SEVEN
publicações acadêmicas

THE AECO INDUSTRY AND INFRAESTRUCTURE IN AFRICA: CHALLENGES AND OPPORTUNITIES IN A DIGITAL TRANSFORMATION CONTEXT

A INDÚSTRIA AECO E AS INFRAESTRUTURAS EM ÁFRICA: DESAFIOS E OPORTUNIDADES NUM CONTEXTO DE TRANSFORMAÇÃO DIGITAL

LA INDUSTRIA AECO Y LAS INFRAESTRUCTURAS EN ÁFRICA: DESAFÍOS Y OPORTUNIDADES EN UN CONTEXTO DE TRANSFORMACIÓN DIGITAL

https://doi.org/10.56238/sevened2025.036-113

José Paulo Kai[1]

ABSTRACT

This article analyzes the Architecture, Engineering, Construction, and Operation (AECO) Industry and the development of infrastructures in Africa, identifying the main challenges and opportunities related to the sustainable transformation of the sector. The research assumes that infrastructure is the foundation of economic and social progress, being essential for competitiveness and quality of life. However, the African continent faces a severe structural deficit across all subsectors—transport, energy, water, sanitation, telecommunications, and housing—which limits its productive integration and ability to attract foreign direct investment. The study is based on documentary and descriptive analysis, complemented by data from international organizations such as the World Bank, the African Development Bank (AfDB), the UN, and Deloitte, to understand the dynamics of financing, innovation, and sustainability in the AECO industry within the African context. The results show that the infrastructure deficit reduces Africa's economic growth by around 2% per year and company productivity by up to 40%, reflecting technological and financial dependence on external sources. Conversely, significant opportunities emerge from construction digitalization, circular economy principles, the use of local materials, and energy transition. It concludes that integrated public policies, combined with technical capacity building and technological innovation, are crucial to boost the AECO sector as a driver of sustainable development in Africa.

Keywords: AECO Industry. Infrastructure. Africa. Sustainability. Circular Economy.

RESUMO

O presente artigo analisa a Indústria da Arquitetura, Engenharia, Construção e Operação (AECO) e o desenvolvimento de infraestruturas em África, identificando os principais desafios e oportunidades associados à transformação sustentável do setor. A investigação parte da premissa de que a infraestrutura é o alicerce do progresso económico e social, sendo indispensável à competitividade e à qualidade de vida das populações. No entanto, o continente africano enfrenta um défice estrutural acentuado em todos os subsetores — transportes, energia, água, saneamento, telecomunicações e habitação — o que limita a sua integração produtiva e a sua capacidade de atrair investimento direto estrangeiro. O estudo baseia-se numa análise documental e descritiva, complementada por dados de organismos internacionais como o Banco Mundial, o Banco Africano de Desenvolvimento (AfDB), a ONU e a Deloitte, para compreender as dinâmicas de financiamento, inovação e sustentabilidade

[1] Dr. in Structural Mechanics. Universidade Agostinho Neto (FEUAN). E-mail: jose.kai@uan.ao
Orcid: https://orcid.org/0009-0006-3255-9900

da Indústria AECO no contexto africano. Os resultados demonstram que o défice de infraestrutura reduz o crescimento económico do continente em cerca de 2% ao ano e a produtividade das empresas até 40%, refletindo-se numa dependência tecnológica e financeira externa. Por outro lado, emergem oportunidades significativas associadas à digitalização da construção, à economia circular, ao uso de materiais locais e à transição energética. Conclui-se que a implementação de políticas públicas integradas, associadas à capacitação técnica e à inovação tecnológica, é fundamental para impulsionar o setor AECO como motor do desenvolvimento sustentável africano.

Palavras-chave: Indústria AECO. Infraestruturas. África. Sustentabilidade. Economia Circular.

