The Effect of Climate Change on Residential Property Values in the Coastline and Non-Coastline Areas, Lagos Metropolis

Amos Olaolu Adewusi,
Department of Estate Management,
The Federal University of Technology, Akure
e-mail: aoadewusi@futa.edu.ng

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Abstract
The growing reality of climate change in recent times on humans, the environment, and the world economy, among others, has continued to attract attention across the countries of the world. It is noteworthy that much of the attention and interventions have focused mainly on humans and the environment, with limited research efforts on the effect of climate change on the property market in developing countries, especially in Nigeria. Therefore, the current study aims to examine the effect of climate change on residential property values in the coastline and non-coastline areas in Lagos Metropolis, Nigeria. Primary data on residential property values (2000 to 2021) were obtained from the databases of the firms of Estate Surveyors and Valuers practicing in Eti-Osa local government (coastline area) and Ikeja local government (non-coastline area). Also, annual data on temperature, rainfall, humidity, and pressure were accessed from the database of Era5 reanalysis from 2000 to 2021. Multiple regression analysis and paired-sampled t-test were adopted to analyze the data. The result of MRA reveals that temperature exerts a negative significant effect on the values of residential properties in both the coastline and non-coastline areas at $p \leq 0.05$. At the same time, pressure has a negative significant effect on the values of residential properties in the coastline area (Eti-Osa). Other climate indicators, including rainfall and relative humidity, have a negative but insignificant effect on the values of the residential properties in the two locations. Further, the result of the paired sample t-test reveals a statistically significant difference in the effect of climate change on residential property values across the coastline and non-coastline areas. The study provides decision inputs for professional valuers, the public, real estate investors, and policymakers.

Key Words: *Climate Change, Property, Values, Coastline, Non-Coastline*

1.0.Introduction

In the recent times, climate change issues have continued to generate sustainable concerns across countries of the world which has led to different movements, campaigns, initiatives among others targeted at mitigating the realities of climate change. Climate change is defined as change in weather conditions largely occasioned by human activities. A substantial shift in the average weather over a period of decades or longer, such as a noticeable increase in temperature, precipitation, or dryness, is referred to as climate change (Turrentine, 2021). Any change in the climate over time, whether brought on by human action or natural variability, is referred to as climate change. (Hong Kong Royal Observatory, 2007).

Climate indicators, such as temperature, variations in rainfall patterns, heat waves, sea level rise, humidity, wind, pressure, and so forth, are used to monitor and convey these impacts. These indicators are also used to assess risks and vulnerabilities, plan for resiliency, and understand how environmental conditions are changing. (Balasubramanian, 2017). A long change in these weather conditions for a period of 30 years constitutes climate change. Climate change is a big concern as it is known to affect humans and countries economy. A warming trend over the past 50 years is really twice for the last 100 years indicating that as year increases the debilitating effect of climate change is equally increasing (Le-treut et. al. 2007). Climate change is expected to have a detrimental impact on nearly every country's economic growth in the 21st century (OECD, 2015 and IMF, 2021). In a similar vein, the International Joint Panel on Climate Change (2021) forecast that the average global temperature—a proxy for climate change—will rise by more than 1.5^0C over the course of the next 20 years. Climate has a geographical impact on the appeal of various places and the standard of living they provide (Albouy et.al.2016). The warm climate, oceanic location, closeness to the equator, and significant importance of the agriculture and fisheries industries will cause the developing countries to experience the worst economic effects (Bercena et al., 2019).

Many scholars have examined the connection between climate and human behavior in general, such as the relationship between climate and crime (Anderson and Anderson, 1984, Rotton and Frey, 1985, Anderson, 1987, Lab and Hirschel, 1988, Field, 1992) and tourism (Maddison, 2001, Stefan Gossling and Hall, 2006, Gossling and Hall, 2006). Others have examined the causes of global warming, such as the greenhouse gases produced by human activity and the consequent climatic issues on human and biological life. However, its impacts and growing threat to housing, infrastructure and property transactions around the world appears too low and largely unsearched (Li, 2009).

