

Application of Artificial Intelligence (AI) Approach to African Real Estate Market Analysis Opportunities and Challenges

*Victoria O. Odunfa¹, Tosin B. Fateye² and A.O.Adewusi³

¹Department of Estate Management and Valuation, The Polytechnic, Ibadan Oyo State, Nigeria

²Department of Estate Management, Kaduna State University, Kaduna State, Nigeria

³Department of Estate Management, The Federal University of Technology, Akure, Ondo State, Nigeria

Corresponding Author (*): odunfavictoria@gmail.com

Abstract

The information on the real estate market is fast growing and becoming more complex to analyse. Therefore there is a need for reliable real estate market analysis for an informed and handsome investment decision making. The study examines the opportunities and challenges of using artificial intelligence (AI) approaches to analyse quantitative data on the Africa real estate market. A systematic review of the literature was conducted. The study found some opportunities characterised by the usage of AI tools to include a reliable forecasting model, good predictive power, ability to perform complex tasks and analyses of a large number of variables. The major constraints of AI tools application in the study area include knowledge gap, weak political will, unstable economic conditions, low level of market transparency, maturity, openness and lack of availability and reliable data and research on the Africa real estate market analysis (AREMA). The study concluded that the Africa real estate market is yet to be ready for the adoption of hi-tech market analysis devices such as AI and machine learning (ML) due to lack of availability and reliable data. However, the study suggests a strong collaboration and cooperation between the public and private sectors to create enabling real estate business environment that prioritises technology infrastructure, data-driven property market and reliable databank to achieve a sustainable Africa real estate market analysis for an informed investment decision.

Keywords: Artificial Intelligence (AI), Africa, Real Estate, Market Analysis, Opportunities, Challenges

1. Introduction

Information on real estate market has significant economic importance. The dynamic trend in the real estate market activities has a strong impact on economic growth and a nation's wealth creation. As recorded by the Bureau of Economic Analysis (BEA) in the first quarter (Q1) of 2021, the U.S. real estate sector comprises real estate, rental and leasing have the largest GDP, contributing more than \$4 trillion (\$4,008,708,000,000) to the country's commonwealth. Also in the face of the Covid-19 pandemic, the sector grew by 3.4% from Q1 2020- Q1 2021 and ranked No. 1 in their industry category 'finance, insurance and real estate' with an average industry output of \$7.87.

In Africa, the Africa property investment (API) Summit 2021 noted that the real estate sector has remained at the forefront in driving the continent's economic recovery forward with more than \$800 million disclosed investment deal in the sector. Also, more efforts are still ongoing to attract more than 500 real estate investors across the globe. The summit identified among others, the high-profile real estate investment deals witnessed across the Africa property market to include \$5.5 million refinance deal in Kenya, \$9 million investment deal in the Congo DR, \$10 million funding of Metroplex Mall in Uganda and \$300 million debt refinancing deal of Longo Real Estate, **South Africa**, which is currently the largest in the sub-Saharan Africa.

The statistics suggest that the continent is fast becoming the real estate investment destination and a competitive market for vibrant property investment. However, to ensure the security and safety of the huge capital invested, grow expected on return, minimise risk, boost investor's confidence and pull investors across the globe, there is a need for a sustainable real estate market that is strongly driven by real-time data, technology innovations, ICT compliant and sophisticated market analytical model. However, one of the pragmatic approaches of achieving sustainable real estate market analyses is the application of artificial intelligence (AI) analytical tools which have been proved to be reliable, yielding a better and accurate results in the areas of market appraisal, trend analysis and forecasting (Taffese, 2006; Kabaivanov and Markovska, 2021).

Meanwhile, the use of AI has been far adopted and enjoyed in the developed real estate market especially in the U.S., U.K. and some fast-growing Asian economies such as China, Arab, Japan, and Malaysia etc. However, some parts of the world especially the less developed and developing continents including Africa are still far behind in the adoption and usage of the technology (AI). It is against this background that the study attempts to examine the application of artificial intelligence (AI) approaches to Africa real estate market analysis (AREMA) using a systematic literature review method. This was done to provide information on the opportunities provided with the use of AI tools and its attendant challenges to achieving a sustainable Africa real estate market.

