



A historical and ethical inquiry into the transformative role of artificial intelligence in scientific research methodologies

Josephat Nairutia Kemei^{1*}
Kizito Muchanga Lusambili²
Pontian Godfrey Okoth³

^{1*} josephatkemei@gmail.com,

² kmuchanga@mmust.ac.ke

³ pokoth@mmust.ac.ke

^{1,2,3}Masinde Muliro University of Science and Technology, Kenya

Recommended Reference: Kemei, J. N., Lusambili, K. M., & Okoth, P. G. (2025). A historical and ethical inquiry into the transformative role of artificial intelligence in scientific research methodologies. *African Quarterly Social Science Review*, 2(4), 595–604. <https://doi.org/10.51867/AQSSR.2.4.55>

ABSTRACT

The evolution of scientific research methodologies has closely mirrored the technological transformations that define human progress—from manual record keeping and statistical modeling to computational and machine-assisted analysis. This paper conducts a historical and ethical inquiry into the transformative role of Artificial Intelligence (AI) in reshaping scientific research methodologies across time and contexts. Anchored in Actor-Network Theory (ANT), the study conceptualizes AI not merely as a technical tool but as a dynamic non-human actor that co-produces knowledge in socio-technical research networks. Using a qualitative historical research design, the study draws on secondary literature, archival data, and oral histories to trace the progression of AI from early computational devices to contemporary deep learning and natural language processing systems. Thematic and content analyses reveal that AI enhances data accuracy, accelerates predictive modeling, and fosters interdisciplinary collaborations, thus redefining epistemic practices and expanding the scope of scientific inquiry. However, the findings also expose critical ethical challenges, including algorithmic bias, data privacy violations, and epistemological opacity that threaten research integrity. To mitigate these risks, the paper proposes a hybrid governance framework that integrates AI literacy, algorithmic transparency, and co-produced ethical accountability between human and machine actors. The study concludes that sustainable integration of AI in scientific research requires balancing innovation with moral responsibility, ensuring that AI serves as a partner in the advancement of credible and ethically grounded knowledge.

Keywords: Artificial-Intelligence, Epistemology, Ethics, Methodology

I. INTRODUCTION

The development of the scientific research methodology has never been isolated of the bigger technological progress of humanity. Since the Sumerian scribes on clay tablets to the algorithmic modeling of the digital era, every age has seen the beginning of a new era in the creation, storage, and sharing of knowledge (Burke, 2012). The rise of Artificial Intelligence (AI) in the late 20th and early 21st centuries is not just a technological breakthrough, but a drastic epistemological change in the long arc of this history. The increasing presence of AI in research not only through the automation of the data analysis process but also the production of an insight into the future redefines the nature and purpose of scientific investigation.

The scientific revolution of the 17th century has historically opened up new perspectives on the subject of observation and experimentation such as the inductive methodology of Francis Bacon and the empirical rationalism of Isaac Newton (Gaukroger, 2006). Such methods were codified even more in the Enlightenment in which reason and tests became the foundation of intellectual development. The statistical devices which began in the 19th century formalized research accuracy and in the early 20th century both the computers and computational devices of Charles Babbage and the conceptualization of machine intelligence by Alan Turing became known (Copeland, 2004).

The basis of AI was, however, laid down in the post-war period. The Dartmouth Conference in 1956 marked the official emergence of AI as a research field, and researchers like John McCarthy and Marvin Minsky envisaged the possibility of machines that could simulate some of the functions of the human mind (Haenlein & Kaplan, 2019). The advancements in machine learning and statistical modelling seen towards the end of the 20th century had allowed scientists to automate tasks that previously required human understanding. This trend has only increased in the 21st century: AI systems now perform more complicated tasks in natural language processing, deep learning, and real-time data duration (Russell & Norvig, 2021).



This historical development requires academic thinking. The current work is the result of the need to approach the implementation of AI in scientific methods of research critically. This is not an issue of efficiency or innovation, but of moral accountability and meticulousness. AI provokes long-term questions that the historian is used to as to the authorship, authoritative position, and agency in the production of knowledge. The issues of algorithmic bias, data ownership, and the lack of transparency in machine-produced findings resemble the debates on objectivity, interpretation, and the politics of knowledge that are more ancient (O'Neil, 2016).

Therefore, this paper explores the transformational aspect of AI in the *longue duree* of research development. It aims at shedding light on the way, in which AI as a product and engine of scientific progress reconstructs the philosophical and ethical outlines of research. The paper assesses the risks and opportunities of AI integration through a historical and moralistic approach, which offers a solid structure in which AI may be incorporated during scientific investigation in a sustainable and considerate manner.