The value of real estate will progressively reflect these risks as climate change continues to affect buildings and markets internationally. This will have an impact on utility bills, operating expenses, and market values (Odjugo 2010, Starkman et al, 2018). However, as serious as the impact of climate change may be to the property market, only very limited attention has been given to studying its impacts on real estate market. (Stansall, 1999; Li, 2009; Andre kruger, 2015; Baldauf, Garlappi, Yamelis, 2019; Hino and Burke, 2021)

Li (2009) reported that while academic researches typically focus on causes of global warming, that is, the greenhouse gases generated by human activities and the associated climate problems on human and biological life, few researches have been carried out to examine the impact of climate change on the real estate market. Criglo et.al (2021) opined that climate change could also deteriorate the value of long-term assets such as real estate while Hermandez et. al. (2022) noted that the possibility of value deterioration in real estate market is high due to climate change. It is pertinent to note that the studies are lacking especially in the developing countries to fully establish the relationship of climate change and property market for planning and decision making. In the meanwhile, research conducted in the US and the UK has discovered a detrimental impact of global warming on housing as indicated by risks of flooding, natural disasters, and exposure to sea level rise (Bemstein et al. 2019). For residential home prices, the predicted higher weather condition in 2050 could represent a substantial negative effect for regions in the world especially in Africa. Also, it is noteworthy that much research has been carried out to determine the factors that affect residential property values across property markets of different countries and despite the prediction of possible danger of climate change on countries located along the coastal regions, the effect of climate change on property values in Lagos, Nigeria is largely unresearched.

Given the undeniable influence climate change has on humans, economic activities, real estate market among others. It is of utmost relevance to estimate relationship between residential property value and climate change. Thus, identifying vulnerabilities and creating plans for adapting to climate change require an understanding of both the existing and anticipated future global climate conditions (Magana et al., 2000). Quantification of the hazards connected with climate change for the real estate market is crucial, as noted by Kruger (2016), Li (2009), Pam (2007), Rukevwe (2008), and Campbell (2015).

Against this backdrop, the current paper investigates the comparative effect of climate change on residential property values of non-coastline (Ikeja) and coastline (Eti Osa) in Lagos Metropolis, Nigeria.
The rest of the paper is structured as follows; the first section focuses on introduction, followed by brief literature review, methodology, results discussion and conclusion in that order.

2.0. Literature Review

2.1.1. Concept of Climate Change

According to the United Nations Framework Convention in Geneva (1996), in addition to natural climatic variability shown over comparable time periods, climate change is defined as a shift in the global atmosphere's symphony brought about by human activities. However, as noted by the Intergovernmental Panel on Climate Change, the term "climate change" refers to any alteration in the course of the climate, regardless of whether it originates from human activity or natural variability (Hong Kong Royal Observatory, 2007).

The majority of the apparent rise in global temperature since the middle of the 20th century, according to the 2007 IPCC Fourth Assessment Report, is caused by an increase in greenhouse gas

levels, which trap infrared radiation. Through the introduction of new sources such as methane, carbon dioxide, nitrous oxide, ozone, and chlorofluorocarbons, human activities raise the levels of greenhouse gases. While the use of fossil fuels and changes in land use are the main causes of the increase in carbon dioxide, agricultural activities are mostly to blame for the increase in methane and nitrogen oxide. Human activity has caused a large increase in all of these greenhouse gasses. A one-minute temperature increase will alter wind patterns and cloud cover, which may have an impact on rainfall (Le Treut et al. 2007). Over the past century, the average surface temperature of the world has increased by 0.6°C (Le Treut et al. 2007).

