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A REVIEW OF ARTIFICIAL INTELLIGENCE (AI) CHALLENGES AND FUTURE PROSPECTS OF EXPLAINABLE AI IN MAJOR FIELDS: A CASE STUDY OF NIGERIA.

***Mohammed, K. & Shehu, A.**

Department of Computer Science, Faculty of Computing and Applied Science, Baze University, Jabi Abuja, Nigeria

***Corresponding Author Email:** Khadijah.saad@bazeuniversity.edu.ng; +2349083030797*

ABSTRACT

Artificial intelligence (AI) has been used widely in essential fields such as energy, health, agriculture, finance etc. However, Artificial intelligence is still faced with social, ethical, legal, and technological challenges. It is important to know how these systems make their decisions while still achieving and implementing the benefits of AI. Explainable AI (XAI) is a technique that is used to explain how a machine made a decision. In this review, we discuss the challenges of AI and recommend XAI as a tool to solve the limitations of AI and suggest a human and conditions-based approach to challenges faced in the technology in Nigeria. This paper employs a narrative review to highlight problems that are limiting the use of AI in four important sectors of Nigeria: Health, Energy, Agriculture, and Finance, and suggest recommendations to solve the AI challenges. The review data was obtained from journals and researchers. We discuss Explainable AI (XAI) as a technique for solving challenges like trustworthiness, bias, lack of data, expertise, and confidence in using AI in major sectors. The paper focuses on the users, conditions, and challenges and recommends that humans and conditions be taken into consideration when building XAI systems.

Keywords: *Artificial Intelligence, Explainable Artificial Intelligence, Challenges, Energy, Health, Machine Learning, Nigeria, oil, Agriculture, Finance.*

INTRODUCTION

Research in Artificial Intelligence (AI) and Machine Learning (ML) has benefited human lives and has had positive impacts in various fields (Zhang & Lu, 2021). In addition to the vast existing contributions of AI, Artificial Intelligence still shows promising improvement which may impact human lives and contribute to the advancements of economies and societies in various sectors such as Health, transportation, security, and law. However, Artificial intelligence is still faced with social, ethical, legal, and technological challenges (Thiebes *et al.*, 2021). Some issues of Artificial intelligence have brought about less trust in AI systems. Examples of these concerns with AI bias, AI systems may have problems of being biassed towards certain populations (Ghassemi *et al.*, 2021; Obermeyer *et al.*, 2019; Alikhademi *et al.*, 2021), swapping faces of people in a video (deep fakes) (Adam *et al.*,2020), or clearview Ai, which could be used in monitoring people against their consent (Thiebes *et al.*, 2021; Hill *et al.*, 2020).

In Nigeria, Artificial intelligence has brought forth opportunities to contribute to areas such as Education (Abayomi, 2021; Sanusi *et al.*, 2022), security (Falode *et al.*, 2021), Energy (Mobayo *et al.*, 2021), Health (Muhammad *et al.*, 2021; Anazodo *et al.*, 2022), however, several papers (Mobayo *et al.*, 2021; Imhanyehor *et al.*, 2021; Okwu *et al.*, 2021) highlight a variety of novel challenges limiting the adoption of AI in Nigeria such as awareness, knowledge of field or system, adequate power supply, computing facilities and trusting of AI systems. These drawbacks could be solved with some technical conditions such as data, algorithms, and computing capabilities. These conditions have led to positive impacts in various areas of industries such as healthcare, retail, automotive, and finance in other parts of the world (Zhang & Lu, 2021). It is beneficial for these conditions to improve in Nigeria for better AI performance and to have some sort of explainability of AI decision systems to make these systems more trustworthy for use in Nigeria.

According to O'Neill (2021), in 2021, about 23.36 percent of Nigeria's GDP came from agriculture, industry such as manufacturing, processing, and transforming of goods contributed to 31.41 percent and 43.79% came from the services sector such as IT and banking. Oil is an important contribution to Nigeria. Between 2001 and 2010, Nigeria was among the countries with the highest GDP growth worldwide due to oil, though prices caused a growth slump (O'neill, 2021). The services sector is growing due to the rise in the relocation of people from rural areas to urban areas (O'neill,2021). Nigeria has the highest concentration of medical doctors but this is still not enough for the populous country of over 200 million people. The government contribution is lower than private contributions to health (Sasu, 2022). The health sector only has an investment of about 3 percent of Nigeria's GDP (Sasu, 2022). 95% of Nigeria's foreign exchange earnings and 80% of its budgetary revenues are provided by the oil sector (The World Bank, n.d.).

Artificial Intelligence can be described as the simulation of the human mind to make computers think and act like humans by performing tasks like learning and problem-solving (Zhang & Lu, 2021). Machine Learning builds systems that improve through data and experience and has been used in the advancement of various fields such as autonomous systems, Natural language processing, computer vision, and medical fields (Jordan & Mitchell, 2015). AI and ML are still being researched to achieve better performance. It is necessary to mitigate the bias and unfairness in data for ethical reasons and to gain users' trust in AI systems (Toreini *et al.*, 2020). Explainable AI (XAI) could help

professionals and AI developers trust and understand decisions made by AI systems (Zhang & Lu, 2021; Ghassemi *et al.*, 2021; Alikhademi *et al.*, 2021). XAI is essentially Machine learning and AI technologies that provide human-understandable justification for their decision (Gunning et. al, 2019).

In the open literature, limitations of technology, and concepts of AI and their applications have been studied in some fields, but in the implementations and use of AI, research in Nigeria is limited. There is an issue connecting AI and its users and the conditions faced. The research is limited to implementing AI and is not focused on the user's view of AI. This study checks the drawbacks of technology and AI in Nigeria and suggests the use of XAI to curb issues. In Nigeria, basic techniques such as Management Systems are used in various sectors, However, there is a lack of use of AI technologies and data, which could help in the advancements of these sectors. These issues include a lack of skilled professionals, privacy, lack of trust, bias, lack of data, and other technologies. We need to use data obtained from Nigerian people or facilities to prevent bias and XAI to solve the issue of trust or lack of skill. This paper highlights the need for XAI and suggests how it can help four important sectors in Nigeria - Health, Finance, Energy, and Agriculture. AI and XAI are suggested to curb some of the issues faced in those sectors. Explaining how the system came to its decision could give better confidence in diagnosis, debugging, and verification, thereby creating more trustworthy systems.