1.1 Statement of the Problem

Artificial Intelligence (AI) ought to strengthen the accuracy, reliability, and openness of a scientific inquiry in an ideal research setting. It should supplement human thinking and become effective in processing data, predictive modeling, and cross-disciplinary cooperation. The implementation of AI in research methodologies, ideally, must be informed by ethical values that are solid enough to yield fairness, accountability, and epistemic integrity, which will lead to the responsible development of scientific knowledge. As a matter of fact, though, technological enthusiasm has influenced the incorporation of AI in the scientific field more than the thoughtful consideration of its effects. The current literature focuses on the technical aspects of AI, including automation, big data analysis, and prediction algorithms, but it does not bring up its historical development, philosophical basis, or ethical concerns. This absence of consistent ethical and methodological standards has led to the idea of algorithmic bias, violation of privacy, and the unclear nature of AI-generated knowledge. Moreover, the classical position of human researcher as the main agent of objectivity and judgment is being redefined with an insufficient theoretical background. As a result, a huge gap in knowledge about the intersection of the technological development of AI with ethical accountability and the epistemological transformation is present. To address this gap, this research aimed to track the historical evolution of AI-based research methods, assess their role in enhancing the validity of data and the cross-disciplinary cooperation, and offer sustainable approaches to ethics to guarantee that AI makes a revolutionary but ethically responsible companion to the scientific investigation.

1.2 Research Objectives

- i. To examine the historical development of AI-driven research methodologies from early computational approaches to present-day innovations
- ii. To analyze the role of AI in enhancing data accuracy, predictive modeling, and interdisciplinary research collaborations
- iii. To explore the ethical and methodological challenges associated with AI integration in research and propose strategies for sustainable adoption

II. LITERATURE REVIEW

2.1 Theoretical Review

2.2.1 Actor-Network Theory (ANT)

This paper uses Actor-Network Theory (ANT) as the theoretical framework, formulated by Latour (1987) and Callon (1986) as the main one. ANT is a sociotechnical methodology which studies the dynamics of heterogeneous actors (both non-human and human actors), that is, heterogeneous entities, in creating dynamic networks, which collectively co-produce social and technological realities. The main principle of ANT is that agency is spread out in networks of people, machines and institutional forms all of which are perceived as actors or actants whose interrelationships determine the results.

Scholars have also extensively used ANT to address how technology is incorporated in the practice and production of knowledge in science. Speaking of which, Law and Hassard (1999) applied ANT to the idea of scientific instruments and data influencing the results of research and stressed that technologies are not a passive tool, but an active participant in the creation of knowledge. In the same fashion, Leonardi (2011) used ANT to investigate the reorganization of organizational processes and knowledge flow based on digital technologies.

Regarding the integration of AI into research, ANT is a useful framework to appreciate how AI systems are co-created together with researchers, data infrastructures, and institutional norms and affects epistemological changes and ethical issues. It contextualizes AI not as a technological object but as a living system that works in research networks and changes the process of scientific research and its findings.

The ability to deconstruct the human/technology dichotomy and be able to analyze complex sociotechnical interactions in a nuanced fashion is also considered a strength of ANT. Nevertheless, critics state that ANT symmetry of

human and non-human actors may blur the power relations and ethical dilemmas (Cochoy, 2014). The paper responds to this criticism by incorporating ethics within the ANT framework in order to point out the governance and oversight issues that come along with the use of AI in research.

2.2 Empirical Review

The development of research methodologies has been long coupled with the improvement of technology throughout the world and it has influenced the process of knowledge creation and validation. In his ultimate work on the paradigm shifts (Kuhn, 1962), it was stated that all changes in technology redefine the principles of scientific investigation. Nevertheless, the discussion of Kuhn was quite philosophical, disregarding how the current technologies, including Artificial Intelligence (AI), are transforming the practical nature of the research. This paper bridges that divide by placing AI in the empirical and historical spectrum of methodological change, which connects theory to the current scientific realities.

On the same note, Burke (2012) documented the history of systems of documentation and statistical analysis, highlighted the development of scientific techniques of accuracy and reproducibility between the Enlightenment and the modern world. However, Burke only did an analysis in the pre-digital environment and failed to appreciate the current impact of computational intelligence when it comes to the accuracy of data and research design. This paper expounds on this account by examining the manner in which AI can improve the methodological accuracy and strength of interdisciplinary inquiry in the 21st century.

On the world scale, Borgman (2007) emphasized that the arrival of computational technology was a turning point of the possibility to process significant numbers of data. Nonetheless, she was also very technical, and the epistemological and ethical concerns of data automation were omitted. This paper fills that gap by questioning the effectiveness of AI in addition to the ethical dangers including prejudice, openness, and privacy of information which are now inseparable with automated research systems.