2.1.2. Climate Change and Real Estate Market

An increasing number of studies have looked into the relationship between climate change and real estate economics (Bunten & Kahn, 2014; Giglio et al., 2015). Though extremely rare, research on the relationship between climate change and real estate values is mostly focused in developed nations. Roback's (1982) study, for instance, was the first to examine the effect of climate on home prices. The author concludes that there are pricing differences for residential real estate between cities. Li (2009) discovers an inverse association between certain weather indicators in Hong Kong and the volume of monthly transactions involving residential properties. Additionally, Li and Rita (2009) examined monthly property transaction data from the Hong Kong Statistical Department, as well as temperature and rainfall data from the Hong Kong Observatory between 1997 and 2006. In addition to showing a strong and negative correlation between temperature and real estate values, the study also included crucial data on real estate transaction forecasts for Hong Kong's upcoming residential real estate market. Campbell (2015) presented an insightful and engaging analysis of the impact of climate change on housing markets utilizing case studies from American cities. The study demonstrates that behavioral biases and heuristics can explain this occurrence and concludes that house prices in many places, including Miami, do not reflect the substantial concerns of impending climate change. Also, Li, Cheng, and Shoaib (2018) document impact of temperature on real estate prices in the Hong Kong market, the paper finds that temperature has negative significant effects on real estate price.

Iruobe, Ugwuebim, and Nworah (2018), on the other hand, examined the effects of climate change on property values in Victoria Island, Eti-osa Local Government Area, Lagos State, with the aim of determining the factors contributing to climate change and their causes, evaluating the condition of properties, and examining changes in the cost and value of properties in the study area. The rental values exhibited a negative connection, with the rental value decreasing with increasing distance from the floodplain. Ultimately, the study's conclusion was based on the belief that properties near floodplains have higher capital and rental values as a result of climate change, and that these properties' negative effects on their structural and decorative values are more noticeable than those of properties farther away in the study area.

3.0. Methodology

3.1. Data Collection and Variable Description

Primary data on property values of residential properties located in two local governments were obtained from the databases of one hundred and ninety-nine firms of Estate surveyors and valuers who manage properties in Ikeja and Eti-Osa local governments being referred to as non-coastline and coastline areas respectively while secondary data on rainfall, temperature, humidity, pressure (2000-2022) were obtained from the database of Era5 reanalysis-the fifth generation of European Centre of Medium-range whether forecast of the global climate covering from 1940 to date.

The study collected information on 5 variables composed of one dependent (property value) and four independent (Temperature, rainfall, humidity, and pressure) variables. The property value is measured in Naira (quantitative) while Temperature, rainfall, humidity and pressure were measured in Celsius degree/year, Milimetre/year, percentage and hPa respectively as shown in table 1;

Table 1: Variable Code and Measurement

Variable	Definition of Variable	Variable code	Measurement
Dependent	Property Value	PV	Actual Number
Independent	Temperature	T	Celsius
	Rainfall	R	mm/year
	Humidity	H	%
	Pressure	P	hPa

Two study locations were selected for the study in the Lagos metropolis, viz, Ikeja local government- a non-coastline area and Eti-osa local government- a coastline region. The two locations were selected to determine whether there is any variation in the weather conditions of the coastline and non-coastline region within Lagos metropolis. A brief description of the study areas is noted as follows;

Lagos is situated at latitude 6.27N and longitude 3.28N on the Bight of Benin, an arm of the Atlantic Ocean. Lagos is the main port as well as the main hub for the economy and culture. Up until 1991, when the Federal Government's seat was transferred to Abuja, in central Nigeria, it functioned as the capital of Nigeria. Lagos' population is extremely diversified and expanding quickly as a result of continuous, large-scale migration from all across Nigeria and its surrounding countries. Lagos State has a wet equatorial climate, which is affected by its proximity to the equator and the Gulf of Guinea. It is influenced by atmospheric interactions, one of which is regulated by the Inter-Tropical Convergence Zone (ITCZ). A warm, humid maritime tropical air mass is thought to be the cause of the ITCZ's northward advance, whereas a hot, dry continental air mass from the interior is thought to be the cause of its retreat. Lagos experiences two distinct seasons as a result of these two air masses: a wet season that typically lasts from April to October and a dry season that runs from November to March.