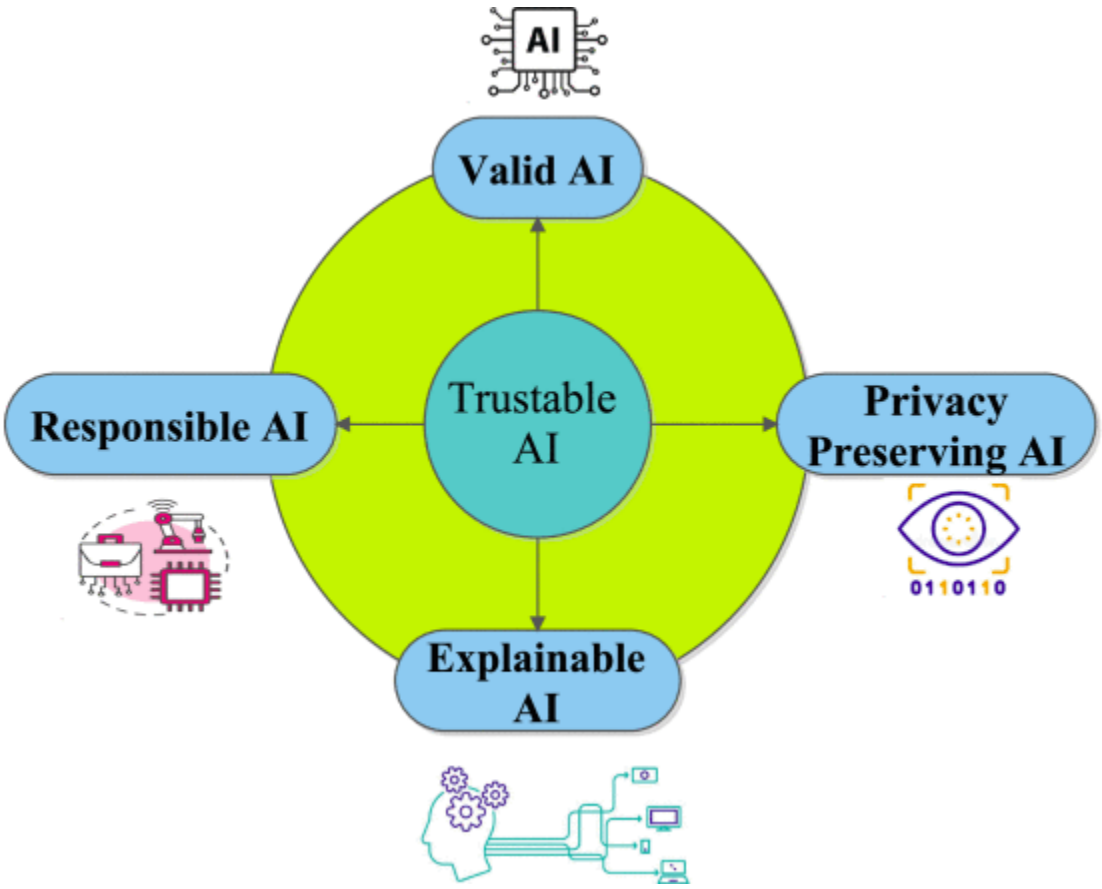

Figure 1: Attributes of a trusted AI (Saraswat *et al.*, 2022)

AIMS AND OBJECTIVES

This study aims to highlight the prospects of AI in Nigeria.

The following are the objectives of the study:

- To review Major fields in Nigeria
- To review Artificial intelligence globally
- To review Explainable AI
- To review Artificial Intelligence in Nigeria
- To recommend prospects of AI in Nigeria.

MAJOR CONTRIBUTIONS

This study aims to highlight the prospects of AI in Nigeria.

The following are the major contributions of the study:

1. To review the challenges of Artificial Intelligence
2. To show the limitations of AI and technology in Nigeria
3. To understand why AI is not used in Nigeria
4. To suggest the use of XAI as a tool for the advancement of AI in Nigeria
5. To show how each of the limitations in Nigeria could be solved using XAI

PURPOSE OF THIS RESEARCH

The purpose of this research is to find ways explainable AI could aid major fields in Nigeria

NOVELTY

In this paper, we contribute to Academia in Nigeria by focusing on both the environment and the users in Nigeria. We review the technology to them being solved by XAI, We analyse the general challenges and suggest a method that could be implemented to suit Nigeria's condition.

BACKGROUND OF LITERATURE

This review analyses the drawbacks of Artificial Intelligence and reviews Explainable Artificial Intelligence as a way to curb these issues. Several researches have been carried out in Explainable Artificial Intelligence (XAI), however, there is no standard method for evaluating or comparing XAI methods. Hence this research reviews the issues of AI and XAI and highlights the need for XAI in various fields field

EXPLAINABLE ARTIFICIAL INTELLIGENCE

There are various reasons for XAI which include trustworthiness, causality, transferability, privacy, awareness and fairness.

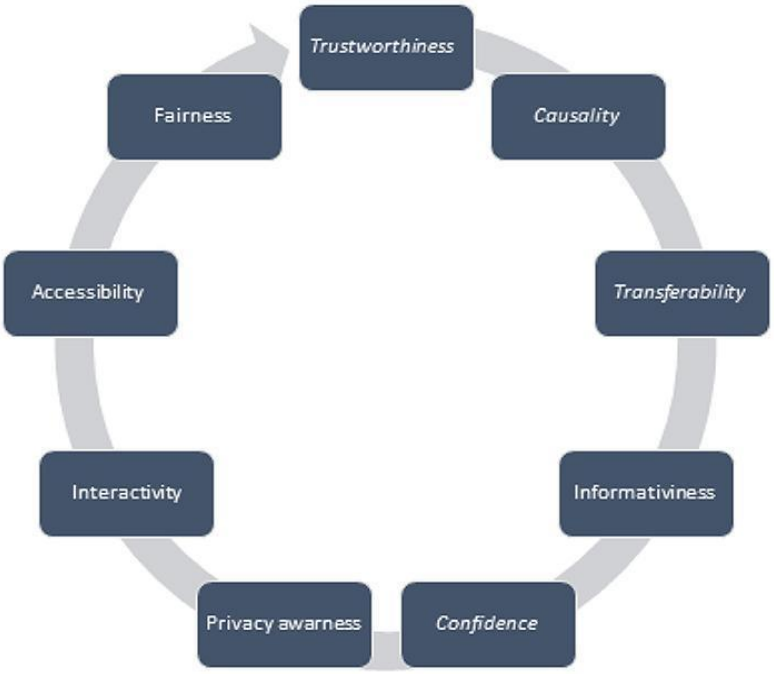

Figure 2: XAI goals (Černevičienė & Kabašinskas, 2022).

METHODS

Explainable Artificial Intelligence is typically divided into two types. The first type Inherent explainability, is where models can be inherently interpretable from their design, for example, linear regression models where as one variable goes up another variable moves up. The second type, post-hoc explainability, is where models can be interpreted from complex models and high-dimensional data such as analysing images, sound, and text. Post-hoc explainability includes saliency maps, locally interpretable model-agnostic explanations (LIME), and Shapley additive explanations (SHAP).