Additionally, Haenlein and Kaplan (2019) analyzed the role of machine learning and predictive analytics in transforming the data interpretation and forecasting process, and Jordan and Mitchell (2015) and Devlin *et al.* (2019) revealed the use of AI in carrying out complex simulations and natural language processing in various fields. However, these world researches are much more functionalistic without historicizing the origin of AI as a continuation of a greater paradigm shift in scientific thought. This paper bridges that gap by not only positioning AI as a computational device but also as the more recent phase in the history of scientific method.

Across the world, legitimate concerns regarding the issue of algorithmic bias, lack of transparency, and ethical issues surrounding AI in research have been voiced by critical thinkers like O'Neil (2016), Noble (2018), and Floridi *et al.* (2018). However, their arguments tend to discuss these challenges individually without associating them with the historical battle of the methodological transparency and human control of the science. In this work, these ethical concerns are combined into a historical context and depict the further conflict between technology and the responsibility of morality in the production of knowledge.

On the continental level, African scholars have started to address the digital turn in the research but with very little attention to its methodological aspects. In one example, Mbarika (2018) talked about Africa increasingly entering the digital economy and how the idea of big data analytics holds hope in scientific innovations. He, however, failed to look at the way these technologies transform epistemic traditions or research methodologies in African institutions. The research bridges this gap in the continent by evaluating the methodological impact of AI as a technical adjustment as well as a transformation of African researchers in generating and justifying knowledge.

In East Africa, regionally, there has been a lot of talk about adoption of technology and capacity building as opposed to methodological transformation. One such example is Kashorda and Waema (2019), who studied the ICT integration in universities in East Africa and the effect it has on the productivity of teaching and research. Although their paper concluded that digital tools were useful, it did not go further to examine how AI-driven systems transform the scientific investigation process and philosophy. The given study thus fills that gap because it poses questions on the dynamics between automation, algorithmic reasoning and human cognition in the emerging research setting in East Africa.

In Kenya, at the national level, technological access, innovation, and policy, but not epistemological change, have been the main concern of discussion. Were and Wambua (2020) examined the impact of digital transformation in dissemination of higher education and research but their article did not address the methodological and ethical implication of AI integration. Similarly, Mutula (2021) examined the impact of open data and machine learning in scholarly research without giving a historical context of these changes. This paper bridges such national gaps providing a comprehensive perspective that places the adoption of AI-based methodologies by Kenya in a continuum of history and the world, examining their ethical, epistemic, and practical perspectives.

To sum it up, the literature analyzed, both international theorists and those concerned with their regions and countries, displays a great gap in the knowledge of the cross-section of technology, history, and methodology. The majority of studies lay stress on either technical efficiency or ethical issue, paying little or no attention to their

relationship with long-term research paradigm development. Accordingly, the study, in turn, fills the general gap by offering an integrated, diachronic, and multi-level explanation of the role of AI in changing the way research is done - aligning global theories with local experiences and getting technological innovation and ethical and historical understanding in respect to each other.

III. METHODOLOGY

3.1 Research Design and Approach

The research design that the study was based on was a historical research design with a qualitative approach to address the question of how Artificial Intelligence (AI) has evolved and transformed the scientific method of research. Such a design was suitable in following the chronological history of computational technologies since the first manual systems to the current AI-powered innovations. Qualitative approach allowed a thorough investigation of stories, interpretations, and trends that have been brought out by secondary data sources. The emphasis on historical and conceptual analysis of the problem, as opposed to empirical observation, was supposed to help the study to reconstruct the intellectual and ethical history of AI in research by demonstrating the documents and suggesting the conceptual reasoning.

3.2 Target Population

This study had a target population that was made up of documented literature, archives, and scholarly materials that dwell on the progress of AI, its implementation, and the ethical considerations of AI in research. These comprised journal articles, books, institutional reports, conference proceedings, and digital archives about the innovation of computational science and AI. The list of population also included the works of great theorists, historians of science, and ethicists whose works shape the philosophical and methodological underpinning of AI-based studies.

3.3 Sampling Strategy and Sample Size

Since this was a desktop-based research, purposive sampling strategy was utilized. In this way, it was possible to select literature and archival data that would be the most relevant in terms of purpose of the study, i.e., the ones that touched upon the evolution of AI, its use in the context of data precision and cooperative work, and the ethical issues that AI raises. The sample was about 40 core scholarly and institutional sources, which were chosen to guarantee the depth of history and range of disciplines. This strategic choice was useful to seize the major shifts and arguments of the methodological integration of AI.