RESUMEN

Este artículo analiza la Industria de Arquitectura, Ingeniería, Construcción y Operación (AECO) y el desarrollo de infraestructuras en África, identificando los principales desafíos y oportunidades relacionados con la transformación sostenible del sector. La investigación parte del supuesto de que la infraestructura constituye la base del progreso económico y social, siendo esencial para la competitividad y la calidad de vida. Sin embargo, el continente africano enfrenta un grave déficit estructural en todos los subsectores —transporte, energía, agua, saneamiento, telecomunicaciones y vivienda— que limita su integración productiva y su capacidad para atraer inversión extranjera directa. El estudio se basa en un análisis documental y descriptivo, complementado con datos de organismos internacionales como el Banco Mundial, el Banco Africano de Desarrollo (AfDB), la ONU y Deloitte, para comprender las dinámicas de financiación, innovación y sostenibilidad de la industria AECO en el contexto africano. Los resultados muestran que el déficit de infraestructura reduce el crecimiento económico del continente en aproximadamente un 2% anual y la productividad empresarial hasta un 40%, reflejando una dependencia tecnológica y financiera externa. Por otro lado, surgen oportunidades relevantes derivadas de la digitalización de la construcción, la economía circular, el uso de materiales locales y la transición energética. Se concluye que la implementación de políticas públicas integradas, junto con la capacitación técnica y la innovación tecnológica, es fundamental para impulsar el sector AECO como motor del desarrollo sostenible africano.

Palabras clave: AECO. Infraestructuras. África. Sostenibilidad. Economía Circular.

1 INTRODUCTION

Infrastructure development is one of the key pillars for sustainable economic growth and the reduction of social inequalities in any region of the world. In the African context, the issue acquires particular relevance, given the magnitude of the structural deficit that affects essential sectors such as energy, transport, water supply, sanitation, telecommunications and housing. The Architecture, Engineering, Construction and Operation (AECO) industry plays, in this sense, a strategic role as a vector of economic transformation and social modernization, as it materializes the physical infrastructure on which the continent's productivity, mobility and connectivity are based.

According to the African Development Bank (AfDB, 2023), the annual infrastructure financing gap in Africa is estimated at between US$68 and US$108 billion, reflecting a historical gap that limits the competitiveness and well-being of populations. The World Bank (2022) reinforces that the low quality of infrastructure reduces the continent's economic growth by about 2 percentage points per year, and decreases business productivity by up to 40%, becoming one of the biggest obstacles to industrialization and regional integration. This reality is compounded by rapid population growth — Africa's population is expected to double by 2050 — which puts increased pressure on already saturated urban systems and natural resources.

AEC Industry, as a multidisciplinary field that integrates the planning, design, construction, operation and maintenance of physical assets, is both part of the problem and part of the solution. On the one hand, the sector is responsible for about 40% of global carbon emissions and the consumption of approximately 50% of the planet's natural resources (UNEP, 2022); on the other hand, it is an essential engine of the economy, generating millions of direct and indirect jobs and promoting technological innovation and industrialization. The need for a transition to sustainable practices, based on principles of circular economy, digitalization and climate resilience, is today recognized as a strategic imperative for the future of African construction.

The global context of energy and technological transformation directly influences the prospects of the AEC sector in Africa. The implementation of decarbonization policies, the emergence of digital twins, Building Information Modeling (BIM) and Smart Infrastructure solutions create unprecedented opportunities to overcome historical limitations in productivity, transparency and efficiency. However, the adoption of these technologies faces

significant challenges related to the initial cost, the lack of standardization, the shortage of skilled labor, and the insufficiency of integrated public policies.

On the socio-economic front, the fragility of Africa's infrastructure translates into persistent inequalities. Data from the United Nations (UN, 2023) indicate that only 38% of the African population has access to electricity, less than 10% to the internet, and only a quarter of the continental road network is paved. These figures illustrate the urgency of structural investment and infrastructure management policies that combine technological innovation with environmental sustainability and social inclusion.

Thus, understanding the challenges and opportunities of the AEC Industry in Africa is essential to outline sustainable development strategies that unite economic growth, social equity and environmental protection. The approach of this study aims to contribute to the academic and technical debate on how to structure and operationalize policies, technologies and management models capable of transforming the African infrastructure deficit into an engine of development.