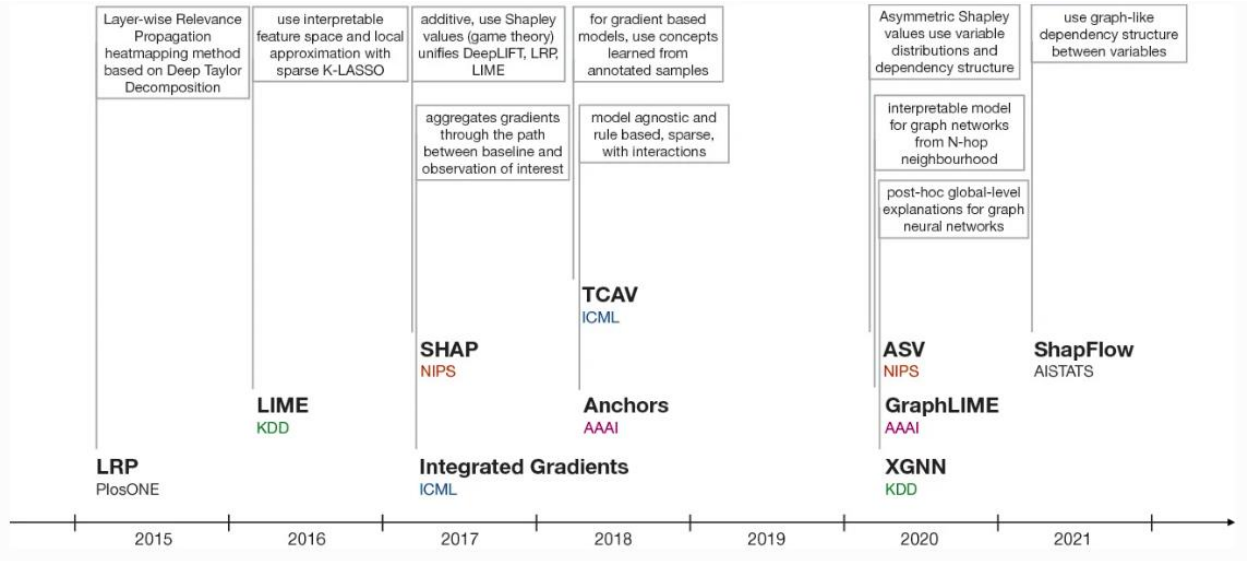

Figure 3: Chronology of the development of Explanatory methods.

Source: Holzinger *et al.* (2022)

CHALLENGES, TECHNOLOGY, ARTIFICIAL INTELLIGENCE, AND EXPLAINABLE ARTIFICIAL INTELLIGENCE

HEALTHCARE

The lack of Skilled professionals and required systems for progress and growth is poor across the board in the health sector in Nigeria (Okoroafor, 2021). Okoroafor (2019) noted that rural areas are understaffed in the health sector due to poor social amenities like water, electricity, telecommunications, security, infrastructure, and working conditions. In Nigeria, various challenges affect the healthcare sector. Okolie et al (2022) also observed various factors, stating the importance of infrastructure, adequate knowledge, and attitudes, cost of screening, anxiety about positive results, and low-risk awareness among Female Health workers. According to the World Health Organization (WHO) (2019), Nigeria accounts for 20% of global maternal deaths. Sexual and reproductive health is low, especially in rural areas and among the youth (Denmo *et al.*, 2015). Some challenges facing access to Sexual and Reproductive Health services are distance to health facilities and opening hours, financial problems, and community and religious beliefs (Nmadu *et al.*, 2020).

AI has been used to improve classification and prediction in healthcare (Verma et.al., 2022). Deep learning, where neural networks can classify medical images from raw data has achieved significant progress. XAI techniques such as Bayesian filtering and salience maps have been used to achieve transparency in AI models (Folke *et al.*, 2021). (Saraswat et.al., 2022) outlined the basics of XAI, associated metrics, and use-case applications for classifying and segmenting covid-19 patients. Their study presented the integration of FL and XAI for decentralised healthcare setups and showed the benefits of AI in health setups. Heat maps or saliency map is a commonly used form of post-hoc explainability (Rajpurkar et. al, 2021) that highlighted the affected area with a saliency map, however, the hottest part, which should be the most useful part, showed both useful and non-useful information and does not explicitly reveal the useful part of that area. It is difficult to measure the ability of the explanatory technique because heatmaps may appear believable even with untrained models. Loh *et al.*, (2022) reviewed research on various XAI techniques and discovered that abnormality detection in 1d biosignals and identification of clinical notes key text required more attention in XAI. (Giuste et. al., 2022) carried out a systematic review of XAI for combating pandemics. In their work, they reviewed approaches in XAI that increase the adoption of AI based on lessons learned from COVID-19. They highlighted that due to the risk-averse nature of clinical information, developers need to know how an AI decision system came to its decision. (Giuste *et. al*., 2022) found that confidence due to unbiased data and bias detection and pattern-discovery in the data were of benefit and will improve patient care. The papers may have achieved XAI, which is hard to measure as there aren't quantifiable means. However, there is a gap in relation to users. Users Should be involved in the development process of youtube the problem to specific users. (Marvin, 2022) developed lattice-based Machine Learning models for explainable prediction of fertility treatment intervention outcomes their research still will be greatly improved if there was research about health centre practices related to neonatal intensive care unit admission to recognise hidden parts to reduce emergency cases. (Khan et. al., 2022) noted the scarcity of professionals, awareness, and tools in point-of-care settings is one of the main causes of maternal and newborn deaths and noted a need for explainability in AI to solve ethical issues.

ENERGY

The Nigerian oil and gas industry has been affected by huge costs while undergoing the exploration and production of fossil fuels (Nkwoji, 2021). Due to oil spills, The Nigerian economy experienced a loss of approximately 3,928,260,196 naira in revenue between 1984-2012. This estimation excludes environmental impact, third-party, and remediation costs (Osuagwu & Olaifa, 2018; Chinonyerem *et al.*, 2017). An average of 700 spills are recorded annually causing environmental degradation, while also having a negative economic impact (Ejiba *et al.*, 2016). Mobayo *et al.* (2021) carried out a study and found that the major challenges of the energy sector in Nigeria are scarcity of skilled professionals, cellular technologies, outdated power system infrastructure, and the growing threat from cyber-attacks cellular technologies. Machine learning algorithms could be used to recognize patterns from data and could be used to identify anomalies. Top energy companies are moving to be data-directed companies. It is essential to help companies understand various performances, including the balance of demand and supply (Nisi *et al.*, 2015). This requires a deep analysis of factors such as products, equipment, weather, days, holidays, and customers. It is also necessary to process data and identify the correlation between data features (Zainab *et al.*, 2021; Nisi *et al.*, 2015). XAI has been used in energy and power systems. (Santos et. al., 2022) used an LSTM model in grid disturbances and carried out the combination of DeepLift andSHap for explainability which provided insights into the misclassifications. (Machlev et.al, 2021) showed the possibility of evaluating explainability in XAI technique and deep learning classifiers and showed how some of the strongest features are not directly related to disturbance when explained with GRAD-CAM. Most XAI in energy use SHAP and LIME, and use traditional Machine learning algorithms and not deep learning (Machlev et. al.,2022). (Machlev et. al.,2022) Highlighted challenges that need to be addressed when implementing XAI techniques in the energy and power systems domain. These include trade-offs, users, standardisation, recommendations, security, and evaluation metrics.