2. Artificial Intelligence (AI) Tools in Real Estate

Basic Concept of Artificial Intelligence

The term 'artificial intelligence is used to refer to a system that simulates human intelligence that is, it performs the task that is normally required of human intelligence. Chegut, Eichholtz and Kok (2017) and Everitt and Hutter (2018) explained that machines do not necessarily need to imitate the way humans behave to achieve a desirable result; however, the primary focus of AI is *on acting* rather than *thinking*, and *doing* rather than *emulating humans*; by the use of machine learning (ML) algorithm. According to Data Robot AI Experience (2018), machine learning (ML) is a form of artificial intelligence; *a system leaning from the past to predict the future*. Prado (2018) added that ML algorithms learn a historic relationship pattern between variables, establish a rule and apply it to the new set of data to predict the future outcomes in a high-dimensional space.

Meanwhile, AI & ML algorithms differs from traditional statistical analytic models. The conventional analytical model performs on rule-based decision-making, AI & ML perform tasks that are difficult to define through step-by-step-rule and it is applied to numerous business scenarios which its outcome depend on hundreds of factors that are difficult or impossible for a human to keep track of. Sadler (2018) posited that there are many cases in which both the normal statistics and machine learning models are used together to achieve higher accuracy and more clarity as to the causation of outcomes.

Cearley et al. (2017) pointed out the importance of *augmented analytics* of AI as a form of artificial intelligence that is fast encroaching into human intelligence capacity in the business environment. Augmented analytical is the use of machine learning (ML) to automate data processing, insight discovery and insight sharing of a broad range of business users, operational workers and citizen data scientists. The authors also noted that augmented analytics software helps to perform a complex analytical task, with little or no human supervision, therefore, increasing the analytic capabilities of business performance. But AI has some limitations in its operations. For instance, the system still requires hands-on machine learning methods to predict value; this implies that AI and ML are not independent.

AI Tools in Real Estate

In real estate, Conway (2018) highlighted some areas where the AI & ML are applied to real estate services (*See Table 1*). Specifically, the author identified 'smart' building operation tools' powered by the Internet of Things (IoT) as one of the emerging real estate technologies that could be defined as artificial intelligence. These tools lean the building users' preferences for light, temperature and other space quality. Also, Simiak, Shavrov and Marina (2020) identified some of the property technology (proptech) that enhance growth in the real estate industry to include home machine tools, drones, virtual reality, building information modelling (BIM), data analytics tools, artificial intelligence, internet of thing (IoT), blockchain and smart contract.

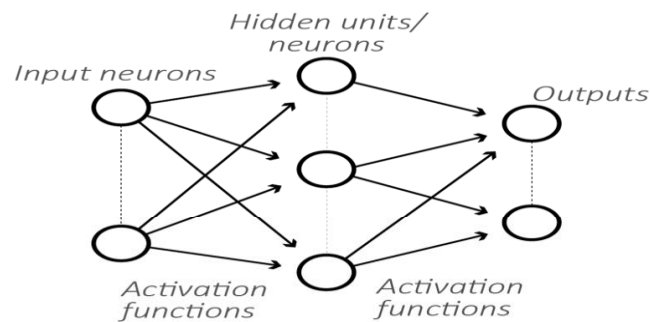
Table 1: Real Estate Functions

Functions	Description
Brokerage and Sales	Real estate product sales and leasing process
Property Management	Managing of building and tenant space
Property Data and Analytics	Real estate data collection, processing and data bank
Property development	Developing real estate for investors
Legal/contract	Real estate law/contract services
Location/Geospatial	Services related to mapping
Valuation	Evaluate current/future values of real estate
Real estate appraisal	Market studies/analyses
Facilities Management	Managing of facilities, workspace and occupants
Project Management	Managing real estate project/development

Source: Field Survey, 2021

In the same vein, Bishop (2006) classified ML in real estate as 'supervised' and 'unsupervised' learning. The former entails the algorithm that observes the pattern of relationship between input variables/vectors to establish a rule(s) and applies them to new input variables to predict a future outcome refers to as target variable/vector. The supervised ML tasks comprise *classification* and *regression* problems. While the latter i.e. the *unsupervised* learning differs in the sense that the outputs of the model are observations about the data itself otherwise known as unlabelled data. However, Chegut (2018) stressed that, despite the enormous opportunities characterised by machine learning of AI, real estate is still very far away from contextual and usage of the machine learning algorithms. However, Fig. 1&2 shows an illustration of an artificial neural network learning system and Table 2 illustrates the ML types, tools and areas of its application in real estate.