Thus, this article aims to critically analyze the challenges and opportunities of the AEC Industry in the context of African infrastructure, highlighting the dynamics of sustainability, innovation and financing. As specific objectives, it is intended to:

a) to identify the main structural and institutional constraints that condition the AEC sector on the African continent;
b) examine emerging trends related to circular economy, digitalisation and climate resilience;
c) to propose strategic lines for strengthening the technical and technological capacity of African infrastructures.

2 THEORETICAL FRAMEWORK

The theoretical framework is structured around four fundamental axes that underpin the analysis of AEC Industry and infrastructure in Africa: (i) the conceptual framework of AEC Industry and its relationship with sustainable development; (ii) the structural deficiencies of the African continent in the field of infrastructure; (iii) the need to transition to a circular and low-carbon economy; and (iv) the incorporation of digital and smart technologies as catalysts for efficiency and innovation.

2.1 AEC INDUSTRY AND SUSTAINABLE DEVELOPMENT

The AEC (Architecture, Engineering, Construction and Operation) industry covers the entire life cycle of buildings – from design and planning to the execution, operation, maintenance and decommissioning of infrastructures. It is an interdisciplinary sector, which integrates the domains of civil engineering, architecture, economics, management and technology, playing a vital role in urban and regional development (Andrade & Silva, 2020).

Contemporary literature recognizes that the construction sector is both one of the largest global economic engines and one of the main emitters of greenhouse gases. According to the United Nations Environment Programme (UNEP, 2022), the built environment is responsible for about 37% of global CO_2 emissions and consumes approximately 36% of the world's final energy. In Africa, although the level of industrialization is still low, the trend of accelerated urbanization — which is expected to reach 60% by 2050 — puts unprecedented pressure on building and infrastructure systems (AfDB, 2023).

The concept of sustainable development, enshrined in the Brundtland Report (World Commission on Environment and Development, 1987), states that economic progress must meet present needs without compromising the capacity of future generations. Applied to the AEC sector, this implies adopting construction practices that minimize the consumption of non-renewable resources, reduce waste, promote energy efficiency, and prioritize the life cycle of materials and buildings.

According to Gibb and Isack (2019), the transition to a sustainable construction model requires "structural changes in the processes of design, planning and execution of works, including digital integration and the circular economy as guiding principles of the construction value chain".

In this way, the AEC Industry in Africa presents itself as a strategic vector for the achievement of the United Nations Sustainable Development Goals (SDGs), especially SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action).

2.2 INFRASTRUCTURE SHORTAGES IN AFRICA

Africa's infrastructure deficit is one of the main obstacles to economic growth and regional integration. According to World Bank estimates (2022), only 38% of the African population has access to electricity, less than 10% to the internet, and only 25% of the continental road network is paved. The cost of infrastructural inefficiency translates into an

average loss of 2% of annual GDP and a reduction of up to 40% in business productivity (World Bank, 2022).

The African Development Bank (AfDB, 2023) estimates that US$93 billion per year would be needed over the next decade to address infrastructure deficiencies in sub-Saharan Africa. Of this total, US$ 60 billion is earmarked for the construction of new infrastructure and US$ 30 billion for the maintenance of existing ones. The following table summarizes the main sectoral shortcomings:

Table 1

Top infrastructure shortages in Africa (2023)

Sector	Current Situation	Economic and Social Impact
Electrical energy	38% population access	Low industrialization and limitations to productivity
Water and sanitation	30% adequate coverage	Public health problems and regional inequalities
Road transport	25% of paved roads	Increases logistics costs by 30–40%
Telecommunications	<10% internet penetration	Limits innovation and digital inclusion
Urban housing	50 million units in deficit	Informal sprawl and urban degradation

Source: World Bank (2022); AfDB (2023); UN-Habitat (2022).

Infrastructural fragility is linked to multiple factors, including:

a) excessive dependence on external financing;

b) absence of maintenance and preventive rehabilitation policies;

c) insufficient regional integration and logistics; and

d) lack of technical and governance skills.

In addition, the infrastructure deficit exacerbates the continent's climate vulnerability. Climate change increases the frequency of floods, droughts, and coastal erosion, directly affecting energy, road, and water infrastructure (IPCC, 2022). Thus, resilient and sustainable construction emerges as a priority need.

