power of the model. This is good considering the sample size. These results infer that about 66% of the variation in rental prices of properties in the study area is explained by the fifteen explanatory variables employed in this model. An F-value of 19.361 was achieved also, making the overall equation significant ($p < 0.01$), a Durbin Watson (DW) value of 0.896 (which is less than 1.0) reveals the presence of auto-correlation.

The results show that out of fifteen explanatory variables used six were significant; these are accessibility, 'commercial environment', 'road conditions', 'security', 'physical structure of building' and 'serenity of environment'. 'Accessibility' and 'road conditions' are significant ($p < 0.01$). 'Security', 'physical structure' and 'serenity of environment' were also found to significantly affect property prices in the study area ($p < 0.05$). 'Accessibility' was found highly significant to property prices confirming existing theory. Other variables that were not very significant are 'electricity', 'drainage', 'street light', 'water supply', 'public transport proximity', 'waste disposal services', 'aesthetics' and 'prestige'.

In also completely fulfilling the first objective of this study, the table above infers the state of availability of the variables used in the study area (in the second column). This reveals a large void in terms of government water provision. In collecting primary data for this study, it was also found that quite a number of respondents provided their own water supply through alternative arrangements.

With specific emphasis on public water infrastructure, a T-value of 0.123 reveals that 'public water' contributes a significant positive influence on rental prices, though not very high. Of all the seven public infrastructure variables, 'road conditions' was the most significant variable. The positive correlation of 'public water' as a significant influence on house rental prices confirms previous assertions (See Harvey, 1994; Odudu, 2003; Adebayo, 2006)

5. Results and Conclusions

This study empirically examined the influence of water infrastructure on property values. Incidentally, the influence of public water infrastructure in property values in the study area is not highly significant, though it positively influences house prices. However, Des-Rosiers et al suggest that water may not affect all properties in the same way; they remain a major issue for local residents and in that regard should therefore not be disregarded.

Information on building characteristics, location and neighborhood infrastructure characteristics were factored into the hedonic model which was used in estimating the relative influence of different variables employed in the study. Findings from this study do not exactly correlate with that of Des-Rosiers, Bolduc and Theriault (1999) where higher priced properties experienced sharper declines in property values as a result of the negative externality which water quality problems caused. Though, the study populations are characteristically

different and may account for variations. Whittington, Briscoe, Mu and Baron (1990) have observed that progress made in improving the quantity and quality of water used by people in the developing world has been unsatisfactory. Fox (1994) reports that residents in some locations acquired water from traditional sources at the expense of more sophisticated and modern means. It is further stated that residents in certain locations in Nigeria do not trust the ability of the government to provide consistent water services; and that evidence of past government failures to deliver water legitimises these concerns. Toutain and Gopiprasad (2006) assert that public authorities need to guarantee all social groups access to water. Further, Fox suggests that results of hedonic studies were submitted as being apt in estimating demand, as meeting a demand for services should be the primary determinant of why projects are chosen. In the same report, water supply infrastructure systems were found inconsistent with local demands mainly due to convenience and ease of access to alternative means. But with care, effective institutions may be designed to deliver improved water services in ways that meet specific local needs. Daniels and Daniels (2003) suggest that where water supply plans have been completed, communities may incorporate inventory information, analysis, goals, and recommendations for action into the local comprehensive plan and where no water supply plan exists; municipalities should work with the community water systems that provide service within their boundaries to compile the necessary data. Once policy makers understand demand dynamics, they can choose the best way to deliver them.

Findings from this study will be useful to both public and private parties involved in land use decisions, urban and infrastructure planning in Lagos especially regarding the mode by which water supply (which is essential for human existence) will be provided in residential areas. Property taxation authorities will also be able to levy taxes based on those services that influence value significantly. Furthermore, studies need to be carried out to ascertain other categories of infrastructure beyond the scope of this study. Emphasis should be placed on practical and procedural modalities of water infrastructure provision in order to better structure its systematic delivery. Also, a very insightful area to be further researched is in comparing the relationship between infrastructure influences for property demand decisions and a hedonic regression analysis of urban infrastructure.

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