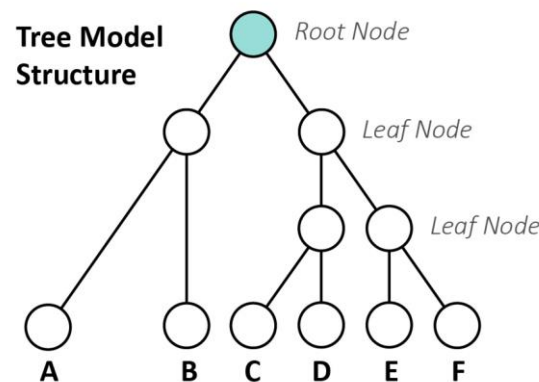
EXHIBIT 11
 Neural Networks



Neural networks consist of layers of hidden units created through activation functions that transform the data to achieve the end result outputs.

Fig. 1: Artificial Neural Networks Machine Learning of AI

Source: Diagram extracted from Conway (2018)



The full training dataset is the root node, which is then split into subsets depending on the variable with the highest predictive value. A-F are the resulting categorizations.

Fig. 2: Decision Tree Machine Learning of AI
Source: Diagram extracted from Conway (2018)

Data and information scientists have explained how some of the AI & ML work. For instance, the artificial neural network (ANN) of AI which has become popular and far embracing in the business and financial world is largely use for data processing. The neural network is made up of systems of neurons similar to human organs and mimic human brain. A neural network system has a layer of interconnected nodes refers to as perceptron. The perceptron is similar to multiple leaner regressions; feeding on the signal produced on a multiple linear regression into an activation function that may be nonlinear. In a multi-layered perceptron (MLP), perceptron are arranged in interconnected layers. The input layer collects input patterns. The output layer has classifications or output signals to which input patterns may map. The artificial neural network operates by capturing the variable input/vector, adapt to changing input; and give the best of result without needing to re-design the output criteria. However, the neural network machine learning algorithm is famous in the field of finance, time series processing, analysis and forecasting, constructing proprietary economic indicators, price derivatives, securities classification and credit risk modelling.

Meanwhile, authors have also raised concerns on the shortcomings of the machine learning algorithm of artificial intelligence across sectors. For instance, in the finance and accounting sector, Prado (2018) pointed out that financial machines do fail, and the quantitative machine learning mistakes do cause a great financial loss. In real estate, Conway (2018) emphasized the need to take caution when applying system algorithms to analyse scientific data including real estate to avoid the pitfalls characterised by the ML & AL tools. The author raised issues such as bias-variance trade-off when optimising data for a high level of precision, the assumption of independent and identical distribution (IID) which may not be realistic in the real estate sector. Prado (2018) raised concern on the 'black box' which has to do with how neural network works and their interpretation in a business environment. Other grey areas include the generality of the algorithm purpose, the problem of hiring expertise and lack of data among others. Table 1: AI & ML in Real Estate

ML Types	Category	Task	AI Tools	Examples
Supervised Learning (Labelled Data Set)	Classification (Predicting Category)	Image classification	Support Vector Clustering (SVC)	To Split real estate assets into recommendations for the highest and best use types based on known attributes using past
		a Internet of Thing (IoT) Natural Language Processing	K-Nearest Neighbours (K-NN) Decision Tree Neural Network Naive Bayes	
Supervised Learning (Labelled Data Set)	Regression (Predicting Value)	Valuation	Support Vector Machine (SVM)	To predict real estate asset values given a set of asset qualities and market characteristics
		a Risk Growth Analysis	Gradient Boosted Tree Neural Network Decision Tree Random Forest Linear Regression	
Unsupervised Learning (Unlabelled Data Set)	Clustering (Predicting Category)	Data Mining	K Means	To divide assets into groups based on physical proximity and building attributes.
		a Geo-location Patterns Object Tracking/Image Processing	Mean Shift Gaussian Mixture Models	
Unsupervised Learning (Unlabelled Data Set)	Diversionary Reduction (Just Looking)	Data visualisation	Principal Components Analysis (PCA)	To simplify or transform real estate data produced by IoT enable devices such as sales/rental prices, location attributes/factors
		Data Compression Internet of thing (IoT)	Linear Discriminant Analysis (LDA) Spectral Embedding	
Reinforcement	Unknown Outcomes	Construction (Root Value function) Navigation) Learning Decision Making IoT	Monte Carlo Neural Networks	To test and remember many potential outcomes of millions of different move combinations