2.3 CIRCULAR ECONOMY AND DECARBONIZATION

The traditional model of construction — linear, resource- and emissions-intensive — is unsustainable in the long term. The transition to a circular economy proposes a systemic approach based on three principles: reduce, reuse and recycle (Ellen MacArthur Foundation, 2021). In AEC Industry, this translates into the design of buildings and infrastructures that

maximize durability, allow dismantling and incorporate recyclable materials.

According to Deloitte (2022), the construction industry is responsible for 40% of global solid waste and 12% of the world's drinking water consumption. In Africa, where waste management systems are fragile, this statistic is critical. Embedding circular practices – such as the use of low-impact, local materials, recycling of construction waste and modular production – can reduce the total life-cycle cost of infrastructure by up to 30% (UNEP, 2022).

The concept of circular construction also involves the integration of Environmental Performance Indicators (PPEs) in the planning and operation of assets. Emerging examples include the use of ecological blocks produced from recycled plastic waste, as in the experience of the company Nelplast, in Ghana, whose products are 30% cheaper and more durable than conventional ones, in addition to promoting social inclusion and reducing emissions (Economic Forum, 2022).

Overall, the targets of carbon neutrality by 2050 put the AEC sector under pressure to adopt low-carbon materials, renewable energies and digitalised processes that optimise energy efficiency. The concept of green and resilient infrastructure therefore becomes a central element of African competitiveness.

2.4 DIGITALIZATION AND TECHNOLOGICAL INNOVATION

Digitalization is recognized as the main driver of transformation of the AEC Industry in the 21st century. Technologies such as Building Information Modeling (BIM), Digital Twins, Internet of Things (IoT) and Artificial Intelligence (AI) are redefining the planning, construction and management of infrastructures on a global scale (KPMG, 2021).

The McKinsey Global Institute (2020) estimates that the adoption of digital technologies can increase the productivity of the construction sector by up to 60% and reduce design and operating costs by between 10% and 20%. In Africa, this transformation is still in its infancy, but with high potential, especially in countries that invest in national BIM and Smart Infrastructure strategies.

The integration of digital platforms allows the management of the life cycle of assets, optimizing maintenance costs, safety and structural performance. In addition, the use of drones, laser scanners, sensors, and infrared thermography has revolutionized the inspection and monitoring of bridges, roads, and buildings, increasing the reliability of engineering decisions.

The African Development Bank (2024) underlines that the digital transition in

construction is an essential condition for increasing transparency, reducing corruption and improving public governance in the sector. The combination of technological innovation and environmental sustainability thus forms the new paradigm of African infrastructure development.

3 METHODOLOGY

The methodology adopted in this study aims to ensure the scientific consistency and replicability of the results, based on principles of applied research and interdisciplinary approach. The analysis of AEC Industry and infrastructure in Africa requires a methodological framework that articulates economic, technological, environmental and institutional dimensions, in view of the systemic complexity of the topic.

3.1 TYPE AND NATURE OF RESEARCH

This is a qualitative and quantitative research (mixed method), with descriptive, exploratory and analytical-comparative characteristics. The qualitative approach allowed us to understand the political-economic and institutional contexts of African infrastructure, while the quantitative approach provided empirical support through statistical data from recognized sources.

According to Gil (2019), descriptive research seeks to "describe the characteristics of a given phenomenon or the relationship between variables", and is suitable for studies in which it is intended to identify causes and consequences of a complex reality. In this article, the reality analysed is the current state of AEC infrastructure and industry on the African continent, as well as the prospects for technological and sustainable evolution.

The research also assumes a bibliographic and documentary character, based on the critical review of reports, scientific articles and databases of international organizations, including:

- African Development Bank (AfDB);
- World Bank;
- United Nations (UN and UNEP);
- Deloitte, McKinsey, KPMG and OECD;
- UN-Habitat;
- Technical reports from African engineering and construction institutions.

