

CHALLENGES AND DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN THE AFRICA CONTEXT

DESAFIOS E DESENVOLVIMENTO DA INTELIGÊNCIA ARTIFICIAL NO CONTEXTO DA ÁFRICA

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RESUMO

This paper presents the impact of artificial intelligence in developing countries, particularly in the African context, identifying the challenges and opportunities that this technology offers. AI emerges as a potential tool to transform various sectors, including health, education, and agriculture, in countries like Angola. Although the current context presents many opportunities, it also faces significant challenges, such as insufficient infrastructure, the need for capacity building, and lack of regulation. The research aims to understand the impact of AI in critical sectors and evaluate the conditions for its effective adoption. The methodology used involves a systematic bibliographic review of programs, articles, books and reports, with a focus on recent publications. The main method of this article is narrative review, because the study was based on a broad and exploratory synthesis of the existing literature. This study uses a qualitative research based on interpretative analysis of data obtained from various sources, including websites, libraries, and national organizations, allowing for the articulation of existing studies on the topic and understanding the reality of AI in developing countries. Overall, the negative impacts may include dependence on technological companies and infrastructure from developed countries, inequality in access to technologies, and ethical and regulatory challenges.

Keywords: Artificial intelligence, Impact, Technology.

ABSTRACT

Este artigo apresenta o impacto da inteligência artificial em países em desenvolvimento, especialmente no contexto africano, identificando os desafios e oportunidades que essa tecnologia oferece. A IA surge como uma ferramenta potencial para transformar diversos setores, incluindo saúde, educação e agricultura, em países como Angola. Embora o cenário atual apresente muitas oportunidades, também enfrenta desafios significativos, como infraestrutura insuficiente, necessidade de capacitação e falta de regulamentação. A pesquisa tem como objetivo compreender o impacto da IA em setores críticos e avaliar as condições para sua adoção efetiva. A metodologia utilizada envolve uma revisão bibliográfica sistemática de programas, artigos, livros e relatórios, com foco em publicações recentes. O principal método deste artigo é a revisão da literatura, porque o estudo foi baseado numa síntese ampla e exploratória da literatura já existente. Este estudo utiliza uma abordagem qualitativa baseada na análise interpretativa de dados obtidos a partir de diversas fontes, incluindo sites, bibliotecas e organizações nacionais, permitindo a articulação de estudos existentes sobre o tema e a compreensão da realidade da IA em países em desenvolvimento. De maneira geral, os impactos negativos podem incluir dependência de empresas tecnológicas e infraestrutura de países desenvolvidos, desigualdade no acesso às tecnologias e desafios éticos e regulatórios.

Palavras-chave: Inteligência artificial, Impacto, Tecnologia.



INTRODUCTION

Artificial Intelligence (AI) is “considered a rapidly developing technology with the potential to create and present previously unimaginable challenges for societies” (Gabbiadini et al., 2024, p. 1). Both developed and developing countries face distinct challenges with the growing adoption of AI. The 21st century has been marked by a technological revolution and radical scientific advances that are continuously transforming our daily lives.

AI has existed since the mid-1970s and constitutes a field of computing that enables interaction between humans and machines. Through specific programming, these machines can perform tasks, reason, learn, and make assertive decisions without emotions (Costa, 2024).

Recent developments in AI have been driven by significant progress in areas such as computer vision, autonomous vehicles, virtual assistants, and personalized medicine. These advances have resulted in more accessible, efficient, and adaptable technologies, allowing some African countries to begin benefiting from these innovations. This article is situated within the context of automation systems and societal transformations, where the study of AI is both current and essential (Smith & Johnson, 2022).

In this context, this paper examines the contrast between technological innovations in developed countries and the challenges faced by developing nations. The research seeks to provide a perspective on possible pathways for developing countries to maximize the benefits of AI while mitigating its disadvantages. While developed nations possess advanced infrastructure and resources to invest in AI research and development, developing countries, such as those in Africa, face challenges such as limited digital infrastructure, lack of human capital, socioeconomic inequalities, regulatory issues, and restricted access to data (Brynjolfsson et al., 2017).