AGRICULTURE

Agriculture is one of the most vital means of reducing poverty in Nigeria (Omodero, 2021). Omodero (2021) researched that participation of youth in agriculture as a primary profession could increase the per capita farm income by ₦31,301.22 - ₦32,150.526 and could reduce poverty by 17% (Osabohein, 2021). Osabohein, (2021) discovered that some farmers do not have enough skills to control the pests ruining farm crops and suggested that the government should supply the required facilities such as training, huge markets, huge markets, modern farming gadget, adequate power supply, and storage spaces to improve agriculture in Nigeria (Omodero, 2021). The cost of farming in Nigeria has increased and this has led to reduced profitability (Osabohein, 2021). They suggested that farmers open tier markets emotionally. The increased cost has an impact on farmers' decision to produce for international markets (Osabohein, 2021).

Global food production should be increased by an estimated 60-70% to feed the increasing population of 9 billion people by 2050 (Rockstrom *et al.*, 2017). Using ML in four sectors (reproduction, production, processing, and distribution) in Agriculture could be very beneficial (Ahumada & Villabos, 2009). ML could be used to predict crop yield, soil properties, disease detection, weather prediction, production planning, distribution cluster, storage, transportation, and consumer analysis (Ben & Hanana, 2021). Ryo (2022) used the global data set of maize crop yield

for data analysis in agriculture. The methods could be applied to any machine learning algorithms after training hence they were post-hoc and model-agnostic. The LIME method was used to show that local variables differed from global ones because of certain conditions. XAI involves the understanding of how organisations deploy AI systems and the user interface in human-Ai joint decision-making (Cartolano *et al.*,2022).

BANKING AND FINANCE

It was found that most banks in Nigeria utilise chatbots that may enhance engagement with customers The most frequently used platform for this was WhatsApp was the most frequently used platform. The chatbots were not able to perform as well when out of their predefined path. The chatbots used English and not any of the local languages. Managers know the promise of AI and are open to establishing AI in business banking but note the issues hindering the adoption of AI (Mogaji & Nguyen, 2022). However, a study by Mogaji and Nguyen (2022), emphasises that banks must understand the objectives of the business, the resources available, and customer needs. Banks should train managers and ensure regulators are involved in the development and inform consumers about AI possibilities.

The utilisation of AI and ML in financial services is transforming industries and societies. Many Financial firms, from financial technology (FinTech) service providers, to fund management firms, to retail and investment banks, are employing Machine Learning expertise (Goodell *et al.*, 2021).

There has not been much study on XAI in Finance (Černevičienė, 2022). The first XAI study in finance was conducted in 2020 by Bussmann et.al (2020), Ariza-Garzón (2020) and Garmegna et. al (2021) Due to the difficulty in evaluating XAI models, Černevičienė (2022) suggested a Multi-Criteria Decision system (MCDM) to combine different mechanisms based on system references and adjunction policy in finance, however, they still need more work in integrating AI and MCDMS. Research in XAI in finance is very dispersed in application areas and methods (Weber et. al., 2022). There is more concentration on informativeness and confidence and trustability and less focus on accessibility, causality, and privacy awareness (Arrieta *et al.*, 2019; Weber et. al., 2022). Weber *et al.* (2022) summarised XAI models, which may be under-researched more than others for further research.

ISSUES OF ARTIFICIAL INTELLIGENCE

Various issues of XAI have been examined in explainable Artificial intelligence. One challenge is that there is no standard for evaluating Artificial Intelligence. One major drawback of XAI is the lack of user involvement in XAI processes. Humans should be involved in the process of XAI for particular scenarios.

Some issues limiting the growth of AI, which affect the Health, Energy, Agriculture, and Finance fields are:

- Data reliability, data uniformity, and Data Volume -: Due to equipment or network failure, data may not be complete and lead to erroneous results. The data may also be noisy or only focused on one aspect. Data could also be collected from multiple sources or may be limited. Combining and finding data may be also difficult (Chen *et al.*, 2015; Sen *et al.*, 2021). Obtaining health data is difficult due to various factors, Electronic Health Records could be stored in various formats making them incompatible with other platforms due to interoperability issues. EHRs make use of different terminologies, symbols, and coding values (Ehrenstein, 2019).

- Privacy is also an issue with obtaining health records as patients may not consent for their data to be shared (Ehrenstein, 2019).
- Standardisation- Technical and code formats may be stored in various formats such as XML, JSON, etc (Brewseter *et al.,* 2017). Research needs to be carried out to promote standardisation to increase interoperability among smart systems (Friha *et al.*, 2021)
- Bias and unfairness in the algorithm/data - if the training data for a model is biased, it may lead to unreliable results. Some records may only contain information from a certain race, gender, or socio-economic factors. Data from urban areas will provide less accurate results when used on people from rural areas. Algorithms should be trained using more diverse data. An issue limiting AI research in healthcare is the lack of standardised methodologies and the use of only historical data. Patients' data should be studied over time.
- Regulation issues: It is important to set out the legal and regulatory rules for governing the management and control of the data. (Parasuraman, 2021). Countries can have different regulations with regard to service facilities such as technological challenges, data protection, and security.
- Market issues: There is a lack of sufficient awareness of smart devices, especially in rural areas. Implementation of smart devices could also be costly (Sinha & Dhanalakshmi, 2022).
- Security: Smart devices may be tampered with (Haseeb *et al.*, 2020). Demestichas (2020) highlighted various security breach cases namely SQL injection attacks, Data Theft, and so on at various IoT layers. Insecurity of Data and insufficient information are part of the main and complex issues of systems (Guo *et al.*, 2019; Zhao *et al.*, 2019; Zhao *et al.*, 2013). It is vital to have means of preventing cyber-attacks because of the cost. Installing digital infrastructure in energy costs approximately $30 billion a year (Fickling, 2019).
- Lack of skills and practical expertise: This adds to the slow growth of AI among decision-makers. Cost of faults is high, which makes it difficult for companies to adopt the use of these new technologies (Ahmad *et al.*, 2021). Using AI in some energy could be complex and challenging for operating grids (Puri *et al.*, 2019).
- Outdated system infrastructure: There may be available data in the AI sector, however, data is disorganised and systems may be outdated (Ahmad *et al.*, 2021).
- Black boxes: Consumers may not understand the internal functions of AI-based applications (Ahmad *et al.*, 2021).
- Complexity: Some systems may e complex and have high dimensionality of data which could be a challenge in systems (Tang *et al.*, 2018)

LIMITATIONS OF THE CURRENT STUDY

The current work shows a limitation that does not focus on the user or is not country-specific. Most studies were tested out by developers and not users, some were carried out on non-Nigerian data, which may cause bias. Some studies are also suited for research and summarise XAI methods, some focus on confidence. However, none focus on challenges and conditions suited to Nigeria.