3.2 METHODOLOGICAL PROCEDURES

The procedures adopted comprised four main steps:

a) *Bibliographic and documentary survey*: A systematic analysis of the academic and technical literature on AEC Industry, infrastructure development and sustainability in Africa was carried out. Sources included databases such as Scopus, ScienceDirect, SpringerLink and African Journals Online, as well as public policy documents and sector performance reports.

b) *Secondary data analysis*: Statistical data on macroeconomic indicators, levels of access to basic services, investment volumes, and environmental performance indicators were compiled and interpreted. The integration of data from different bodies allowed a comparative and transversal view of the continent.

c) *Analytical structuring*: A thematic analysis matrix with three central axes — Structural Challenges, Strategic Opportunities and Technological Trends — was used, which served as the basis for the critical synthesis presented in the Results and Discussion section.

d) *Conceptual validation*: Source triangulation was employed to ensure the coherence and reliability of the findings, as recommended by Yin (2021) in studies of an interpretative nature.

3.3 UNIT OF ANALYSIS AND DELIMITATION

The unit of analysis of this study is the African continent, considered as a whole, with no emphasis on specific national cases. The choice for a continental approach is justified by the need to understand the common structural patterns, regional gaps and converging trends that characterize African infrastructural development.

The time limit covers the period from 2015 to 2024, corresponding to the implementation of the African Union's Agenda 2063 and the intensification of international commitments to the Sustainable Development Goals (SDGs). This time frame allows us to analyze recent changes in infrastructure policies and the adoption of sustainable construction technologies.

3.4 ANALYSIS TOOLS AND TECHNIQUES

The data were analyzed using two complementary techniques:

a) Thematic content analysis, applied to literature and technical reports, in order to identify the most recurrent categories of challenges and opportunities in the African AEC Industry. This technique followed the guidelines of Bardin (2016), allowing the grouping and interpretation of qualitative evidence in a structured way.
b) Comparative analysis and descriptive statistics, used to organize and synthesize quantitative data on access to infrastructure, investment and emissions. These data were presented in tables and tables prepared according to ABNT standards, with indication of primary sources.

3.5 ETHICAL CONSIDERATIONS AND LIMITATIONS

The research respected the ethical principles of scientific integrity, according to the UNESCO Code of Ethics (2021), ensuring transparency in the citation of sources and reliability of interpretations. No confidential data was used, limited to public and official information.

Among the limitations of the study, the following stand out:

- the heterogeneity of statistical sources among African countries, which makes direct comparisons difficult;
- the scarcity of specific data on technology adoption in the African AEC sector;
- the absence of complete historical series for some sustainability indicators.

Despite these restrictions, methodological triangulation and the cross-referencing of international sources provided a comprehensive, rigorous, and up-to-date view on the subject.

4 RESULTS AND DISCUSSIONS

The analysis of data and specialized literature allowed the identification of a set of persistent structural challenges and emerging opportunities that shape the future of AEC Industry and infrastructure in Africa. This section presents the synthesis of these results, supported by empirical evidence and a critical reading of continental trends.

4.1 STRUCTURAL CHALLENGES OF AEC INDUSTRY AND INFRASTRUCTURE IN AFRICA

Africa's infrastructure is characterized by multidimensional shortcomings, which go beyond physical insufficiency and include gaps in planning, management, capacity building, and financing. The analysis highlights five central dimensions of challenge: structural, economic, institutional, technological and environmental.

4.1.1 Structural deficit and infrastructure obsolescence

The deficit of basic infrastructure is the most limiting factor of African development. It is estimated that around 600 million Africans lack access to electricity, 400 million lack adequate access to clean water, and more than 60% of the urban population lives in informal settlements (UN-Habitat, 2023).

Transport, energy and communications networks are, in many countries, in a state of obsolescence. Only 25% of African roads are paved, which increases the logistics costs of goods by 30 to 40% (World Bank, 2022). The poor integration between national and regional infrastructures prevents the consolidation of production chains and the efficient circulation of goods and services.

Table 2

Critical Infrastructure Indicators in Africa (2023)

Indicator	Continental average value	World average
Access to electricity	38% of the population	90%
Internet access	9,8%	65%
Paved roads	25%	55%
Annual investment in infrastructure	$93 billion (required)	—
Percentage of urbanization	45% (in 2024)	56%

Sources: AfDB (2023); World Bank (2022); UN-Habitat (2023).