Given this reality, there is an urgent need to investigate the impact of AI in African countries. This research aims to identify areas where AI can generate the greatest benefits, particularly by making digital services more accessible to citizens in developing nations. In summary, “what we need to decide now is no longer whether we will have AI, but how we will have AI” (Carvalho, 2021, p. 32). This highlights that the central challenge lies not in the mere presence of AI, but in its implementation, considering the potential risks and benefits it may bring to developing societies.

The central question of this study is: What challenges and opportunities can the implementation of Artificial Intelligence bring to developing countries, considering the advances of the technological industry? Accordingly, the aim of this article is to investigate the impact of AI in



developing nations, with a particular focus on Angola, highlighting the challenges and opportunities in adopting these technologies while taking into account their economic and social specificities.

The article is structured as follows: Section 2 presents the theoretical framework and the history of AI; Section 3 describes the research methodology; and Section 4 discusses the results and outlines the study's conclusions.

The literature review and Brief History of Artificial Intelligence

Artificial intelligence is a field of Computer Science that aims to create machines or systems capable of performing tasks that typically require human intelligence (Frey & Osborne, 2017). The term was first used in 1956 by John McCarthy at the Dartmouth Conference, considered the founding event of AI. The goal was to create machines capable of carrying out cognitive tasks such as problem-solving and learning (McCarthy, 1956). According to Reisier, 2024, p.20), Intelligence is:

A multifaceted attribute that encompasses various intellectual characteristics, such as knowing, understanding, reasoning, and interpreting. Originating from the Latin term *intelligentia*, it refers to the ability to choose among various possibilities, involving the process of evaluating the advantages and disadvantages of options through reasoning, thought, understanding, memory, judgment, abstraction, imagination, and conception. This definition of intelligence may vary according to the context, such as in psychology, where it refers to the ability to learn and relate, or in biology, associated with adaptation to new environments.

The field of AI has witnessed significant advances, particularly with the emergence of Deep Learning in 2016 and Generative AI in 2020, which includes the release of GPT-3 and GPT-4 (Brown et al., 2020). AI encompasses concepts such as Machine Learning (ML), which enables machines to learn from data without being explicitly programmed, examples include recommendation systems used by Netflix, YouTube, Siri, and Alexa and Deep Learning (DL), which uses multilayer neural networks to identify complex patterns for example Tesla's self-driving cars and medical diagnostics.

Technologies such as Natural Language Processing (NLP) and robotics are also key components of AI examples include voice assistants like Siri and Google Assistant, which interpret voice commands Robotics (Craig, 2005). AI is very useful for our personal, work, and school activities because it generates various patterns.

On a global scale, developed countries lead innovation and investment in AI, while developing countries strive to keep pace and harness the opportunities offered by this technology (Smith &

Neupane, 2018). Zuboff (2019) argues that AI can increase the disparity of power between global corporations and local economies, particularly in developing nations. The lack of adequate infrastructure in these countries may prevent AI from driving economic growth, thereby widening the gap between nations rather than closing it.

AI can also be leveraged to achieve sustainable development goals, especially in health and education. With the onset of COVID-19, many developing countries invested in AI models to predict outbreaks and optimize the allocation of hospital resources (Giordano et al., 2023).

Therefore the journey of Artificial Intelligence, the distinction between weak and strong Artificial Intelligence plays a crucial role. Then according to Reisier (2024, 53) argue that:

These two types of AI differ significantly in terms of capacity and scope, outlining the limits and possibilities of the technology. Weak or Narrow Artificial Intelligence Machine learning. It specializes in one area and solves a problem. Strong or General Artificial Intelligence refers to a computer that is intelligent like a human being in all aspects.

Despite these benefits, AI also presents disadvantages, as it may fail to generate positive outcomes if there is no infrastructure or workforce training to keep up with innovations (Brynjolfsson et al., 2017). Authors such as Sousa (2017), Brynjolfsson et al. (2017), Lee (2018), Zonta et al. (2020), Wang et al. (2023), and other reports have discussed these pros and cons of AI, which this paper considers as challenges and opportunities.