OBSERVATIONS AND RECOMMENDATIONS

We observed various challenges in AI in Nigeria. For example, In Abuja, Nigeria, we carried out a task of obtaining clinical data for cervical and Ovarian cancer for Machine Learning research. However, we were not able to obtain the data for research due to the unavailability of data. The records were either deleted, not stored for over a year, not annotated, or not approved for distribution. Data for cervical cancer was available on the internet but could not be used to make a reliable output for women in Nigeria due to Nigeria being underdeveloped while the data retrieved was uploaded from a developed country.

We researched statistical data contributing to the growth of Nigeria and hindering the well-being of Nigerians. The following fields were analysed:

- Health: We discovered that this vital field lacked factors like practical expertise.
- Energy: This is an important field in Nigeria. Oil contributes significantly to the GDP.
- Agriculture: There is a need to improve agricultural practices as the human population keeps growing,
- Banking and Finance: The Services sector contributes to almost half of Nigeria's GDP. Banking and IT are examples of these services.

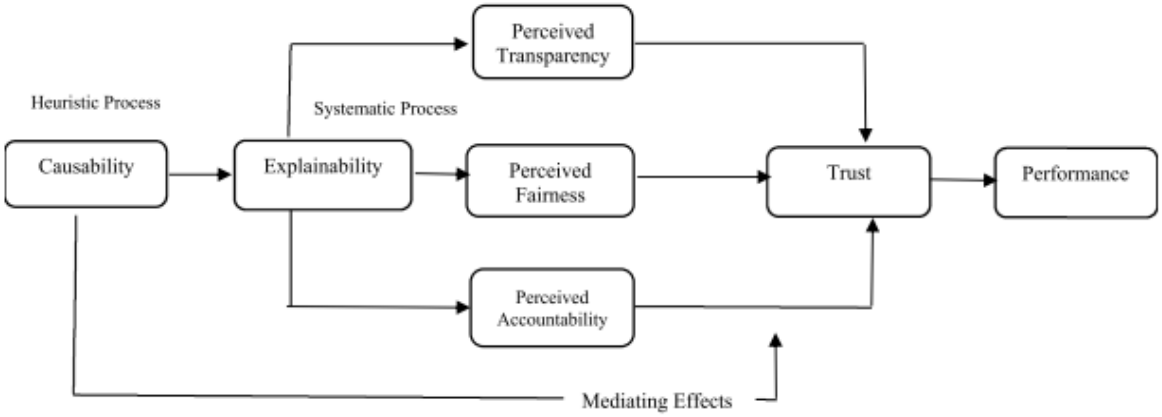

Figure 4: Causability and Explainability in Human-AI Interaction

Source: Shin (2021)

From Figure 4, Shin (2021) showed the effect of causability and explainability to show explanations of why certain events are recommended and the need for causability to justify what and how should be explained based on the relative importance of the properties of explainability.

RECOMMENDATIONS FOR NIGERIA

We suggest that when building XAI systems for Nigeria, both humans and conditions be taken into account. Using humans would provide additional feedback and help in debugging the system. Using conditions will also give feedback based on those conditions which may be unique to Nigeria. XAI should provide explanations and justify systems based on conditions.

RECOMMENDATIONS FOR THE HEALTH SECTOR IN NIGERIA

Based on our research, we suggest that the standard medical terminologies should be used with data retrieved from Nigeria. We suggest data should be stored based on ethical principles putting into mind privacy and bias. Hospitals should try to work with researchers to try to solve healthcare challenges with AI technologies. To mitigate bias, the data stored should include records of various populations (such as socio-economic factors) to provide more reliable results - this can also show how people from a certain region or socio-economic factor are affected more by a particular disease and AI technologies could be used to highlight these populations for further actions by aiding bodies. We also suggest that Explainability should work with these expert systems to give end-users of the system (i,e radiologist or patients) more trust and confidence in the decisions. We suggest a baseline for explainability be defined.

RECOMMENDATIONS FOR THE ENERGY SECTOR IN NIGERIA

Based on our research, we suggest the following for Energy in Nigeria:

There is data for the energy sector, however, due to the lack of expertise, we suggest

XAI should be explored. Having some sort of explainability could help the workers who lack experience by suggesting the system has output this due to this, so they can make more confident decisions.

RECOMMENDATIONS FOR THE AGRICULTURAL SECTOR IN NIGERIA

Studies show youth are positive to participate in agriculture and show that this can reduce poverty and increase per capita income. However, the youth may not know about farming there for XAI should work alongside ML applications to make the new farmers more confident in what the systems suggest when asked about a problem.

Different foods are grown across various parts of the world. So, could the agricultural data used in another part of the world be used elsewhere? Would the decisions or recommendations from the AI system be reliable? This might give an issue of bias. Having some Explainability may back the decisions better.

RECOMMENDATIONS FOR THE FINANCIAL SECTOR IN NIGERIA

We discovered AI is mainly used for chatbots in Nigeria, and suggest that AI applications be implemented in Nigeria to help with risk assessment and monitoring, cyber security, and advisory services. Workers should be trained and made aware of AI uses in Nigeria. We also suggest the use of Explainable Artificial Intelligence as an aid to prevent bias, and aid in accountability and transparency.

CONCLUSION

Artificial intelligence has transformed various industries and societies. AI has had a positive impact on human lives and well-being. However, AI also comes with challenges that need to be tackled. Due to the impact of AI decisions on human lives, users of an AI system should be given explanations of certain decisions to be more confident in decisions. The current research does not focus on conditions in Nigeria. The focus is more on confidence, and methods and not on conditions or challenges. There is no standard way to evaluate AI, hence involving humans and using conditions pertaining to Nigeria works best.

The global issues of AI include the following:

- Localisation: can the AI system work diversely across various regions, demographics, cultures, and languages? It is important to keep the numerous markets in mind while building models so they can adapt to users' experiences.
- Difficulty in data acquisition: We explained how difficult it was to acquire data in Nigeria due to unavailability, unlabeled/not annotated, not being recorded, or unapproved. We also explained that there may be a problem of bias if we were to use data available on the internet because of various factors like race, gender, and socio-economic factors.
- Accountability, if a problem goes wrong, one would not know who to blame, XAI can give users an explanation for example "If you make X it will give you Y due to Z" that as we can see why the system is telling the user to pick 'X', and the user will only pick X if they are satisfied with the explanation.
- Lack of expertise: if one is not an expert in a certain field and the expert system gives a recommendation, the system can say "this is X due to the Y being at Z and as big W do X so it does not become faulty due to Y" then the practitioner may know how and why the algorithm has arrived at a specific decision in following user's made a decision
- Trustworthiness: In health for example, if neither the doctors nor patients do not trust the system, they will unlikely not follow the prognosis or diagnosis output by the system.