3. Applications of Artificial Intelligence (AI) to Real Estate Market Analyses: A systematic Review of Literature

The real estate market is characterised by multi-task activities which are complicated in many cases. Every real estate market is unique and largely driven by local-specific factors such as economic, social and political. This suggests that the analysis of the real estate market is largely independent, fraught with difficult decisions, challenging relationships and a multitude of variables. Therefore, there is a need to develop tech-driven analytical tools that will facilitate the optimisation of a large volume of real estate data for effective use.

As observed by Kabaivanov and Markovska (2021), the abundance of information on real estate markets and transactions requires sophisticated machine learning (ML) analytical tools such as artificial intelligence for data optimization and improvement. Conway (2018) expressed that today's real estate market challenges are becoming more complex, the use of artificial intelligence (AI) approach to solving the emerging challenges will help the sector to be more proactive, efficient and data-driven in all aspects including property/project/facility management, valuation/appraisal, investment decision and physical development process. Meanwhile, a large body of literature has examined the applications of the artificial intelligence approach to real estate market activities. Yu and Yan (2020) used the neural network algorithm of artificial intelligence to check the forecast potential problems in time series analysis. The function of the AI among others is to identify outliers and examine the feature of the analysed

time-series data such as stationary, autocorrelation and predictive ability. The authors concluded that neural network algorithms can be explored with similar data in the real estate market. Also, as a result of some unique features of the real estate market especially the ones associated with a longer period of closing transaction deals and the influence of economic shock, Wang, Lu and Ma (2020) recommended the integration of AI software to real estate market analyses. The authors explained that the use of the neural networks AI tool will help in portfolio rebalancing and detect early problems for informed investment decision making.

Costantino, Di Gravio and Nonino (2015) and Hung (2018) noted the importance of artificial intelligence methods in project management. The authors posited that real estate projects especially for investment purposes are faced with several risks such as site selection, financial, time, technical, economic, market, institutional/government intervention etc. However, the use of neural network AI will help in critical analysis of project scenarios at different points in time in general and a case-specific analysis. The study recommends the adoption of AI for better financing options and to increase the chances of project critical success factors. Similarly, Case, Clapp, Dubin and Rodriguez (2004), Wang, Chang and Wang (2019) and Calka (2019) use the spatial autocorrelation method (Geo-statistics) to analyse the change in real estate prices and concluded that the use of AI tools will not only give accurate valuation but will improve timing required to implement complex investment plans. Also, Manganelli and Morano (2014) concluded that the real estate sector needs accurate appraisals of property value because the several objectives of stakeholders are under the control of real estate values or returns.

Giudice, Paola and Forte (2017) researched to interpret the existing relationship between real estate rental prices of housing units and their respective geographical locations in the Chiaia neighbourhood of Italy using a genetic algorithm (GA). The authors justified the use of the AI approach (GA) to appraise the real estate housing market, expressed that GA ensures reliability and possesses high predictive and accuracy potential. The study however submitted that the rapid rate at which real estate market analyses is growing, the emerging difficulties in the forecasting and the relevant knowledge required for real estate prediction, investment and tax issues have necessitated the need to explore alternative approaches such as artificial neural networks that could provide reliable predictions and information on real estate value and market analysis. Similarly, Pinter, Amir and Felde (2020) and Rhoads et al. (2020) work emphasised the need to deploy an advanced accurate predictive model to explain real estate price behaviour modelled. The authors opined that reliable real information of estate market analysis is essential to urban development and critical to economic functions. The study however recommends the use of AI approaches such as call detail records (CDR), claiming that CDR is a novel machine learning method that tackles real estate modelling complexities.