Further, there are two peak times for rainfall during the rainy season: May to July and September to October. The first peak period experiences the most intense rainfall. Usually, during these times of highest rainfall, floods happen. The inadequate surface drainage systems in the coastal lowlands exacerbate these floods. Lagos State has consistently high temperature, with the mean monthly maximum temperature of about 30 degrees Celsius. The state's hottest and lowest temperatures are recorded in November through December and February through March, respectively, and June through July, which also happens to be the middle of the first period of peak rainfall. There are two distinct rainy seasons in Lagos State: the strongest rainy season occurs in October and November, while the greatest rains occur from April to July. August and September see a fair amount of dry weather, while December through March is a lengthy dry season. The average monthly rainfall during May and July is more than 400 mm (16 in), although August and September see 200 mm (7.9 in) and December sees as little as 25 mm (0.98 in). Harmattan winds from the Sahara desert accompany the main dry season; these winds can be particularly severe between December and February. In Lagos, the greatest recorded temperature was 37.30°C (99.10°F), while the lowest recorded temperature was 13.90°C (57.00°F).

Owing to its significant economic impact and previous status as the country's capital, inward migration into Lagos State and the city itself has resulted in a notable increase in the city's population, which grew from over 760,000 in 1960 to over 9 million by 2006 and is expected to reach 25 million by 2025, making Lagos the third largest megacity globally. One of the biggest and busiest seaports in the world is currently located there. The Lagos Lagoon, which empties into the Atlantic, and other interior waterways, along with the conurbation's extensive road and building network, make it a major hub for Nigeria's tourism, economic, and transportation sectors.

The capital City of Lagos State is Ikeja. Latitudes 6°23'N and 6°41'E and longitudes 2°42'E and 3°42'E are where Lagos state is situated. Lagos State shares borders with Ogun State to the north and east, the Atlantic Ocean and Gulf of Guinea to the south, and the Republic of Benin to the west.

The coordinates of the Ikeja Local Government Area are 30° 30' West and 70° 30' North. It is located in Lagos State's upland/continental region. The Local Government is bordered by Kosofe Local Government Area in the Eastern Region and Agege, Alimosho, and Ifako-Ijaye Local Government Area in the Western Region. Additionally, Ikeja Local Government maintains its boundaries to the south with Oshodi/Isolo and Mushin Local Government Areas, and to the north with Lagos State's boundary with Ogun State. After the country's 19 states were formed, Ikeja was designated as the capital of Lagos State's local government. Since then, the local government has grown significantly, becoming the center of the state's commerce, industry, and administration. Because of its advantageous location and market structure, it is unquestionably the greatest area of the Lagos mainland to locate a firm. Ikeja is home to a sizable number of businesses, the most of which are service and retail enterprises.

The second Local Government Area in our study is Eti-Osa. With 283,791 residents, the area makes up 3.11% of the state's total population. Most locals are employed in farming, commerce, and fishing. Nonetheless, Eti-Osa is the home of numerous sizable local and foreign corporations due to its historical status as the capital of the country. Eti-Osa is a commercial district with a number of public and private establishments, including banks, lodging facilities, nightclubs, and contemporary marketplaces where goods and services are exchanged. Ikoyi-Obalende LCDA, Eti-Osa East, and Iru Victoria Island LCDA are among the districts that make up Eti-0sa.