METHODOLOGY

The methodology adopted in this study was based on a narrative and exploratory literature review. This approach was chosen as it is suitable for articulating existing studies on the subject, allowing for a broad and descriptive synthesis of the published literature on Artificial Intelligence in developing countries, with a focus on Angola. The research gathered information from databases such as Scopus and Google Scholar. Additionally, reports, decrees, government programs, and documents from international organizations such as the UN, the World Bank, and the IMF were analyzed.

In Google Scholar, ten works were found using the descriptors “Angola” and “internet,” of which 20 addressed the importance of the internet. When the descriptor “AI” was included in the search criteria, the number dropped to ten, a recurring and relevant issue for the topic.

This research adopts a qualitative, exploratory approach, aiming to address the research objective through a literature discussion: “focused on understanding and interpreting



consequences, considering the meaning attributed by others to their practices” (Bortolotti, 2015, p.77).

The main method of this article is narrative review, because the study was based on a broad and exploratory synthesis of the existing literature (Vergara, 2014). The idea is to explore previously established concepts regarding the risks, challenges, and opportunities of Artificial Intelligence in developing countries, from the technological perspective of a developed country, reviewing the main theories related to AI.

Data collection was further complemented by reviewing articles from the *Jornal de Angola* and scientific publications from national and international digital libraries. The study employs an interpretative analysis to integrate different authors’ perspectives, aiming to understand the advantages and challenges of AI in both the African and Angolan contexts, so we discuss with many authors.

In this stage, ChatGPT was used as support for text correction and the organization of bibliographic references.

RESULTS AND DISCUSSIONS

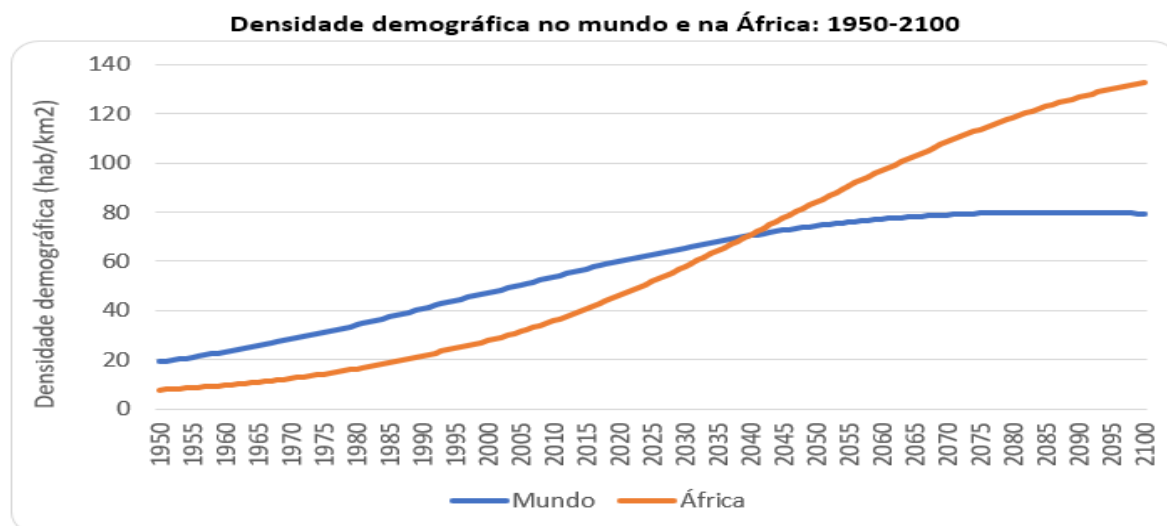
The implementation of AI in developing countries varies considerably depending on political and socioeconomic factors (Arakpogun, 2021). Several studies emphasize that AI holds the potential to transform key sectors such as health, education, and agriculture across Africa. Nonetheless, scholars point out that its adoption continues to face substantial barriers, particularly related to security, governance, and the institutional capacity required to establish a solid foundation for technological deployment (Arakpogun, 2021).