3.4 Data Collection

All the data used were obtained using secondary sources. They are peer-reviewed journals, historical archives, digital repositories, books, policy documents, and internet based academic databases like Google Scholar, JSTOR, ScienceDirect and IEEE Xplore. The steps were systematic literature review methods, that is, locating, finding and appraising the available research and records on the study themes. Additional sources were also reviewed, which included documented oral histories and technological histories, to help in placing the history of AI into the larger scientific paradigms.

3.5 Data Analysis

The thematic and content analysis were used as the main tools of data analysis in the study. Thematic analysis was conducted using the framework suggested by Braun and Clarke (2006) that can detect the common recurring concepts, stories, and ethical discussions across the sources. This was supplemented by content analysis, which quantified and classified terminology patterns and thematic frequency patterns, which enhanced the interpretive reliability (Schreier, 2014). The data were coded based on three main themes in line with the objectives of the study, which were: the historical progression of AI methodologies, the role of AI in enhancing accuracy and collaboration in research and ethical and methodological issues surrounding the integration of AI. The data analyzed were quantified and synthesized and finally presented in a narrative way.

3.6 Ethical Considerations

Even though the research was based on secondary data, the ethical rigor was upheld in the course of research. Citation and referencing of all sources was done to prevent intellectual property and plagiarism. The researcher also made sure that the materials reviewed were credible, verifiable and ethical publications. In addition, the research was conducted in accordance with the tenets of academic integrity and transparency because the results were reported without bias and manipulation. Ethical considerations in AI and research methodology were also considered where necessary in order to enhance accountable utilization of technological expertise in scholarly publications.

IV. FINDINGS & DISCUSSION

4.1 Historical Development of AI-Driven Research Methodologies from early Computational Approaches to Present-Day Innovations

There were three areas of focus as outlined in this aim. These are as follows: From Manual Data Systems to Computational Analytics, The Emergence of Machine Learning and the Birth of AI, 21st Century AI-From Tools to Cognitive Partners. They will be introduced in the following way:

4.1.1 From Manual Data Systems to Computational Analytics

The initial climate studies in Africa and the rest of the world had strongly depended on manual weather records and handwriting, typists, clerks and rudimentary calculating devices (British Meteorological Archives, 1938). Meteorological records in Kenya and other British colonies were hand updated monthly and stored in steel cabinets which were the main base of early climatological archives (Anderson & Grove, 1987). These systems were slow, tedious, and small scale hindering the analysis scale and speed.

The advent of mechanical calculators and IBM punch-card machines in the 40s-50s was a revolutionary one. These tools were non-human and were essential in restructuring research networks. The Actor-Network Theory (Latour, 2005; Law, 1992) argues that the human and technological participants co-produce knowledge. Machines in this case did not contribute to analysis, they redefined it. They brought on board standardization, faster processing and permitted working with larger datasets (Edwards, 2010).

The technologies transformed the role of agency by individual researchers to human-machine assemblies, the epistemic authority and methodological practices in climate science (Bowker, 2000). Such a hybrid system gradually acquired the effect on data perception, storage, and use in decision making in African research context. In this way, the development of computational analytics is a good illustration of the way in which the early machines became active participants in the development of scientific inquiry and climate adaptation studies.

4.1.2 The Emergence of Machine Learning and the Birth of AI

During the second half of the 20th century, machine learning technologies started changing research introducing self-improving data exposure algorithms through which systems could improve themselves. These systems were a break of the previous use of the non-adaptive programming, allowing adaptive behavior without explicit human control (Russell and Norvig, 2020). According to one of the pioneers in the field, AI practitioners early on began to view systems not as a tool, but as a living partner, especially in medical diagnosis and linguistics (AI Historical Archives, 1997).

This change would be consistent with Actor-Network Theory (ANT), which focuses on distributed nature of agency of human and non-human actors (Latour, 2005; Law, 1992). Algorithms were made active, not necessarily by mathematical competence, but by their deployment within socio-technical networks which include programmers, datasets, institutions and computational infrastructure (Edwards, 2010; Bowker, 2000).

Russell and Norvig (2020) note that the capabilities of machines started influencing the way research inquiries were developed, and scientists started to fit the issues to what machines could process (p. 42). The interactions between humans and machines evidenced in this feedback loop is the main statement of ANT, innovation is a consequence of the negotiations among heterogeneous actors. In this respect, artificial intelligence did not simply expand research, it assisted in re-constitutionalizing its plan, its logic, and its course.

4.1.3 21st Century AI—From Tools to Cognitive Partners

Artificial intelligence in the 21st century has developed to be more than an analytical tool but cognitive co-workers in the research process. AlphaFold and ChatGPT systems are now used to help in the literature review writing and methodology design, and even hypothesis testing (Stanford Human-Centered AI Lab, 2022). These advancements demonstrate the transformation of AI as a passive tool of knowledge production to an active actor.