Multiple regression analysis was adopted to determine the effect of predictor variables on the criterion variable. According to (Kmenta, 1997) multiple regression can be mathematically defined as shown in equations 1 and 2, respectively;

$$Y_i = \beta_0 + \beta_1 X_{li} + \varepsilon_i \quad (1)$$

$$Y_i = \beta_0 + \beta_1 X_{li} + \beta_{2\,X_{2i}} + \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\beta_k X_{ki} + \varepsilon_i \quad (2)$$

Where Y_i = predicted value $\beta_0$regression constant

β_1 slope of $Y_{\square}$with variable X_1 when variables X_2, X_3, ….., X_k are held constant

β_2 slope of $Y_{\square}$with variable X_2 when variables X_1, X_3, ….., X_k are held constant

β_k slope of $Y_1$with variable X_k when variables X_2, X_3, ….., X_{k-1} are held constant

ε_i = random error in $Y_{\square}$for observation i

$\beta_1\beta_2\beta_3$, , , …….β_k, are referred to as the regression coefficients.

4.0. Result and Discussion

From Table 2, the result of the regression analysis for Ikeja region reveals that p> f value 0.0471, which implies that the independent variable estimated model has a goodness of fit and it is significant at 5% confidence level while R-squared of 0.3985 (40%) variation in property value is explained by the four climatic conditions. The 40% contributions of climatic factors to residential property price variation appears somehow substantial which indicates that professional Estate Surveyors and Valuers should begin to reflect and accommodate the effect of climate change in valuation processes and expression of valuation opinions. Table 2 further reveals that only temperature has a negative significant effect on rental value p<0.025 while other weather conditions such as pressure, rainfall and relative humidity have inverse but non-significant effect on the property value of the residential properties of non-coastline area.

Table 2: Regression Model for Property Values in Ikeja and Eti-osa

Location	Independent Variable	Dependent Variable	Coef.	Std. Err.	P-val.
Ikeja (Non-coastline)	Pressure	Property value	-194817.70	313510.3	0.542
	Temperature	Property value	-1070582**	439442	0.025
	Rainfall	Property value	-438.77	628.2412	0.494

	Relative Humidity	Property value	-107104	85917.83	0.229
	Constant		-1.14e08	3.45e+08	0.745
	No. of Obs.		23		
	F-val		2.99		
	Prob>F		0.0471**		
	R-Squared		0.4		
Eti-Osa (Coastline)	Pressure	Property value	-835795.80*	458076.1	0.085
	Temperature	Property value	-1571780**	594598.1	0.017
	Rainfall	Property value	-472.45	657.251	0.481
	Relative humidity	Property value	-259667.3	184773.7	0.177
	Constant	Property value	-1.29e09	4.92e+08	0.017
	No. of Obs.		23		
	F-val		2.58		
	Prob>F		0.0726*		
	R-Squared		0.40		

On the coastline area (Eti-osa), Table 2 also reveals that the model is significant at 10% and 40% variation in property value is explained by the four weather conditions- temperature, rainfall, humidity and pressure. It further reveals that only temperature and surface pressure have negative significant effect on property values of residential properties in the coastline area at $p \leq 0.05$ and $p \leq 0.4$ respectively indicating that as surface pressure and temperature increase, the value of property in the coastline region decreases.

In summary, temperature has a negative significant effect on property values in both the non-coastline and the coastline regions which also indicates that a unit increase in temperature will lead to a decrease in the property values. This finding is consistent with the desire of households to avoid hot days (Hermandez *et al*., 2022). The finding also corroborates the work of Li *et al* (2018) which claim that effect of increase in temperature will lead to increased residential electricity consumption. This could be the reason why household prefer to live in areas with more stable temperatures.

It is also noteworthy that generally, rainfall along coastline areas often predispose the areas to flood risk and other hazard which in a way should naturally reduce property value in a significant way. However, the situation is contrary both in the coastline and non-coastline areas, especially the coastline areas. Although the study reveals that a unit increase in rainfall has negative effect on

property value both in the coastline and non-coastline areas but the effect is insignificant. Thus, rainfall has a marginal effect on property value. Table 3 shows the result of paired T-test which was adopted to test if there is significant difference in the effect of the four climate indicators and property value across coastline and non-coastline regions. The test shows that there is a significant difference in the effect of climate change and property at $p \leq 0.000$ which also indicates that the effect is more at the coastline but rising towards the non-coastline as shown in Table 4;

Table 3 Paired sample Test between the Climatic condition in Eti-Osa and Ikeja.