In line with these findings, a World Bank (2021) report underscores that the slow adoption of AI in Africa is largely explained by persistent limitations in technological infrastructure. Challenges such as the insufficient availability of computers, network connectivity, and reliable access to electricity are identified as critical obstacles. At the same time, the report highlights that AI can play an important role in advancing education by enabling personalized learning pathways, supporting teachers, and improving education management systems (World Bank, 2021).

Another key dimension addressed in the literature relates to Africa’s demographic dynamics. According to the United Nations Development Programme (UNDP), the continent has one of the youngest populations globally, combined with one of the highest growth rates, which generates increasing pressure on education systems to adopt innovative methods (UNDP, 2024). Projections further suggest that Africa’s population will double by 2050. Scholars argue

that this demographic boom makes it imperative to adopt scalable technologies capable of responding to growing social demands, particularly in education and health.

Figure 1. Illustration of the long-term evolution of global and African population density



Source: Adapted from United Nations/ESA, World Population Prospects, 2022.

In 1950, the global population density was 19.2 inhabitants/km², increasing to 61.2 in 2022, with projections indicating it will reach 80 by 2100. In Africa, the density was 9.1 inhabitants/km² in 1950 and is expected to surpass the global average by 2040, reaching 133 inhabitants/km² by 2100.

The discussion regarding Angola, in particular, reveals a scenario of contrasts. The United Nations Population Fund (UNFPA) estimates that Angola will reach 38.9 million inhabitants in 2024. Although internet infrastructure remains limited, especially in rural areas (Furtado, 2020), the country has made significant investments. The number of internet users in Angola increased from 6 million in 2022 to over 11 million between 2021 and 2023 (Angotic, 2024), with 75% of the population accessing the internet via mobile phones.

The Angolan government has intensified investments in the telecommunications sector, leading to an increase in operators and ICT services. These initiatives aim to improve digital infrastructure and expand connectivity, boosting digital transformation and global market competitiveness (Barbante, 2020).

Companies such as Unitel, Movitel, and Africell are investing in submarine cables to enhance Angola's connectivity. A key example is Angosat-2, a satellite designed to improve national communications. The National Bank of Angola (2021) highlights AI's innovations in the

banking sector, enhancing efficiency and financial inclusion. To operate it, a Mission Control Center (MCC) was established in Luanda. Figure 2 shows an image of the MCC.

Figure 2. Satellite Mission and Control Center



Source: Adapted by Parque de Transmissão de Satélites e Intercâmbio (2023)

These investments are crucial for the modernization of Angola's digital infrastructure and for expanding internet access, which forms the foundation for any AI adoption. However, the scarcity of professionals specialized in AI and the need for an adequate regulatory framework remain significant barriers (Tavares, 2020). AI, as a tool, must be guided by humans to ensure its ethical and responsible use.

According to Reisier (2024, 386) think that:

The introduction of Artificial Intelligence in the labor market brings both benefits and challenges. So far, technology and automation have contributed to increasing human productivity, which, in turn, has stimulated the economy to create types of jobs. This phenomenon, known as “technological unemployment,” has not yet resulted in mass unemployment, mainly because new opportunities continue to arise as certain tasks are automated.

The same author If and when this scenario materializes, governments and developed societies or in Angola will face the challenge of restructuring their economic and social systems.

Tables 1 and 2, adapted from Zuboff (2019) and Heeks (2017), respectively, illustrate the challenges and opportunities of AI in the Angolan and African contexts. AI can exacerbate inequalities if there is no investment in education and social inclusion (Brynjolfsson et al., 2017). On the other hand, the technology can optimize public services and stimulate economic growth (Heeks, 2017).

Table 1. Challenges of Artificial Intelligence

Challenges	
Social and Economic Inequality	Increases inequalities between countries, generating the concentration of wealth in developed countries.
Lack of digital infrastructure	Inadequate internet connections and low data processing capacity affect the adoption of AI.
Scarcity of human capital	Limits the effective implementation of these technologies.
Regulatory issues	For data protection and privacy.
Access to data	For AI algorithms to work efficiently, large volumes of data are required.
Technological dependence	This technology is still found in large technology companies in developed countries.