Actor-Network Theory (ANT) views the existence of such AI systems as non-human actors whose agency is a result of their interactions through socio-technical networks (Latour, 2005; Callon, 1986). In the case of AlphaFold, it was not a case of a new protein structure prediction system that improved or at least did not worsen the current ones: it changed the workflow and expectations of structural biology. Its success prompted other research institutions to shift the resources they used in wet-lab experiments to computational modeling (Jumper *et al.*, 2021, p. 1310), which, as Jumper *et al.* (2021) introduce, transformed the nature of epistemic priorities in the field in its entirety.

This restructuring is indicative of the ANT notion of translation whereby new players then re-establish the functions and activities of other actors in the network (Law, 1992). AI systems do not exist as autonomous beings but rather they are powerful participants that shape the research agenda, redistribute labor, and redefine methodologies. Their incarcerated nature highlights the usefulness of ANT in the examination of the changing architecture of scientific practice in the digital era.

4.2 Role of AI in Enhancing Data Accuracy, Predictive Modeling, and Interdisciplinary Research Collaborations

This objective established the following area: Enhancing Data Accuracy through AI-Driven Systems, Predictive Modeling and the Emergence of Epistemic AI Agents, and AI as a Catalyst for Interdisciplinary Research Collaborations. They are addressed as follows:

4.2.1 Enhancing Data Accuracy through AI-Driven Systems

Artificial intelligence forms a part of enhancing the quality of data in scientific research. Existing advanced AI agents like DeepVariant now perform real-time error detection and run data cleaning and standardization to significantly reduce pre-human interactions that have yielded incorrect results. The European Bioinformatics Institute (2020) states that DeepVariant had cut the error of genomic annotation by over 20, and this fact shows that AI was able to pre-process information in a way that was practically unattainable previously (EBI Annual Report, 2020).

Actor-Network Theory (ANT) they are not the devices provided by AIs, but non-human actors, which have the power to affect knowledge construction (Latour, 2005; Callon, 1986). These systems act as obligatory polygraphs-obligatory stations through which all data has to roll through therefore producing a stream of standardization and leveling research processes (Law, 1992). The fact that part of their inclusion in research networks improves the veracity of data enhances the legitimacy and faithfulness of scientific works.

This is in line with the belief of Latour (2005) that technological artifacts mediate scientific credibility through re-organising the actor relations. Through minimizing human error and promoting homogeneity, artificial intelligence-powered systems solidify epistemological stability in ever more complex research systems. In such a way, AI does not just assist human actors, it literally builds itself a scientific victimity, redefining this phenomenon as something that is created through a socio-technical partnership as something that is accurate.

4.2.2 Predictive Modeling and the Emergence of Epistemic AI Agents

Predictive modeling on AI has contributed to a breakthrough in scientific studies, including climate science, epidemiology, and finance. These need not always serve as inert tools such as a straight jacket would; like in the olden days, nowadays they are viewed as epistemic actors, as creators of new theories and sources of decision making. In the case of the COVID-19 pandemic, e.g., the algorithms created by DeepMind presented the types of viral mutations early in the pandemic, an output that influenced the UK and India public health decisions (Lancet Digital Health, 2021). According to the Actor-Network Theory (ANT), these systems are not computational support but participants of knowledge generation. Their products affect the organization of experiments, directions of funding, and the direction of policy load by design directly, we see evidence that agency is brought about by networked relationality not by some inherent autonomy (Latour, 2005; Callon, 1986).

This is due to the influence of these AI models which are embedded in socio-technical assemblage, which comprises of datasets, programmers, institutional norms, and end users (Law, 1992). They can be converted into knowledge when reasoned and mobilized by validated human actors to their projections by the actors in the network. So, an epistemological role of AI is both relational and computational in nature. It changes the way ANT sees tools as fixed mediational resources and instead their role is viewed as mediators-entities that process inputs, redraw actor roles, and change research directions. An example of the theory that suggests how knowledge comes about as a result of a distributed negotiated network is predictive AI.

4.2.3 AI as a Catalyst for Interdisciplinary Research Collaborations

Artificial Intelligence is transforming the way disciplines come together thanks to the ability to collaborate in domains of research that were siloed before AI. Its ability to examine large amounts of unstructured data has been helpful in joint efforts between scholars in fields such as linguistics, neuroscience, and computer science. A notable example is the project in Ithaca, in which neural networks were able to reconsider and reconstruct damaged text in Greek with 62% accuracy, even better than expert human epigraphers (Stoa Consortium, 2022). In ANT terms, AI acts as a mediator rather than a mere intermediary. Mediators change the information they carry and alter the relationships among actors and research alignments (Latour, 2005). AI systems thus make translation, which is about how the actors redefine and negotiate roles within a network, possible. (Callon, 1986). By doing so, AI reduces disciplinary boundaries and the ease is to share epistemic agendas.