Chronic underinvestment in maintenance exacerbates the problem. The AfDB (2023) estimates that one third of existing infrastructure is severely structurally degraded, requiring urgent rehabilitation. The lack of preventive maintenance policies leads to accelerated loss of assets and increased reconstruction costs.

4.1.2 Financial and investment challenges

Financing is one of the biggest obstacles to African infrastructure development. According to the Global Infrastructure Hub (2023), only 12% of financing for African infrastructure comes from domestic sources (governments and the local private sector), while 88% depends on external capital, mostly from China, the World Bank, and multilateral funds.

The main financial constraints include:

- high public debt and low credit rating;
- lack of risk mitigation instruments for private investment;
- political and exchange rate instability;
- absence of regional development banks with high leverage capacity.

In addition, existing funding is mainly focused on transport and energy megaprojects, neglecting areas such as maintenance, affordable housing and urban sanitation, which perpetuates territorial inequalities.

4.1.3 Institutional deficit and governance

African infrastructure governance is often characterized by institutional fragmentation, corruption, and low transparency in public procurement processes. Transparency International (2023) points out that construction is the second most vulnerable sector to corruption in Africa, after the exploitation of natural resources.

Institutional weaknesses include:

- absence of integrated urban and territorial planning policies;
- deficiencies in the regulation and technical inspection systems;
- lack of performance standards and technical standardization (particularly in public works);
- scarce culture of facility management and post-construction maintenance.

These gaps reduce the efficiency of investments and compromise the sustainability of public assets.

4.1.4 Technological and capacity building challenges

African AEC Industry is still based on traditional construction methods, with low productivity and reduced technological integration. The McKinsey Global Institute (2020) shows that construction productivity in Africa is about 40% lower than the world average.

Key technological limitations include:

- low adoption of BIM (Building Information Modeling) and Digital Twins;
- absence of technical standards and data interoperability;
- insufficient training in digital engineering, automation and sustainability.

The shortage of skilled labor is another relevant obstacle: according to the African Union Commission (2022), only 1 in 10 engineering professionals in Sub-Saharan Africa have received formal training in digital tools applied to construction.

4.1.5 Environmental and climate impacts

The AEC sector is responsible for approximately 40% of global carbon emissions, with infrastructure alone responsible for 53% of these emissions (UNEP, 2022). The African challenge is particularly sensitive, as local infrastructure is highly vulnerable to extreme weather events — floods, droughts, and storms — exacerbated by climate change (IPCC, 2022).

In addition, the use of energy-intensive materials (cement, steel and concrete) increases the ecological footprint of construction. The transition to low-carbon materials and circular economy practices is, therefore, essential to mitigate the sector's environmental impacts.

4.2 STRATEGIC OPPORTUNITIES OF AEC INDUSTRY AND INFRASTRUCTURE IN AFRICA

Despite the structural challenges identified, Africa presents a robust set of strategic opportunities that can transform the AEC sector into a catalyst for sustainable growth, social inclusion and technological innovation. These opportunities are aligned with the African Union's Agenda 2063 and the Sustainable Development Goals (SDGs).

4.2.1 Urban growth and industrialization potential

Accelerated urbanization is both a challenge and an opportunity. The African continent will have 1.3 billion urban dwellers by 2050, which will require urban infrastructure, housing, mobility and basic services on an unprecedented scale (UN-Habitat, 2023). This growth creates a continuous demand for the AEC sector, stimulating employment, local industrialization and innovation in construction materials and technologies.

The industrialisation of the sector can be supported by regional value chains, encouraging local production of cement, steel and modular components, which would reduce import costs and increase economic resilience.

4.2.2 Innovation and digitalisation of construction

The digitalization of the AEC sector is considered one of the most promising vectors of transformation. The use of BIM, Digital Twins (Figure 1), IoT and Artificial Intelligence allows integrated planning, reduction of design errors, cost control and real-time performance monitoring.

Studies by KPMG (2021) and McKinsey (2020) indicate that the adoption of digital tools can reduce the cost of operating and maintaining infrastructures by up to 25% and increase construction productivity by 60%. Countries such as Morocco, Egypt, Kenya and South Africa have already started national programs for the implementation of BIM and smart infrastructures, with positive results in transparency and public efficiency.