Source: Adapted of Zuboff (2019).

In the same sequence, we also present the opportunities for the implementation of Artificial Intelligence, as shown in Table 2 below.

Table 2. Opportunities of Artificial Intelligence

Opportunities	
Optimization of public economic services	AI can improve the efficiency of public services, such as healthcare, education, and transportation, providing more effective and accessible solutions
Digital Inclusion	The technology can facilitate access.
Economic Development Improvement in Decision Making	The adoption of AI can stimulate economic growth, creating new job opportunities and innovating traditional sectors.
Improvement in Decision Making	AI contributes to decision-making in complex cases.

Source: Adapted of Heeks (2017)

Sousa (2017, p.3), an Angolan professor and researcher in the fields of Technology and Information, argues that:

The industrial sector, for example, with the automation of its services and the implementation of ICT, has made it possible to carry out activities in a short period of time that would not be feasible without this type of technology. This process allows for time optimization and increased production in this sector.



This perspective from Sousa highlights the efforts Angola has been making in the field of Information Technology.

Despite the challenges, we recognizing the importance of this discussion, some legislative proposals have been introduced in both Brazil and Angola. According to Law no.23/11(2011) concerning electronic communications and information society services. Article 14, section (a), of this law states: “Ensure universal access to information and knowledge for all citizens, combating social inequalities and info-exclusion, and eliminating the digital divide caused by economic, geographic, and physical barriers”.

Meanwhile, Brazil's Law 2338/23, in Chapter V on civil liability, establishes in Article 27 that:

The provider or operator of an artificial intelligence system that causes material, moral, individual, or collective damage is required to fully compensate for it, regardless of the system's degree of autonomy. In cases involving high-risk or excessive-risk artificial intelligence systems, the provider or operator is strictly liable for damages caused, according to their level of involvement in the harm.

This comparison highlights the importance of a clear regulatory framework to guide the implementation of the technology.

In Angola, studies show that despite progress in communication and information policies, the country still faces significant challenges. Internet infrastructure remains limited, particularly in rural areas, which directly affects the use of AI, as it relies heavily on connectivity. Moreover, there is a shortage of professionals specialized in AI, data science, and technology, which hinders AI's rapid advancement in the country.

In Angola, policies are still under development, and there is an urgent need for a regulatory framework that promotes technological innovation while ensuring data protection and user privacy.

Thus, technologies such as quantum computing, ChatGPT 4.4, computer vision, deep learning, machine learning, generative AI, quantum machines, and the Da Vinci robot remain virtually nonexistent in many developing countries due to a lack of qualified human resources and technological infrastructure.

Universities play a crucial role in fostering AI skills, particularly in applying this technology to areas such as diagnostics and healthcare services in remote and hard-to-reach regions. The development and widespread adoption of AI technologies have revolutionized various aspects of human activity. Forecasts indicate that AI will continue to drive even deeper economic and social transformations in the near future, expanding its impact across multiple spheres of society.

CONCLUSIONS

Despite facing challenges related to infrastructure and workforce training, Angola holds immense potential for artificial intelligence to drive development, particularly in sectors such as education, healthcare, agriculture, and financial services.

For AI to have a positive impact, it is essential to invest in education and the training of professionals in AI and data science. Developing a skilled workforce is crucial to fostering innovation and encouraging the adoption of this technology.

Moreover, it is necessary to establish a regulatory framework that both promotes technological innovation and ensures data protection and privacy. Comparing regulatory approaches from countries like Brazil and Angola can provide valuable insights into best practices and help accelerate AI development in Angola.

Cooperation between developing and developed nations is vital for knowledge sharing, technology transfer, and resource exchange. However, increasing international partnerships is essential to drive AI implementation in Africa's development, particularly in Angola a promising country facing both challenges and opportunities.

Finally, it is crucial to adopt a critical perspective on AI usage, considering both its opportunities and risks. While the adoption of new technologies in the 21st century is highly significant, we must be cautious in their use, ensuring that AI serves as a tool to enhance human intelligence rather than replace it.

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