In addition to these, authors have attested to the outstanding performance of artificial intelligence approaches to real estate market analysis. for instance, Ishaku and Lewu (2021) used an artificial neural network to predict the auction values of real estate in Ghana. Simiak, Shavrov and Marina (2020) investigated to know whether propech tools such as home machine tools, drones, virtual reality, building information modelling (BIM), data analytics tools, artificial intelligence, internet of thing (IoT), blockchain and smart contract among others and posited that propech devices do not only have a positive impact on the real estate industry growth, but the advent property technology innovations have continued to change the structure of real estate market, increase in demand for hi-tech tools in property management, encouraging new skills and enhance flexible policy challenges for estate industry. Similarly, Kang et al. (2020) developed a forecasting model for real estate auction prices using a genetic algorithm (GA). The authors concluded that the GA model exhibits optimum performance, effective tool for regional segregation and improve predictive accuracy.

Africa Real Estate Market Constraints to Adoption of AI & ML Tools

Despite the vibrant potential of the Africa property market for real estate investment, the property market is plagued with many challenges. RICS (2014) and Knight Frank (2017) research on Africa real estate market reported that except for the South Africa property market, other property markets on the continent have not experienced a major improvement. The reports identified some of the critical problems faced in most of the Africa property market to include weak infrastructure, poor business and institutional environment, high level of corruption and professional skills gap. Other challenges pointed out include weak political will, unstable economic condition, low level of market transparency, maturity, openness and lack of availability and reliable data and research on the African real estate market.

Meanwhile, the highlighted challenges and others have created a clog in the wheel of adopting AI to the Africa real estate market analysis. For instance, the inability of the government to facilitate and promotes an economic and business environment that prioritises infrastructure such as prop-tech, encourage the development of a strong institutional framework and the bridge knowledge gap. Also, the private sector of the economy that is supposed to lead the sustainable development in different sectors of the African countries and by extension the real estate market in ICT and technology innovation has been bereaved with ill-political interference. The unhealthy government policies on physical development control and regulation, bad governance and undeveloped property taxation system have been the major constraints sustainable protection market structure, creating a frightening and uncertain business environment.

Another major constraint hampering the application of a hi-tech artificial intelligence tool is the lack of availability and reliable real estate dataset. The lack of real-time real estate property data pointed out to be the critical reason while a larger number of Africa countries including Nigeria, Egypt, Morocco, Zambia, Rwanda and Ghana were ranked to be low transparent including in technology and databank (JL-Lasalle, 2020). The report expressed that the majority of African real estate markets regulation is still nascent and not yet matured. By implication, trending information on Africa real estate market are yet to be readily available, open and free flow, while the available ones may lack credibility. While the application of machine learning and artificial intelligence devices requires a big and larger volume of the dataset to function optimally, the availability and adequacy of reliable data that guaranteed sustainable real estate market analysis for potential investors remain a great concern.

4. Conclusion and Practical Implications

The research investigates the utilization of artificial intelligence (AI) in real estate market analysis, specifically targeting the African property industry. The study's core objectives are to identify the prospects presented by AI methodologies and their principal limitations. A rigorous literature review methodology was utilized. The research revealed that nations adopting AI experience advantages including a dependable forecasting model, strong predictive capabilities, proficiency in executing intricate jobs, and the capacity to analyze numerous variables. In the African real estate markets, with the exception of South Africa, the others are classified as fledgling, lacking transparency, and immature. The primary obstacles encompass a knowledge deficit, insufficient political will, uncertain economic conditions, poor market transparency, maturity, openness, and a lack of accessible and trustworthy data and research regarding the African real estate industry. The study concluded that although numerous African real estate markets are not yet prepared for the adoption of advanced market analysis technologies such as AI and ML due to insufficient and unreliable data, there is a necessity for ongoing evaluation of the African property market to assess its progress, particularly in terms of technological advancement, maturity, and transparency. Furthermore, collaboration between

the public and private sectors should be promoted to foster an enabling real estate business environment that prioritizes technological infrastructure and a data-driven property market, ultimately leading to a sustainable African real estate market.

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