Figure 1

Digital twins

Source: Image taken from the internet

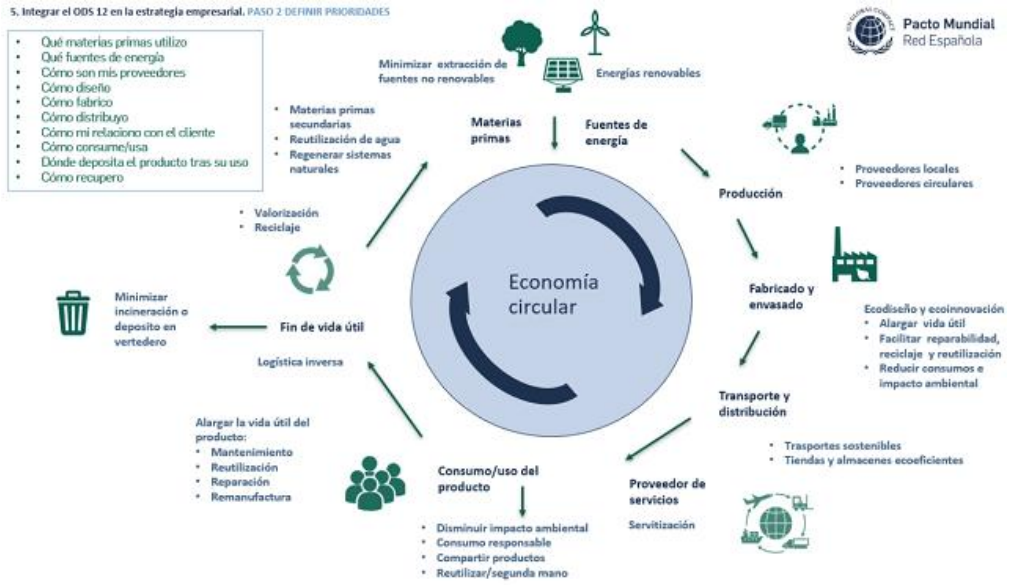
4.2.3 Circular Economy and Material Innovation

The circular economy offers opportunities for a more efficient and inclusive construction model, Figure 2. Experiences such as that of the company Nelplast Eco, in Ghana, which converts plastic waste into paving blocks and ecological bricks, demonstrate the potential of local and sustainable solutions. These materials reduce production costs by 30% and are more durable and waterproof (World Economic Forum, 2022).

Promoting production chains of sustainable materials — expanded clay, bamboo, natural fibers, and recycled aggregates — can generate endogenous innovation, local employment, and a reduction in the ecological footprint.

Figure 2

Circular economy cycle



Source: Image taken from the internet

4.2.4 Green finance and public-private partnerships

The transition to a sustainable economy drives new sources of financing, such as Green Bonds, Climate Funds and Public-Private Partnerships (PPPs). The African Development Bank (2023) highlights that the continent raised more than US$20 billion in green bonds between 2019 and 2023, with a growing share of the sustainable construction and renewable energy sector.

PPPs, when well structured, can leverage private investment and transfer execution risks, as long as they are accompanied by adequate regulation and transparency guarantees.

4.2.5 Technical training and institutional strengthening

Strengthening local technical capacities is key to ensuring the sustainability and independence of the African AEC sector. Initiatives such as the African Infrastructure Fellowship Program (AIFP) and the Pan-African University Institute for Water and Energy Sciences (PAUWES) already train engineers and public managers in topics such as resilient infrastructure, digitalization, and project governance.

The creation of regional centers of excellence and integrated public innovation policies is essential to consolidate technical knowledge, normative standardization, and technological diffusion in the continent.

4.2.6 Climate resilience and sustainability

The incorporation of green infrastructure and nature-based solutions is another strategic opportunity. These solutions – such as sustainable drainage, urban reforestation and permeable pavements – contribute to mitigating flooding, improving environmental quality and increasing the resilience of African cities (UNEP, 2023).