With these issues, it is believed that XAI should be explored in Nigeria to curb the issues discussed above. XAI should aim to give accurate, fair, transparent output that will make us understand why a system came to a particular decision. So, if there is a problem with data, we want the system to say it is bringing this result due to a certain factor. This way we can see why and spot if the explanation is satisfactory to the end-user of the system.

AI is still being explored in Nigeria and still has many areas that need exploration and implementation. Some issues limiting AI in Nigeria are. Only when clients are informed, convinced, and confident in AI models can they be effective in making accurate predictions. Consumers would prefer to use a system only when data is secured

The issues with AI in Nigeria are lack of data - We found out that it was difficult to acquire data as it was difficult to obtain from data centers, not annotated or not available, Standardisation, Lack of Skilled professionals, Infrastructure, Computational capabilities, Awareness, lack of confidence, Security, Awareness.

We recommend an approach that takes into account users and conditions. Our suggestions for AI in Nigeria are:

- A human-in-the-loop approach should be used, to obtain satisfaction in XAI
- Conditions should be taken into consideration to build a system that fits the problem.
- Organisations should cooperate in research, this includes storing data ethically, annotating data (giving it correct labels), and sharing data ethically for research purposes.
- Organisations should have a standard set of terms to use in research.
- It is also important to get data across various populations to curb the problem of bias. and to make data more inclusive. For example, with the chatbots, we see that most applications are English based but expansion to other languages such as Hausa, Yoruba, and Igbo should be carried out.

- More research and implementation should be carried out in Artificial Intelligence in Nigeria to solve the issues highlighted in this paper.
- More research should be carried out in XAI - though research in XAI still has more room for exploration, XAI can still be used in Nigeria using the influence and visualisation methods that have been implemented elsewhere.
- Nigeria can also join in the research for DL models in Explainable Artificial Intelligence.

CONFLICT OF INTEREST

We declare that there is no known conflict of interest that could influence our work.

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REFERENCES

Abayomi, O. K., Adenekan, F. N., Abayomi, A. O., Ajayi, T. A. & Aderonke, A. O. (2021). Awareness and perception of artificial intelligence in the management of university libraries in Nigeria. *Journal of Interlibrary Loan, Document Delivery & Electronic Reserve*, **29**(1-2): 13-28.

Adam, M., Wessel, M. & Benlian, A. (2021). AI-based chatbots in customer service and their effects on user compliance. *Electronic Markets*, *31*(2), 427-445.

Ahmad, T., Zhang, D., Huang, C., Zhang, H., Dai, N., Song, Y. & Chen, H. (2021). Artificial intelligence in sustainable energy industry: Status Quo, challenges and opportunities. *Journal of Cleaner Production*, **289**: 125834.

Ahumada, O., & Villalobos, J. R. (2009). Application of planning models in the agri-food supply chain: A review. *European journal of Operational research*, **196**(1): 1-20.

Alikhademi, K., Richardson, B., Drobina, E., & Gilbert, J. E. (2021). Can explainable AI explain unfairness? A framework for evaluating explainable AI. *arXiv preprint arXiv:2106.07483v1* doi:10.48550/arXiv.2106.07483

Anazodo, U. C., Adewole, M. & Dako, F. (2022). AI for Population and Global Health in Radiology. *Radiology: Artificial Intelligence*, **4**(4): e220107.

Ariza-Garzón, M. J., Arroyo, J., Caparrini, A., & Segovia-Vargas, M. J. (2020). Explainability of a machine learning granting scoring model in peer-to-peer lending. *Ieee Access*, **8**: 64873-64890.

Ben A., R. & Hanana, M. (2021). Artificial intelligence to improve the food and agriculture sector. *Journal of Food Quality*, *2021*(5584754):1-7. doi:10.1155/2021/5584754.

Brewster, C., Roussaki, I., Kalatzis, N., Doolin, K. & Ellis, K. (2017). IoT in agriculture: Designing a Europe-wide large-scale pilot. *IEEE communications magazine*, **55**(9): 26-33.

Bussmann, N., Giudici, P., Marinelli, D. & Papenbrock, J. (2020). Explainable AI in fintech risk management. *Frontiers in Artificial Intelligence*, **3**(26) doi:10.3389/frai.2020.00026

Cartolano, A., Cuzzocrea, A., Pilato, G. & Grasso, G. M. (2022, December). Explainable AI at Work! What Can It Do for Smart Agriculture?. In *2022 IEEE Eighth International Conference on Multimedia Big Data (BigMM)* (pp. 87-93). IEEE.

Černevičienė, J. & Kabašinskas, A. (2022). Review of multi-criteria decision-making methods in finance using explainable artificial intelligence. *Frontiers in artificial intelligence*, **5**:35 doi:10.3389/frai.2022.827584

Chinonyerem, N. T., Ntor-Ue, M., Chukwudi, I. C. & Chinedum, O. (2017). Economic implications of marine oil spill to Nigeria: A case for improvement in coastal pipeline management and surveillance practices. *International Journal of Economy, Energy and Environment*, **2**(3): 40-47.

Chen, F., Deng, P., Wan, J., Zhang, D., Vasilakos, A. V., & Rong, X. (2015). Data mining for the internet of things: literature review and challenges. *International Journal of Distributed Sensor Networks*, **11**(8): 431047

Demestichas, K., Peppes, N. & Alexakis, T. (2020). Survey on security threats in agricultural IoT and smart farming. *Sensors*, **20**(22): 6458.

Ehrenstein, V., Kharrazi, H., Lehmann, H. & Taylor, C. O. (2019). Obtaining data from electronic health records. In *Tools and technologies for registry interoperability, registries for evaluating patient outcomes: A user's guide, 3rd edition, Addendum 2 [Internet]*. Agency for Healthcare Research and Quality (US).

Ejiba, I. V., Onya, S. C., & Adams, O. K. (2016). Impact of oil pollution on livelihood: evidence from the Niger Delta region of Nigeria. *Journal of Scientific Research and Reports*, *12*(5), 1-12.

Falode, A. J., Faseke, B. O., & Ikeanyichukwu, C. (2021). Artificial Intelligence: The Missing Critical Component in Nigeria's Security Architecture. *LASU Journal of History and International Studies (LAJOHIS)*, **3**(1):18-37

Fickling, B.D., 2019. Cyberattacks Make Smart Grids Look Pretty Dumb. Bloomberg Bloomberg. Retrieved on 12th January, 2022 from: https://www.bloomberg.com/opinion/articles/2019-06-17/argentina-blaming-hackers-for-outage-makessmart-grids-look-dumb,

Folke, T., Yang, S. C. H., Anderson, S., & Shafto, P. (2021, April). Explainable AI for medical imaging: explaining pneumothorax diagnoses with Bayesian teaching. In *Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications III* (Vol. 11746, pp. 644-664). SPIE.