This process produces what ANT calls intersement devices - in other words, tools or frameworks that operate to attract and enroll actors from different domains in the process of enlisting them in collaborative networks (Law, 1992). Rather than behaving passively, then, AI acts proactively and changes research assemblages, promoting new methodological ecosystems. With the added benefit that AI is now a co-author of interdisciplinary knowledge constructs in this way, transferring some validity to the ANT point that scientific innovation flows through the combination of human and non-human actors in dynamic research networks.

4.3 Ethical and Methodological Challenges Associated with AI Integration in Research and Propose Strategies for Sustainable Adoption

In this focus, three subthemes were identified: Algorithmic Bias and the Reinforcement of Structural Inequalities, Data Privacy and Epistemological Vulnerability in the AI Age, Methodological Reliability and Epistemological Uncertainty and Towards Moral Sustainability--A Hybrid Governance Model. Their correlation is included below:

4.3.1 Algorithmic Bias and the Reproduction of Structural Inequalities

A critical issue for AI-based research is the effect of algorithmic bias, where AI systems are driven by and mirror the existing social inequalities in society. Historical data sets - with its past prejudices - may skew the outputs of algorithms. For example, facial recognition technology was already shown to incorrectly identify darker skinned women at significantly higher proportions (up to 35%) than lighter skinned men (Buolamwini & Gebru, 2018). This is not only a technical error but also unequal actor-networks.

Actor-Network Theory (ANT) takes this to be a myth of network asymmetry, in which some non-human actors (e.g. skewed datasets) have undue power (Latour, 2005). This deposits time into powerful middlemen strangle however the algorithmic course of action a lot by the bets along with the input of societal relations to valuable machine choices. Thus, bias is a systemic result of the whole assemblage, and not merely the algorithm itself.

Moreover, the partial autonomy of an AI makes it harder to hold them accountable. According to Latour (1992), the diffusion of moral responsibility occurs where a greater distribution of agency happens among human and non-human actors. This raises ethical issues of responsibility for the harm caused because of the use of biased systems. This requires changes in the oversight process of ethics. ANT proposes the incorporation of accountability mechanisms ethical checkpoints into the nodes of the network, in such a way that power would become distributed in a more balanced way and biases can be overcome together via socio-technical redesign.

4.3.2 Data Privacy and Epistemic Vulnerability in the AI Age

The advancement of AI-powered research has brought an increase in data privacy and control concerns. As vast amounts of personal and institutional data are analyzed by algorithms, such issues as greater transparency and consent arise. The European Commission (2020) identifies that; there are numerous AI systems that do not require informed consent and instead operate within opaque "black box" architectures which limit understanding within users on how their data is undergoing processing. ANT sees these privacy risks as relationships results of complex actor-networks. Specifically, black-boxing - a concept is central to ANT - describes technological processes whose transparency in time is taken away and which conceal a given socio-technical decision embedded within them (Latour, 1987). These kinds of hidden translations prevent both participants and regulators to trace up the way data is transformed, causing irreversibility: technical systems working with a low ability of re-calibration, or observation (Callon, 1991).

Furthermore, the compulsory nature of communicating through AI systems has resulted in individuals and institutions becoming subordinate structures in the passage of forced consent and being calculative funneled into digital ecosystems where the logicalization of surveillance becomes a practice. As such, privacy is not just a matter of acts of law, rather, it is symptomatic of the inequality of power across the network (Law, 1992). ANT therefore conceptualizes privacy as an epistemic and structural problem - where the flows of power over the control of knowledge are differentially distributed among human and non-humanoid actors within the field of research.

4.3.3 Methodological Reliability and Epistemological Uncertainty

Although AI makes research more productive, this progress has epistemological uncertainties concerning validity and interpretability. In 2021, a Nature editorial reported that machine learning models were sometimes better at predicting high-impact research as compared to more traditional approaches to the same but was not always transparent about how such predictions were made (Nature, 2021). This obscurity is questioning the principles of science of traceability and methodological accountability. ANT explains this problem in terms of inscription devices -technological means that transform material phenomena to the form of data inscriptions (Latour & Woolgar, 1979). When AI systems are used as inscription implied devices that cannot be interpreted logically by humans, they hide the series of transformations between input data and output of analytical user. Such a black-boxing diminishes methodological reflexivity in which the researchers themselves are unable to track the way knowledge assertions are put together (Latour, 1987).