Sustainable infrastructure, when associated with digital monitoring mechanisms and intelligent management, constitutes a new paradigm of African engineering, capable of simultaneously responding to the needs of development, climate mitigation and social inclusion.

5 CONCLUSION

This study has provided a comprehensive understanding of the challenges and opportunities of AEC Industry and infrastructure in Africa, in a context marked by deep structural asymmetries and the imperative of sustainable transformation. The results show that Africa's infrastructure deficit — estimated at about US$ 93 billion annually — is one of the main obstacles to the continent's economic and social development. This deficit manifests itself in severe shortages in the energy, transport, sanitation, housing and telecommunications sectors, affecting the competitiveness, productivity and quality of life of the population.

The study also showed that institutional and financial weaknesses, low technological integration and climate vulnerability increase the complexity of the African infrastructure problem. The lack of preventive maintenance policies, the dependence on external financing

and the insufficiency of technical standards and effective supervision limit the efficiency of investments and perpetuate the degradation of assets.

However, the African scenario is equally fertile in structuring opportunities. The rapid process of urbanization, increasing industrialization, and the expansion of new green financing mechanisms offer the potential for an unprecedented qualitative leap. The adoption of digital technologies – such as BIM, digital twins and smart sensors – combined with the circular economy and the use of sustainable local materials, can reduce costs, increase productivity and mitigate the environmental impact of the AEC sector.

Sustainable and digital construction thus represents the new frontier of African engineering. For the continent to capitalize on these opportunities, integrated public policies, institutional strengthening and systematic investment in technical training are necessary. The creation of regional innovation centres, the harmonisation of construction standards and the encouragement of applied research in sustainable technologies are essential pillars for strengthening African technological autonomy.

It is concluded that the future of AEC Industry in Africa depends on the collective capacity to articulate governance, innovation and sustainability. The challenge is no longer just to build more, but to build better, with efficiency, equity and environmental respect.

The integration between the public, private and academic sectors will be decisive in transforming the infrastructure deficit into an engine of inclusive and resilient development, consolidating the role of the AEC sector as the structuring axis of the 2063 Agenda and the Sustainable Development Goals on the continent.

REFERENCES

African Development Bank. (2023). African economic outlook 2023: Mobilizing private sector financing for climate and green growth in Africa. AfDB.

Andrade, L. M., & Silva, R. C. (2020). Gestão e sustentabilidade na indústria AECO: Desafios globais e perspectivas futuras. Oficina de Textos.

Bardin, L. (2016). Análise de conteúdo. Edições 70.

Deloitte. (2022). Africa construction trends report 2022: Building resilient infrastructure. Deloitte.

Ellen MacArthur Foundation. (2021). Circular economy in the built environment. EMF.

Gibb, A., & Isack, F. (2019). Sustainable construction management and economics. Routledge.

Gil, A. C. (2019). Métodos e técnicas de pesquisa social (7ª ed.). Atlas.

Global Infrastructure Hub. (2023). Infrastructure financing in Africa. GIH.

Intergovernmental Panel on Climate Change. (2022). Sixth assessment report: Impacts, adaptation and vulnerability. IPCC.

KPMG International. (2021). Future-ready infrastructure: Digital transformation in construction. KPMG.

McKinsey Global Institute. (2020). Reinventing construction: A route to higher productivity. McKinsey & Company.

Organização das Nações Unidas. (2023). Sustainable infrastructure for the SDGs. United Nations.

Transparency International. (2023). Corruption perceptions index 2023. TI.

United Nations Environment Programme. (2022). 2022 global status report for buildings and construction: Towards a zero-emission, efficient and resilient buildings and construction sector. UNEP.

UN-Habitat. (2023). World cities report 2023: Envisioning the future of African cities. United Nations Human Settlements Programme.

World Bank. (2022). Africa's infrastructure: A time for transformation. World Bank.

World Commission on Environment and Development. (1987). Our common future (The Brundtland report). Oxford University Press.

World Economic Forum. (2022). Building the future: Green materials in construction. WEF.

Yin, R. K. (2021). Case study research and applications: Design and methods (6th ed.). SAGE Publications.