Friha, O., Ferrag, M. A., Shu, L., Maglaras, L., & Wang, X. (2021). Internet of things for the future of smart agriculture: A comprehensive survey of emerging technologies. *IEEE/CAA Journal of Automatica Sinica*, **8**(4): 718-752.

Ghassemi, M., Oakden-Rayner, L., & Beam, A. L. (2021). The false hope of current approaches to explainable artificial intelligence in health care. *The Lancet Digital Health*, **3**(11): e745-e750.

Giuste, F., Shi, W., Zhu, Y., Naren, T., Isgut, M., Sha, Y., & Wang, M. D. (2022). Explainable artificial intelligence methods in combating pandemics: A systematic review. *IEEE Reviews in Biomedical Engineering*, , *arXiv preprint arXiv:2112.12705*

Goodell, J. W., Kumar, S., Lim, W. M. & Pattnaik, D. (2021). Artificial intelligence and machine learning in finance: Identifying foundations, themes, and research clusters from bibliometric analysis. *Journal of Behavioral and Experimental Finance*, 32(100577). doi:10.1016/j.jbef.2021.100577

Gunning, D., Stefik, M., Choi, J., Miller, T., Stumpf, S., Yang, G., 2019. XAI: explainable artificial intelligence. *Science robotics*, **4**(37): 7120. https://doi.org/10.1126/scirobotics. Aay7120.

Guo, Y., Wang, J., Chen, H., Li, G., Huang, R., Yuan, Y., ... & Sun, S. (2019). An expert rule-based fault diagnosis strategy for variable refrigerant flow air conditioning systems. *Applied Thermal Engineering*, **149**:1223-1235.

Haseeb, K., Ud Din, I., Almogren, A. & Islam, N. (2020). An energy efficient and secure IoT-based WSN framework: An application to smart agriculture. *Sensors*, **20**(7): 2081.

Hill, K. (2020). The secretive company that might end privacy as we know it. In *Ethics of Data and Analytics* (pp. 170-177). Auerbach Publications. Retrieved on 11th January, 2022 from: https://www.nytimes.com/2020/01/18/technology/clearview-privacy-facial-recognition.html,

Holzinger, A., Saranti, A., Molnar, C., Biecek, P. & Samek, W. (2022, April). Explainable AI methods-a brief overview. In Proceedings of the International Workshop on Extending Explainable AI Beyond Deep Models and Classifiers, Vienna, Austria, 17 July 2020; pp. 13–38.. Cham: Springer International Publishing..

Imhanyehor, G. O. (2021). Digital Literacy and Primary Educational System in Nigeria. *Journal of Public Administration, Finance and Law*, **10**(20):206-221.

Jordan, M. I. & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. *Science*, **349**(6245), 255-260.

Khan, M., Khurshid, M., Vatsa, M., Singh, R., Duggal, M. & Singh, K. (2022). On AI Approaches for Promoting Maternal and Neonatal Health in Low Resource Settings: A Review. *Frontiers in Public Health*, **10**:1864. doi:10.3389/fpubh.2022.880034. Retrieved on 9th January, 2022 from: https://www.frontiersin.org/articles/10.3389/fpubh.2022.880034/full

Loh, H. W., Ooi, C. P., Seoni, S., Barua, P. D., Molinari, F., & Acharya, U. R. (2022). Application of explainable artificial intelligence for healthcare: A systematic review of the last decade (2011–2022). *Computer Methods and Programs in Biomedicine*, 226: 107161. doi: 10.1016/j.cmpb.2022.107161.

Machlev, R., Heistrene, L., Perl, M., Levy, K. Y., Belikov, J., Mannor, S., & Levron, Y. (2022). Explainable Artificial Intelligence (XAI) techniques for energy and power systems: Review, challenges and opportunities. *Energy and AI*, 9: 100169. doi: 10.1016/j.egyai.2022.100169

Machlev, R., Perl, M., Belikov, J., Levy, K. Y., & Levron, Y. (2021). Measuring explainability and trustworthiness of power quality disturbances classifiers using XAI—Explainable artificial intelligence. *IEEE Transactions on Industrial Informatics*, **18**(8): 5127-5137.

Marvin, G. (2022). *Quantum lattice learning and explainable artificial intelligence for maternal and child healthcare* (Doctoral dissertation, Brac University).

Mobayo, J. O., Aribisala, A. F., Yusuf, S. O., & Belgore, U. (2021). Artificial intelligence: Awareness and adoption for effective facilities management in the energy sector. DOI: 10.36615/digitalfoodenergywatersystems.v2i2.718

Mogaji, E. & Nguyen, N. P. (2022). Managers' understanding of artificial intelligence in relation to marketing financial services: insights from a cross-country study. *International Journal of Bank Marketing*, **40**(6): 1272-1298.

Muhammad, L. J., & Algehyne, E. A. (2021). Fuzzy based expert system for diagnosis of coronary artery disease in Nigeria. *Health and technology*, **11**(2): 319-329.

Nisi, M., Renga, D., Apiletti, D., Giordano, D., Huang, T., Zhang, Y., Melia, M., & Baralis, E. (2019, March). Transparently Mining Data from a Medium-voltage Distribution Network: A Prognostic-diagnostic Analysis. In *EDBT/ICDT Workshops*.

Nkwoji, N. (2021). Environmental accounting and profitability of selected quoted oil and gas companies in Nigeria (2012-2017). *Journal of Accounting and Financial Management*, **7**(3): 22-39.

Nmadu, A. G., Mohammed, S. & Usman, N. O. (2020). Barriers to adolescents' access and utilisation of reproductive health services in a community in north-western Nigeria: A qualitative exploratory study in primary care. *African journal of primary health care & family medicine*, **12**(1):e1–e5. https://doi.org/10.4102/phcfm.v12i1.2307

Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S. (2019). Dissecting racial bias in an algorithm used to manage the health of populations. *Science*, **366**(6464): 447–453.

Okolie, E. A., Barker, D., Nnyanzi, L. A., Anjorin, S., Aluga, D., & Nwadike, B. I. (2022). Factors influencing cervical cancer screening practice among female health workers in Nigeria: A systematic review. *Cancer Reports*, **5**(5): e1514.

Okoroafor, S. C., Ongom, M., Mohammed, B., Salihu, D., Ahmat, A., Osubor, M., & Alemu, W. (2021). Perspectives of policymakers and health care managers on the retention of health workers in rural and remote settings in Nigeria. *Journal of Public Health*, *43*(Supplement_1), 12-19. doi: 10.1093/pubmed/fdaa262.