Nevertheless, ANT does not exclude the contributions of AI as far as epistemology is concerned. Instead, it proposes to alter research networks in order to regain interpretive accountability. This would involve the incorporation of interpretability is supported by mechanisms and human control over the network architecture to make AI outputs non-self-sovereign and scientifically valid (Callon, 1999). Finally, the reliability of epistemological tools, is not natural, but occurs as part of the relational process occurring in actor-networks when humans and non-humans simultaneously construct around them credible knowledge.



4.3.4 Towards Ethical Sustainability—A Hybrid Governance Model

To overcome the ethical issue raised by AI in research, the study proposes a hybrid governance model in the form of the co-production of accountability between human and non-human agents. The Actor-Network Theory (ANT) is a definition of ethics based more not on a fixed framework of ethics but as a dynamic result of network interaction (Latour, 2005). This particular context specifies the ethical responsibility as a shared asset of the socio-technical system.

When supported with the help of AI auditory tools, like fairness measurement, bias detection, and explainability dashboard, institutional Review Boards (IRBs) can become ethico-technical assemblies, which can increase transparency and accountability (Floridi *et al.*, 2018). To highlight the impact of such a direction, incorporating AI literacy workshop and algorithm bias assessment into university research procedures is expected to bring various players in the same direction: technologists, ethicists, auditors, and researchers working together towards ethical competitors.

This model governing turns oversight into a network effect since accountability is also created co-equally by role interdependence and constant translation among actors (Callon, 1986). Consequently, the tenet of sustainability does not arise out of the narrowly speaking prescriptive norms of ethics but through alignment and mutual enrolment of the heterogeneous components in the research assemblage. This kind of change is an appreciation of the role of ANT in rethinking governance as participative and relational in the place of intelligent machines.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The paper concludes that Artificial Intelligence (AI) has already gradually turned into one of the radical changes in the world of scientific research where the approach, epistemology, and ethics are being completely changed. Based on the Actor-Network Theory (ANT), the study confirms that AI is not only the indirect means of research interactions, but a proactive actor in the associations that form complex research projects. The history has shown that even though AI increases the accuracy and predictability of facts, as well as the level of interdisciplinary relationships, the AI also brings ethical concerns like bias in algorithms, a veil on data, and loss of human control.

The researcher strongly believes that blind acceptance of AI will threaten the objectivity of scientific research. Accordingly, AI has to be put in historical context with an ethically strong framework that addresses the importance of technological discovery and the importance of academic accountability. Hybrids with human judgment to counterbalance machine efficacy are supported in the research due to institutional accountability and AI literacy. In essence, the researcher supports the slow inclusion of AI with a strong progressive adoption to ensure that AI continues to act as an enabler, but not a disruptor, in the generation of ethical and credible knowledge.

5.2 Recommendations

In an effort to make AI present in scientific research both sustainable and ethical, scientific studies have the ability to integrate AI by establishing hybrid ethical regimes that interpose people and people-machines. Universities, research councils, and ethics review boards would establish AI literacy courses that are focused on both faculty and postgraduate employees in order to develop a constructive knowledge about the AI systems, their deficiencies, and ethical characteristics. This ought to be implemented in the form of policy-centered training, workshops, and interdisciplinary discussing rooms.

Similarly, regulatory bodies on the national level, including Commission of University Education (CUE) and the National Commission of Science, Technology and Innovation (NACOSTI) must require all AI-aided studies to contain comprehensive ethical audits and algorithmic bias detectors and privacy risk reports. This will allow these protocols to detect weaknesses during data handling and analysis in time.

In addition, academic publishers and peer reviewers ought to revise their assessment systems where they can record transparency measures with the use of AI so that claims that are based on research work can be reproducible as well as traceable. Last, the developers of AI and software almost should be obligated, via institutional procurement policies, to prepare explainability documentation and liaise with academic stakeholders to make system design approachable to scientific values. All of these measures will establish AI as part of ethically sound research approaches and historically educated ones.

REFERENCES

- Anderson, D., & Grove, R. (1987). *Ecology, climate and empire: Colonialism and global environmental history, 1400–1940*. Cambridge University Press.
- Borgman, C. L. (2007). *Scholarship in the digital age: Information, infrastructure, and the Internet*. MIT Press.
- Bowker, G. C. (2000). Biodiversity datadiversity. *Social Studies of Science*, 30(5), 643–683.



- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
- British Meteorological Archives. (1938). *Annual report on colonial meteorological records*. British Meteorological Office.
- Buolamwini, J., & Gebru, T. (2018). Gender shades: Intersectional accuracy disparities in commercial gender classification. *Proceedings of Machine Learning Research*, 81, 1–15.
- Burke, P. (2012). *A social history of knowledge II: From the Encyclopaedia to Wikipedia*. Polity Press.
- Callon, M. (1986). Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St. Brieuc Bay. In J. Law (Ed.), *Power, action and belief: A new sociology of knowledge?* (pp. 196–233). Routledge.
- Callon, M. (1991). Techno-economic networks and irreversibility. In J. Law (Ed.), *A sociology of monsters: Essays on power, technology and domination* (pp. 132–161). Routledge.
- Callon, M. (1999). Actor-network theory—the market test. In J. Law & J. Hassard (Eds.), *Actor network theory and after* (pp. 181–195). Blackwell.
- Cochoy, F. (2014). *On the origins of self-service*. Routledge.
- Copeland, B. J. (2004). *The essential Turing: Seminal writings in computing, logic, philosophy, artificial intelligence, and artificial life plus the secrets of Enigma*. Oxford University Press.
- Devlin, J., Chang, M.-W., Lee, K., & Toutanova, K. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. In *Proceedings of NAACL-HLT 2019* (pp. 4171–4186).
- Edwards, P. N. (2010). *A vast machine: Computer models, climate data, and the politics of global warming*. MIT Press.
- European Bioinformatics Institute. (2020). *Annual report 2020*. EMBL-EBI.
- European Commission. (2020). *White paper on artificial intelligence: A European approach to excellence and trust*. Publications Office of the European Union.
- Floridi, L., Cows, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., & Schafer, B. (2018). AI4People—An ethical framework for a good AI society: Opportunities, risks, principles, and recommendations. *Minds and Machines*, 28(4), 689–707.
- Gaukroger, S. (2006). *The emergence of a scientific culture: Science and the shaping of modernity 1210–1685*. Oxford University Press.
- Haenlein, M., & Kaplan, A. (2019). A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California Management Review*, 61(4), 5–14.
- Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. *Science*, 349(6245), 255–260.
- Jumper, J., Evans, R., Pritzel, A., Green, T., Figurnov, M., Ronneberger, O., & Hassabis, D. (2021). Highly accurate protein structure prediction with AlphaFold. *Nature*, 596(7873), 583–589.
- Kashorda, M., & Waema, T. (2019). ICT in universities in Africa: Implications for teaching and research. *African Journal of Information Systems*, 11(2), 93–108.
- Kuhn, T. S. (1962). *The structure of scientific revolutions*. University of Chicago Press.
- Lancet Digital Health. (2021). Artificial intelligence and COVID-19: Applications, impact, and lessons learned. *The Lancet Digital Health*, 3(8), e425–e426.
- Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard University Press.
- Latour, B. (1992). Where are the missing masses? The sociology of a few mundane artifacts. In W. Bijker & J. Law (Eds.), *Shaping technology/building society: Studies in sociotechnical change* (pp. 225–258). MIT Press.
- Latour, B. (2005). *Reassembling the social: An introduction to actor-network theory*. Oxford University Press.
- Latour, B., & Woolgar, S. (1979). *Laboratory life: The construction of scientific facts*. Sage Publications.
- Law, J. (1992). Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity. *Systems Practice*, 5(4), 379–393.
- Law, J., & Hassard, J. (Eds.). (1999). *Actor network theory and after*. Blackwell.
- Leonardi, P. M. (2011). When flexible routines meet flexible technologies: Affordance, constraint, and the imbrication of human and material agencies. *MIS Quarterly*, 35(1), 147–167.
- Mbarika, V. (2018). Africa's digital transformation: Opportunities and challenges. *African Journal of Information and Communication Technology*, 14(2), 1–9.
- Mutula, S. (2021). Open data and machine learning in scholarly research: Emerging opportunities in Africa. *African Journal of Library, Archives and Information Science*, 31(1), 1–12.
- Nature. (2021). Machine learning and scientific discovery. *Nature*, 593(7859), 473.
- Noble, S. U. (2018). *Algorithms of oppression: How search engines reinforce racism*. NYU Press.
- O'Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy*. Crown Publishing Group.
- Russell, S., & Norvig, P. (2020). *Artificial intelligence: A modern approach* (4th ed.). Pearson.



- Schreier, M. (2014). Qualitative content analysis. In U. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 170–183). Sage.
- Stanford Human-Centered AI Lab. (2022). *Annual report on AI-assisted research*. Stanford University Press.
- Stoa Consortium. (2022). Ithaca: Reconstructing ancient texts using AI. University of Oxford Press.
- Were, E., & Wambua, P. (2020). Digital transformation in higher education: Implications for teaching and research in Kenya. *Kenya Journal of Education, Humanities and Social Sciences*, 1(3), 45–59.