Variable	Mean	SD	t	Df	Sig
Pair 1(Etiosa and Ikeja) PV	35958	608527.354	2.834	22	0.010

Table 3 establishes the fact that there is a significant difference in the effect of climatic conditions on residential property values in Eti-Osa and Ikeja property markets. In order to establish the region with the highest effect and flow of effect, paired sampled statistics is adopted as shown in Table 4, The mean score of Eti-Osa is 45.5 which is higher than the mean score of Ikeja which translates to the fact that Eti-Osa (coastline) receives greater effect of the climatic change while a significantly reduced effect is detected in Ikeja (coastline) given the mean score of 40.5 and p- value of 0.0000. This finding corroborates the work of Li (2009) which claims that areas around the coast are more prone to the effect of climate change than areas that are farther away from the coast.

Table 4: Paired Sample Statistics Climatic condition in Eti-Osa and Ikeja.

	Mean	N	Std. Deviation	Std. Error Mean
Pair: Climatic Condition (Eti-Osa)	45.5	23	5.16	.95
Climatic Condition (Ikeja)	40.2	23	5.18	.95

5.0. Conclusion

The paper attempts to investigate the effect of climate change on the residential property values of coastline (Eti-Osa) and non-coastline (Ikeja) areas in Lagos Metropolis, Nigeria. Data on residential property values from 2000 to 2021 were obtained from the databases of one hundred and ninety-four firms of Estate Surveyors and Valuers who manage properties in the coastline and non-coastline regions of Lagos Metropolis while annual data on climate indicators such as temperature, rainfall, pressure and relative humidity were accessed from the database of Era5 reanalysis-the fifth generation of European Centre of Medium-range weather forecast of the global climate covering from 1940 to date. Multiple regression analysis and paired samples t- test were adopted to determine the effect of climate change as reflected by weather conditions on the residential property values and to determine whether there is significant difference in the effect of weather conditions on property values across coastline and non-coastline regions respectively. The result of the regression analysis shows that temperature has a negative significant effect on the residential values of coastline area, however, other weather conditions- rainfall, pressure and

relative humidity have negative but insignificant effect on the residential property values of Ikeja property market. On the coastline region of Eti-Osa, the MR result shows that temperature and surface pressure were found to have negative significant effect on the residential properties, indicating that as temperature and pressure increase, the property value will decrease. The result of the paired t-test also reveals that the effect of climate change is significantly different across the coastline and non-coastline areas in Lagos Metropolis. The significant effect of temperature on residential property values in both coastline and non-coastline areas indicate that climate change is not a challenge that is peculiar to coastline areas only but its effect also affect properties that are far from the coastline areas, this holds significant implication for professional valuers to always act consciously as per climate change and make necessary allowance for its effect when presenting valuation opinions for different purposes such as sales, purchase, insurance, mortgage, etc. The finding of the study also provides decision inputs for real estate investors, stakeholders and policy makers as per vulnerability of each area to climate change effect. The finding in the current study is consistent with the works of Semenenko & Yoo, (2019). and Li and Fu (2008) which claim that climate change has significant negative effect on property values. It is pertinent to note that favorable weather is one of the factors activating household purchasing /renting behavior. The result of the current study is limited to the two areas within the coastline and non-coastline areas and the data obtained for the analysis. Further studies should investigate the effect of climate change on more regions in the Lagos Metropolis and possibly determine its effect on volume of real estate transactions, cost of property maintenance and property absorption period in the residential property market of Lagos Metropolis.

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