Okwu, E. (2021). Academic Libraries, Science and Technology Development and the Nigerian Smart City Initiative (NSCI): Issues, roles and Challenges. Retrieved on 12th January, 2022 from: https://www.researchgate.net/profile/Emmanuel-Okwu/publication/351224041_Academic_Libraries_Science_and_Technology_Development_and_the_Nigerian_Smart_City_Initiative_NSCI_Issues_roles_and_Challenges/links/6090181ca6fdccaebd073169/Academic-Libraries-Science-and-Technology-Development-and-the-Nigerian-Smart-City-Initiative-NSCI-Issues-roles-and-Challenges.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail

Omodero, C. O. (2021). Sustainable agriculture, food production and poverty lessening in nigeria. *International Journal of Sustainable Development and Planning*, 16(1), 81–87. https://doi.org/10.18280/ijsdp.160108

O'neill A. (2021). Distribution of gross domestic product (GDP) across economic sectors Nigeria 2021. Statista. Retrieved on 11th January, 2022 from: https://www.statista.com/statistics/382311/nigeria-gdp-distribution-across-economic-sectors/,

Osabohien, R., Wiredu, A. N., Nguezet, P. M. D., Mignouna, D. B., Abdoulaye, T., Manyong, V., ... & Awotide, B. A. (2021). Youth participation in agriculture and poverty reduction in Nigeria. *Sustainability*, **13**(14): 7795

Osuagwu, E. S., & Olaifa, E. (2018). Effects of oil spills on fish production in the Niger Delta. *PloS one*, **13**(10): e0205114.

Parasuraman, K., Anandan, U., & Anbarasan, A. (2021, February). IoT based smart agriculture automation in artificial intelligence. In *2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)* (pp. 420-427). IEEE.

Puri, V., Jha, S., Kumar, R., Priyadarshini, I., Abdel-Basset, M., Elhoseny, M., & Long, H. V. (2019). A hybrid artificial intelligence and internet of things model for generation of renewable resource of energy. *Ieee Access*, **7**: 111181-111191.

Rajpurkar, P., Irvin, J., Zhu, K., Yang, B., Mehta, H., Duan, T., ... & Ng, A. Y. (2017). Chexnet: Radiologist-level pneumonia detection on chest x-rays with deep learning. *ArXiv*, *abs/1711.05225*. doi:10.48550/arXiv.1711.05225

Rockström, J., Williams, J., Daily, G., Noble, A., Matthews, N., Gordon, L. & Smith, J. (2017). Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio*, **46(1):** 4-17.

Ryo, M. (2022). Explainable artificial intelligence and interpretable machine learning for agricultural data analysis. *Artificial Intelligence in Agriculture*, **6**: 257-265.

Santos, O. L., Dotta, D., Wang, M., Chow, J. H. & Decker, I. C. (2022). Performance analysis of a DNN classifier for power system events using an interpretability method. *International Journal of Electrical Power & Energy Systems*, **136**: 107594.

Sanusi, I. T., Olaleye, S. A., Agbo, F. J. & Chiu, T. K. (2022). The role of learners' competencies in artificial intelligence education. *Computers and Education: Artificial Intelligence*, *3*:100098. doi: 10.1016/j.caeai.2022.100098

Saraswat, D., Bhattacharya, P., Verma, A., Prasad, V. K., Tanwar, S., Sharma, G., ... & Sharma, R. (2022). Explainable AI for healthcare 5.0: opportunities and challenges. *IEEE* doi: 10.1109/ACCESS.2022.3197671.

Sasu, D.D. (2022, Nov 18). *Health in Nigeria - statistics & facts.* Statista. Retrieved on 11th January, 2022 from: https://www.statista.com/topics/6575/health-in-nigeria/#topicOverview

Sen, A., Roy, R., & Dash, S. R. (2021). Smart farming using machine learning and IoT. *Agricultural Informatics: Automation Using the IoT and Machine Learning*, 13-34 doi: 10.1002/9781119769231.ch2

Shin, D. (2021). The effects of explainability and causability on perception, trust, and acceptance: Implications for explainable AI. *International Journal of Human-Computer Studies*, **146**: 102551.

Sinha, B. B., & Dhanalakshmi, R. (2022). Recent advancements and challenges of Internet of Things in smart agriculture: A survey. *Future Generation Computer Systems*, **126**: 169-184.

Tang, Y., Huang, Y., Wang, H., Wang, C., Guo, Q. & Yao, W. (2018). Framework for artificial intelligence analysis in large-scale power grids based on digital simulation. *CSEE Journal of Power and Energy Systems*, **4**(4): 459-468.

Tao, F., Akhtar, M. S., & Jiayuan, Z. (2021). The future of artificial intelligence in cybersecurity: A comprehensive survey. *EAI Endorsed Transactions on Creative Technologies*, **8**(28): 3.

The World Bank (n.d). *Nigeria.* . Retrieved on 11th January, 2022 from: https://data.worldbank.org/country/nigeria

Thiebes, S., Lins, S. & Sunyaev, A. (2021). Trustworthy artificial intelligence. *Electronic Markets*, 31(2): 447-464.

Toreini, E., Aitken, M., Coopamootoo, K., Elliott, K., Zelaya, C. G. & Van Moorsel, A. (2020, January). The relationship between trust in AI and trustworthy machine learning technologies. In *Proceedings of the 2020 conference on fairness, accountability, and transparency* (pp. 272-283).

Verma, A., Bhattacharya, P., Patel, Y., Shah, K., Tanwar, S. & Khan, B. (2022). Data localization and privacy-preserving healthcare for big data applications: Architecture and future directions. In *Emerging Technologies for Computing, Communication and Smart Cities: Proceedings of ETCCS 2021* (pp. 233-244). Singapore: Springer Nature Singapore.

World Health Organization (WHO). (2019, June 25) Maternal health in Nigeria: generating information for action. Retrieved on 11th January, 2022 from: https://www.who.int/reproductivehealth/maternal-health-nigeria/en/.

Zainab, A., Ghrayeb, A., Syed, D., Abu-Rub, H., Refaat, S. S., & Bouhali, O. (2021). Big data management in smart grids: Technologies and challenges. *IEEE Access*, **9**: 73046-73059.

Zhang, C., & Lu, Y. (2021). Study on artificial intelligence: The state of the art and future prospects. *Journal of Industrial Information Integration*, *23*(100224).

Zhao, Y., Li, T., Zhang, X., & Zhang, C. (2019). Artificial intelligence-based fault detection and diagnosis methods for building energy systems: Advantages, challenges and the future. *Renewable and Sustainable Energy Reviews*, **109**: 85-101.

Zhao, Y., Xiao, F., & Wang, S. (2013). An intelligent chiller fault detection and diagnosis methodology using Bayesian belief network. *Energy and Buildings*, **57**: 278-288.